

School of Psychology

**Misconceptions and Critical Thinking Ability In Undergraduate
Exercise Science Students, Vocational Fitness Students, and
Exercise Professionals**

Daniel Jolley

This thesis is presented for the degree of

Doctor of Philosophy of Curtin University

September 2019

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by another author except where due acknowledgement has been made.

This Thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research studies received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Numbers HRE2016-0292 and HRE2016-0807.

Signature:

Date:

Abstract

Misconceptions of exercise science and nutrition information have been identified in exercise science students and professionals. However misconceptions have not been examined in vocational education (VET) students, or VET qualified personal trainers, and little is known about the relationship between misconceptions, knowledge, and critical thinking skills.

The first objective of this research was to identify fundamental exercise and nutrition misconceptions that may be popular in students, professionals, and the public, the information that may lead to developing these misconceptions, and potential methods of correction. Lecturers from university exercise science courses and VET fitness courses ($n = 12$) were interviewed regarding their opinions of prevalent misconceptions, potential sources of misconceptions, and methods of correction. Interview transcripts were analysed using a directed content analysis. Lecturers considered misconceptions existed before entering a course, persisted throughout, and involved simple subject matter. Popular media was identified as a possible source, as was superseded, or misunderstood, research evidence. Improving critical thinking skills was seen as an appropriate method of correcting misconceptions by participants at both levels of education. A survey was developed using the misconceptions identified in these interviews.

The second objective was to examine and compare the prevalence of these fundamental exercise and nutrition misconceptions in first year ($n = 159$) and third year ($n = 57$) exercise students, practicing exercise professionals ($n = 51$), and members of the general population ($n = 54$) in a cross-sectional survey. Sources of information used and trusted by participants was identified, and critical thinking ability was assessed. Misconceptions were more common in first year than the public or third year students, and more common in all other groups than degree qualified professionals. Better knowledge, and critical thinking ability, was associated with fewer misconceptions.

The third objective was to identify the extent of these fundamental exercise and nutrition misconceptions in vocational fitness students ($n = 66$), and vocationally trained personal trainers ($n = 70$). A longitudinal survey of VET fitness students was conducted from the beginning to the end of their course, and compared to practicing personal trainers, using the same survey. Misconceptions decreased throughout the VET fitness course, but there was no difference between graduates and practicing

personal trainers. The use of unreliable sources was associated with more misconceptions, but years of professional experience was not.

The fourth objective was to identify whether a critical thinking professional development activity will effectively counter fitness and nutrition misconceptions and improve critical thinking ability in practicing personal trainers. An online, fitness specific, critical thinking course for personal trainers ($n = 83$) was designed and evaluated using a randomised control trial. This intervention was effective in reducing misconception scores, increasing critical thinking ability, and improving participants' trust in reliable sources.

Inaccurate or misinterpreted sources of information have previously been identified as common sources of misconceptions. This is supported by the opinions of lecturers, and the finding that in most groups, higher levels of education, critical thinking ability, and the use of reliable sources was associated with fewer misconceptions. The level of education achieved appears to be more important than exercise qualifications, or years of experience, in preventing fundamental misconceptions. That VET qualified professionals did not possess fewer misconceptions than students, while degree qualified professionals did, suggests that the education or professional development of VET professionals should be reviewed.

Instruction in critical thinking was effective in reducing these misconceptions, but this is not a major focus of VET. Critical thinking skills have an important role in correcting fundamental exercise and nutrition misconceptions. These skills need to be embedded into VET fitness qualifications, and professional development in these skills provided for fitness professionals.

Key words: personal trainers, education, sources of information

Acknowledgements

Dr Megan Walske: Thank you for encouraging me to attempt a doctorate at all! You're right, I did really enjoy it. And also for your support and encouragement for the last three and a half years. Sorry I have more degrees than you now.

Associate Professor Melissa Davis, & Dr Andrew Lavender: Thank you both for your expert supervision and guidance. You provided just enough help to keep me from making any major mistakes, but not so much that I didn't need to learn as I progressed. I've learnt an enormous amount, and grown in confidence throughout the process.

Associate Professor Lynne Roberts: thank you for stepping in late in this project to add your expertise and a fresh set of eyes. Your feedback was invaluable, and helped add a lot of clarity to the finished product!

Dr Bill Sukala: Thank you for being a pioneer in evidence-based personal training, and calling out nonsense wherever you see it. And thanks for being so engaging when you do it, in person and on the page. Your presentation at WAFIC a decade ago really got me thinking!

Tallen Ames, Luke Dimasi, and Heather Slaven: Thank you all for your great help finding research participants. This could have been really challenging given the size of this project, but the number of students and trainers you gave me a chance to talk to made things go much more smoothly.

James Taylor: Thanks for providing your expertise in all things e-learning! Your comments and suggestions made the critical thinking course a much more interesting and engaging environment, and helped me create a piece of work I'm very proud of.

Contents

Abstract.....	1
Acknowledgements.....	5
List of Tables and Figures.....	11
List of Abbreviations	14
Chapter 1: Introduction.....	15
1.1 Objectives	17
1.2 Overview of the Research.....	18
1.3 Overview of the Thesis	19
Chapter 2: Review of the Literature.....	21
2.1 Overview.....	21
2.2 Introduction.....	21
2.3 Origins and Sources of Misconceptions	24
2.4 Misconceptions in Students	29
2.5 Misconceptions in Exercise Professionals	32
2.6 Correcting Misconceptions	37
2.6.1 Active Learning	38
2.7 Critical Thinking Skills.....	39
2.7.1 Teaching Critical Thinking.....	41
2.8 Conclusions.....	46
Chapter 3: The Origin and Correction of Misconceptions in Students.....	49
3.1 Introduction.....	49
3.1.1 Misconceptions in Students.....	50
3.1.2 Misconceptions in Exercise Professionals.....	50
3.1.3 Correcting Misconceptions.....	51
3.2 Objectives	52
3.3 Method	52
3.3.1 Participants	52

3.3.2 Materials	53
3.3.3 Procedure	65
3.4 Findings.....	66
3.4.1 Perceived Sources of Misconceptions in Students	67
3.4.2 Misconceptions in Professional Practice	70
3.4.3 Teaching Strategies.....	72
3.4.4 Critical Thinking Ability	75
3.4.5 The Presence of Misconceptions in Participants	77
3.4.6 Exercise Science Knowledge Survey	80
3.5 Conclusions	81
Chapter 4: The Presence of Misconceptions in Exercise Science Students and Professionals	84
4.1 Introduction	84
4.2 Method	86
4.2.1 Design.....	86
4.2.2 Participants	86
4.2.3 Measures	87
4.2.4 Procedure	90
4.2.5 Data Analysis.....	91
4.3 Results	92
4.3.1 Knowledge and Misconceptions.....	92
4.3.2 Confidence in Knowledge and Misconceptions	100
4.3.3 Sources of Information	101
4.4 Discussion	103
4.4.1 Conclusions	107
Chapter 5: The Presence of Misconceptions Before and After a Vocational Fitness Course	108
5.1 Introduction.....	108

5.1.1 Misconceptions in Students	109
5.2 Method	111
5.2.1 Design.....	111
5.2.2 Participants	111
5.2.3 Procedure	112
5.2.4 Measures.....	112
5.2.5 Data Analysis.....	113
5.3 Results.....	114
5.3.1 Dropouts	114
5.3.2 Knowledge and Misconceptions.....	115
5.3.3 Confidence in Knowledge and Misconceptions	122
5.3.4 Sources of Information	123
5.3.5 Differences between VET and Higher Education Students and Graduates	125
5.4 Discussion.....	127
5.4.1 Conclusions.....	132
Chapter 6: An Online Critical Thinking Intervention for Fitness Professionals	133
6.1 Introduction.....	133
6.1.1 Misconceptions in Exercise Professionals.....	134
6.1.2 Correcting Misconceptions.....	135
6.1.3 Online Education	137
6.1.4 Objectives	139
6.2 Method	139
6.2.1 Design.....	139
6.2.2 Participants	140
6.2.3 Material.....	142
6.2.4 Measures.....	144

6.2.5 Procedure	145
6.2.6 Data Analysis.....	146
6.3 Results	146
6.3.1 Dropouts	146
6.3.2 Critical thinking, Misconceptions and Knowledge	147
6.3.3 Confidence in Knowledge and Misconceptions	151
6.3.4 Sources of Information	152
6.4 Discussion	153
6.4.1 Conclusions	157
Chapter 7: Discussion	158
7.1 Introduction	158
7.2 Sources of Misconceptions	159
7.2.1 Informal Sources.....	161
7.2.2 Sources of Misconceptions in Professionals.....	162
7.3 Measures	163
7.3.1. Exercise Science Knowledge Survey	163
7.3.2. Cognitive Reflection Test	165
7.4 Misconceptions in Exercise Science Students & Graduates	167
7.5 Misconceptions in Vocational Fitness Students & Personal Trainers	168
7.6 Confidence	171
7.7 The Correction of Misconceptions.....	173
7.7.1 Critical Thinking in the Correction of Misconceptions.....	174
7.7.2 Critical Thinking Interventions.....	176
7.8 Limitations	177
7.9 Directions for Future Research	179
7.10 Conclusions	180
References	183

Appendix A: Participant Information Sheets	222
A.1 Participant Information Statement – Interview	223
A.2 Participant Information Statement – Survey	227
A.3 Participant Information Statement – Intervention.....	231
Appendix B: Consent Forms.....	235
B.1 Consent Form - Interview	236
B.2 Consent Statement – Survey & Intervention.....	238
Appendix C: Ethics Approvals	239
Appendix D: Exercise Science Knowledge Survey	244
Appendix E: Online Critical Thinking Intervention	251
Appendix F: Copyright Clearance	368

List of Tables and Figures

Figure 2.1. The interaction and overlaps of content knowledge, pedagogical knowledge, and critical thinking knowledge (Ab Kadir, 2017).....	43
Table 3.1. List of potential misconceptions discussed with participants	54
Figure 3.1. An example of an exercise intensity wall chart	57
Table 3.2. List of questions to be discussed for each misconception	66
Table 3.3. The percentage of higher education (HE) professionals ($n = 8$) and vocational education (VET) trainers ($n = 4$) that reported observing misconceptions in students, the public, and professionals.....	67
Table 3.4. Misconceptions and knowledge statements included in the Exercise Science Knowledge Survey	83
Table 4.1. Demographic characteristics of participants in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) students ($n = 57$), and degree qualified professional (DQP) ($n = 51$) groups.....	87
Table 4.2. Factor analysis for the Knowledge subscale in the Exercise Science Knowledge Survey	89
Table 4.3. The presence of misconceptions in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$), and degree qualified professional (DQP) ($n = 51$) groups.	93
Table 4.4. Agreement with knowledge statements in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$) student, and degree qualified professional (DQP) ($n = 51$) groups.....	95
Table 4.5. Mean (SD) Knowledge, Misconceptions, and critical thinking ability reported by general public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$) students, and professionals (DQP) ($n = 51$)	96
Table 4.6. Correlation between study variables ($N = 321$)	97
Table 4.7. Unstandardised (B) and standardised (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor variable on each step of a hierarchical multiple linear regression predicting Misconceptions ($N = 321$).....	98

Table 4.8. Mean (<i>SD</i>) Confidence in Knowledge and Misconception responses for the public (<i>n</i> = 54), first (<i>n</i> = 159) and third year (<i>n</i> = 57) students, and degree qualified professionals (<i>n</i> = 51)	101
Table 4.9. Correlation between Confidence score, highest educational achievement (AQF level), and Exercise Science Knowledge Survey Scores (<i>N</i> = 321)	101
Table 4.10. Participants from public (PUB) (<i>n</i> = 54), first (FYS) (<i>n</i> = 159) and third year (TYS) (<i>n</i> = 57) student, and degree qualified professional (DQP) (<i>n</i> = 51) groups who reported accessing each category of sources.....	102
Table 4.11. Mean (<i>SD</i>) trust of the public (PUB) (<i>n</i> = 54), first (FYS) (<i>n</i> = 159) and third year (TYS) (<i>n</i> = 54) students, and degree qualified professional (DQP) (<i>n</i> = 51) groups in each category of sources	103
Table 5.1. Mean (<i>SD</i>) group demographic characteristics for VET fitness students (<i>n</i> = 66) and personal trainers (<i>n</i> = 70).....	111
Table 5.2. The presence of misconceptions in personal trainers (PT) (<i>n</i> = 70) and students (<i>n</i> = 66) pre- and post-VET fitness course.....	116
Table 5.3. Agreement with knowledge statements in personal trainers (PT) (<i>n</i> = 70) and students (<i>n</i> = 66) pre- and post-VET fitness course.....	118
Table 5.4. Mean (<i>SD</i>) critical thinking ability, Knowledge, and Misconception scores for pre- and post-VET fitness students (<i>n</i> = 66)	119
Table 5.5. Mean (<i>SD</i>) critical thinking ability (CTA), Knowledge (KNOW), and Misconception (MISC) scores for personal trainers (PT) (<i>n</i> = 70), and comparison to pre- and post-VET fitness students (<i>n</i> = 66).	119
Table 5.6. Correlation between study variables (<i>N</i> = 136)	120
Table 5.7. Unstandardised (<i>B</i>) and standardised (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor variable on each step of a hierarchical multiple linear regression predicting Misconceptions (<i>N</i> = 136).....	121
Table 5.8. Mean (<i>SD</i>) Confidence scores in student groups pre- and post-VET fitness course (<i>n</i> = 66)	122
Table 5.9. Mean (<i>SD</i>) Confidence scores for personal trainers (PT) (<i>n</i> = 70), and comparison to pre- and post-VET fitness students (<i>n</i> = 66)	123

Table 5.10. Correlation between Confidence measures and demographic variables, critical thinking ability (CTA), and ESKS scores for Knowledge (KNOW) and Misconceptions (MISC) ($N = 136$)	123
Table 5.11. Percentage of pre- and post-VET fitness students ($n = 66$), and personal trainers (PT) ($n = 70$) accessing each source, and mean (SD) trust in each source .	124
Figure 6.1. Attrition of participants in the immediate, and delayed start groups.....	140
Table 6.1. Mean (SD) group demographic characteristics, for immediate ($n = 45$) and delayed ($n = 38$) start groups.....	141
Table 6.2. Mean (SD) critical thinking ability, Knowledge, and Misconception scores for delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups.....	148
Table 6.3. Percentage of participants observed to possess individual misconceptions in the delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups	149
Table 6.4. Agreement with knowledge statements in the delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups	150
Table 6.5. Mean (SD) Confidence scores in delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups	151
Table 6.6. Participants from delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups who reported accessing each category of sources	152
Table 6.7. Mean (SD) trust in categories of sources of information reported by participants from Delayed (DEL) ($n = 38$) and Immediate (IMM) ($n = 45$) start groups.	153
Table 7.1. Summary of research aims, key findings, and recommendations.....	182

List of Abbreviations

ANOVA – analysis of variance	KMO – Kaiser-Meyer-Olkin
AQF – Australian Qualifications Framework	KNOW – Knowledge score
CEC – continuing education credits	MISC – Misconceptions score
CI – confidence interval	MIX – sources of mixed or unknown reliability
CON - confidence	OTH – other health professionals (not exercise or nutrition related)
CRT – Cognitive Reflection Test	PRO – exercise and nutrition professionals
CTA – critical thinking ability	PT – personal trainer
DEL – delayed start intervention group	PUB – public
DOMS – delayed onset muscle soreness	REL – reliable sources
DQP – degree qualified exercise professional	RER – respiratory exchange ratio
EPOC – excess post-exercise oxygen consumption	RQ – respiratory quotient
ESKS – Exercise Science Knowledge Survey	SD – standard deviation
ESSA – Exercise and Sports Science Australia	TAFE – Technical and Further Education
FYS – first year exercise science student	UK – United Kingdom
HE – higher education	US – United States
HIIT – high intensity interval training	VAK – visual-auditory-kinaesthetic
HSD – honestly significant difference	VET – vocational education and training
IMM – immediate start intervention group	TYS – third year exercise science student

Chapter 1: Introduction

Modern information technology has vastly improved access to information, allowing the public to be more engaged in decisions about health, nutrition, and fitness than ever before. This can have significant benefits, leading to increased control and empowerment in personal health decisions (Lemire, Sicotte, & Paré, 2008). But with this access is the risk of outdated, incomplete, or inaccurate information from sources that lack the expertise, or inclination, to provide high-quality information.

There is a plethora of sources for information and topics related to health, nutrition and fitness including peer reviewed journal articles, textbooks, magazines and a variety of online sources, such as blogs and social media sources, that represent the writer's opinion and may not be well fact-checked. People looking for information in the modern era are most likely to start with online sources, since they are easily accessible, and often free. But the variable quality of online health information has been clearly established (Eysenbach, Powell, Kuss & Sa, 2002; Miles, Petrie, & Steel, 2000; Zhang, Sun & Xie, 2015), with a lack of author credentials, clear sources, and declared sponsorship arrangements common. Despite these quality concerns, the number of health information websites is increasing (Sillence, Briggs. Harris & Fishwick, 2007). Furthermore, users of online information may not have the skills to assess the credibility of online sources rigorously (Diviani, van den Putte, Giani & van Weert, 2015), and may instead rely on group consensus and heuristics (Metzger, Flanagan & Medders, 2010).

A heuristic is a cognitive shortcut which is used to reduce a complex mental task into a simple judgement, which speeds up processing, and requires little conscious attention (Stanovich, Toplak & West, 2008). While this is often helpful, heuristics can have negative impacts on learning. When exposed to new information, we form an opinion of this information based on earlier evidence. Further evidence is then judged based on its agreement with this opinion, a tendency known as confirmation bias (Nickerson, 1988). Later evidence inconsistent with this opinion is diminished in importance (Sherman, Zehner, Johnson & Hirt, 1983), while evidence which confirms this opinion is readily accepted, thus reinforcing the opinion. While it is possible to adjust one's opinion, these adjustments tend to be insufficient (Tversky & Kahneman, 1974), and over time a misconception can develop.

Misconceptions are “persistent beliefs that are contradicting current scientific views” (Badenhorst, Mamede, Hartman & Schmidt, 2015, p. 404). A misconception requires exposure to information that is either incorrect, or misunderstood, then continues to exist despite attempts at correction. It is strengthened as the holder of the misconception will tend to seek out information that confirms their (incorrect) opinion (Koriat, Lichtenstein & Fischhoff, 1980), and may even be spread to others, becoming popular over time.

Exercise and nutrition topics can be rich sources of misconceptions. Not only can information be misinterpreted in classroom settings (Morton, Doran & Maclaren, 2008), but misconceptions may form due to personal experiences. Those without relevant expertise may arrive at a fast, intuitive explanation (Baylor, 2001), but this is likely to be incomplete, or incorrect. Misconceptions have been identified in the public regarding topics such as dietary supplements (Duellman, Lukaszuk, Prawitz & Brandenburg, 2008; O’Dea, 2003) and weight loss (Abdel-Hamid, Ankel, Battle-Fisher, Gibson, Gonzalez-Parra, Jalali et al., 2014), while university students have demonstrated misconceptions in cardiac (Ahopelto, Mikkilä-Erdmann, Olkinuora, & Kääpä, 2011), exercise (Morton et al., 2008), and respiratory (Michael, Richardson, Rovick, Modell, Horwitz, Hudson et al., 1999) physiology. Given the prevalence of these misconceptions, it is important that the public has access to professionals who can interpret information correctly and provide appropriate advice.

The most readily available fitness professional for many people may be a personal trainer. However, personal trainers are usually vocationally qualified, and may possess misconceptions of their own, or lack the depth of knowledge to adequately correct misconceptions (Kruseman, Misarez & Kayser, 2008; Malek, Nalbone, Berger & Coburn, 2002; Zenko & Ekkekakis, 2015). While personal trainers in Australia are required to undertake professional development to maintain registration with the peak body, this registration is voluntary, and trainers have a broad scope to select the type, and volume, of professional development they participate in. While research has examined the knowledge of trainers in other countries, it is not yet clear to what extent personal trainers in Australia possess misconceptions, or the possible sources of these misconceptions.

Misconceptions may develop during a trainer’s education. It has been suggested that misconceptions can develop in the classroom when complex concepts are oversimplified, and the interaction of physiological systems is not appreciated

(Badenhorst et al., 2015; Michael, 2007). Existing research has not examined this in vocational education, focussing instead on undergraduate students. Given that assessment in vocational education focusses on competent task performance, rather than assessing knowledge directly (Gonczi & Hager, 2010), it is possible that this appreciation of the complexity and interaction of systems is lacking, and a prospective trainer's misconceptions could survive into professional practice.

A number of strategies have been proposed to correct misconceptions, using both direct instruction from lecturers, and active learning tasks. While the structure of active learning tasks varies significantly, a key component is critical thinking ability, defined as "reasonable reflective thinking" (Ennis, 1993, p. 180). This includes skills such as the ability to interpret and evaluate arguments, research information, assess evidence, consider alternative conclusions, as well as a willingness to apply these skills when needed (Abrami, Bernard, Borokhovski, Waddington, Wade & Persson, 2015). Many of these skills are not taught explicitly in vocational education, as they are not required by lower levels of the Australian Qualifications Framework (Australian Qualifications Framework [AQF] Council, 2013). However, these skills are required at higher levels of education, and are considered highly desirable by employers (Jackson & Chapman, 2012; Pithers & Soden, 2000). It is likely that without explicit instruction in critical thinking vocational students and graduates do not critically examine the basic misconceptions they hold. With improved critical thinking skills, they may be able to identify and correct misconceptions independently, potentially improving client outcomes.

1.1 Objectives

The aims of this research were:

1. To identify fundamental exercise and nutrition misconceptions that may be popular in students, professionals, and the public, the information that may lead to developing these misconceptions, and potential methods of correction.
2. To examine and compare the prevalence of these fundamental exercise and nutrition misconceptions in first year and third year exercise students, practicing exercise professionals, and members of the general population, and to determine if these misconceptions are predicted by demographic factors or exercise history.
3. To identify the extent of these fundamental exercise and nutrition misconceptions in vocational fitness students, and vocationally trained exercise professionals

(specifically, personal trainers), and whether these misconceptions are corrected, or persist throughout the course and into professional practice.

4. To identify whether a critical thinking professional development activity will effectively counter fitness and nutrition misconceptions and improve critical thinking ability in practicing personal trainers.

1.2 Overview of the Research

The research presented in this thesis consists of four studies. The first study involved developing a set of common misconceptions related to exercise and nutrition knowledge, to be used in Studies 2, 3 and 4. This involved semi-structured interviews with experienced teaching staff from university exercise science departments, and vocational fitness trainers. These participants were interviewed for their opinions on common misconceptions in their students, the public, and exercise professionals. They were also asked to provide their opinions on the potential sources of exercise and nutrition misconceptions in these groups, and the information, and teaching strategies, that could be used to correct these misconceptions. Responses were transcribed and analysed using content analysis.

The responses of these educators were used to develop an Exercise Science Knowledge Survey, consisting of 20 statements. Ten were misconception statements, while ten factual statements were included, each one corresponding to a correct understanding of the topic of a misconception. The survey asked participants to state whether or not they agreed with each statement and state their confidence in their answers. Participants were also asked to provide demographic information, identify their sources of exercise and nutrition information, and complete a short test of critical thinking ability.

The Exercise Science Knowledge Survey was used in a series of studies assessing the presence of misconceptions in the public, as well as student and professional groups. Study 2 was a cross-sectional survey of students of an Exercise and Sports Science Australia (ESSA) accredited university exercise science program, and qualified professionals, to assess the prevalence of misconceptions during early and late stages of an exercise science degree, and in professional practice. First year students were surveyed in the first weeks of their degree, while third year students were surveyed late in their final year. Degree qualified exercise professionals, currently working in exercise delivery to adults, were recruited. A comparison group

was also recruited, consisting of members of the public without exercise qualifications. The relationship between knowledge, misconceptions, critical thinking ability and confidence was assessed, as were the differences between groups. Additionally, the association of education, the length of professional practice, demographic factors, and exercise history with knowledge and misconceptions was also examined.

Study 3 was a longitudinal survey of vocational fitness students that assessed the prevalence of misconceptions in the first week of their course, and again in the final week. Changes in knowledge, misconceptions, critical thinking ability, and sources of information used by students were assessed. Results were compared to a sample of vocationally qualified personal trainers to assess differences in the presence of misconceptions as a result of their professional practice, or to identify differences in sources of information, and trust in these sources, between students and professionals. As above, associations with demographic factors were also examined.

The final study examined whether a critical thinking intervention would affect the presence of misconceptions in personal trainers. An online critical thinking course was designed using fitness specific content, for qualified personal trainers registered with the peak body. To confirm that changes in misconceptions or critical thinking ability could be attributed to the intervention, rather than time or repeated assessments, participants were randomly allocated to either an immediate or a delayed start group. The immediate start group had access to the intervention immediately upon completing the Exercise Science Knowledge Survey for the first time. The delayed start group had a six-week waiting period and were surveyed again at the end of this delay. They then had access to the course. Participants completed the Exercise Science Knowledge Survey immediately upon finishing the course, and the effect of the course on survey results was examined.

1.3 Overview of the Thesis

This thesis is divided into seven chapters, including this introduction. Chapter 2 reviews the literature examining the sources of misconceptions, their presence in students and professionals, and possible strategies to correct misconceptions. Chapter 3 describes the development of the Exercise Science Knowledge Survey, including the qualitative findings of the opinions of teaching

professionals regarding common exercise and nutrition misconceptions, and the information and teaching strategies used to correct them. Chapter 4 reports the findings of the cross-sectional survey of university exercise science students, degree qualified exercise professionals, and the general public. Chapter 5 reports on the longitudinal study of vocational fitness students and practicing personal trainers. Chapter 6 reports on the critical thinking intervention, and its success in reducing the presence of misconceptions in practicing personal trainers. Lastly, Chapter 7 discusses these findings within the context of the existing literature on misconceptions, and provides recommendations for future research, and pedagogical approaches.

Chapter 2: Review of the Literature

2.1 Overview

This literature review is divided into eight sections, including this overview. The concept of misconceptions, and the principles which underlie their formation, are introduced in the second section. The next section is an examination of the possible sources of misconceptions. A model of how misconceptions form is discussed, and potential sources of misconceptions are identified, from both formal learning and outside the classroom. The fourth section begins with an examination of misconceptions that have been identified in students in a range of different content areas, before misconceptions specific to exercise science and fitness are discussed in depth. These are examined in higher education students, before the state of research of misconceptions in vocational education and training (VET) is reviewed. The fifth section is a discussion of the presence of misconceptions, or the potential for misconceptions to develop, in exercise professionals, and includes a discussion of the scope of practice of these professionals.

Strategies that have been used to correct misconceptions, including both direct instruction and active learning approaches, and the role of critical thinking in these approaches, are examined in the sixth section. In the seventh section critical thinking ability is defined, and its potential role in the correction of misconceptions explored. Teaching strategies are examined, and the potential for teaching critical thinking in VET environments. Finally, conclusions are drawn based on the literature examined, and gaps in the research identified for investigation in the studies reported in subsequent chapters.

2.2 Introduction

In his seminal text on educational psychology, Ausubel (1968) stated “If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.” (p. vi). Implicit in this is determining where errors in knowledge exist that students are unaware of, as students’ estimation of their knowledge may differ from the instructor’s estimation. As will be discussed below, this may have a negative impact on learning outcomes.

Students’ awareness of errors in their knowledge may be unreliable due to biases that influence information processing. Foremost among these is confirmation

bias (Tversky & Kahneman, 1974). This is when an opinion forms based on early information, then further information is judged based on its agreement with this initial view, as the primary goal when interpreting information becomes defending this position (Nickerson, 1988). New information that is inconsistent with the early opinion is discounted, or diminished in importance (Sherman et al., 1983). This bias survives both formal training, and experience (Tversky & Kahneman, 1974), therefore errors in knowledge resulting from this bias may also survive.

Confirmation bias not only affects the reception of information, but also the manner in which someone may search for information and discuss it with others. Supporting information is sought out, and contradictory information neglected or discounted (Koriat et al., 1980; Klaczynski & Lavalley, 2005). Additionally, research suggests that more sophisticated reasoning is used to attack opposing arguments than to examine supporting ones. For example, Klaczynski and Lavalley (2005) found that when presented with a generalisation about different occupations, high school and college students found the generalisations less convincing, and used different counterarguments, when they were critical of the students' chosen career. In these instances participants were more likely to identify small sample sizes, and confounding variables, as arguments against these generalisations. Occupational identity was a significant predictor of these justification biases, but inductive reasoning ability was not.

Making corrections to our understanding of misinterpreted information is difficult due to our tendency to be “cognitive misers” (Tetlock, 1985, p. 305), and rely on the intuitive processing of information. Baylor (2001) proposed a model of intuition as a U-shaped curve along a continuum of expertise, with each end of the curve representing faster decision making. The decreased availability of intuition with intermediate levels of expertise is explained by learning an analytical approach to a task, which requires metacognitive control over reasoning (Kuhn, 1989). Baylor (2001) proposed that with expertise, and improved control over the application of analytical reasoning, the speed of processing increases, and intuition returns.

These types of intuitive judgements are known in dual-process theory (first proposed by Evans, 1984) as system 1 judgements: they are automatic, and largely involuntary and effortless (Kahneman & Klein, 2009). More deliberative judgements (system 2) require significant cognitive resources and attention and are inhibited by concurrent tasks. Kahneman and Klein (2009) describe that while experts can make

quick decisions using stored knowledge (a system 1 process consistent with intuition in Baylor's 2001 model), checking this decision is a system 2 process.

When learning something new we may enter the learning process with a fragmented understanding of a topic (Hannust & Kikas, 2006), or develop an understanding of a topic that is either incomplete or incorrect (Taber, 2001). Incorrect understandings may take a number of forms in addition to just a flawed statement, including flawed mental models, categorical errors, or missing schemas (Chi, 2013). This error could therefore conflict with correct knowledge in a number of ways.

Then, due to the ease in which system 1 processing is performed, we default to the heuristics that enable the quick processing of new information (Toplak, West & Stanovich, 2011). This means the decisions about how to interpret, and how much to trust this information, are not always rational, and we may demonstrate a bias towards confirming the incorrect understanding. Subsequent information can therefore reinforce the error, so it survives opportunities for correction. This resistance to correction is the defining characteristic of a misconception (Badenhorst et al., 2015). The resistance to correction can be even greater if there is a motivation to hold the misconception (Ecker, Lewandowsky, Fenton & Martin, 2014). Larkin (2012) proposed that misconceptions can be a useful part of the learning process, and act as stepping stones to a better understanding of a topic. However, compared to simple ignorance, misconceptions have implications beyond an individual's understanding of a topic. While ignorance can be corrected with presenting correct information, the holder of a misconception may reject this information (Lewandowsky, Ecker, Seifert, Schwarz & Cook, 2012; Newton & Miah, 2017). The misconception could also be spread with confidence and conviction (Lewandowsky et al., 2012). While Lewandowsky et al. (2012) were largely discussing conspiracy theories, the same circumstances can occur in educational contexts, as Newton and Miah (2017) demonstrated when examining belief in the concept of visual-auditory-kinaesthetic (VAK) learning styles, a highly prevalent misconception in education (Newton, 2015; Sharp, Bowker & Byrne, 2008; Tardif, Doudin & Meylan, 2015). In this case, not only did some participants (all higher education professionals) express their intention to continue using this notion when planning lessons, some accused the researchers of bias, and asking leading questions, despite careful pilot testing. In these examples those who have developed the misconceptions in question may

perceive a false consensus (Ross, Greene & House, 1977) due in part to their exposure to confirming information and opinions. This will make correction with accurate information more difficult. However it is worth considering that there is a diverse range of potential sources of misconceptions, and an awareness of these could inform attempts to prevent or correct these misconceptions.

2.3 Origins and Sources of Misconceptions

It is proposed that resistance to some scientific concepts can form early in childhood (Bloom & Weisburg, 2007). This can occur when scientific claims clash with emerging, intuitive expectations. For example, when discussing the relative movement of the earth and the sun young children are more likely to have geocentric (the sun orbiting the Earth), rather than heliocentric (the Earth orbiting the sun) perspectives (Siegal, Butterworth & Newcombe, 2004), and may also have incorrect conceptions of the shape of the Earth, due to their perceptions. That is, the Earth appears flat (Hannust & Kikas, 2006). Children are more likely to resist correction if these claims are contested in society (Bloom & Weisburg, 2007), but the fringe nature of beliefs such as heliocentrism in popular culture and education mean they do not survive, as they are not reinforced.

Furthermore, misconceptions can develop where a correct, though possibly naïve, conception of knowledge existed. In an exploratory qualitative study, Thompson and Logue (2006) identified that some children interviewed had correct conceptions of some scientific principles (such as why some objects will float in water, but others sink), though they were largely intuitive or experiential, rather than based on classroom content. For example, a 15-year-old student understood that the density of objects, rather than their weight, would dictate whether they would float or sink, while a ten-year-old did not. However, this older student did not include the concept of surface tension in their conception. While the naïve understanding led the older student to a correct answer in this instance, it may not be adequate in other situations. The authors proposed that a naïve conception which might be adequate in some situations may in fact interfere with subsequent learning.

A model of learning impediments was proposed by Taber (2001), which incorporates the prerequisite circumstances for a misconception to develop. This model divides learning impediments into two categories. A “null impediment” is a lack of knowledge, when the learner either lacks the required information

(deficiency), or the information is fragmented, and they cannot make sense of it. Knowledge that is misunderstood is referred to as a “substantive impediment” and involves incorporating new content into an alternative understanding. If this alternative explanation endures attempts at correction, it may strengthen and become a misconception. Substantive impediments could occur because of a misinterpretation of classroom information (pedagogic factors), or real-life events, experiences, or observations (ontological factors). These two subcategories can interact, as experiences outside the classroom could affect how a student interprets classroom information (Taber, 2001).

2.3.1 Pedagogical Sources of Misconceptions

Qualitative exploration of the experiences of lecturers in physiology (Michael, 2007) and health sciences (Badenhorst et al., 2015) identified some consistent themes in the pedagogic sources of misconceptions. Badenhorst et al. (2015) concluded that students could understand complex systems, but tended to study topics in isolation, rather than, for example, transferring their knowledge of physiological structure (i.e. anatomy) into understanding processes (physiology), or from micro to macro levels. As a result, students were found to struggle with understanding movement between, or the interaction of, different systems. The authors identified that overly simplistic diagrams and analogies, as well as a lack of integration between subjects, could contribute to this lack of understanding. Michael (2007) drew similar conclusions, while also noting lecturers perceived that students equated learning with merely memorising course content, rather than understanding the systems involved, and their processes and interactions.

Michael’s (2007) survey of physiology lecturers identified that the ability to reason causally was considered lacking in students. But while this was a qualitative study, and the author identified that detailed responses were provided by participants, this was not elaborated on. Chi (2005) studied this in far more depth and focussed on the nature of the process or system that is being taught as the origin of the misconception. Chi examined students’ comprehension of the circulatory system, and the process of diffusion, because while both involve transferring molecules to different areas of the body, the processes are inherently different. Chi concluded that students found circulation a simple process to understand, as it is a direct process with distinct and sequential steps. In contrast, Chi proposed that

diffusion was harder to understand as it is an emergent rather than a direct process, and requires understanding of simultaneous, independent, continuous physiological processes. Chi suggested that misconceptions could occur when students attempt to understand emergent processes as direct processes. These would resist correction more than if the incorrect understanding was within the appropriate process, as it requires a conceptual change across ontological categories (Chi & Slotta, 1993).

Understanding these complex processes can be made more difficult if students lack prerequisite knowledge for the course, or if educators are unaware of students' understanding. Morton et al. (2008) suggested misunderstood high school content could lead to misconceptions developing in higher education. However, Rovick, Michael, Modell, Bruce, Horwitz, Adamson, et al. (1999) identified that physiology lecturers were poor judges of new students' knowledge, when assessed in the first week of a range of physiology courses at different levels (first year to fourth year). While tending to underestimate the factual knowledge students possessed, lecturers overestimated students' ability to apply this knowledge. It is possible that a large disparity between this knowledge and lecturers' awareness increases the risk of misconceptions developing.

But while higher education physiology lecturers surveyed by Michael (2007) did not think that the way information was presented contributed to misconceptions, the author was consistent with other researchers in suggesting teaching practices must contribute. Michael et al. (1999) identified imprecise language, poor analogies, and inaccurate visual representations as potential sources of misconceptions. Similarly, Badenhorst et al. (2015) also identified inaccurate terminology, and lecturers not adequately integrating content from different topics.

2.3.2 Ontological Sources of Misconceptions

Traditionally, members of the public (and students outside the classroom) have relied on experts to act as “linguistic gatekeepers” (Abrahamson, Fisher, Turner, Durrance, & Combs Turner, 2008, p. 311), and translate technical language into something easier to understand, while maintaining meaning (Abrahamson et al., 2008). This has changed given the wealth of information available with access to the Internet, as the public may now have direct access to technical or scientific information. While access to information has increased, so has the potential for misconceptions. Not only a risk of the classroom, misconceptions can stem from

exposure to isolated, incorrect knowledge from informal, unscientific sources (Bensley & Lilienfeld, 2015). Exacerbating this potential, those who access health information online have been noted to perceive themselves as more competent, and in control, for having done so (Lemire, Sicotte and Paré, 2008), though they may lack expertise to make judgements about the quality or accuracy of the information.

A systematic review of research evaluating the quality of consumer health information online (Eysenbach et al., 2002) found that the majority of websites did not disclose sponsorships, author credentials, disclaimers, or references. Seventy percent of the studies included in the review concluded that online information was unreliable, particularly nutrition sites. Only nine percent of studies had a positive conclusion about the quality of information online, though none of these studies used the presence of evidence based-content on a site as a criterion to assess quality. A more recent systematic review (Zhang, Sun & Xie, 2015) confirmed these findings, with 55% of included studies having negative, and 37% mixed conclusions, about the quality of online health information. Other research has shown that the trustworthiness of a website does not dictate its popularity (Lemire, Paré et al., 2008), indicating that inaccurate information has the potential to spread widely.

It is therefore necessary for people to make judgements about the accuracy of information accessed online to prevent misconceptions from forming. But this requires deliberative, system 2 decision-making, which the reader needs both the skills, and the inclination, to apply. Consistent with dual-process theory, Metzger (2007) proposed that before information can be evaluated, the reader needs to be first motivated, and second, capable, of evaluating the information. They may then make a systematic, deliberate judgement, or one based on heuristics. These heuristics include unhelpful cues like endorsement by others, the violation of (or adherence to) expectations, and any detection of persuasive intent (Metzger et al., 2010). These may be unrelated to the accuracy of the content.

People may also be exposed to misconceptions through information they receive from other people. Duellman et al. (2008) identified that high school athletes preferred parents, friends, and coaches to nutrition professionals when seeking information about the effectiveness of protein supplements. Unsurprisingly, the authors found that misconceptions were common among those using protein supplements, and that users had unrealistic expectations about their effectiveness. O'Dea and Rawstorne (2001) observed a similar phenomenon, identifying parents,

friends, teachers, and magazines as sources of information for young males trying to gain muscle mass.

Though this could be attributed to the ease with which these informal sources are accessed, it appears that this pattern persists even with convenient access to professionals. For example, Burns, Schiller, Merrick, and Wolf (2004) found only 14% of football players in eight Division I college football programs in the US consulted a dietitian as a primary source of nutrition information, though at least 50% had a dietitian available on their team's staff. Without accessing appropriate professionals, the opportunity to help interpret information gathered from other sources and possibly correct misconceptions, is lost.

Professionals also risk developing misconceptions from accessing poor sources of information. An investigation into the popularity of misconceptions of neuroscience (such as hemispheric dominance, or the effectiveness of teaching to students' preferred VAK learning styles) found these were common not only in teachers, but also in trainers of teachers (Tardif et al., 2015), and emerged largely from informal sources such as colleagues, and the media. Other research has also identified the popularity of these misconceptions, and informal sources of information (Dekker, Lee, Howard-Jones & Jolles, 2012; Gleichgerrcht, Luttges, Salvarezza & Campos, 2015). Additionally, Dekker et al. (2012) identified that there was no effect of education on the presence of these misconceptions in teachers from the United Kingdom (UK) and the Netherlands. While it is not clear in this instance that the professional practice of teachers is changed as a result of possessing this misconception (Horvath, Donoghue, Horton, Lodge & Hattie, 2018; Newton & Miah, 2017), they remain popular and durable, resisting correction (Newton & Miah, 2017).

Gleichgerrcht et al. (2015) replicated the research of Dekker et al. (2012) with Latin American teachers as participants. They similarly identified that informal sources of information used by participants, and that the level of qualification, or amount of experience of participants did not affect the acceptance of misconceptions. Seventy-one percent of participants claimed to read scientific literature however the authors considered this figure highly inflated. Given these teachers received no training in research methods, it was concluded that participants may have mistakenly identified some lower quality information as primary sources (Gleichgerrcht et al., 2015). If primary sources were accessed, then misconceptions could also develop

from misunderstanding research evidence, in the absence of a ‘gatekeeper’ as discussed above.

While misconceptions most likely develop in the public from ontological sources, in professionals these origins are more complex, as there is the potential for misconceptions to develop in the classroom, or even through the interaction of personal experience, informal sources, and formal learning. It is possible that a student could leave a learning environment with the correct understanding, then develop misconceptions through exposure to non-academic sources in their professional practice. The presence of misconceptions in both students, and professionals, needs to be assessed in order to identify the sources of these misconceptions.

2.4 Misconceptions in Students

Misconceptions have been thoroughly examined in psychology students, beginning with Vaughan (1977) in a study designed to measure the effect of course content on the presence of misconceptions of psychology. However the attempted longitudinal study was abandoned when lecturers administering the survey to their class immediately discussed the survey items with them, meaning researchers could not assess the effect of course content alone on post-course responses. An additional problem with this work was that it lacked correct statements. Since all the statements in the survey were misconceptions, the nature of the survey may have been detected by some participants. Regardless, a number of popular misconceptions were identified, with participants on average agreeing with 44% of misconceptions (32 from 72 statements). More recent research has confirmed that psychology undergraduate students hold a number of common misconceptions (Hughes, Lyddy, Kaplan, Nichols, Miller, Saad et al., 2015; Bensley & Lilienfeld, 2015). Hughes et al. (2015) confirmed that many of these misconceptions resisted correction in undergraduate students, only showing significant reductions in prevalence at post-graduate level.

Students in other areas, such as the allied health fields, have also been shown to possess misconceptions. Understandably, many students possess naïve, or incomplete knowledge when beginning a university course (Badenhorst, Mamede, Abrahams, Bugarith, Friedling, Gunston et al., 2016), which could form the basis of later misconceptions. Badenhorst et al. (2016) found that first year medical students

had conceptions of respiratory physiology that misunderstood the nature of homeostasis, and the role of the nervous system in respiration, among others. These findings are consistent with earlier research examining exercise science students (Michael et al., 1999). The presence of cardiac physiology misconceptions was also identified by Ahopelto et al., (2011), who found that a specific problem-based learning activity was only partially successful in reducing misconceptions, and that new knowledge had deteriorated when students were reassessed 12 months later.

Misconceptions in chiropractic students have been identified as not only prevalent, but resilient (Innes, Leboeuf-Yde & Walker, 2018). While chiropractic treatment is often proposed to impact a range of body systems, this is not supported by evidence (Ernst, 2008). Innes et al. (2018) proposed that chiropractic students should be less willing to offer advice about health conditions outside their scope of practice (e.g., diabetes) compared to musculoskeletal complaints, though 74% of fourth and fifth year students they surveyed said they would ‘often’ provide advice about preventing cardiovascular disease, and 70% about preventing diabetes, in their future professional practice. Additionally, approximately half of fourth and fifth year students surveyed thought that chiropractic spinal adjustments improved the immune system, made childbirth easier, and improved the health of infants, among other claims unsupported by evidence. The authors found that this persistence of unscientific beliefs in chiropractic students was at odds with a curriculum intended to prepare lifelong learners. This is consistent with previous research that has found that a number of popular misconceptions in chiropractic students (and graduates) such as a belief in the efficacy of spinal manipulation for non-musculoskeletal conditions (Gliedt, Briggs, Williams, Smith & Blampied, 2012), and a significant minority of practicing chiropractors possessing misconceptions around vaccination (McGregor, Puhl, Reinhart, Injeyan & Soave, 2014).

2.4.1 Misconceptions in Tertiary Exercise Science Students

Tertiary exercise science students have been found to possess significant biases which, as discussed above, could contribute to misconceptions developing. Richardson, Fister and Ramlo (2015) identified that third and fourth-year exercise science students focussed excessively on exercise and controlling energy intake as weight loss strategies, consistent with their personal beliefs, and course content to that point. Following a summer school course on weight management, which

included behavioural, and bariatric interventions, a portion of the students assimilated the new content, while the rest maintained their original opinion. While this study did not use a representative sample of exercise science undergraduates (summer school students, with an average age of 24) other research has also demonstrated that exercise science students hold biases regarding obesity (Langdon, Rukavina & Greenleaf, 2016). As mentioned earlier, these biases can lead to misconceptions forming as new information is misinterpreted, in this case regarding issues such as the effectiveness of weight loss interventions.

Errors in the knowledge of exercise science students have also been identified. Ekkekakis, Albee and Zenko (2016) demonstrated that students possessed a poor knowledge of exercise prescription guidelines throughout a four-year degree program, and there was a considerable gap between their own perceived, and actual knowledge, which increased in later years. And the research by Michael et al. (1999) discussed above demonstrated that up to 90% of students surveyed possessed misconceptions about respiratory physiology. Similarly, Morton et al. (2008) found that nine out of the 10 misconceptions proposed by the authors were present in third year students, only one having been adequately corrected.

Caution must be exercised when interpreting these results, as differing terminology between studies may cause confusion. Ekkekakis et al. (2016) refer to errors in knowledge, whereas Morton et al. (2008) use the term ‘misconception’. Further, both these studies are cross-sectional studies of a degree program. As a misconception as defined here resists change, repeated measures designs are required to directly assess understanding of a topic across a program of study, and errors in fundamental knowledge persisting late into a program of study can safely be considered a misconception.

2.4.2 Misconceptions in Vocational Education Students

There is no known published research that directly examines the presence of misconceptions in VET students. The conditions for misconceptions to exist in VET are present, in part, due to the nature of competency-based training, which assesses the performance of job-specific tasks rather than students’ knowledge or understandings (Wheelehan & Moodie, 2011). In this environment students may be able to create the veneer of expertise through demonstrating adequate performance, without sound underlying knowledge (Meyer & Land, 2003).

Despite this focus on competency-based training, both VET trainers and students have been found to value deep knowledge and well-developed pedagogical skills (Smith & Yasukawa, 2017). But given VET trainers usually only require vocational qualifications in the skill being taught, and another in training and assessment, it is unlikely VET trainers will possess both deep knowledge and well developed pedagogical skills. And given that depth of knowledge has been identified as important in avoiding misconceptions (Badenhorst et al., 2015; Michael, 2007), it is highly likely that misconceptions will be present in the knowledge of VET graduates.

2.5 Misconceptions in Exercise Professionals

Given the misconceptions identified in exercise science students, it is possible that these misconceptions survive into professional practice. Supporting this possibility, research to date has shown that the knowledge of degree-qualified exercise professionals does not differ significantly to final year students (Ekkekakis et al., 2016). It has also been demonstrated that more years of professional practice do not result in greater levels of knowledge (Malek et al., 2002; Zenko & Ekkekakis, 2015). This suggests that ongoing formal education may be key to reducing the presence of misconceptions, and that the professional development courses required to maintain an industry registration may not meet this need.

In contrast to other allied health professions, exercise professionals are presented with low barriers for entry into the profession (Central YMCA Qualifications, 2014), with most personal trainers in Australia and the UK being vocationally trained. Other countries have even lower barriers to entry, with Switzerland having no education requirements (Kruseman et al., 2008). The US also has no required standard of education. Most trainers choose to certify with one of a number of different certifying agencies, though these have varying standards of assessment (Melton, Katula & Mustain, 2008). This means the quality of personal trainers' knowledge is highly variable.

Gavin (1996) was the first to examine the professional practice of personal trainers in light of their qualifications. He concluded that the majority of personal trainers were offering mental wellbeing advice to clients, despite this not being a part of their qualification. While at the time the scope of practice of personal trainers had not been clearly established, concerns about the knowledge, and practice, of personal

trainers continued to be expressed in a limited body of research focussing on personal trainers in the United States (US). Malek et al. (2002) administered an extensive (55-item) multiple choice questionnaire based on content from the certification exams of the major accrediting bodies for personal trainers in the US. Respondents were mostly not degree qualified, and performed poorly, with the average score being less than 50%. Similarly, Zenko and Ekkekakis (2015) found that personal trainers scored 43% on an 11-item multiple choice survey that tested their knowledge of exercise prescription guidelines. They also found that personal trainers without degree qualifications performed more poorly than those with bachelor, or post-graduate degrees. It is worth noting in that in the US these certifications issued by accreditation bodies may be the only qualification that personal trainers possess, so personal trainers without a degree may not have had any formal education in preparation for their assessment. As such, caution must be exercised when applying these findings to the industry in Australia, where a Certificate IV in Fitness is required prior to certification as a personal trainer.

Compounding these poor results in knowledge assessments are the sources of information that personal trainers have been found to use. This is an area that has been researched more thoroughly. A recent survey of Australian personal trainers (who were largely VET qualified) identified that participants were not confident in their ability to access up to date, evidence-based nutrition information (Barnes, Desbrow & Ball, 2016), though they rated their confidence to provide nutrition advice as high. Additionally, Bennie, Wiesner, van Uffelen, Harvey and Biddle (2017) identified high- and low-quality sources of information following a survey of experts (university academics, and key industry professionals) who had high level qualifications relating to exercise prescription. Sources considered high quality were academic textbooks, scientific journals, and specialised workshops, while low quality sources identified were other personal trainers, online forums, websites, and popular fitness magazines. In a subsequent online survey of personal trainers, the authors found that over 50% of personal trainers reported using sources of information identified as low quality by these experts.

The use of low quality, unreliable sources may be due to the inability to determine the quality of sources, but research here is mixed. A meta-analysis by Stacey, Hopkins, Adamo, Shorr and Prud'homme (2010) found that personal trainers acknowledged having difficulty identifying the quality of information they are

exposed to and tended to use the Internet as their primary source of information. However, only two studies met the criteria for inclusion, one of these being a qualitative study of 10 participants. By contrast, in semi-structured interviews of 11 personal trainers by De Lyon and Cushion (2013), participants expressed high levels of confidence in finding and interpreting information. Trainers reported observing and learning from other trainers, accessing printed sources such as textbooks and industry publications, and the frequent use of online sources. Additionally, formal learning was seen as less relevant than on-the-job training and practical experience. This preference for informal sources suggests that while personal trainers may feel confident about their ability to identify reliable information, this confidence may be misplaced.

These findings suggest that not only do personal trainers generally possess low levels of formal professional knowledge, they may also use poor sources of information. This may be due to the misguided valuing of informal sources, or unintentional if they are unable to determine the quality of information accurately. Given that knowledge is not improved by the length of practice of a personal trainer, it appears that these errors in knowledge persist. It is highly likely that these are misconceptions which will resist further attempts at correction, and could be passed on to clients, and other trainers.

2.5.1 Exercise Professionals' Scope of Practice

The accepted minimum qualification for personal trainers in Australia is a Certificate IV in Fitness (currently SIS40215), for which the only pre-requisites are core units from a lower level Certificate III qualification (SIS30315). These qualifications are often completed back-to-back in order to qualify as a personal trainer, though some training providers may only offer the prerequisite units, rather than the complete Certificate III.

The scope of practice for personal trainers is defined by the industry peak body (Fitness Australia). It includes exercise program design and delivery, provision of healthy eating advice in accordance with national dietary guidelines, and referral to medical or allied health professionals as needed (Fitness Australia, 2014). This scope of practice explicitly excludes nutrition information “outside of basic healthy eating information and nationally endorsed standards and guidelines” (Fitness

Australia, 2014; p. 3), detailed individualised meal plans, exercise prescription for high risk clients, and therapeutic or rehabilitative exercise without guidance.

It is unclear to what extent personal trainers limit their professional practice based on their scope of practice. De Lyon and Cushion (2013) reported that participants in their study reported that their professional practice would differ to the behaviours they exhibited while learning, when they were performing in the manner required to achieve the qualification. The personal trainers also commonly reported that formal learning had limited practical application to their role. It is unclear if the interviewed personal trainers would feel any restriction from a formal scope of practice, as this was not discussed in the interviews.

While registration with Fitness Australia is voluntary, and therefore not every Australian personal trainer may be aware of the scope of practice, the implications of this document apply to all trainers. A trainer's legal liability is informed by the standards of a reasonable, competent person possessing particular qualifications (Dietrich et al., 2013). Given the scope of practice is heavily informed by the vocational qualifications available in Australia (Fitness Australia, 2014), it provides guidance into this standard of liability.

However, the scope of practice may vary between countries, and between accrediting or registration bodies. Trainers have been found to exceed their scope of practice (or the scope of their qualification, where no formal scope of practice exists) in a number of ways. Gavin (1996) found that personal trainers perceived their role to include aspects of mental health. Anderson, Elliott and Woods (2010) identified that more than half of trainers prescribed therapeutic exercise, and Lobb, Lobb and Hallam (2008) found that most trainers thought their colleagues would advise clients not to take anti-obesity medications if prescribed by their general practitioner.

More research has been conducted on the nutrition advice practices of personal trainers. Studies of Swiss (Kruseman et al., 2008) and Canadian (Anderson et al., 2010) personal trainers have identified that while providing nutrition advice to clients was extremely popular, few referred to national healthy eating guides, or provided information around issues such as salt, water, and alcohol consumption (Anderson et al., 2010). Kruseman et al. (2008) also found that 58% of surveyed trainers encouraged the use of supplements to their clients, which is explicitly excluded by the Australian scope of practice.

Australian research following the release of the scope of practice document by Fitness Australia is consistent with these international findings. McKean, Slater, Oprescu and Burkett (2015) identified from an online survey of 286 personal trainers that most provided nutritional advice to clients, and many offered advice on issues such as heart disease, diabetes, and nutritional supplements. The majority of personal trainers did minimal (< 10 hours) professional development in nutrition following receiving their qualification, and many used informal sources of information such as magazines, the Internet, and other personal trainers. Coming so soon after the first publication of the Fitness Australia scope of practice however, it is possible that not all participants were fully aware of the contents of this. It is also possible that the sample of personal trainers in this study were not representative of the wider industry. While the education and experience of participants was consistent with available demographic information (Fitness Australia, 2016), the participants of McKean et al. (2015) were older, and largely female (68%). Similarly, Barnes, Ball and Desbrow (2016) reviewed the websites and social media accounts of 36 fitness businesses operating within two Australian federal electorates and found that only 14% displayed nutritional content within their scope of practice. In contrast, 52% clearly breached the scope of practice, while 34% were at risk of doing so. While this has not been assessed in Australia yet, recent research in the US (Manore et al., 2017) identified that most personal trainers were familiar with their scope of practice. If this is the case in Australia as well, it is possible that this scope of practice is being ignored.

Both these studies suggest personal trainers possess a high measure of confidence in their nutrition knowledge. This is consistent with the results of Barnes, Desbrow and Ball (2016), whose participant group shared similar demographic characteristics to the group surveyed by McKean et al. (2015). Barnes, Ball and Desbrow (2016) suggested that personal trainers may not be familiar enough with the scope of practice to routinely operate within it, but also identified some ambiguity in this document, and the possibility that personal trainers did not feel bound to this scope of practice as it is a position statement, and not legally binding. This scope is, however, a useful guide to the potential legal liabilities of personal trainers as discussed above. Given that even seemingly benign nutritional advice could have negative health consequences (Sass, Eickhoff-Shemek, Manore & Kruskall, 2007),

personal trainers operating outside this scope are exposing themselves to legal liability.

As a result of a low levels of formal education, a preference for informal sources of information, and inconsistent adherence to the scope of practice, the potential for misconceptions in the fitness industry to develop, or spread, is high. While personal trainers are obliged to undertake professional development in order to maintain their registration, more experienced trainers do not necessarily possess higher levels of knowledge (Malek et al., 2002; Zenko & Ekkekakis, 2015). This suggests that existing professional development opportunities may not be useful in correcting misconceptions, so other strategies for correcting misconceptions in exercise professionals need to be examined.

2.6 Correcting Misconceptions

It is unclear if simply presenting accurate information is effective in correcting misconceptions. Kowalski and Taylor (2009) found that misconceptions in psychology could be corrected by presenting the misconception, as well as information directly refuting the misconception, in a first-year psychology course. This was more effective than a standard lecture in which information was presented, but the misconception was not referred to. In contrast, Newton and Miah (2017) examined the prevalence of belief in VAK learning styles in higher education lecturers, and found that even when presented with information identifying the lack of evidence for the concept, 33% of participants stated they would persist with using these learning styles to inform their practice. Furthermore, Lewandowsky et al. (2012) point out that presenting a misconception with the correct information may in fact spread a misconception, since this might paradoxically strengthen individuals' ability to recall the incorrect information. It must be noted that Lewandowsky et al. (2012) were examining conspiracy theories, when the motivation to hold the misconception is different to classroom content, though this could be applicable to students and graduates in exercise related fields, who may possess a passion for their vocation. This passion can lead to the biases demonstrated by Richardson et al. (2015), and their participants' excessive preference for nutrition and exercise interventions as weight loss strategies.

Part of the difficulty in correcting misconceptions could stem from those holding the misconception also having unwarranted levels of confidence in the

integrity of their knowledge. This was described in the seminal paper by Kruger and Dunning (1999), and similar findings have been observed in exercise professionals (Zenko & Ekkekakis, 2015), athletic trainers (Torres-McGehee, Pritchett, Zippel, Minton, Cellamare & Sibiliala, 2012), and both nursing professionals and students (Parker, Steyn, Levitt & Lombard, 2011). When correlations were examined (Kruger & Dunning, 1999; Zenko & Ekkekakis, 2015), confidence was still positively associated with actual knowledge, though those with high levels of knowledge tended to underestimate their performance, while those with lower levels of knowledge overestimated performance. If those who possess misconceptions also possess unfounded confidence, they may be less willing to accept correcting information, and maintain their opinions as discussed above.

It has been proposed that some misconceptions persist when there is a need for conceptual change (Chi, 2005). For this conceptual change to occur, students (or personal trainers) need to experience dissatisfaction with their existing knowledge, and have a new, intelligible, plausible conception to replace it (Posner, Strike, Hewson & Gertzog, 1982). Otherwise, new information may be seen as irrelevant, compartmentalised so it does not conflict with their concept, or assimilated into their existing concept. The shallow understanding of physiological topics, and the lack of appreciation for the interrelatedness of physiological systems (identified by Badenhorst et al., 2015 and Michael, 2007) create the conditions for this conceptual change to fail, and for a misconception to form, or strengthen. Merely presenting information to correct a misconception may not consistently facilitate this conceptual change, so other strategies need to be considered.

2.6.1 Active Learning

It is possible that active learning approaches, which engage the learner in meaningful learning activities, and thought about these activities (Prince, 2004), may be useful in facilitating the conceptual change required to correct misconceptions by highlighting the relevance of new information. Active learning has previously been proposed in research examining misconceptions in physiology (Michael, 2006; Morton et al. 2008), while direct instruction has not demonstrated reliable success (Cliff, 2006).

A range of active learning approaches have been effective in teaching physiology. Modell, Michael, Adamson, Goldberg, Horwitz, Bruce et al. (2000), and

Modell, Michael, Adamson and Horwitz (2004) assessed activities in which students were required to make a prediction before, and reflect after, completing a laboratory task. The best results were observed when students received more feedback, particularly when this feedback was immediate (Modell et al., 2004).

Ahopelto et al. (2011) used a problem-based learning approach to address misconceptions in cardiac physiology among first year medical students, assessing students before and after a six-week course aimed at clarifying students' representations of the central cardiovascular system. While the authors did not specify what problem-based learning activities were used, and did not have a comparison group, they found the course to be effective. In some students however, misconceptions persisted, and these students were also found to perform worse on clinical reasoning tasks. Nybo and May (2015) used an inquiry-based learning approach, where students designed, and conducted an experimental protocol, but needed to study independently prior to conducting the experiment. This led to better results than for students who participated in a traditional course, of whom very few did any self-directed study.

It is evident then that a range of active learning approaches are useful in correcting misconceptions in physiology, which encompasses much of the knowledge required by exercise professionals. However, the approaches described here are mostly lab-based. These may not be possible in VET environments which do not have access to the laboratories and equipment that universities possess, as well as instructors with sufficient depth of knowledge to design appropriate learning activities. And while hands-on activities are a key component of competency-based training (as described earlier), this may not facilitate deep learning in the same way as these lab-based activities.

2.7 Critical Thinking Skills

The reasoning and reflection skills identified in the above active learning tasks are key components of critical thinking (Pithers & Soden, 2000). While Pithers and Soden (2000) use the concise definition of Ennis (1993, p. 180), which identifies critical thinking as “reasonable reflective thinking”, the American Philosophical Association provided a consensus statement that included specific traits and skills such as inquisitiveness, open-mindedness, flexibility, diligence in seeking relevant

information, being prudent and fair in evaluation, as well as identifying the need to be well informed about the topic in question (Facione, 1990).

It may be assumed that these skills are developed implicitly in higher education through exposure to course content, and its underlying evidence. However a meta-analysis by Tsui (1999) concluded that classroom instruction has little effect on critical thinking ability, though multiple studies have suggested benefit from active learning tasks (Abrami et al., 2015; Tsui, 1999). Osborne (2010) proposed that skills such as argument and debate, which rely on mastery of the skills outlined above, are important parts of scientific discourse that are neglected during education. Further, it is clear that students who engage in argument activities use scientific knowledge more appropriately (Zohar & Nemet, 2002), suggesting there is a value in the explicit use of critical thinking skills in course content.

There is some evidence that suggests that critical thinking ability may be useful in reducing the presence of misconceptions. Bensley, Lilienfeld and Powell (2014) proposed that both the knowledge of critical thinking skills, and the disposition to think critically, are related to the endorsement of misconceptions. The authors found that the ability to differentiate between pseudoscientific and evidence-based practices predicted performance in their misconceptions test, as did low levels of paranormal belief, low performance on a measure of intuition, and better performance in a test of thinking dispositions in psychology (from an unpublished manuscript). Additionally, Hughes et al. (2015) identified that psychological misconceptions persisted regardless of the number of undergraduate psychology units taken by students. This suggests that content knowledge was not a key factor in reducing the presence of these misconceptions. But the length of time spent at university predicted less agreement with misconceptions, and post-graduate students possessed significantly fewer misconceptions than undergraduates. Post-graduate students have an increased emphasis on research, including the reasoning and analysis skills required to design, conduct, and interpret research. However, none of these studies included a direct assessment of critical thinking ability; rather, critical thinking disposition was self-reported. And while knowledge of evidence-based practices is useful, the application of this knowledge was again not assessed. It is possible that an increased focus on learning and applying critical thinking skills at lower levels of education will have the effect of reducing misconceptions.

2.7.1 Teaching Critical Thinking

Much of the research on critical thinking examines whether to use implicit (tasks that require critical thinking ability, but using domain specific content) or explicit (instructing students in the skills they are expected to develop) approaches to teaching critical thinking skills (Abrami, Bernard, Borokhovski, Wade, Surkes, Tamim, et al., 2008). Within explicit instruction, there is also an option to use generic, or domain specific critical thinking content, though there is debate around whether generic instruction in critical thinking is even possible (Wang, 2017), as some knowledge of a topic is required (Facione, 1990). It is argued by some (e.g., Davies, 2013) that the implicit or explicit debate is a false dichotomy, as an ‘infusion’ approach, involving a scaffolded progression of critical thinking tasks, can include both.

A model for critical thinking instruction outlined by Ikuenobe (2001) provides more detail, outlining an approach that begins with forming and evaluating arguments (a generic skill). Progressively complex skills are then introduced, such as assessing the reasonableness of generalisations and inferences, evaluating trends and causal relationships, extrapolating from patterns to see ideas and beliefs as part of a coherent structure, to finally contextualising these abilities within various disciplines and subject matter. This approach has not been assessed to date, however, as most assessments of critical thinking instruction focus on individual lessons or skills, rather than a broader approach.

At the base of this infusionist pyramid are basic argument skills. These have been demonstrated to be weak in the general population (Kuhn, 1991), though can be improved with a range of instructional interventions (Kuhn, 2010; Larson, Britt & Kurby, 2009; Sealey & Crowe, 2014). This was demonstrated in an exercise science setting by Sealey and Crowe (2014) with some success. Students in this study reported favourable outcomes, such as improved ability to argue, improved research skills, and critical thinking ability, though these were self-reported perceived changes only.

A structured argument need not be verbal. In a qualitative assessment of four higher education institutions, Tsui (2002) observed that those institutions in which students had previously recorded the largest self-reported increases in critical thinking ability also had a greater focus on written work. Students at these institutions were more often required to complete written assessments (rather than

multiple choice, for example), were given explicit instruction on how to structure their writing, and were required to assess or critique the work of other students. Other authors (e.g., Cavder & Doe, 2012) have proposed scaffolded essay tasks as an activity to strengthen arguments. In this approach students submit a written piece of work, then once feedback is received are required to write a second essay, essentially answering the same question to a higher standard. This is consistent with the findings of Tsui (2002), which identified the type of written task as important, and that lecturers should demand analysis rather than merely description, and provide opportunities for rewriting.

Improving the academic literacy of students has also been suggested as an approach to improve critical thinking skills (Borglin & Fagerström, 2012), consistent with the intermediate levels of the Ikuenobe (2001) model. The use of ‘classic papers’ has been identified as a useful teaching strategy in physiology (Brown, 2006), and was suggested as a method for reducing the presence of misconceptions (Mortan, Doran & MacLaren, 2008), but the focus in these examples appears to be on the physiology content, rather than understanding the research methods involved.

Explicit instruction in research methods has been shown to be effective, though the manner in which the topics are taught is important. Burkley and Burkley (2009) used clips from the popular science television show “Mythbusters” as an aid to teaching specific research methods using a direct instruction approach. When students were assessed, they performed better on questions which were related to video content than on control items.

Active learning tasks have also been shown to be effective. Gruber, Knefe, Waelchli and Schreyer (2008) found a collaborative research writing task led to clear writing and the appropriate use of sources when guided by a university librarian, though there was no comparison condition in this case. In a different approach, Adam and Manson (2014) found that students performed better on a critical thinking assessment following an activity where students had to critique pseudoscientific claims made in an infomercial, than a group that had received direct instruction in research methods. In the active learning condition, students were able to correctly identify order effects, placebo effects, reliance on anecdote, small sample sizes, and the need for experimenter blinding.

A meta-analysis on critical thinking instruction (Abrami et al., 2008) concluded that explicit instruction, combined with domain specific content, was the

most effective approach to improving critical thinking skills. More recently however, Abrami et al. (2015) did not identify a preferred method for delivering critical thinking content, other than concluding that domain specific content appeared to be more effective than generic content. They did, however, identify the importance of mentoring when combined with group discussion and simulated problems, consistent with both Pithers and Soden (2000) and Badenhorst et al. (2015), who highlighted the importance of instructors modelling critical thinking skills. Pithers and Soden (2000) also identified instructors' behaviour that inhibited critical thinking in students, including limiting student interaction with information, using reproof rather than praise, and focussing on correct answers, rather than processes.

It appears then, that effective instructors need to possess more than deep content knowledge, and relevant pedagogical knowledge. To teach critical thinking within a domain they also require knowledge of critical thinking as it relates to the domain, and appropriate pedagogical techniques to enhance critical thinking ability. The complexity of this was outlined in a model proposed by Ab Kadir (2017), as shown in Figure 2.1.

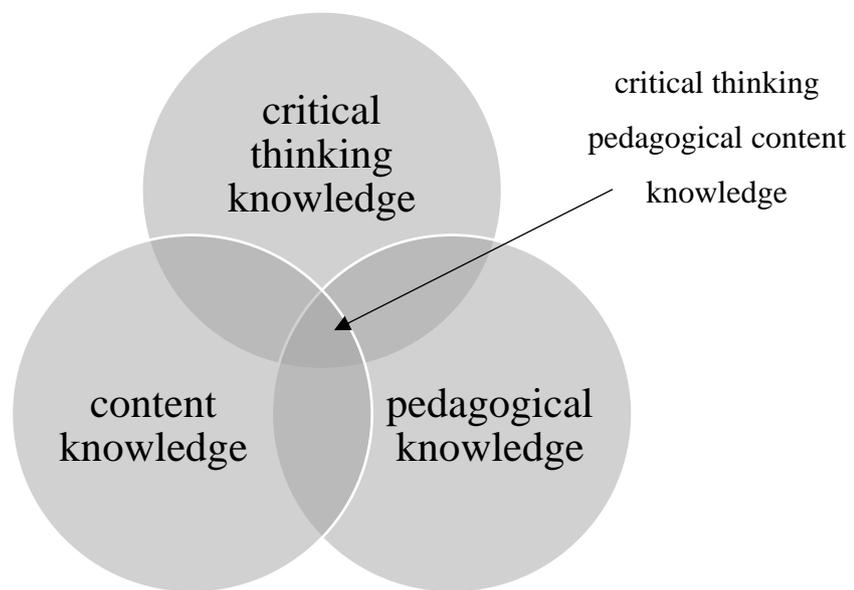


Figure 2.1. The interaction and overlaps of content knowledge, pedagogical knowledge, and critical thinking knowledge (Ab Kadir, 2017)

Ab Kadir proposed that the sub-discipline at the intersection of these three knowledge domains (critical thinking pedagogical content knowledge) is the foundation of effective critical thinking instruction. It was proposed that in order to

teach critical thinking effectively lecturers need to be able to plan a curriculum, lessons, and assessments that addresses higher order thinking goals, teach in a way that engages students in tasks requiring these skills, be able to facilitate the transfer of these skills between tasks (and even disciplines), and identify reasoning difficulties and apply appropriate strategies to treat them. Clearly this will be difficult for lecturers without specific training, so both the ability, and the inclination, of the instructor to teach critical thinking will be an important factor in the success of any intervention.

2.7.2. Online Teaching of Critical Thinking

Of the approaches to critical thinking instruction examined so far, most have examined undergraduate students, in face-to-face learning environments (Abrami et al., 2008). More recent research has used online instruction and has found evidence of improvements in critical thinking ability in learners (Alexander, Commander, Greenberg & Ward, 2010; Kalelioğlu & Gülbahar, 2014; Marin & Halpern, 2011), using both implicit and explicit approaches.

There may even be some advantage in using online learning management systems in the instruction of critical thinking, due to the different tools available to facilitators, such as discussion forums. Guiller, Durndell and Ross (2008) found students preferred online discussion to face-to-face interaction in an activity where they critically analysed a provided text. Students found online work less intimidating than face-to-face interaction and appreciated the extra time to consider their work. Additionally, more examples of students providing justifications with evidence were observed in the online condition, though there was no difference in the frequency other critical thinking skills were demonstrated.

The research suggests that online instruction can lead to increases in critical thinking ability, with research using a sample of Thai secondary students concluding this is an effective approach (Chongwong, Sukkamart & Sissan, 2018), though this study had no control or face-to-face condition, and a relatively high volume of learning. Nonetheless, there appears to be an advantage over face-to-face learning, with the asynchronous nature of the discussion forums than can be used in online learning, as students can compose their contributions carefully, and with more detail (Wichadee, 2014). The use of an online intervention could be useful in improving the critical thinking skills of exercise professionals, who may appreciate the

flexibility an online professional development course provides over face-to-face training.

2.7.3 Critical Thinking in Vocational Education

As identified earlier, the majority of the research on critical thinking has been conducted on undergraduate students. Not only can critical thinking skills have a major impact on undergraduate retention and success (as argued by Lamar & Lodge, 2014), improvements in critical thinking ability are a major component of learning outcomes in higher education. Bachelor degree graduates (AQF level 7) are required to have skills to “review critically, analyse, consolidate and synthesize knowledge” and to “exercise critical thinking and judgement in identifying and solving problems with intellectual independence.” (Australian Qualifications Framework Council, 2013; p. 16). In contrast, a Certificate IV graduate is required to be able to “analyse, compare and act on information from a range of sources”, and “apply and communicate technical solutions... to a defined range of predictable and unpredictable problems” (Australian Qualifications Framework Council, 2013; p. 15).

Given the differences in the requirements of analysing and interpreting information between these two levels, findings from research on undergraduate students should not be applied to VET students. While many VET students attempt to move into higher education, their success is mixed, as they may struggle with the demands for more independent learning and analysis, and lower levels of support provided (Bandias, Fuller & Pfitzner, 2011).

Pithers and Soden (2000) propose that critical thinking is impossible without adequate content knowledge. This is supported by the research demonstrating that instruction within a domain of knowledge most effective (Abrami et al., 2008; Abrami et al., 2015). Due to the task-oriented nature of competency-based training described above, and the shallow understanding of underlying knowledge VET students may possess as a result, they may not develop adequate critical thinking skills during these qualifications. And VET trainers may themselves lack the skills to teach critical thinking effectively, within this domain of knowledge (Ab Kadir, 2017). This means VET graduates may be disadvantaged when entering the workforce, unless they undertake further learning.

While a Certificate IV is intended to be a pathway to higher levels of education (Australian Qualifications Framework Council, 2013), this is not assured, due to the challenges of moving on to higher education noted above. Some generic skills have been identified as highly desirable by employers in a variety of industries (Jackson & Chapman, 2012; Lloyd, 2008), such as effective communication, autonomy, and the ability to interact with text, information, and technology. Underpinning these skills is the ability to hold “a critical and reflective stance” (Gonczi & Hager, 2010, p. 406). Additionally, these skills are required to fulfil the role of a personal trainer, which may involve work with complex and high-risk clients (Bennie, Thomas, Wiesner, van Uffelen, Khan, Kolbe-Alexander, et al. 2018), involving receiving and interpreting complex information from the client as part of the pre-exercise screening process, or other professionals. A highly reflective and inquisitive disposition is key to assimilating this information appropriately, even if this is just to identify the limits of the trainer’s knowledge and scope of practice. While definitions of competence in VET have changed to refer to problem solving, reflection, and other thinking skills, competency-based training is not adequate to meet these needs (Biemans, Nieuwenhuis, Poell, Mulder & Wesselink, 2004; Wheelahan & Moodie, 2011).

To date, no research has assessed the critical thinking ability of Australian VET students, in any industry. There is a body of research looking at US community colleges, which was examined in a recent meta-analysis (Fong, Kim, Davis, Hoang & Kim, 2017). While the authors concluded that critical thinking ability was weakly associated with academic success, they did not examine whether the education provided improved these skills. It is also not clear that these findings can be applied to the Australian VET sector, which provides almost exclusively certificate and diploma level qualifications, rather than Bachelor degrees, or pathways towards these, which are available at community colleges (Horn, Nevill & Griffith, 2006).

2.8 Conclusions

It is well established that humans use cognitive resources sparingly and tend to rely on automatic intuitive judgements when making decisions about information. This can lead to biases influencing these decisions, and we can place undue trust in incorrect information. A misconception forms when this information then resists correction, and can be strengthened, and passed on to others.

The origins of misconceptions have also been established. In learning environments, they may form due to content that is misunderstood, or incomplete. A shallow understanding of the topic, and a lack of appreciation for the relationship between complex systems, have been proposed as key causes of misconceptions, though most of the research in this topic has taken place in higher education institutions. It is not clear if the same factors contribute to misconceptions in VET.

Outside the classroom individuals, including professionals, often rely on informal sources of information. These may be people without specific expertise, but chosen due to trust and ease of access, like friends, family, and coaches. To explain physiological phenomena we may rely on intuitive explanations based on our own experience. Fitness professionals such as personal trainers may be just as prone to misconceptions developing due to their choices of information and professional development. Length of experience does not seem to equate to better knowledge according to prior research, and personal trainers often use unreliable sources, and operate outside of their scope of practice. This is a rich environment for misconceptions to spread to clients and other trainers.

Due to the biases described above, simple correction of a misconception may not be an effective approach. Tasks that have been shown to be effective engage the student with the content and require the application of critical thinking skills. These could be argument and debate activities, research tasks, or lab-based activities. However, these tasks are not always available to the public, or to exercise professionals, who may lack the access to information, or qualified instructors to guide their learning.

It is possible that critical thinking ability may be protective against misconceptions forming. Furthermore, instruction designed to enhance critical thinking ability may be useful in reducing the presence of misconceptions. A range of teaching strategies has been shown to foster critical thinking ability, including online approaches, but the research is equivocal about which approach is most effective. It is clear, however, that instruction specific to the knowledge domain in question is required. It is also proposed that teaching critical thinking skills is a challenge for educators, who are required to possess content and pedagogical knowledge, as well as understanding how to teach, and foster, critical thinking ability.

While exercise and nutrition misconceptions have been researched in undergraduate student populations, these are often too complex for comparison to general populations. It is also not been shown whether or not better critical thinking ability relates to fewer exercise and nutrition misconceptions. The extent of misconceptions, and the critical thinking ability, of VET students is not known, as this has been almost entirely neglected by research to date.

Errors of knowledge in exercise professionals, especially personal trainers, have been clearly identified, and it is likely that these lead to misconceptions developing over time. But the critical thinking ability of these professionals, and the relationship between this ability and the presence of misconceptions, has not been examined. It is possible that a domain specific intervention, designed to improve the critical thinking ability of personal trainers, will reduce the presence of misconceptions, and result in better choices of sources of information.

Chapter 3: The Origin and Correction of Misconceptions in Students

3.1 Introduction

As identified in Chapter 2, misconceptions can have both pedagogical, and ontological origins (Taber, 2001). While some pedagogical sources of misconceptions have been proposed (Badenhorst et al., 2015; Michael et al., 1999), sources of misconceptions, as defined by Badenhorst et al. (2015), outside the classroom have not been closely examined. Research to date uses a number of different terms to represent similar concepts, such as endorsement of conspiracy theories (Sunstein & Vermeule, 2009), or “fake news” (Lazer et al., 2018). But as these may not necessarily involve knowledge (or ignorance) of current scientific views, or the resistance to correction, the findings from this research do not necessarily apply to misconceptions.

Regarding misconceptions of human physiology, Michael et al. (1999) speculated that experiences not obviously conforming to classroom explanations were potential sources. These could lead to a practical model forming in students, which explains observed phenomena well enough, but is not correct. Other research has proposed parents (O’Dea, 2003), coaches and athletic trainers (Duellman, et al., 2008), and the media (Morton et al., 2008) as potential sources, but these have not been assessed empirically.

While previous research on misconceptions in physiology has examined complex concepts such as cardiac (Aholpelto, et al., 2011) and respiratory physiology (Michael et al., 1999) in students, more ubiquitous are the basic applications of physiology, such as nutrition and exercise. These have the potential to be passed on to the public, impacting nutrition and exercise habits and outcomes. Some research has also examined these simple misconceptions (e.g. ‘strength training causes women to become larger and heavier’, Ebben & Jensen, 1998), though their prevalence is only assumed by the authors (Ebben & Jensen, 1998; Kieffer, 2008) rather than being empirically examined. It is possible that ontological sources have a greater influence on the formation of misconceptions in these fundamental topics, which can be easily (though not necessarily correctly) explained intuitively, and with limited knowledge. However more research needs to be done to confirm the presence of these misconceptions, and their origins.

3.1.1 Misconceptions in Students

The length of a person's education appears to reduce the presence of misconceptions, though some misconceptions have been shown to exist well into degree programs (e.g. Hughes, et al., 2015; Morton et al., 2008). Hughes et al. (2015) identified that this was independent of the number of subjects completed in the degree subject matter, suggesting that factors other than content knowledge, such as critical thinking ability, which may develop over an extended period of study, may influence the presence of misconceptions.

Research into misconceptions has largely overlooked the VET sector. Given the brevity of many vocational courses, and the focus on competent task performance rather than theoretical knowledge (Australian Qualifications Framework Council, 2013), it is possible that misconceptions are more prevalent in VET than higher education. As the pathways students take to higher education become more varied (Bandia, Fuller & Pfitzner, 2011), misconceptions could persist from VET into further study, and professional practice.

3.1.2 Misconceptions in Exercise Professionals

Many people rely on exercise professionals, such as personal trainers, to inform their exercise and nutrition habits. Previous research has identified errors in personal trainers' knowledge of fundamentals such as exercise prescription guidelines (Zenko & Ekkekakis, 2015) and nutrition (Malek et al., 2002). However it is not clear if these errors in knowledge are necessarily misconceptions; that is, whether they continue to exist despite attempts to correct them (Chi, 2005). Morton et al. (2008) identified a number of misconceptions that persisted into the final year of a higher education exercise science program, but many of these were more complex than a VET qualified personal trainer may be expected to correct confidently.

While it is important to identify appropriate teaching strategies to correct misconceptions, these may not continue to have an effect on students following graduation. A sizeable minority of personal trainers complete no further education after receiving their qualification (McKean et al., 2015), and subsequently may not even meet the professional development requirements to maintain their registration with the peak body. Therefore it is necessary to identify methods of correcting or

preventing misconceptions that have a long lasting effect, and influence personal trainers' professional practice.

It has also been shown that personal trainers may value industry experience and self-directed learning more than formal education (De Lyon & Cushion, 2013), and a meta-analysis by Stacey et al. (2010) showed evidence that personal trainers reported difficulty determining the quality of information. Misconceptions could therefore survive a vocational education or be formed as a result of the sources of information used by personal trainers. The role of qualifications in equipping personal trainers with the cognitive skills to select appropriate information needs to be examined.

3.1.3 Correcting Misconceptions

A range of approaches to correcting misconceptions in students have been examined. Some popular misconceptions can be addressed early, and explicitly, in course content, to pre-empt those misconceptions forming. Kowalski and Taylor (2009) showed this explicit approach was effective in countering misconceptions in psychology, however others have demonstrated that simply correcting misconceptions may be ineffective (Lewandowsky et al., 2012). Other approaches have focussed on improving an understanding of the depth, and context of knowledge (Badenhorst et al., 2015) to overcome threshold concepts (Meyer & Land, 2003). Active learning tasks, defined as instructional methods that engages the learner in meaningful learning activities, and thinking about these activities (Prince, 2004), have also been effective (Ahopelto et al., 2011). Additionally, DeGolier (2010) suggested interventions to improve critical thinking ability (a key component of active learning) could be an effective strategy, though evidence is mixed (Tiruneh, Verburgh & Elen, 2014).

Given VET students are assessed based on their competence completing required tasks (Gonczi & Hager, 2010), opportunities to provide detailed correction of misconceptions, or explicit instruction in critical thinking, may be limited. Further, given the existing research on critical thinking focuses on higher education, a comparison of the two modes of education could inform future instruction in critical thinking in VET, or for VET graduates. Students transitioning from VET to higher education express difficulty with academic conventions, research skills, and self-directed critical reflection (Griffin, 2014), suggesting that critical thinking skills

need to be developed in these students. However, these skills have not been directly assessed.

3.2 Objectives

To date, no research has examined the presence of fundamental exercise and nutrition misconceptions across professionals, students, and public populations. Similarly, the differences between higher education and VET students in the presence of misconceptions, or approaches to correcting these misconceptions, has not been examined.

In order to investigate these issues in the current research program, it was necessary to identify prevalent misconceptions, and the information required to obtain a correct understanding of each topic. This would allow the development of a set of misconceptions and provide insight into effective methods for correcting misconceptions. While a standard set of misconceptions have been used in education (Horvath, Donoghue, Horton, Lodge & Hattie, 2018), and several measures used in psychology (Bensley et al., 2014) this is yet to be attempted in the area of fundamental exercise and nutrition knowledge.

The aims of the study reported in this chapter were therefore:

1. To identify fundamental exercise and nutrition misconceptions that are prevalent in VET and higher education students, graduates, and the public, the information
2. To identify the errors in knowledge that lead to the formation of these misconceptions, the knowledge required to correct them, and potential methods of correction.
3. To explore pedagogical and ontological sources of these misconceptions.

This was to inform the development of a survey to assess the presence of misconceptions, and a study package for exercise professionals to improve their critical thinking skills.

3.3 Method

3.3.1 Participants

A convenience sample of twelve educators from a variety of institutions was purposively sampled, to represent a cross-section of higher education exercise science, and VET fitness courses. Eight participants (four men and four women) were higher education professionals, six with PhD qualifications in exercise

physiology, from three universities. Two were dietitians, with either PhD or Bachelor qualifications in dietetics, who taught nutrition subjects in exercise science degrees. The four VET trainers (two men and two women) were selected from three institutions: two colleges of Technical and Further Education (TAFE), and one private training institution. All three institutions taught Certificate IV in Fitness courses, though the private institution only taught the Certificate III pre-requisite units, while the two TAFEs taught the full Certificate III. Two of the VET trainers had Bachelor qualifications, and the others possessed Certificate IV qualifications. All VET trainers possessed relevant industry experience.

Participants ranged in age from 27 to 56 years (Mean = 40 ± 10.34 years) and had a mean of $10 (\pm 7.37)$ years of teaching experience.

3.3.2 Materials

Thirteen misconceptions were identified from previous research on misconceptions and other relevant literature. Topics varied in difficulty which allowed for meaningful discussion with, and comparison of, both university and VET participants, given differences in the difficulty of their respective courses. The 13 misconceptions and a scientific source that supports each as being a misconception are presented in Table 3.1.

Misconceptions included were considered to be broadly within the scope of practice (Fitness Australia, 2014) of VET qualified personal trainers. That is, personal trainers should be expected to identify each of these statements as misconceptions. Misconceptions were excluded if in the opinions of the participants they were too complex for the public to develop a correct understanding, relied on knowledge outside that which personal trainers could be expected to possess, or if they were not considered prevalent in students and the public.

3.3.2.1 Spot reduction: if a part of your body is exercised hard, you will lose fat mass from that area

The proposed misconception is that body fat levels can be changed preferentially, by exercising areas of the body where this change is desired. This misconception was first proposed by Checkley (1890, p. 88), stating “this dissipation of fat is local; that is to say, it disappears in localities in which muscles are active, and in proportion to their activity. Thus people will accumulate fat in accordance very largely with their personal habits.”

Table 3.1 – list of potential misconceptions discussed with participants

Misconception	Reference
Spot reduction: if a part of your body is exercised hard, you will lose fat mass from that area	Ramírez-Campillo et al. (2013)
The more protein, the better: protein is the most crucial nutrient for muscle growth and sports performance	Tipton (2008)
Women have a risk of getting too muscular if they lift heavy weights	Ebben & Jensen (1998)
Perform cardio at lower intensity for a better weight loss effect	Wewege et al. (2017)
Gentle, static stretching prior to exercise reduces your injury risk	Shrier (1999)
A short term fast or juice cleanse flushed toxins out of your system, and helps kick start weight loss	Klein & Kiat (2014)
A vitamin supplement can improve your well-being, energy levels, and exercise performance	Rodriguez et al. (2009)
A high protein, high fat diet, with little dairy or grain, is healthier than current healthy eating recommendations	Genoni et al. (2016); National Health & Medical Research Council (2013)
Lactic acid causes fatigue	Robergs et al. (2004)
No pain, no gain: to get stronger or fitter, we need to endure pain in our exercise	Flann et al. (2010); Nosaka et al. (2002)
Spending time in a sauna will help sweat body fat away	Kauppinen (1997)
Train as hard as possible during your workouts. A higher intensity workout is better for you	Nybo et al. (2010)
Cramping is caused by a lack of salt	Miller (2015)

Early research was ambiguous, as investigators relied on the dissection of animal cadavers (Buchwald & Cori, 1931; Cuthbertson, 1925), and less accurate measurement techniques such as girth and skinfold measurement (Mohr, 1965; Noland & Kearney, 1978; Olson & Edelstein, 1968), and photography (Schade, Helledrandt, Waterland & Carns, 1962). However, following the availability of more sophisticated body composition assessment techniques such as ultrasound (Krotkiewski, Aniansson, Grimby, Björntorp, & Sjöström, 1979), magnetic resonance imaging (MRI) (Kostek, Pescatello, Seip, Angelopoulos, Clarkson, Gordon, et al., 2007), and DXA scan (Ramírez-Campillo, Andrade, Campos-Jara, Henríquez-Olguín, Alvarez-Lepín, & Izquierdo, 2013; Vispute, Smith, LeCheminant

& Hurley, 2011), results over the last 40 years have provided overwhelmingly negative results. In fact, the site of metabolism of body fat is a function of the deposition of body fat, which is influenced by individual, ethnic, and gender variation (Geer & Shen, 2009), and is not influenced by physical activity.

A lack of understanding of the different physiological systems of metabolism is a potential cause of this misconception. Specifically, that metabolism is a central (rather than peripheral) process, and that fat metabolism responds to energy demands, rather than the site of the exercise performed (Whitney, Rolfes, Crowe, Cameron-Smith & Walsh, 2011, p. 212). This is also evident in the fact that single limb sports do not see preferential reductions in body fat in exercising versus non-exercising limbs (Gwinup, Chelvam & Steinburg, 1971).

3.3.2.2 The more protein, the better: protein in the most crucial nutrient for muscle growth and sports performance

This misconception emerges from the role of protein in the synthesis of new muscle fibres as an adaptation to training. As this synthesis cannot occur in any meaningful way without dietary protein, the misconception assumes that increased consumption of protein will result in increased muscle synthesis.

While it is common practice for some people to have higher dietary protein intakes, particularly athletic populations (American College of Sports Medicine, 2009), this misconception is a gross oversimplification. Ignored are key variables such as the role of the training stimulus and associated exercise programming variables (Kraemer & Ratamess, 2004), the role of carbohydrate in fuelling high intensities of exercise (which could be displaced in the diet by increased protein consumption), and the lack of a mechanism for storing excess protein in the body (Whitney, et al., 2011, p. 211). There is no benefit to training adaptation from very high protein intakes (Tipton, 2008), though the mechanisms for this upper limit of benefit would not be clear without an understanding of the process of protein metabolism.

3.3.2.3 Women will get too muscular if they lift heavy weights

This misconception has its origins in late nineteenth century concerns about the impact of strenuous sport on the reproductive ability of women (Todd, 1992). This sentiment persisted, with different resistance training recommendations for men

and women as late as the 1970s (Baechle & Boyce, 1974). However, it is now widely accepted that to achieve significant muscle hypertrophy, specific training variables need to be applied (Kraemer & Ratamess, 2004), regardless of the gender of the exerciser (Holloway & Baechle, 1990). And while women can achieve similar relative strength and hypertrophy increases to men through resistance training (Abe, DeHoyos, Pollock & Garzarella, 2000; Cureton, Collins, Hill & McElhannon, 1988), due to the large differences in size and body composition between genders, women's absolute hypertrophy effects are smaller.

An additional factor influencing muscle gain is the influence of nutrition (Kraemer & Ratamess, 2004; Phillips, 2011). Specifically, significant muscle hypertrophy requires higher protein intakes and higher energy intakes, both of which can be controlled by those not looking to achieve weight gain.

3.3.2.4 Perform cardiovascular training at a lower intensity for better weight loss

As early as the 1930s the role of an energy deficit in successful weight loss was well understood (Steinhaus, 1934), though it was concluded that the volumes of exercise required to lose weight through exercise alone meant this was an unsafe approach. The misconception in this case appears to have emerged from later research. The earliest research into which exercise intensity elicited the best weight loss response was ambiguous (Askew & Hecker, 1976), though this research was conducted on rats, and the exercise protocol was combined with an energy deficit. Thompson, Jarvie, and Lahey (1982) identified that lower intensities were more sustainable than higher intensities, and cited Jones (1980) when proposing that lower intensities were preferable for weight loss, due to the greater fat metabolism. The misconception from this early research continues to exist in the popular culture as cardiovascular training equipment often refers to a moderate exercise intensity as a “fat burning zone” (see Figure 3.1).

While it is well established that fat oxidation is a prominent source of energy at lower exercise intensities (Spriet, 2014), this misconception appears to confuse the proportions of substrates used in exercise with total substrate metabolism (Zelasko, 1995). Which substrate is used during a bout of exercise is inconsequential, given other considerations such as the energy expended during the session, excess post-exercise oxygen consumption (EPOC), and the fact that digested carbohydrates not

immediately required to provide energy are eventually converted to fats for storage (Whitney et al., 2011, p. 200). Furthermore, research has demonstrated increased EPOC after higher exercise intensities (Børsheim & Bahr, 2003), and the effectiveness of higher intensities of exercise for those that can tolerate them (Wewege, van den Berg, Ward, & Keech, 2017), with the added benefit of reduced training times required to elicit the same contribution to weight loss as lower intensities.

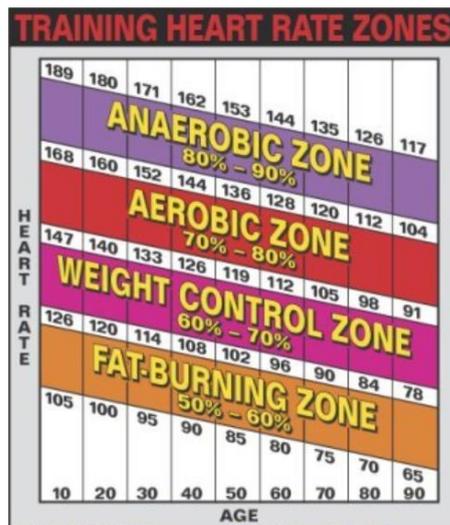


Figure 3.1 - An example of an exercise intensity wall chart. Downloaded from <https://www.amazon.com/Heart-Rate-Zones-Laminated-Chart/dp/B0017T6S7W>

3.3.2.5 Static stretching before exercise reduces injury risk

Static stretching is when muscles are held in an elongated position for a period of time, in order to improve mobility around a joint. The origins of this misconception have not been determined, but static stretching before and after exercise appears to have been standard advice for exercisers (Clement & Taunton, 1980), either alone, or as part of a larger progressive warm up.

However, the assertion that this reduces the risk of injury appears to have been unsupported by the majority of the research evidence. Multiple systematic reviews have concluded there is no reduction in injuries rates (Shrier, 1999; Thacker, Gilchrist, Stroup & Kimsey, 2004), and muscle fatigue was determined to be a key factor in injury risk (Mair, Seaber, Glisson & Garrett, 1996; Pope, Herbert, Kirwan & Graham, 2000).

Static stretching prior to exercise also appears to have a performance decrement (Frantz & Ruiz, 2011; Nelson, Kokkonen & Arnell, 2005), which becomes more apparent with longer duration stretching protocols (Behm, Blazevich, Key & McHugh, 2013). In contrast, dynamic warm ups have been shown to have performance benefits (Perrier, Pavol & Hoffman, 2011; Van Gelder & Bartz, 2011), allow for skill rehearsal of the activities to follow and prime metabolic responses (Brunner-Ziegler, Strasser & Haber, 2011), and also potentially decrease viscous resistance (Bishop, 2003). This effect on performance needs to be considered along with the potential for injury.

However, evidence of the efficacy of stretching has lately become more ambiguous. More recent systematic reviews now suggest that the risk of acute muscle strains during exercise may be reduced with static stretching, though other types of injury (such as overuse injuries) are not (Behm et al., 2013; McHugh & Cosgrave, 2010). These reviews acknowledge that further investigation is required, so it is unlikely that the way this topic is taught in education will change in the short term. For this reason, this statement can still be considered a misconception.

3.3.2.6 A short term fast or juice cleanse flushed toxins out of your system, and helps kick start weight loss

This misconception seems to have its origins in popular media, as the few academic resources devoted to the concept are a reaction to the misconception itself. It may persist in the public due to the influence of alternative medicine, as ‘detoxification’ is widely practiced in modalities such as naturopathy (Allen, Montalto, Lovejoy & Weber, 2011). The concept of eating patterns contributing in a major way to ‘detoxification’ is unlikely given the prominent role of the liver and kidneys in this process, which alter or remove a range of compounds that would otherwise accumulate to toxic levels in the body (Tortora & Grabowski, 1996, p. 782).

This misconception is ambiguous, with proponents of the concept generally having vague, or contradictory definitions (Klein & Kiat, 2014), so discussion of this misconception can be broad in nature, and include other short-term interventions that had an element of energy restriction such as highly restrictive diets consisting of a few prescribed foods. While Klein and Kiat (2014) identify nutritional interventions that have demonstrated success removing particular chemicals, these are very

specific, and usually are only demonstrated in animal studies (e.g., citric acid has been demonstrated to accelerate aluminium elimination in mice). They also identify that the use of commercial ‘detoxification’ products, which make extravagant claims with no plausible mechanism by which they are proposed to work, has not been supported by any clinical evidence (Ernst, 2012; Klein & Kiat, 2014).

Additionally, research suggests that extreme kilojoule restriction can be counterproductive for weight loss, due to the body’s adaptive response to energy restriction (Sainsbury & Zhang, 2010), and the stressful nature of such deprivation (Pankevich, Teegarden, Hedin, Jensen & Bale, 2010).

3.3.2.7 Vitamin supplements improve well-being, energy levels, and exercise performance

Similar to the above misconception regarding ‘detoxification’, it can be difficult to identify and address specific misconceptions due to the wide range of claims around vitamin supplements. Often these supplements are perceived as a more ‘natural’ way to achieve good health than other interventions, and therefore considered safe (Saper, Eisenberg & Phillips, 2004). While older adults often take supplements to prevent future disease and illness (Goston & Correia, 2010), others are attempting to counter a perceived inadequate diet (Froiland, Koszewski, Hingst & Kopecky (2004), or gain a performance benefit, though often with unrealistic expectations about the benefits (Duellman et al., 2008) of supplementation. Possibly due to these perceived benefits, the use of vitamin and mineral supplement by Australian adults is common (Burnett, Livingstone, Woods & McNaughton, 2017), despite the general population largely meeting their micronutrient needs (Australian Bureau of Statistics, 2014).

Among these perceived benefits is the idea that a vitamin supplement will lead to an increase in energy levels. This is a consistently popular idea, with between 30% (Jacobson, Sobonya & Ransone, 2001) and 76% (Jacobson & Aldana, 1992) of college students surveyed believing this misconception. While more recent research has not replicated the extreme popularity of this misconception identified by Jacobson and Aldana (1992), it remains common (Herbold, Vazquez, Goodman & Emans, 2004; Rosenbloom, Jonnalagadda & Skinner, 2002).

While there may be performance benefits to vitamin supplementation for those with highly restricted energy intakes (Rodriguez, Di Marco & Langley, 2009),

this is not applicable to the overwhelming majority of people taking supplements. In addition to the lack of a benefit to exercise performance, a large body of research has found none of the other proposed health benefits of vitamin supplementation, such as improving exercise performance (Rodriguez, Di Marco & Langley, 2009), reducing rates of cancer or heart disease (Fortmann, Burda, Senger, Lin & Whitlock, 2013), and improving cognitive function (Grodstein, O'Brien, Kang, Dushkes, Cook, Okereke, et al., 2013). In fact, Bjelakovic, Nikolava, Gluud, Simonetti, and Gluud (2007) even found an increase in mortality in those taking antioxidant supplements.

3.3.2.8 A diet high in protein and fat, and low in carbohydrates, is healthier than current dietary guidelines

Variations of low carbohydrate diets have a long history in research and popular media, beginning with William Banting, who in a letter describes his personal weight loss experience (Banting, 1864) using an eating pattern very low in carbohydrates. The most well-known modern iteration of this type of diet was the Atkins Diet, outlined in Atkins' 1972 book, which was the first to propose a ketogenic diet outside of a medically supervised setting (cited in Freedman, King & Kennedy, 2001).

As the popularity of diets may evolve quickly, for the present research this misconception was refined to reflect the most common variation of this eating pattern at the time of the interviews – the Paleolithic diet, which is a high protein, high fat diet that eliminates dairy products, and most grains. The term 'paleolithic' in this instance is a misnomer. Although the premise of the diet is that it is modelled on the eating patterns of early humans, in reality the human diet prior to the advent of agriculture and animal husbandry was largely a diet of opportunity (Gowlett, 2003), and as such was highly varied.

Again, the evidence is not conclusive, as some research exists that supports high protein, low carbohydrate patterns of eating for weight loss (Halton & Hu, 2004). The current dietary guidelines, however, encourage moderate consumption proteins, fats, and carbohydrates, as well as the moderate consumption of whole grains and dairy products, or vegetarian alternatives (National Health & Medical Research Council, 2013). While high protein, high fat diets contrast starkly against previous versions of the Australian Dietary Guidelines, which encouraged eating a diet low in fat (National Health & Medical Research Council, 2003), the most recent

guidelines identify that the macronutrient composition of diets is less important than overall energy intake (National Health & Medical Research Council, 2013).

The Paleolithic diet has been shown to lead to short term improvements in body weight and other components of metabolic syndrome (Manheimer, van Zuuren, Fedorowicz & Pijl, 2015), but has also shown to have relatively low compliance (Genoni, Lo, Lyons-Wall & Devine, 2016; Hammarström, Wiklund, Lindhal, Larsson & Ahlgren, 2014), and there are concerns about its impact on bowel health (Genoni et al., 2016). And while debate exists in the popular media, the evidence that reducing saturated fat intake (which may increase with an increased intake of animal products as a result of the Paleolithic diet) significantly lowers the risk of cardiovascular disease is clear (Hooper, Martin, Abdelhamid & Davey Smith, 2015).

3.3.2.9 Lactic acid causes fatigue

This misconception is based on early research which identified a linear relationship between blood pH (which does contribute significantly to fatigue) and muscle lactate concentrations (Margaria, Edwards & Dill, 1933). Lactic acid is produced as a result of the increase in anaerobic metabolism of carbohydrate during higher intensities of exercise, which then disassociates into hydrogen ions (which increase muscle pH), and lactate. This led to the misconception that when exercising at high intensity, this lactic acid accumulates (those holding this misconception usually not differentiating between lactic acid and lactate), causing fatigue along with a painful burning sensation. And even though this has been understood to be a misconception since the 1960s, and other factors contribute to acidity (Robergs, Ghiasvand & Parker, 2004), it persists in the public.

Morton et al. (2008) examined the prevalence of this misconception in sports science students, and identified that first and second year students considered lactate a waste product of anaerobic metabolism causing fatigue, or producing hydrogen ions that caused fatigue. More accurately, while blood pH drops, and pain and fatigue are experienced during exercise (Robergs et al., 2004), acidosis may in fact delay fatigue (Pedersen, Nielsen, Lamb & Stephenson, 2004). A more complete understanding would also identify the other factors contributing to fatigue, such as muscle damage (discussed below), aerobic capacity, substrate metabolism, reduced central drive, and motivational factors (Noakes, 2000).

3.3.2.10 No pain, no gain: to get stronger or fitter, we need to endure pain in our exercise

This misconception also seems to have its origins in popular media, as it is not analogous to any concepts discussed in the academic literature. But similar to others discussed in this chapter, the misconception is caused by an incomplete understanding of physiological processes, in this case the adaptations to exercise. While exercise of almost any type at an intensity the individual is unaccustomed to will result in some muscle damage (and subsequent delayed onset muscle soreness [DOMS]), this may lead to a short term reduction in exercise performance (Cheung, Hume & Maxwell, 2003).

DOMS is a common result of exercise, particularly when the exerciser is exposed to a less familiar stimulus, or as a result of eccentric resistance exercise (Cleak & Eston, 1991). Distinct from other types of exercise, and resistance training, exercising specifically to elicit a hypertrophy response will generate significant muscular fatigue, and microtrauma to muscle tissue (Schoenfeld, 2010), which will result in greater DOMS. However, DOMS is a poor indicator of actual muscle damage and inflammation (Nosaka, Newton & Sacco, 2002), and muscle hypertrophy can occur independently of muscle damage (Flann, LaStayo, McClain, Hazel & Lindstedt, 2011), so this may not be a useful indicator of the benefit of a training session.

3.3.2.11 Spending time in a sauna will help sweat body fat away

The pseudoscientific claims around saunas are varied, making it difficult to identify a specific misconception to address, though the broad term ‘detoxification’ covers a number of claims. Cecchini (2006, cited in Allen, Montalto, Lovejoy & Weber, 2011) identified that saunas were used as part of a ‘detoxification’ program for World Trade Centre first responders administered by the Church of Scientology, and saunas have also been proposed to contribute to a range of other ‘detoxification’ methods (for examples see Hyman, Quinn, Marshall & Snyder, 2007). However, no known scientific mechanism exists for the use of saunas for ‘detoxification’ (Ernst, 2012), and research into the health benefits of saunas suffer from small sample sizes and a high risk of bias (Hussain & Cohen, 2018).

This misconception identified in the present research is that at least a portion of the weight loss associated with the use of a sauna is a result of losing body fat. While the origins of this misconception are unclear, it is notable in popular media, which propose a number of mechanisms. For example, it has been claimed that traditional saunas cause a 20% increase in metabolic rate (Innovex, 2018), or that infrared saunas directly cause fat metabolism (Goop, n.d.), though supporting evidence is not provided in these instances.

Saunas are traditionally used for physical and mental relaxation, and may involve either a sustained stay in the heated room, or contrasting temperatures including periods in a cold pool or shower (Kauppinen, 1997). They are also safe, with few identified health risks, even in people who have previously been advised not to participate in saunas, such as those with a history of hypertension or coronary heart disease (Kukkonen-Harjula & Kauppinen, 2006).

Furthermore, that saunas will contribute to weight loss is not in question. In fact, this is a strategy often used by athletes who need to achieve rapid weight loss (Caldwell, Ahonen & Nousiainen, 1984). However, the weight loss achieved is through sweating (Kauppinen, 1997), which may inhibit athletic performance when done too quickly (Caldwell, Ahonen & Nousiainen, 1984), and the weight will return as the athlete rehydrates.

3.3.2.12 Train as hard as possible during your workouts. A higher intensity workout is better for you

This misconception is a misunderstanding of the relative benefits of different exercise intensities, or the appropriateness of these intensities to different populations. While variations in cardiovascular exercise intensity have been identified as a method of modifying exercise outcomes since proposed by Åstrand, Åstrand, Christensen and Hedman (1960), recent fitness industry trends indicate a preference for higher exercise intensities. This is demonstrated by the growth of Crossfit since 2000, which has over 15 000 franchised gyms (Crossfit, n.d.). In CrossFit training, which may involve a combination of resistance and cardiovascular training, performing movements at a high intensity (in this case, at the fastest possible speed) is inherent to the mode of exercise (Mullins, 2015). While the growth of exercise modalities such as CrossFit is testament to the popularity of high

intensity training, the benefits of exercise intensities appear to be more specific, so it cannot be assumed that a higher intensity is more appropriate.

Cardiovascular training can be performed at a higher intensity by prescribing shorter sessions, with short bouts of challenging exercise separated by periods of recovery, known as high intensity interval training (HIIT). While it is clear that HIIT is beneficial, the research is not clear that it is consistently a better choice than lower intensities of exercise that can be performed continuously (Boutcher, 2011). High intensity training may lead to greater improvement of aerobic capacity than lower intensity exercise (Nybo et al., 2010; Swain & Franklin, 2006), and maximises EPOC (Børsheim & Bahr, 2003), but there is no difference in other adaptations like muscle capillary density (Duscha, Annex, Johnson, Huffman, Houmard & Kraus, 2012) and body composition change (Swain & Franklin, 2006; Wewege et al., 2017).

Furthermore, it is well established that different intensities of resistance training will result in different exercise outcomes, so the appropriate intensity is entirely dependent on the desired adaptation (Bird, Tarpenning & Marino, 2005; Kraemer & Ratamess, 2004; Sheppard & Triplett, 2016, p. 457). Exercise intensity may additionally depend on the exercise and medical history of the participant, so may be highly individualised.

3.3.2.13 Cramping is caused by a lack of salt

This misconception involves a lack of appreciation of the diverse factors that may contribute to cramping, and the controversy that still exists in the research about this. Despite this controversy, it is a popular opinion among professionals (such as athletic trainers) that a reduction in blood sodium concentration is the major cause of cramping (Stone, Edwards, Stemmans, Ingersoll, Palmieri & Krause, 2003).

While some research has shown no association between blood sodium concentration and cramping (Maughan, 1986), this theory has some support. Other research has shown that those who cramp during exercise have lower blood sodium concentrations than those that do not (Horswill, Stofan, Lacambra, Toriscelli, Eichner & Murray, 2009; Stofan, Zachwieja, Horswill, Murray, Anderson & Eichner, 2005). However the strength of this evidence is weak (Miller, 2015), relying on small samples of athletes, in uncontrolled exercise and environmental conditions. Others have concluded that this difference between crampers and non-crampers is

within normal ranges, so is not a cause of cramping (Schwellnuss, Nicol, Laubscher & Noakes, 2004; Sulzer, Schwellnuss & Noakes, 2005).

Yet others have identified that cramping can occur despite preventative hydration strategies (Jung, Bishop, Al-Nawwas & Dale, 2005). A review by Schwellnuss, Drew and Collins (2008) identified the greatest risk factors appeared to be a previous history of cramping, exercising at a higher relative intensity or duration, and hot or humid conditions, and that the evidence associating cramping with electrolyte disturbances was mixed. Miller (2015) proposed that changes in the nervous system, rather than dehydration, may be a major contributor to cramping, but identified a lack of well-designed randomised control trials into the issue.

3.3.3 Procedure

Ethics approval was granted by the Curtin University Human Research Ethics Committee (HRE2016-0292). All participants were volunteers who provided informed consent, and consent to be recorded prior to completing the survey. All responses were anonymised before being coded.

The interviews were semi-structured and lasted approximately 60 minutes. No incentive or recompense was provided for participation. Discussion of each misconception began with a series of closed questions, to establish if the participants considered the misconceptions to be prevalent, and in which groups (see Table 3.2). Open questions then explored the nature of the misconception, its potential impact on learning, and the information, and methods, used to correct it. Discussion was not limited to these questions and follow up discussion explored topics where participants had further insight. For example, question four (“does the misconception exist in professional practice?”) would lead to a discussion about which exercise professionals might possess the misconception, what education they may possess, or what inaccurate sources of information they may have sought out. Participants were informed that if a particular misconception was outside their field of expertise they could decline to comment.

Interviews were audio recorded using a smartphone and transcribed by the author verbatim. Text was analysed using NVivo 11 for Windows (QSR International, London, UK), using directed content analysis (Hsieh & Shannon, 2005). Affirmative responses to questions one to four were tallied, to determine the proportion of participants that observed each misconception. For subsequent

questions, coding was done using an unconstrained coding matrix (Elo & Kyngäs, 2008), for a combination of manifest and latent content.

Table 3.2 – list of questions to be discussed for each misconception

1	Is the misconception common in students entering the course?
2	Does the misconception persist throughout the course?
3	Does the misconception exist in the public?
4	Does the misconception exist in professional practice?
5	How does the misconception interfere with learning?
6	What information would you present to correct the misconception?
7	How would you present this information?

The manifest content was the responses to open questions (four to seven) and subsequent discussion. These were coded for the proposed source of the misconception in students (pedagogical or ontological), the public, or professionals. Other codes categorized the specific information used to correct the misconception, and the teaching strategies used in this correction. Responses were further coded to identify whether they came from higher education professionals, or VET trainers, so differences in the strategies and information used to correct each misconception could be examined. Latent content identified was the potential presence sources of misconceptions in those being interviewed. These were coded as identified for the source and type of error made (i.e. insufficient knowledge of the participant, or an error in reasoning).

A sample of transcribed interviews was reviewed by a second coder, to verify the content in each.

3.4 Findings

Three misconceptions were excluded from further discussion during data collection. ‘Spending time in a sauna will help sweat body fat away’ was not considered a commonly held misconception. ‘Cramping is caused by a lack of salt’ was excluded because the scientific evidence (and therefore the status of the misconception) was unclear. ‘Train as hard as possible during your workouts. A higher intensity workout is better for you’ was removed due to difficulty clarifying the misconception statement, as there are benefits from exercise at a range of

intensities (Nybo et al., 2010), and many instances where a high intensity of training is preferable. The perceived prevalence of each remaining misconception by participants is shown in Table 3.3.

All 10 remaining misconceptions were considered present in at least 50% of one of the groups identified above (students, professionals, or the public). Higher education professionals perceived that misconceptions resisted correction in their students more than VET trainers. Both groups of educators agreed that these misconceptions existed in professionals however, even when they considered the misconception corrected in students.

Table 3.3. The percentage of higher education (HE) professionals ($n = 8$) and vocational education (VET) trainers ($n = 4$) that reported observing misconceptions in students, the public, and professionals.

Misconception	Students entering the course		Students finishing the course		Public		Exercise professionals	
	HE	VET	HE	VET	HE	VET	HE	VET
Spot reduction	38	100	12.5	0	100	100	75	50
The more protein, the better	88	100	88	25	100	75	88	100
Women & heavy weights ^a	57	100	26	0	100	75	86	0
Low intensity cardio	50	50	12.5	0	75	75	50	0
Static stretching ^b	66	25	0	0	100	50	83	0
Detoxes	38	75	25	0	100	100	25	75
Vitamin supplements	88	100	50	25	100	100	75	75
High protein, high fat diet ^a	86	66	71	0	57	66	86	33
Lactic acid causes fatigue ^{a b}	100	25	100	0	83	25	83	50
No pain, no gain ^c	100	100	66	66	66	100	66	100

^a This misconception was possessed by one or more participants, so planned questions were not asked in some interviews. ^b Nutrition HE professionals declined to answer, as this topic was outside their expertise. ^c This misconception was suggested by a participant, and was only included in seven interviews.

3.4.1 Perceived Sources of Misconceptions in Students

Several ontological and pedagogical factors were repeatedly proposed as sources of misconceptions, consistent with the sources of substantive learning

impediments in the model described by Taber (2001). Two main pedagogical sources of misconceptions were identified: an incorrect or incomplete understanding of course content (identified by six participants), or a lack of the appreciation of the interaction of physiological systems (three participants). Of three main ontological sources identified, poor quality information (including advertising and social media) was raised by seven participants. The influence of role models (six participants) and personal experience (three participants) were also regularly identified.

Of the two main pedagogical sources that were identified by participants, the most common was an incorrect, or incomplete understanding of content. Two participants identified that this could be the result of a lack of exposure to preparatory content in secondary school (such as human biology classes). Others suggested a lack of detailed understanding contributed to misconceptions, such as this example discussing ‘a vitamin supplement can improve your well-being, energy levels, and performance’:

...we almost stop at macronutrients with regard to our scope of practice, and what we are able to teach. This means that we don’t go into any depth, and detail, about the vitamins and minerals, and so there is less education there for students to call on when they graduate.

While it was agreed among higher education professionals that teaching a high level of detail was desirable, this was not unanimous among VET trainers. One suggested “I think simplifying is good” though later identified a consequence of this being that “the deep understanding of it probably isn’t as good”. VET trainers favoured simple analogies and visual representations when using a direct instruction approach. For example, when discussing the impact of resistance training on weight loss, the influence of training on resting metabolism was represented by drawing a clock and a fire on the whiteboard during the discussion. Another participant also discussed ‘if a part of your body is exercised hard, you will lose body fat from that area’ in simple terms, referring to sports with dominant limbs in order to refute the concept, as the composition of dominant and non-dominant limbs are similar. Despite some VET lecturers preferring these simple analogies, oversimplification has previously been identified as a potential source of misconceptions (Michael et al. 1999).

The other main pedagogical factor raised was a lack of appreciation of the interactions between physiological systems. This is consistent with the findings of

Badenhorst et al. (2015), who in similar qualitative research found that students struggled to form a conceptual understanding of topics, then failed to appreciate the complexity and interaction of systems. The lack of integration of subjects by higher education professionals was seen as contributing, as the relationship between systems was not communicated clearly to students. When discussing the misconception ‘lactic acid causes fatigue’, one participant stated:

Students really struggle to understand fatigue, because they're taught it by a biomechanist, a physiologist, a psychologist, and all these different people are talking about different aspects of fatigue.

This shallow understanding was also evident when discussing spot reduction. One higher education professional proposed that the fundamental concept of energy (as a unit of work) was poorly understood, as well as the role of macronutrients:

People don't have a good understanding of what energy is anyway, and what carbohydrates do, and what proteins do, and what fats do in the body. I guess people just don't understand the basics of nutrition, let alone what exercise and nutrition do together, and the utilisation of fuel.

Another participant drew the distinction between responses to exercise that are either central (such as the metabolic adaptations to exercise), or peripheral (such as changes in muscle fibre type, or capillary density), and suggested that students are confusing these.

Inadequate sources, particularly social media and advertising, were identified to an extent not seen in previous literature. One higher education professional when discussing the ‘spot reduction’ misconception offered “It’s compounded by media messages, saying ‘do this exercise and blast belly fat.’ That kind of misconception I think is construed through the media, and that media will – magazine, internet, article, whatever – target a specific group.” This was consistent in both higher education and VET groups, with one VET trainer stating “this age group is just getting hammered by Instagram, and YouTube, and Facebook”. Morton et al. (2008) proposed exposure to sports commentary and advertising as potential sources of misconceptions, but other research has focussed on pedagogical sources.

Role models, such as mentors, peers, and parents, were proposed as influential sources. One VET trainer suggested “their family’s been brought up on

vitamin C every day, or when they're crook", consistent with the findings of O'Dea (2003), who suggested parents were influential in beliefs about the efficacy of vitamin supplements. Duellman et al. (2008) also identified coaches, and athletic trainers as sources of misconceptions of nutrition among student athletes, all of who were preferred to nutrition professionals as sources of information. Also prominent was the influence of exercise subcultures, such as bodybuilding and CrossFit. When discussing a dietary misconception, one higher education participant offered "that is one and the same: CrossFit and nutrition. CrossFit's seen as a lifestyle, so inclusive in this lifestyle is nutrition. Eat nuts and seeds, fruits, and vegetables, avoid dairy, avoid grains." The strength of misconceptions of students immersed in these subcultures was noted by several participants, one suggesting "it tends to be a lot of the ones that, are like, fanatical... they're looking for something... to improve themselves so much that they'll probably not really investigate, they'll give it a go."

Personal experience was proposed as an ontological source of misconceptions, particularly subjective experiences of diet and exercise, consistent with previous research (Michael et al., 1999). For example, influencing the misconception 'lactic acid causes fatigue' was the assertion from one VET trainer that "if you're exercising at high intensity, you're going to feel a burning sensation. That burning sensation is because of lactic acid." In this instance, an understanding of the processes involved is missing, and the correlation of these two events leads to a simplistic understanding of fatigue. This explanation mirrors the reasoning students may use to explain their subjective experiences.

3.4.2 Misconceptions in Professional Practice

Participants identified that the source of information that exercise professionals (particularly personal trainers), used to update their knowledge was the major source of misconceptions. Four participants identified advertising, while five identified other unreliable or non-scientific sources. Two identified sources that were outdated, though might previously have been considered correct. Three participants (all VET trainers) identified concerns about the quality and quantity of professional development that exercise professionals participate in.

That the use of unreliable evidence (such as personal experience, the media, and poor mentors) was identified as a source of misconceptions is consistent with previous research (Bennie et al., 2017; De Lyon & Cushion, 2013; McKean et al.,

2015; Stacey et al. 2010). Participants also considered personal trainers were not able to discern the quality of different sources (consistent with Stacey et al., 2010), as illustrated by one higher education participant stating diplomatically “I think there are professionals out there that are aligned themselves with certain evidence, that may not be of high quality.” This is in contrast to personal trainers interviewed by De Lyon and Cushion (2013), who considered they were capable of doing this accurately.

Advertising, particularly by the nutritional supplement industry, featured heavily in responses. Specifically identified were multi-level marketing organisations that promised personal trainers a passive income. Participants felt that personal trainers, despite receiving education in nutrition, were not different to the general population in their susceptibility to these sources:

If they can lure the general population in as well as they can, I think they can take a couple of trainers with them. Or if there is a trainer who has come through a course where they have learnt the basics of nutrition, and then the marketing guys from these products say ‘this is a new one, this one works’, they can rope them in with that kind of pitch.

Relying on sources based on superseded research was raised by two participants. When discussing ‘perform cardiovascular training at a lower intensity for better weight loss’ one VET trainer identified that the early research which initially formed this misconception continues to influence the exercising public as cardiovascular training equipment often refers to a moderate exercise intensity as a ‘fat burning zone’ (see Figure 3.1 above). It was also proposed that even if a personal trainer did not have an incorrect understanding of a concept, if a client did the trainer may adjust their practice to match the client’s expectations. They may then fall into the habit of reinforcing the misconception through this practice and modify their explanations to match.

The quality of, and access to, professional development was raised by multiple participants. One VET trainer stated “I don’t think there’s enough education... for the fitness profession. It’s something that people who are interested in that sort of thing will go towards”, suggesting that those not already inclined to continue their education may not do so. De Lyon and Cushion (2013) reported that industry experience is more highly valued among personal trainers than

qualifications, and Barnes, Desbrow and Ball (2016) showed the confidence of personal trainers in their knowledge is high, though this knowledge is often incomplete (Malek et al., 2002; Zenko & Ekkekakis, 2015). It is clear from this research, and the opinions of participants, that ongoing education should be a priority for personal trainers.

3.4.3 Teaching Strategies

A combination of traditional direct instruction, and active learning approached were proposed. Eleven participants identified direct instruction as an appropriate method to correct misconceptions. Of these, nine reported using weaker evidence such as case studies or anecdotes to support their teaching. Of the active learning approaches, labs and practical activities were most popular (nine participants), followed by guided discussions in class (5 participants). Two participants recommended modelling correct behaviour, rather than directly correcting a misconception.

Direct instruction was overwhelmingly the most popular method of correcting misconceptions. At times this was blunt, such as by refuting incorrect information by saying “that doesn’t happen”, however higher education participants indicated that they would also provide relevant references. A popular direct instruction approach was the “fads and fallacies” lecture, included early in courses to proactively address misconceptions. Other participants would discuss a common misconception to introduce a topic, a method which has been successful in undergraduate psychology courses (Kowalski & Taylor, 2009).

Much of this direct instruction approach focussed on increasing the depth of understanding of students. For example, to correct the misconception regarding spot reduction higher education professionals focussed on the process of carbohydrate and fat metabolism, and the response of the body to different exercise intensities. While not explicitly identifying the central (rather than peripheral) nature of metabolism, it was proposed that the student should develop an awareness that fat metabolism responds to energy demands, rather than the site of the exercise performed (Whitney et al., p. 212). The importance of the volume, and intensity, of the exercise on the amount of fat metabolised will then become clear. Regarding the misconception ‘perform cardiovascular training at a lower intensity for better weight loss’, which relies on similar underlying knowledge, one higher education

professional was particularly detailed, covering the relationship between exercise intensity and respiratory exchange ratio (RER) as well as EPOC.:

So we talk about high intensity exercise, when we do $\dot{V}O_{2max}$ we talk about RER or RQ [respiratory quotient], we talk about predominantly burning fat vs. predominantly burning carbohydrate, how it's not one or the other, it's a spectrum, and we also - though I probably don't address it enough - talk about oxygen deficit, and how if you do a high intensity exercise your oxygen deficit post-exercise is greater, which means potentially that your energy expenditure is higher after high intensity exercise, which may influence energy balance.

Participants indicated that research evidence was considered reliable, though not compelling to students in either higher education or VET. Nine participants reported using case study evidence or anecdotes either instead of, or to complement, this research evidence. For example, one higher education professional suggested using case studies to correct the misconception of spot reduction, noting “case studies of people’s anthropometric data, and how that changes with changes in energy expenditure and intake ... show that weight loss occurs across all sites of the body, regardless of activity.” This approach was proposed despite the recognised shortcomings of case studies:

...a randomised controlled trial is something they can take away and apply to all the information they get in the future. If we share anecdotes about one topic, all they take away is their understanding of that topic. It's the short term solution.

Another participant noted “I think they respond better to the practical examples, when you show them a case study, as opposed to citing journal articles.” Adding a personal touch to anecdotes, two higher education professionals reported attempting fad diets themselves, even when the rationale for the diet was flawed. They found it effective to share this experience in discussions, as they could speak subjectively about the diet for those that would be convinced by this, while also discussing stronger evidence.

VET trainers frequently reported relying on prescribed guidelines rather than research evidence to provide a rationale for claims. For example, when discussing ‘the more protein, the better’ one trainer suggested:

So we sort of start with ‘this is what the government recommends’.

These are the people that have put all this money, and all this research into this, and nutrition hasn’t changed in forever, and if you go back to old nutrition texts, it’s all the same stuff.

While this trainer was obviously aware of the existence of this research, it did not form an integral part of their correction of misconceptions, other than to note that it informs the development of guidelines.

Active learning has been shown to have a long term effect on misconceptions in physiology (Ahopelto et al. 2011), and a number of active learning approaches were suggested by participants, including assessing diet records, and labs assessing energy expenditure, to assist with understanding weight loss concepts, and the efficacy of vitamin supplementation.

Guided discussions, requiring students to explicitly express knowledge and structuring logical arguments, were a popular alternative to direct instruction for higher education professionals. One discussed ‘if a part of your body is exercised hard, you will lose body fat from that area’ by asking students to explain the process of fat metabolism. This was followed by a discussion of fat utilization at varying exercise intensities, then the intensities and energy expenditure of different exercise options, to demonstrate that the spot reduction misconception was inconsistent with these concepts. Similarly, ‘women will get too muscular if they lift heavy weights’ was corrected by one higher education professional by using controversies around hyperandrogenism in sport to provide discussion of the role of hormones in the development of muscle mass. However, only one VET trainer reported using this technique.

As noted earlier, modelling correct behaviour was seen as important to correct the misconception ‘static stretching reduces injury risk.’ In both VET and higher education, participants indicated that they would model appropriate warm-up activities at the beginning of practical activities, and require students to implement similar warm-ups throughout the course:

Every single prac that I do, they will do a warm up that will be followed by dynamic stretching, and those dynamic activities will lead into whatever we are doing in that class that day.

Both higher education and VET participants indicated that the repetition was seen as more effective in leading to correct behaviour than explanations in class. Although some research evidence was alluded to in justifying the behaviour being modelled, it was not the focus of lecturers.

The misconceptions ‘vitamin supplements improve well-being, energy levels, and exercise performance’ was seen to be relatively harmless, and posing a low risk to students or future clients, so correction of these was not a focus for two participants (one higher education professional and one VET trainer). When addressing this the VET trainer concluded:

If they're taking a multivitamin once a day I'd say they might just be getting more expensive urine. Is unlikely to be doing any damage?
Probably not. If you were taking mega doses of things, different story.

3.4.4 Critical Thinking Ability

The importance of critical thinking ability in countering misconceptions was raised by both higher education and VET participants. It was proposed these skills are gained during a university degree when embedded in course content and assessments, and participants offered examples of research assessments, and labs that used control conditions and double blinded designs, such as when assessing the impact of sports drinks on cycling performance.

The implicit use of critical thinking skills was also evident in some of the corrections to misconceptions proposed by lecturers. When discussing ‘vitamin supplements improve well-being, energy levels, and exercise performance’ some participants identified circumstances in which specific supplements could lead to a performance benefit, or recovery from exercise. But in these instances they also identified the small effect demonstrated, inconsistency in the research, or the very specific populations these findings could be applied to. These participants also suggested referring to the literature (mentioned above) that has found none of the proposed benefits of vitamin supplementation in those with otherwise adequate diets. In this instance, therefore, the correct understanding of this literature requires

students to understand the extent to which this research evidence could be applied to broader populations, so some appreciation of research methodology may be helpful.

Similarly, higher education professionals highlighted the distinction between an association and a causal relationship between two variables. For example, when discussing ‘no pain, no gain’, one higher education professional stated:

We know that eccentric exercise induces muscle damage. It is true that eccentric exercise is a very important stimulus for muscle hypertrophy. Also it is true that soreness is induced by eccentric contractions... That is why people think that soreness induces hypertrophy... eccentric exercise without any soreness can still induce hypertrophy. So that is one of the causes of the misconception; pain and hypertrophy both come from the same source, the eccentric muscle contraction.

When discussing ‘lactic acid causes fatigue’ one participant stated “we certainly associate fatigue with it, but that doesn't mean it's the cause”, before highlighting a range of other factors that contribute. VET lecturers did not appear to appreciate this subtlety: at best they would correct students by saying that it was the hydrogen ions, rather than the lactate itself, that was the cause of fatigue.

While this implicit approach to critical thinking was popular among higher education professionals it is not clear if implicitly teaching critical thinking is effective. A meta-analysis by Abrami et al. (2015) concluded that although evidence was mixed, an explicit approach was more effective. There was also no mention of an explicit approach among VET trainers, though two did explicitly identify the need for critical thinking ability in their students. One proposed that developing these skills was more productive than correcting individual misconceptions, as students could subsequently analyse claims themselves:

I often find the best place to start is with some background on the scientific method, and critical analysis... And this sets up the topic so that they take what they've learnt prior to that point as their opinion, and they treat what we're showing them as the truth.

Even when suggesting the use of critical thinking however, this participant was not explicitly encouraging analysis of the information provided by their organisation, referring to this as “truth”, and other sources as informing “opinion”. The second

identified that students need to “be detectives”, encouraging them to read further and ask questions, though no specific instruction was provided, and this participant thought the tendency of students to be a “detective” deteriorated after graduation. While it was proposed by DeGolier (2010) that critical thinking interventions could be used to confirm or challenge weight loss claims, the effectiveness of critical thinking instruction in fundamental exercise and nutrition topics has not been examined.

It was acknowledged by this first VET trainer that critical thinking ability is not taught sufficiently in VET, leaving personal trainers susceptible to new misconceptions. This is despite the AQF requiring each level to prepare students for higher levels of study. As Diploma qualifications requiring graduates to be able to “analyse, synthesise, and act on information from a range of sources” (Australian Qualifications Framework Council, 2013, p.39), and be able to solve complex problems, simple analysis skills need to be introduced at Certificate IV level. There is little evidence from the present study that VET fitness graduates (with Certificate IV qualifications) are adequately prepared in this area.

3.4.5 The Presence of Misconceptions in Participants

While it was not an aim of this study, during the course of some interviews, it became evident that some participants possessed one or more of the misconceptions being discussed. In these cases, the interview focused on clarifying the participant’s reasoning, and other planned questions were not asked. Misconceptions were more often held by VET trainers, or higher education professionals in topics outside their discipline, and appeared to be from a range of sources.

3.4.5.1 Personal Experience

One factor contributing to the maintenance of a misconception was personal experience being at odds with evidence on the topic. This may be because personal experience is more readily recalled than other knowledge and is more influential in judgments (Tversky & Kahneman, 1974). Subsequent information that contradicts our opinion is then reduced in importance or rejected. Supporting information is more influential, and the misconception strengthens.

One of the higher education nutrition professionals possessed the misconception ‘women get too muscular if they lift heavy weights’, based largely on

their personal experience of resistance training, and the perception that they became more muscular than desired. Although prompted, and despite this knowledge being within the scope of their qualification, the participant did not elaborate on other factors which influence muscle gain (such as excess kilojoule intake).

Another higher education professional possessed the misconception that ‘static stretching reduces injury risk’ and reported a personal preference for static stretching prior to exercise. The participant proposed that the ability to check muscle stiffness before exercise may reduce injury risk, and that proprioception was improved. This is despite most research evidence not showing reduced injury rates (Shrier, 1999; Thacker et al., 2004).

Three VET trainers displayed strong personal preferences for high intensity exercise, which seemed to be associated with errors in knowledge. One did not demonstrate an awareness of the different training adaptations possible at different exercise intensities. Another expressed the opinion that “your goal should be to work as hard as humanly possible – for you – in whatever given amount of time you have” and was willing to adjust the length of a training session, but not the relative intensity.

3.4.5.2 Critical Thinking Ability

Despite both higher education professionals and VET trainers professing to encourage critical thinking and research skills, several flaws in reasoning were demonstrated during the interviews. The modelling of appropriate critical thinking skills is particularly important in both university and vocational courses, as they are usually not taught independently, and instead are embedded in course content. It is assumed students develop these skills throughout their courses, though this approach is generally not effective (Abrami et al., 2008).

One higher education physiology professional suggested that the concept of ‘if a part of your body is exercised hard, you will lose body fat from that area’ may not be a misconception, despite research clearly refuting the concept (Kostek, et al., 2007; Ramírez-Campillo, et al., 2013; Vispute, et al., 2011). This participant made the observation that body fat tended to accumulate in the torso, rather than the limbs, which were supposedly more active. They then confirmed that they considered this a causal relationship, despite the lack of a plausible mechanism for this.

3.4.5.3. Insufficient Depth of Knowledge

Teaching to develop an appreciation of the complexity of topics can assist students in appreciating the boundaries of their knowledge. Both Michael et al. (1999) and Badenhorst et al. (2015) identified that participants thought the complexity of physiological systems was not understood by students, which led to misconceptions developing. Multiple examples of participants possessing misconceptions due to insufficient knowledge were identified during the interviews. This makes it highly likely that not only will the students also lack an appropriate depth of knowledge, but the misconception will also be passed on.

When discussing ‘women get too muscular if they lift heavy weights’, some participants tended to discuss the benefits of resistance training as a counterargument, though this does not directly address the misconception. Higher education participants focussed on the physiological benefits of resistance training, while VET trainers focussed more on the appearance of women who performed resistance training. Almost all participants stated they would discuss the hormonal differences between genders as an effective way of correcting this misconception, though only one higher education participant elaborated on specifics, even when pressed for detail.

VET trainers demonstrated a lack of detail in their understanding of metabolism when discussing ‘a short term fast flushes out toxins and helps weight loss’. One response to why this was a misconception was “...you need to look at everything in moderation, because that’s how the body works.” This indicates an awareness that highly restrictive diets may be counterproductive, although more detail was not provided when prompted. Another agreed that the statement was a misconception, stating “anything that is calorie reduction is a diet, and diets don’t work.” The fact that it involved reducing kilojoule intake was the major issue for this participant, rather than the highly restrictive nature of the strategy. This participant demonstrated a strong bias towards exercise as a weight loss strategy, rather than reducing kilojoule intake, saying “you can’t be a 24-hour calorie burning machine if you’re starving the body.”

3.4.5.4 Epistemology

One VET trainer demonstrated a multiplist epistemology during the discussion of misconceptions. This was characterised by the opinion that some topics were entirely open to interpretation, and a fitness professional could make a valid decision one way or the other. For example, when discussing the efficacy of vitamin supplementation, it was stated “if you put 100 nutritionists in a room, 50 will say take a multivitamin, and 50 won’t. So, you’ll have to make a choice in your career.”

When discussing the misconception of ‘no pain, no gain’ this participant responded “that’s a hard one, because exercise hurts.” This participant also demonstrated a strong preference for high exercise intensities during the interview. While they acknowledged that some professionals may have different opinions, this was attributed to personal preference, and was seen as equally valid. The concept of manipulating exercise variables to meet the needs and ability of the client, or the type of adaptation required, was not evident.

Kuhn (1991) described those possessing a multiplist epistemology as seeing knowledge as an idea, rather than objective facts, or something to be evaluated. As such, an exchange of ideas is unnecessary when another’s opinion is equally valid. In this context, an exercise professional may not see the need to engage in professional development, limiting the quality of information and services they can provide to clients, and missing the opportunity to improve knowledge or correct misconceptions.

3.4.6 Exercise Science Knowledge Survey

The responses to the above misconceptions were used to develop a factual statement, designed to represent a correct understanding of each topic, using relatively simple language. A corresponding misconception statement was written for each factual statement, which would succinctly summarise the flawed understanding of each topic. The inclusion of factual statements (and the title of the survey) serve to prevent participants from identifying that the survey attempts to identify agreement with misconceptions (Hughes et al., 2015). The factual and misconception statements are displayed in Table 3.4. These 20 statements form the Exercise Science Knowledge Survey, which was used to assess the knowledge, and misconceptions, of participants as reported in Chapters 4-6.

While “true” and “false” responses have been used in previous misconception surveys (e.g., Vaughan, 1977), this may lead to inflated misconception scores from participants with an acquiescence (yea-saying) response style, and deflated scores for those with a counter-acquiescence style (Bensley et al., 2014). To minimise this, a “don’t know” response was included to express uncertainty (Bensley et al., 2014; Gardner & Dalsing, 1986). A rating of the confidence in each response was also included, to identify the strength of conviction in misconceptions, and allow comparison with other research examining the confidence of exercise professionals (Barnes, Desbrow & Ball, 2016; Zenko & Ekkekakis, 2015).

3.5 Conclusions

The aim of the study reported in this chapter was to identify fundamental exercise and nutrition misconceptions, the information that leads to the formation of these misconceptions, and the knowledge required to correct these misconceptions in both VET and higher education. An additional aim was to explore pedagogical and ontological sources of these misconceptions, and the potential influence of critical thinking ability correcting these misconceptions. The Exercise Science Knowledge Survey resulting from this study may be used as a standard assessment of knowledge and misconceptions across a broad population, though the effectiveness of the survey will need to be assessed.

The misconceptions discussed in the present investigation have varied origins, though there are some consistent themes. All participants considered that misconceptions of fundamental concepts exist before entering a course, persist throughout, and involve simple subject matter. While some misconceptions stem from popular media sources, many persist from superseded research evidence, and a subsequent misunderstanding, or incomplete understanding, of current evidence.

Higher education professionals and VET trainers differed greatly in their ability to explain, and develop an appreciation in students of, the complexity of physiological systems and interactions in the body. This should be emphasised in order to correct misconceptions. Higher education professionals focussed on increasing this depth of understanding and would back this up with reference to key research. While some VET trainers would attempt this for certain misconceptions, this was inconsistent, as they often lacked the depth of understanding themselves to attempt this approach. Instead, VET trainers would use simple analogies, or refer to

freely available public health information, to support their course content. An understanding of course content in excess of course requirements is required at both levels of education. Active learning tasks, and instruction in critical thinking ability, such as simple research methods, and discerning the quality of sources, should have a greater emphasis in VET. These skills should be modelled by VET trainers. Further research is required to determine if the perceptions of participants regarding the popularity of these misconceptions are correct. And while research has examined the change in misconceptions over the course of degree programs, the extent to which they persist in VET, and in VET qualified personal trainers, is unclear. Furthermore, the critical thinking ability of students and professionals (both VET and higher education) in exercise qualifications has not been assessed. It is possible improving these skills will reduce the presence of misconceptions, lead to an improvement of public understanding of exercise concepts, and improve exercise outcomes.

Table 3.4: Misconceptions and knowledge statements included in the Exercise Science Knowledge Survey

Misconceptions	Knowledge statements
Gentle, static stretching before exercise is a good way to reduce your risk of getting injured	A gradual, progressive increase in the intensity of exercise is a good way to warm up and prevent injury
Protein is the most crucial nutrient for muscle growth. If you want to get bigger or stronger, the more you can eat, the better	Very large quantities of protein are not necessary to improve your response to training. Your body only uses as much as it needs, extra protein gets broken down and excreted in urine
An hour of low intensity cardio training will burn more fat than an hour at high intensity. Therefore, you will lose weight faster doing low intensity cardio training	Higher intensity exercise uses more energy than lower intensities. Increased energy expenditure is a key part of successful weight loss programs, so this should be encouraged when safe to do so
A diet high in protein and fats, with little or no dairy or grains, is healthier than what is recommended in the Australian Dietary Guidelines	A healthy diet should be generally consistent with the Australian Dietary Guidelines, contain food from all the major food groups (including grains & dairy), and contain moderate amounts of carbohydrate, fat, and protein
If a part of your body is exercised hard, you will lose body fat from that area. For example, stomach crunches will help to flatten your stomach	Fat metabolism is not a local process. You can't pick where you lose body fat from by exercising specific parts of the body
If you want to lose weight, then a short term fast or juice cleanse to flush toxins out of your system is a good way to get things started.	The weight loss result from a short term fast or juice cleanse is usually a result of reduced muscle glycogen storage, and less water retention. This weight will return once the fast finishes
When we exercise hard lactic acid builds up in our muscles. This is the cause of fatigue	You get tired when you exercise at high intensity for several reasons, including (but not limited to): depleted muscle glycogen, accumulated muscle damage, increased acidity in the muscle, and psychological fatigue
A vitamin supplement (like a multivitamin) can improve your well-being, energy levels, and exercise performance	A healthy, balanced diet provides most of the micronutrients you need. Vitamin supplements are unnecessary for most people
"No pain, no gain." To get stronger or fitter, you need to endure some pain. This is necessary to make your body adapt to exercise	It is possible for most people to get stronger without feeling significant pain. Muscle damage (and resulting pain) is largely caused by eccentric muscle contractions, and you can still get stronger while keeping soreness to a minimum
Women have a risk of getting too muscular if they lift heavy weights. To avoid this, use lighter weights, and perform more repetitions	Most people can lift heavy weights for improved strength and health, and not get too muscular. Women will generally find gaining muscle much harder than men, due to hormonal differences between genders

Chapter 4: The Presence of Misconceptions in Exercise Science Students and Professionals

4.1 Introduction

With the increasing accessibility of the Internet, the public has been able to directly access information that previously may have involved contact with a ‘gatekeeper’, for instance a qualified professional, who could filter information, only providing to the consumer that which had merit (Metzger et al., 2010). Specifically, searching for health information online is popular among the public (Fox & Duggan, 2013; Hall, Bernhardt, Dodd & Vollrath, 2015), though there are concerns about the quality of this information (Eysenbach et al., 2002; Miles et al., 2000).

It has also been found that people rely on cognitive shortcuts when assessing the quality of online information (Metzger et al., 2010), which can lead to errors in comprehension. So there is still a place for a professional to help the public interpret this information. However, research has demonstrated that some professionals have misconceptions in their knowledge, sometimes about fundamental information. This has been demonstrated in concepts of body weight and energy regulation (Abdel-Hamid, et al., 2014), exercise prescription guidelines (Zenko & Ekkekakis, 2015), nutrition, and special populations (Malek et al., 2002). In spite of this, the confidence of exercise professionals in their knowledge tends to be high (Barnes, Desbrow & Ball, 2016; Zenko & Ekkekakis, 2015).

While the origin of these misconceptions may vary, their persistence has been demonstrated repeatedly. Hughes et al. (2015) identified that misconceptions in psychology can persist throughout an undergraduate degree. Similarly, Morton et al. (2008) found misconceptions in exercise science to be enduring, with only one of ten examined misconceptions largely corrected during a degree program. One misconception about fat oxidation even became more commonly held. It is clear from these findings that the mere possession of a qualification does not ensure that the knowledge of the graduate is free of misconceptions.

But while these misconceptions may survive an undergraduate degree, those with postgraduate qualifications have been shown to possess fewer misconceptions (Hughes et al., 2015). While some authors propose that increasing the appreciation for the complexity of knowledge will reduce misconceptions (Badenhorst et al., 2015; Michael, 2007), Hughes et al. (2015) identified that a reduction in

misconceptions was not related to the number of psychology units taken by students. This suggests factors other than the accumulation of knowledge contribute to the reduction of misconceptions.

A key component of a postgraduate education is critical thinking ability, defined as “reasonable reflective thinking” (Pithers & Soden, 2000, p. 239). This includes skills such as the ability to interpret and evaluate arguments, research information, assess evidence, consider alternative conclusions, as well as a willingness to apply these skills when needed (Abrami, et al., 2015). Stacey et al. (2010) identified that personal trainers with postgraduate qualifications used better sources of information, and medical students who possessed fewer misconceptions about cardiac physiology have been found to perform better on clinical reasoning tasks (Ahopelto et al., 2011). To date the only known published research examining critical thinking skills and misconceptions is by Bensley et al. (2014), who found that psychological misconceptions were negatively associated with critical thinking disposition and knowledge.

Errors in knowledge have been assessed in exercise professionals (Malek et al., 2002; Zenko & Ekkekakis, 2015), and students (Ekkekakis et al., 2016). However, little is known about the presence of fundamental misconceptions about exercise and nutrition in exercise science students or exercise professionals, as the research to date has focussed on more complex concepts (Michael et al., 1999; Morton et al. 2008). And while misconceptions in the public have been speculated on (Ebben & Jensen, 1998; Kieffer, 2008), there is no known empirical investigation of factors that relate to the presence of misconceptions in this group, or in comparison to qualified professionals or students.

The sources of information used by exercise professionals has been assessed (Bennie et al., 2017; McKean et al., 2015), but this has largely focussed on personal trainers rather than degree qualified professionals. Differences between professionals and the public have not been assessed, nor has the influence of critical thinking ability on these choices.

Therefore, the aims of this study were to:

1. Assess the presence of misconceptions, knowledge, and critical thinking ability of exercise science students, exercise professionals, and the public.

2. Determine whether the presence of misconceptions was related to lower critical thinking ability, knowledge, level of education, or exercise history.
3. Explore the relationship between participants' confidence in their answers, their knowledge, and the presence of misconceptions.
4. Identify the sources of information used by students, professionals and the public, and whether the use, or trust, of particular categories of sources was associated with knowledge, critical thinking ability, or the presence of misconceptions.

4.2 Method

4.2.1 Design

This investigation was a cross-sectional correlational design with a between-groups component. Participants were first and third year exercise science students, degree qualified exercise professionals, and a general public comparison group. All participants were surveyed within the same academic year.

4.2.2 Participants

Students completing a three-year exercise science degree were recruited from a university in Perth, Western Australia. This was a fully accredited exercise science program with ESSA. All students were completing their degree on campus (rather than online). One hundred and fifty-nine first year students (FYS), and 57 third year students (TYS) were recruited.

The professional group consisted of 51 degree-qualified exercise professionals (DQP), currently working in the delivery of exercise programs to adults, recruited via the author's industry contacts, and subsequent snowball recruitment.

The general population group (PUB) was a convenience sample of 54 participants, who did not possess an exercise qualification, and were not working in an exercise-related role. The demographic characteristics of each group are shown in Table 4.1.

Table 4.1. Demographic characteristics of participants in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) student ($n = 57$), and degree qualified professional (DQP) ($n = 51$) groups.

	PUB	FYS	TYS	DQP	
Gender (n)	Male	20 (37%)	84 (53%)	31 (54%)	33 (65%)
	Female	34 (63%)	75 (47%)	26 (46%)	18 (35%)
Mean age in years (SD)	40.35 (14.97)*	19.54 (3.69)**	21.6 (2.57)**	30.9 (8.87)*	
Median highest educational achievement (AQF level)	7	3	3	8	
Mean industry experience in years (SD)				8.84 (8.38)	
Exercise AQF level				7.91 (0.96)	

* significantly different to all other groups ($p < .05$). ** significantly different to public and professional groups ($p < .05$). Note: information on the ESSA accreditation status of degree qualified professionals was not gathered. Note: AQF level 3 = Certificate III or high school graduation, 7 = bachelor's degree, 8 = honours degree or graduate diploma.

A power analysis using G*Power 3.1 (Faul, Erdfelder, Lang & Buchner, 2007) determined that a total sample size of 44 was required to yield an actual power of 0.8 for a one-way ANOVA to assess differences between groups. This was based on an estimated effect size of 0.68, determined from an eta squared ($\eta = .32$) reported by Taylor and Kowalski (2004). One hundred participants were required for a multiple linear regression yielding a power of 0.8, based on eight predictors of misconceptions (group, critical thinking ability, knowledge, AQF level, number of sources of information used, and trust ratings for degree qualified professionals, and sources of mixed and unknown reliability). This was based on a Cohen's f^2 effect size of .10, reported by Gardner and Brown (2013).

4.2.3 Measures

The Exercise Science Knowledge Survey was developed from the misconceptions identified in Chapter 3. The survey consisted of a series of 10

misconception statements, and 10 knowledge statements, to assess participants' endorsement of common misconceptions related to exercise and nutrition. Participants were required to indicate their agreement with each statement ("yes", "no", or "don't know" responses), and were instructed not to guess. For each item rated "yes" or "no", participants were also asked to rate their confidence in their response, using a three-point scale (1 = slightly confident to 3 = very confident). A "don't know" response resulted in a confidence score of zero for that item. The order of knowledge and misconception statements was randomised.

The Exercise Science Knowledge Survey produced a Knowledge (KNOW) score, and a Misconception (MISC) score. Knowledge is the sum of knowledge statements rated as a "yes" (maximum value 10), while the Misconceptions score is the sum of misconception statements agreed with (maximum value 10). Corresponding confidence scores for both Knowledge and Misconceptions were also produced (maximum value 30). Cronbach's alphas for the Knowledge and Misconception scores were .46 and .68, respectively. The reliability of the Misconception scale, while slightly below commonly accepted standards (Ponterotto & Ruckdeschel, 2007), is still acceptable to explore a new measure, especially given the varied levels of exercise education of participants in this investigation. The reliability of the Knowledge scale, while very low, is expected given the diverse knowledge being assessed by this subscale (Taber, 2017).

As the Knowledge scale reliability was poor, the possibility of using separate exercise and nutrition subscales was investigated. Principal axis factoring was used to examine whether the underlying structure of the variables permitted the use of these subscales, though it was understood that factor analysis may not be informative given the low number of variables, and the broad knowledge being assessed by these statements (Fabrigar, Wegener, MacCallum & Strahan, 1999). This factor analysis is shown in Table 4.2. Bartlett's test of sphericity ($\chi^2(45) = 151.32, p < .001$) and the Kaiser-Meyer-Olkin (KMO = .607) measure of sampling adequacy indicated that the data was acceptable for factor analysis. While the sample size required for a factor analysis is debated in the literature (Mundfrom, Shaw & Ke, 2005; Reise, Waller & Comrey, 2000), the present sample ($N = 321$) is considered adequate for most analyses (MacCallum, Widaman, Zhang & Hong, 1999). The analysis yielded four factors explaining a total of 52.66% of total variance. However, even after a Varimax

rotation was performed there was not an obvious pattern to these factors. Additionally, three items loaded significantly on more than one factor (Tabachnick & Fidell, 1989). This means individual responses have been examined where appropriate, as well as the composite score.

Table 4.2. Factor analysis for the Knowledge scale in the Exercise Science Knowledge Survey

Scale items	Factor			
	1	2	3	4
It is possible to get stronger without feeling significant pain	.78			
The weight loss from a fast will return once the fast finishes	.64			
Women can lift heavy weights for improved strength and health, and not get too muscular	.55			.36
Very large quantities of protein are not necessary	.34	.35		
A progressive increase in exercise intensity is a good warm up		.76		
Higher intensity exercise uses more energy than lower intensities		.57		
Fatigue during high intensity exercise occurs for several reasons		.36	.73	
Fat metabolism is not a local process			.80	
A healthy diet should be generally consistent with healthy eating guidelines				.75
Vitamin supplements are unnecessary for most people				.67
Percentage of variance	14.98	13.21	12.67	11.80
Eigenvalue	1.84	1.20	1.11	1.10

Critical thinking ability was assessed using the Cognitive Reflection Test (CRT) (Frederick, 2005), which requires participants to derive answers to three mental arithmetic questions that have deliberative, accurate answers that are usually obtained after considering an incorrect, intuitive answer. Total scores are calculated from the number of correct responses, ranging from zero to three. Frederick (2005) did not report reliability, though Liberali, Reyna, Furlan, Stein & Pardo (2012) found good reliability ($\alpha = .74$) (Ponterotto & Ruckdeschel, 2007). Cronbach's alpha for the current sample was .62. While this is lower than generally acceptable reliability,

this is influenced by the low number of items in the scale (Ponterotto & Ruckdeschel, 2007). The Cognitive Reflection Test has been shown to predict performance in tests of bias and heuristics (Toplak et al., 2011), and a range of other cognitive skills (Oechssler, Roeder & Schmitz, 2009; Pennycook, Cheyne, Seli, Koehler & Fugelsang, 2012) which make up critical thinking ability, so whilst this reliability was considered adequate for the present investigation, the results should be interpreted with some caution.

Demographic information (age, gender), and highest educational achievement (AQF level) were collected, as was information about participants' exercise history (exercise frequency, and years of consistent exercise without a break of longer than three months). Degree qualified professionals were also asked to provide the length of their professional practice, and their highest exercise qualification (exercise AQF level).

Participants also identified the sources of exercise and nutrition information accessed in the previous 12 months, from a list of 21 options of varying quality (such as degree qualified exercise and nutrition professionals, online sources, academic sources, and informal sources such as friends, or people they meet in the gym). Participants were asked to rate the trustworthiness of each source on a five-point Likert-type scale (1 = not at all trustworthy, 5 = very trustworthy), regardless of whether they had accessed this source.

4.2.4 Procedure

Ethics approval was granted by the Curtin University Human Research Ethics Committee (HRE2016-0292). All participants were volunteers, and informed consent was gained prior to completing the survey. All responses were anonymous.

Students were recruited via the university delivering the degree and were surveyed during laboratory classes. First year students were surveyed in the first two weeks of the academic year. Third year students were surveyed three weeks before the end of the academic year, so as not to disrupt exam preparation.

Degree qualified professionals and the general public group were recruited via convenience snowball sampling. All participants completed the survey in person, on a provided tablet device, without using reference material. The survey took approximately 15 minutes to complete.

4.2.5 Data Analysis

Differences between all groups in demographic characteristics, years of exercise, Knowledge, Misconceptions, critical thinking ability, and Confidence (in both KNOW and MISC responses) were assessed using one-way ANOVAs. Tukey's post-hoc analysis was used to identify the difference between individual groups. Cohen's *d* effect sizes were calculated to assess the practical significance of differences between groups. A chi-square test of independence was used to assess the differences in exercise frequency between groups.

Pearson's bivariate correlations were used to examine the association between trust scores and Knowledge, Misconceptions, critical thinking ability, age, and AQF level.

A hierarchical multiple linear regression analysis was used to examine the relationship between participants' group, prior education, critical thinking ability, Knowledge, and sources, and the presence of misconceptions.

Sources of information were combined into four categories for analysis. Reliable sources (e.g. textbooks, public health promotion campaigns [REL]), and sources of mixed or unknown reliability (e.g. friends, social media, alternative health practitioners [MIX]), were grouped together according to categories identified by Bennie et al. (2017). Additional categories for exercise and nutrition professionals (degree qualified professionals, personal trainers, and physiotherapists [PRO]), and other health professionals (general practitioners and pharmacists [OTH]) were established. Use of each source was coded as either zero (did not access this source in the previous 12 months) or one (did access this source). The modal response in each category was used to classify whether a participant was a user of these sources, while the trust score for each category was the mean score for those items.

Chi-square tests for independence were used to examine differences between groups in the sources of information used. Cramér's *V* was used to measure the strength of the association between participants' group, and the use of sources. Differences between those using sources, and those not, were examined using an independent samples *t*-test. Differences between groups in trust measurements were examined using a one-way ANOVA, with Tukey's post-hoc analysis used to assess differences between individual groups.

Significance for all tests was accepted at $p < .05$, except where stated.

4.3 Results

Although some differences in exercise history and exercise frequency were observed between groups, these were not associated with other variables in a meaningful way, so are not reported further.

4.3.1 Knowledge and Misconceptions

The percentage of participants in each group who possessed individual misconceptions is illustrated in Table 4.3. Differences in each group from the expected prevalence of individual misconceptions was examined using a chi-square test of independence. Cramér's V was used to measure the strength of the association between participant group, and possession of each misconception.

Five misconceptions were relatively uncommon in the public, with less than 20% of participants from this group agreeing that 'low intensity cardio burns more fat than high intensity', 'a high protein, high fat diet is healthier than recommended healthy eating guidelines', 'if a part of your body is exercised hard, you will lose body fat from that area', 'a short term fast flushes out toxins and helps weight loss', and 'women get too muscular if they lift heavy weights'. Only one misconception ('static stretching reduces injury risk') was more frequent in this group than the expected result.

In the first year student group, only two misconceptions ('low intensity cardio burns more fat than high intensity', and 'a high protein, high fat diet is healthier than recommended healthy eating guidelines') were possessed by fewer than 20% of participants. This group agreed with misconceptions significantly more than the expected value for seven out of 10 misconception statements.

Misconceptions were less prevalent in third year students, who possessed misconceptions at, or below, the expected level for nine out of 10 statements. Only for 'lactic acid causes fatigue' did they agree with the statement more than the expected value. This misconception was very common in both first year (84%) and third year (86%) students.

Table 4.3. The presence of misconceptions in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$), and degree qualified professional (DQP) ($n = 51$) groups.

Misconception	PUB	FYS	TYS	DQP	χ^2	p	V
Static stretching reduces injury risk	79.6%*	71.1%*	35.1%*	15.7%*	89.39	< .001	.53
The more protein, the better	48.1%	61.0%*	26.3%*	41.2%	42.23	< .001	.36
Low intensity cardio burns more fat than high intensity	18.5%	15.7%	17.5%	7.8%	21.60	.001	.26
A high protein, high fat diet is healthier than recommended healthy eating guidelines	13%	10.1%	12.3%	15.7%	13.03	.04	.20
If a part of your body is exercised hard, you will lose body fat from that area	14.8%	38.4%*	22.8%	0%*	41.85	< .001	.36
A short term fast flushes out toxins and helps weight loss	9.3%	20.8%	15.8%	9.8%	27.25	< .001	.29
Lactic acid causes fatigue	61.1%	84.3%*	86%*	49%*	60.37	< .001	.43
A vitamin supplement can improve your well-being, energy levels, and performance	48.1%	57.9%	43.9%	52.9%	19.02	.004	.24
No pain, no gain	51.9%	62.3%*	52.6%	33.3%*	25.28	< .001	.28
Women get too muscular if they lift heavy weights	18.5%	21.4%	19.3%	5.9%	34.64	< .001	.33

* significantly different to expected values ($p < .004$)

Degree qualified professionals recorded lower than expected agreement with five misconception statements ('static stretching reduces injury risk', 'if a part of your body is exercised hard, you will lose body fat from that area', 'lactic acid causes fatigue', 'no pain no gain', and women get too muscular if they lift heavy weights). Four misconceptions were relatively common, with a notable minority of professionals agreeing that 'a high protein, high fat diet is healthier than recommended healthy eating guidelines' (41%), 'lactic acid causes fatigue' (49%), and 'no pain, no gain' (33%), and a majority (53%) agreeing that 'a vitamin supplement can improve your well-being, energy levels, and performance'.

The general public group provided more "don't know" responses when responding to the statements 'the more protein, the better', 'low intensity cardio burns more fat than high intensity', and 'lactic acid causes fatigue', even when the frequency with which they agreed with the misconception was consistent with the expected value. The first year student group did not record more "don't know" responses than expected for any item, consistent with third year students and degree qualified professionals, despite their lack of education.

The percentage of participants in each group who identified knowledge statements as correct is illustrated in Table 4.4. Differences in each group from the expected prevalence of individual misconceptions was examined using a chi-square test of independence. Cramér's *V* was used to measure the strength of the association between participants' group, and possession of each misconception.

The general public group recorded lower than expected agreement with knowledge statements in only two items ('fatigue during high intensity exercise occurs for several reasons', and 'women can lift heavy weights for improved strength and health, and not get too muscular'), and more "don't know" responses on three items. By contrast, the first year student group recorded lower agreement than expected on five items ('higher intensity exercise uses more energy than lower intensities', 'fat metabolism is not a local process', 'the weight loss from a fast will return once the fast finishes', 'vitamin supplements are unnecessary for most people', and 'it is possible to get stronger without feeling significant pain'), and did not demonstrate more "don't know" responses than expected on any item. Third year students and degree qualified professionals only recorded agreement as frequently, or more frequently than expected (on two items, and seven items, respectively).

Table 4.4. Agreement with knowledge statements in the public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$) students, and degree qualified professional (DQP) ($n = 51$) groups.

Knowledge statement	PUB	FYS	TYS	DQP	χ^2	p	V
A progressive increase in exercise intensity is a good warm up	100%	96.2%	96.5%	100%	7.83	.25	.11
Very large quantities of protein are not necessary	46.3%	47.8%	77.2%*	92.2%*	48.33	<.001	.39
Higher intensity exercise uses more energy than lower intensities	81.5%	74.2%*	96.5%*	98%*	26.07	<.001	.28
A healthy diet should be generally consistent with healthy eating guidelines	85.2%	89.3%	96.5%	88.2%	4.79	.57	.12
Fat metabolism is not a local process	72.2%	63.5%*	84.2%	96.1%*	32.34	<.001	.22
The weight loss from a fast will return once the fast finishes	66.7%	56%*	68.4%	88.2%*	28.14	<.001	.30
Fatigue during high intensity exercise occurs for several reasons	74.1%*	89.9%	98.2%	98%	29.78	<.001	.30
Vitamin supplements are unnecessary for most people	87%	77.4%*	87.7%	98%*	15.28	.02	.22
It is possible to get stronger without feeling significant pain	61.1%	54.1%*	61.4%	84.3%*	25.91	<.001	.28
Women can lift heavy weights for improved strength and health, and not get too muscular	61.1%*	78.6%	89.5%	94.1%*	27.70	<.001	.29

* significantly different to expected values ($p < .004$)

Significant differences between groups in Knowledge ($F(3, 317) = 27.84, p < .001$), Misconceptions ($F(3, 317) = 22.454, p < .001$), and critical thinking ability ($F(3, 317) = 4.55, p = .004$) were observed. These data are reported in Table 4.5. Post-hoc analysis using Tukey's HSD revealed that the public and first year student groups had similar Knowledge scores, though the public scored lower in Misconceptions ($d = 0.48$), and higher in critical thinking ability ($d = 0.56$). Third year students had higher Knowledge scores than the public group ($d = 0.72$) or first year students ($d = 0.83$), while degree qualified professionals had higher Knowledge than all other groups, with either large (PUB: $d = 1.35$; FYS: $d = 1.55$) or moderate effect sizes (TYS: $d = 0.73$), and a lower mean Misconceptions score (PUB: $d = 0.82$; FYS: $d = 1.29$; TYS: $d = 0.60$). There were no other significant differences in critical thinking ability.

Table 4.5. Mean (SD) Knowledge, Misconceptions, and critical thinking ability reported by general public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$) students, and professionals (DQP) ($n = 51$).

	Knowledge	Misconceptions	Critical thinking ability
PUB	7.35 (1.95)	3.63 (1.62)	1.30 (1.14)**
FYS	7.27 (1.73)	4.43 (1.71)*	0.72 (0.927)
TYS	8.56 (1.34)*	3.31 (1.74)	0.89 (0.994)
DQP	9.37 (0.82)*	2.32 (1.57)*	0.92 (0.997)

* significantly different to all other groups ($p < .05$). ** significantly different to first year students ($p < .05$).

Correlations between Misconceptions, Knowledge, critical thinking ability, highest educational level, the number of sources used, and trust of categories of sources in all participants are shown in Table 4.6. Misconception scores showed small negative associations with critical thinking ability and Knowledge. Trust in reliable sources was negatively associated with Misconceptions, while trust in sources of mixed or unknown reliability was positively associated.

Table 4.6. Correlation between study variables ($N = 321$)

	CTA	KNOW	MISC	Sources				
				No.	DQP	OTH	REL	MIX
CTA	-	.02	-.19*	.03	.02	-.01	.10	.02
KNOW		-	-.19*	.25*	-.23*	-.15	.17	-.18*
MISC			-	-.16	.25*	.18	-.13	.24*
No.				-	-.12	-.02	.08	-.02
DQP					-	.36*	.28*	.27*
OTH						-	.24*	.44*
REL							-	.18*
MIX								-

Note: AQF level (AQF), critical thinking ability (CTA), Knowledge (KNOW), Misconceptions (MISC), number of sources used (No.), and trust in categories of sources (degree qualified professionals [DQP], other professionals [OTH], reliable [REL], mixed/unknown reliability [MIX])
 * $p < .001$ (Bonferroni adjusted)

Knowledge showed a similar pattern, with higher scores associated with higher trust in reliable sources, and lower trust in sources of mixed or unknown reliability. Knowledge was negatively associated with Misconceptions, but not associated with critical thinking ability.

A hierarchical multiple regression was conducted to predict Misconceptions scores based on participants' group, AQF level, critical thinking ability, Knowledge, and trust in categories of sources of information (see Table 4.7). Before interpreting the results, a number of assumptions were tested. Stem-and-leaf plots indicated that educational achievement and critical thinking ability were positively skewed, though all other variables were normal. An inspection of the normal probability plot of standardised residuals and scatterplot of standardised residuals against standardised predicted values indicated that assumptions of normality, linearity, and homoscedasticity of residuals were met. Box plots identified univariate outliers in Knowledge, trust in degree qualified professionals, and trust in sources of mixed and unknown reliability. When these outliers were adjusted there was no difference in the regression analysis, so they were not changed. Mahalanobis distance exceeded the critical χ^2 for $df = 8$ (at $\alpha = .001$) of 26.13, indicating multivariate outliers. Two outliers were identified, but Cook's Distance indicated a low influence of each, so these were kept in the analysis.

Table 4.7. Unstandardised (B) and standardised (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor variable on each step of a hierarchical multiple linear regression predicting Misconceptions ($N = 321$)

Predictor	B [95% CI]	β	sr^2
Block 1			
Public	0.31 [-.313, 0.94]	.06	.00
Degree	-1.00 [-1.64, -0.37]*	-.20	.02
First year	1.11 [.60, 1.62]**	.30	.05
Block 2			
Public	0.92 [0.16, 1.69]*	.19	.01
Degree	-0.18 [-1.08, 0.71]	-.04	.00
First	1.12 [0.61, 1.62]**	.30	.05
AQF level 9	-0.45 [-1.74, 0.82]	-.06	.00
AQF level 8	-0.35 [-1.62, 0.92]	-.05	.00
AQF level 7	0.15 [-0.99, 1.29]	.03	.00
AQF level 6	0.44 [-2.13, 3.01]	.02	.00
AQF level 5	-0.16 [-1.49, 1.18]	-.02	.00
AQF level 4	0.44 [-0.83, 1.7]	.06	.00
AQF level 3	0.8 [-0.22, 1.82]	.22	.01
AQF level 2	1.24 [-2.51, 1.79]	.05	.00
AQF level 1	-0.36 [-2.5, 1.79]	-.02	.00
Block 3			
Public	1.08 [0.32, 1.84]*	.22	.02
Degree	-0.16 [-1.04, 0.72]	-.03	.00
First	1.06 [0.56, 1.57]**	.29	.04
AQF level 9	-0.49 [-1.76, 0.78]	-.07	.00
AQF level 8	-0.22 [-1.47, 1.03]	-.03	.00
AQF level 7	0.17 [-0.95, 1.29]	.03	.00
AQF level 6	0.36 [-2.17, 2.89]	.02	.00
AQF level 5	-0.28 [-1.6, 1.04]	-.03	.00
AQF level 4	0.55 [-0.69, 1.79]	.07	.00
AQF level 3	0.84 [-0.17, 1.85]	.24	.01
AQF level 2	1.22 [-1.29, 3.72]	.05	.00
AQF level 1	-0.51 [-2.62, 1.61]	-.03	.00
Critical thinking ability	-0.31 [-0.5, -0.12]**	-0.17	.03
Block 4			
Public	1.08 [0.30, 1.86]*	.22	.02
Degree	-0.16 [-1.04, 0.73]	-.03	.00
First	1.07 [0.54, 1.59]**	.29	.04
AQF level 9	-0.49 [-1.76, 0.79]	-.07	.00
AQF level 8	-0.22 [-1.48, 1.04]	-.03	.00
AQF level 7	0.17 [-0.95, 1.3]	.04	.00
AQF level 6	0.36 [-2.2, 2.93]	.02	.00
AQF level 5	-0.28 [-1.6, 1.04]	-.03	.00
AQF level 4	0.55 [-0.69, 1.79]	.07	.00
AQF level 3	0.84 [-0.17, 1.85]	.24	.01
AQF level 2	1.22 [-1.30, 3.73]	.05	.00

* $p < 0.05$. ** $p < 0.001$

Table 4.7. (cont.) Unstandardised (B) and standardised (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor variable on each step of a hierarchical multiple linear regression predicting Misconceptions ($N = 321$)

Predictor	B [95% CI]	β	sr^2
AQF level 1	-0.51 [-2.63, 1.61]	-.03	.00
Critical thinking ability	-0.31 [-0.5, -0.12]**	-.17	.03
Knowledge	0.002 [-0.12, 0.12]	.00	.00
Block 5			
Public	0.95 [0.09, 1.82]	.19*	.01
Degree	-0.11 [-1.08, 0.86]	-.02	.00
First	-0.88 [0.16, 1.6]*	.24	.01
AQF level 9	-0.55 [-1.82, 0.72]	-.08	.00
AQF level 8	-0.17 [-1.42, 1.08]	-.02	.00
AQF level 7	0.06 [-1.06, 1.19]	.01	.00
AQF level 6	0.26 [-2.30, 2.81]	.01	.00
AQF level 5	-0.32 [-1.63, 1.00]	-.04	.00
AQF level 4	0.46 [-0.78, 1.70]	.06	.00
AQF level 3	0.73 [-0.28, 1.74]	.20	.01
AQF level 2	1.06 [-1.46, 3.57]	.04	.00
AQF level 1	0.49 [-2.61, 1.62]	-.03	.00
Critical thinking ability	-0.33 [-0.51, -0.14]**	-.18	.00
Knowledge	0.01 [-0.12, 0.13]	.01	.00
Trust in degree qualified professionals	0.17 [-0.27, 0.61]	.06	.00
Trust in sources of mixed/unknown reliability	0.43 [-0.05, 0.91]	.10	.01

* $p < .05$. ** $p < .001$. Note: AQF levels 1-4 = certificates 1-4, level 5 = diploma, level 6 = advanced diploma, level 7 = bachelor degree, level 8 = honours degree or graduate certificate, level 9 = masters, level 10 = doctorate. High school graduation was considered equivalent to AQF level 3.

Variables were entered into the hierarchical multiple linear regression in order of their causal priority (Petrocelli, 2003) beginning with the most general and unchanging variables (group, then AQF level, then critical thinking ability), and finishing with the most specific and changeable (exercise and nutrition Knowledge, and trust in sources). The trust scores were entered in the final block together as it was anticipated that they would be closely related, as shown by the correlation matrix in Table 4.6. Participant group was dummy coded (into public, degree, and first year variables), and all three dummy variables were included in step one. Step one was group, which accounted for 17.5% of the variance in misconceptions ($R^2 = .175$, $F(3, 317) = 22.45$, $p < .001$). In step two highest educational achievement was dummy coded (into variables for each AQF level). This accounted for a non-significant 3.2% of the variance in misconceptions ($\Delta R^2 = .032$, $\Delta F(10, 308) = 1.39$, $p = .19$). In step three critical thinking ability accounted for an additional 2.7% of the variance in misconceptions ($\Delta R^2 = .027$, $\Delta F(1, 307) = 10.73$, $p = .001$). In step four

Knowledge did not account for any additional variance in misconceptions ($\Delta R^2 = .00$, $\Delta F(1, 306) = 0.001$, $p = .97$). In the final step trust in degree qualified professionals, and trust in sources of mixed and unknown reliability were added. These accounted for a non-significant 1.2% of the variance in misconceptions ($\Delta R^2 = .012$, $\Delta F(1, 304) = 2.48$, $p < .085$).

Together the set of variables accounted for approximately 25% of the total variance in Misconceptions scores ($R^2 = .246$, $F(16, 304) = 6.22$, $p < .001$). By Cohen's (1988) conventions, a combined effect of this magnitude is considered moderate ($f^2 = .32$).

4.3.2 Confidence in Knowledge and Misconceptions

Confidence in Exercise Science Knowledge Survey responses are reported in Table 4.8. Significant differences were observed between groups for both Knowledge Confidence ($F(3, 303) = 37.38$, $p < .001$), and Misconceptions Confidence ($F(3, 303) = 29.79$, $p < .001$). Post-hoc comparisons using the Tukey HSD test indicated that degree qualified professionals had significantly higher Confidence in both Knowledge and Misconception responses than other groups. Effect sizes showed that the difference in Confidence between degree qualified professionals and third year students was moderate for Knowledge Confidence ($d = 0.72$), and large for Misconceptions Confidence ($d = 1.08$). All other difference were very large for both Knowledge Confidence (PUB: $d = 1.57$; FYS: $d = 1.81$), and Misconceptions Confidence (PUB: $d = 1.58$; FYS: $d = 1.62$). Third year students' Confidence scores were significantly higher than the public and first year students, with large effect sizes for Knowledge Confidence (PUB: $d = 0.80$; FYS: $d = 0.92$) and moderate effect sizes for Misconceptions Confidence (PUB: $d = 0.67$; FYS: $d = 0.67$).

Both Confidence scores were positively associated with highest educational achievement (AQF level) and Knowledge, and negatively associated with Misconceptions across the entire sample, as displayed in Table 4.9.

Table 4.8. Mean (*SD*) Confidence in Knowledge and Misconception responses for the public (*n* = 54), first (*n* = 159) and third year (*n* = 57) students, and degree qualified professionals (*n* = 51).

	Mean Knowledge Confidence	Mean Misconceptions Confidence
Public	18.98 (6.11)	18.10 (5.62)
First year students	18.61 (5.39)	18.22 (5.33)
Third year students	23.52 (5.24)**	21.79 (5.33)**
Degree qualified professionals	26.67 (3.29)*	25.41 (3.33)*

* significantly different to all other groups ($p < .05$). ** significantly different to first year students and public ($p < .05$).

Table 4.9. Correlation between Confidence scores, highest educational achievement (AQF level), and Exercise Science Knowledge Survey scores (*N* = 321)

	AQF level	Knowledge	Misconceptions
Knowledge Confidence	.30*	.74*	-.23*
Misconceptions Confidence	.27*	.53*	-.20*

* significant correlation ($p < .01$)

4.3.3 Sources of Information

Almost all participants reported having searched for exercise or nutrition information in the last 12 months (PUB 85%, FYS 84%, TYS 96%, DQP 98%). A chi square analysis revealed a small, but significant overall effect ($\chi^2 (3) = 12.37, p = .006, V = 0.20$), though post-hoc analysis showed no significant effects for individual groups.

The use of categories of sources by each group is shown in Table 4.10. Due to the use of each category being based on the mode of participants' responses to sources in that category, some participants who acknowledged searching for exercise and nutrition information may not have been recorded as a user of a category, if they only used an isolated source within that category. For example, 85% of the general public group identified searching for exercise or nutrition information in the last year, but only 38% recorded a mode of one (instead of zero) for any individual category. This disparity was only notable for the public and first year student groups.

Table 4.10. Participants from public (PUB) ($n = 54$), first (FYS) ($n = 159$) and third year (TYS) ($n = 57$) student, and degree qualified professional (DQP) ($n = 51$) groups who reported accessing each category of sources.

	Exercise & Nutrition Professionals	Other Professionals	Reliable Sources	Mixed or Unknown Reliability
PUB	24.1%	4.7%	7.4%*	1.9%
FYS	28.9%*	0.7%	5.7%*	5%
TYS	38.6%	0%	59.6%*	10.5%
DQP	70.6%*	0%	70.6%*	7.8%

* significantly different to expected values ($p < .006$).

There were significant differences to expected values in the use of exercise and nutrition professionals ($\chi^2(3) = 33.22, p < .001, V = 0.32$), with degree qualified professionals more likely to have accessed this source ($p < .001$), and first year students less likely ($p = .006$). All groups differed significantly from the expected use of reliable sources ($\chi^2(3) = 130.60, p < .001, V = 0.64$), with degree qualified professionals ($p < .001$) and third year students ($p < .001$) more likely to have used these sources, and first year students ($p < .001$) and the public less likely ($p < .001$). There were no differences between groups in the use of other professionals ($\chi^2(3) = 6.01, p = .11, V = 0.15$), or sources of mixed or unknown reliability ($\chi^2(3) = 4.34, p = .23, V = 0.12$).

There were significance differences in the trust that groups placed in different sources of information, as reported in Table 4.11. The student groups were significantly different to all other groups in their trust of exercise and nutrition professionals ($F(3, 317) = 93.17, p < .001$), with first year students expressing more trust than any other group (PUB: $d = 0.71$; TYS: $d = 2.56$; DQP: $d = 1.12$), and third year students expressing less trust (PUB: $d = 1.84$; DQP: $d = 1.35$). Degree qualified professionals had significantly less trust in other professionals ($F(3, 317) = 9.98, p < .001$; PUB: $d = 0.54$; FYS: $d = 0.85$; TYS: $d = 0.62$) and sources of mixed or unknown reliability ($F(3, 317) = 17.659, p = .001$; PUB: $d = 0.81$; FYS: $d = 1.18$; TYS: $d = 1.20$) than other groups. For reliable sources, the only difference was between third year students and degree qualified professionals ($F(3, 317) = 3.70, p = .012; d = 0.61$).

Table 4.11. Mean (*SD*) trust of the public (PUB) (*n* = 54), first (FYS) (*n* = 159) and third year (TYS) (*n* = 54) students, and degree qualified professional (DQP) (*n* = 51) groups in each category of sources.

	Exercise & Nutrition Professionals	Other Professionals	Reliable Sources	Mixed or Unknown Reliability
PUB	3.96 (0.45)**	3.82 (0.92)	3.77 (0.54)	2.64 (0.51)
FYS	4.28 (0.45)*	4.02 (0.71)	3.84 (0.53)	2.73 (0.38)
TYS	3.14 (0.44)*	3.84 (0.74)	3.70 (0.45)***	2.74 (0.38)
DQP	3.76 (0.48)**	3.32 (0.93)*	4.02 (0.59)	2.27 (0.40)*

* significantly different to other groups ($p < .05$). ** significantly different to FYS and TYS ($p < .05$). *** significantly different to DQP ($p < .05$).

4.4 Discussion

The aims of this study were to assess the presence of misconceptions in, and knowledge and critical thinking ability of, exercise science students, professionals, and the public; and to determine whether the presence of misconceptions was related to lower critical thinking ability, knowledge, level of education, or exercise history. Additional aims were to explore the relationship between participants' confidence, knowledge and misconceptions; and finally, to identify the sources of information used by participants, and whether the use, or trust of categories of sources of exercise and nutrition information were associated with knowledge, critical thinking ability, or the presence of misconceptions.

The misconceptions 'a vitamin supplement can improve your well-being, energy levels, and performance', and 'lactic acid causes fatigue', were common across all groups, which is consistent with previous research. The presence of misconceptions around vitamin supplementation has been well documented in adolescents (Herbold et al., 2004), student athletes (Rosenbloom et al., 2002), and older adults (Goston & Correia, 2010), and the use of vitamin supplements is extremely popular, despite a lack of clear benefit, as discussed in the previous chapter. The misconception about lactic acid has been demonstrated in first and second year exercise science students (Morton, et al., 2008), but the present findings are the first time these misconceptions has also been demonstrated in degree qualified professionals.

The misconceptions ‘the more protein, the better’, ‘if a part of your body is exercised hard, you will lose body fat from that area’, ‘lactic acid causes fatigue’, and ‘no pain, no gain’ were more prevalent than expected in first year students, but not the general public. There were only minor differences in the use, and trust, of sources between these groups, but it must be noted that both the mean educational level, and mean age of these groups were significantly different. It is possible that higher educational achievement and greater maturity allows someone to more easily identify the flawed logic in misconception statements, even without large amounts of content knowledge.

Unexpectedly, the misconception ‘the more protein, the better’ was more popular among degree qualified professionals than third year students. While this could be that professionals were more detailed in their examination of the statement, and were more aware of the importance of the timing and quantities of dietary protein for athletic populations (Kreider et al., 2010), it is also possible that their understanding of the processes of protein metabolism has deteriorated over time. Doran et al. (2008), while assessing the knowledge in students exclusively, also found that a misconception regarding fat oxidation became more popular in later years of study, though in that example it was clearly not due to a lack of exposure to course content.

No misconception in the present study was significantly more common in third year students than first year students, though some (‘a vitamin supplement can improve your well-being, energy levels, and performance,’ and ‘lactic acid causes fatigue’) appeared to resist correction. It is possible that when communicating with those less qualified, degree qualified professionals rely on simple explanations and lose some of the understanding of the complexity of topics, as discussed in Chapter 3.

Total Misconception scores were significantly lower for degree qualified professionals than other groups. First year students scored higher than any other group, including the general public, despite both groups not possessing any specialist education. Critical thinking ability was negatively associated with Misconceptions, and was a significant predictor of Misconceptions, while Knowledge was not. Although Knowledge was negatively associated with Misconceptions, it appears that critical thinking ability is more important, consistent with previous findings (Hughes et al., 2015).

Degree qualified professionals and third year students scored higher in Knowledge than other groups, and degree qualified professionals scored lower in Misconceptions, however the relationship between exercise science and knowledge is not a simple one. It is likely that those with exercise qualifications would score higher in Knowledge, and score lower in Misconceptions, and the regression analysis showed that group membership was the major predictor of misconceptions. After group had been taken into account though, Knowledge was not a significant predictor of Misconceptions, though the more generic critical thinking ability was. Previous research into correcting misconceptions has focussed on improving the depth of knowledge (Badenhorst et al., 2015), or sought to foster critical thinking skills through active learning tasks (Ahopelto et al., 2011). These findings suggest that approaches that improve both domain specific knowledge, and critical thinking ability, have a role in reducing misconceptions.

Students and professionals scored more highly in the present study than previous research examining the professional knowledge of these groups (Malek et al., 2002; Zenko & Ekkekakis, 2015), though the items making up the Exercise Science Knowledge Survey are more fundamental, and those with lower level (i.e. VET) qualifications were excluded, meaning high scores were expected. Appropriately for those with (or close to completing) tertiary qualifications, confidence in answers among degree qualified professionals and third year students was higher than other groups. While both Confidence measures were strongly, positively associated with Knowledge, the negative associations with Misconceptions, while still significant, were small. Previous research has assessed either the confidence (Barnes, Desbrow & Ball, 2016) or knowledge (Malek et al. 2002) of personal trainers. Only one prior study has examined both knowledge and confidence in exercise professionals (Zenko & Ekkekakis, 2015), finding that personal trainers overestimated their knowledge, though this confidence, like in the present study, was closely associated with actual knowledge.

The majority of participants in each group reported that they had searched for information related to exercise or nutrition information within the previous 12 months. Differences in the types of sources used were stark, with degree qualified professionals more likely to have used other professionals as a source, and reliable sources (textbooks, academic articles, and public health promotion campaigns). And while first year students and the public having higher trust in sources of mixed and

unknown reliability is predictable, it also appears that these groups favour professionals over reliable sources. In fact, first year students trusted professionals more than any other participant group and used them as their major source of information. Most likely these professionals are the students' lecturers, and this trust and use is despite the increased access to sources of information the public now enjoys. The higher levels of trust enjoyed by degree qualified professionals than reliable sources is despite the fact that these professionals presumably get information from these same reliable sources, and could misinterpret them, or have an incomplete understanding of a topic. It is possible that first year students have not yet developed an appreciation of the quality of this category of evidence.

Although the exercise and nutrition knowledge participants possessed was a factor in the presence of misconceptions, critical thinking ability and trust in appropriate sources of information were also shown to be important factors. This investigation is the first to examine the critical thinking ability of exercise science students, and professionals, and found that critical thinking ability was associated with lower Misconception scores. It is possible that enhancing the critical thinking ability of both exercise professionals, and the public, will improve the communication of, and public understanding of, exercise and nutrition topics, leading to improved health outcomes for the public.

These findings need to be interpreted with some limitations in mind. As the present study was cross-sectional, and not longitudinal, it is not possible to comment on how Misconceptions, or critical thinking ability, would change over the course of a degree, or professional practice.

The findings in the general public group should also be applied with caution. Participants in this group were a sample of convenience, and due to the snowball recruitment method used, this group was in fact highly educated, and are therefore not likely to be representative of the general public. This may have resulted in higher Cognitive Reflection Test scores, and lower Misconception scores for this group.

There are also difficulties in creating a knowledge and misconceptions survey such as the Exercise Science Knowledge Survey that will be appropriate for both professional and public populations. The large differences in exercise literacy of participants mean that concepts are difficult to express clearly for all groups. Degree qualified professionals may find oversimplified statements to be inaccurate, while those with less relevant education may find complex statements difficult to interpret.

4.4.1 Conclusions

The results of this study showed that basic exercise and nutrition misconceptions were less common in third year exercise science students than in first year students, and less common again in degree qualified exercise professionals. Confidence increased closely with knowledge, but the association between misconceptions and confidence was less clear and warrants further investigation.

Better knowledge was associated with fewer misconceptions, so improving student and public understanding of these topics through education is an appropriate strategy. However critical thinking ability, and generic skills attained through higher education, may also serve to protect against misconceptions. The role of explicit instruction of critical thinking in correcting exercise and nutrition misconceptions should be explored further.

The number of sources a person accesses was not related to better knowledge, or fewer misconceptions, but their trust of high quality sources was. The public, and first year students, placed high levels of trust in professionals to provide exercise and nutrition advice, rather than academic sources, or public health promotion campaigns. Improving the appreciation of these sources (possibly as part of broader instruction in critical thinking), could assist the public in making better choices when searching for information, better identify what they can interpret for themselves, and what information they need a professionals to help interpret for them.

Chapter 5: The Presence of Misconceptions Before and After a Vocational Fitness Course

5.1 Introduction

In Australia there are over 27 000 people working as fitness instructors, who provide advice and guidance on exercise. The majority of these professionals are vocationally qualified personal trainers (Fitness Australia, 2016), possessing the Certificate IV in Fitness qualification (SIS40215). Being highly accessible, people may turn to personal trainers to help make appropriate decisions in the face of complex and confusing exercise, nutrition, and health information. Yet the sources of information personal trainers themselves use to inform their practice are variable and have been found to be unrelated to their experience, or level of qualifications (Bennie et al., 2017). This is potentially due to personal trainers having difficulty assessing the quality of information they are presented with (Stacey et al., 2010).

Barnes, Desbrow, and Ball (2016) identified that personal trainers in Australia report high levels of confidence in their knowledge (in this instance regarding their ability to provide nutritional advice). But given that personal trainers place importance on experience, and on-the-job training, over formal qualifications (De Lyon & Cushion, 2013), and many operate outside their scope of practice (McKean et al., 2015), this confidence may be misplaced. While Barnes, Desbrow and Ball (2016) did not assess the actual knowledge of personal trainers, other research has identified significant errors in knowledge (Kruseman et al., 2008; Malek et al., 2002; Zenko & Ekkekakis, 2015).

It is possible that these errors in knowledge persist to become misconceptions, though it is unclear to what extent this occurs. It is also not known whether misconceptions develop during personal trainers' education, or through their professional practice. While personal trainers in Australia are required to undertake professional development to maintain registration with the peak body, this registration is voluntary, and personal trainers have a broad scope to select the professional development they participate in. Therefore, it is possible that trainers could be exposed to very little evidence-based information.

Personal trainers may lack the depth of knowledge to adequately correct potential misconceptions. The Certificate IV qualification is often completed within six months (possibly up to a year, if students also complete the lower level

Certificate III in Fitness), and VET focuses largely on competent task performance rather than developing a deep understanding of knowledge (Gonczi & Hager, 2010). As a result misconceptions can be retained, and potentially interfere with clients' exercise outcomes. For this reason it is important to understand more about personal trainers' knowledge of fundamental exercise and nutrition information, what misconceptions are prevalent, and the potential origins of these misconceptions. It is unknown whether misconceptions exist prior to entering a vocational fitness course, are developed during the course, or emerge during professional practice due to the sources of information personal trainers rely on.

5.1.1 Misconceptions in Students

Misconceptions related to exercise and nutrition topics can arise, not only from the misinterpretation of information in instructional contexts (Morton et al., 2008), but also due to personal experience. Those without relevant expertise may arrive at a fast, intuitive explanation for a phenomenon (Baylor, 2001), but this may be incomplete, or incorrect, and interfere with further learning. University students have demonstrated misconceptions in cardiac (Ahopelto et al., 2011), exercise (Morton et al., 2008), and respiratory (Michael et al., 1999) physiology, and results in Chapter 4 indicate that first year exercise science students bring fundamental misconceptions of exercise and nutrition into their course, which are only partially corrected. However, the presence of similar misconceptions has not been assessed in VET fitness students.

It has been proposed that an appreciation of the level of complexity of physiological systems, and the interaction between these systems, will reduce the presence of these misconceptions (Badenhorst et al., 2015; Michael, 2007). However, this depth of knowledge is not typically a feature of VET, as discussed above (Gonczi & Hager, 2010). Although it is a requirement of VET to prepare students for higher levels of study (Australian Qualifications Framework Council, 2013), students transitioning to university have been found to struggle with the more independent, less scaffolded learning, and higher stakes knowledge assessments (Ambrose, Bonne, Chanock, Cunnington, Jardine & Muller, 2013). These students also reported challenges understanding complex theoretical concepts, and academic literacy (Ambrose et al., 2013).

A key component of academic skills is critical thinking ability. And while a recent meta-analysis identified that research in the US community college system confirmed the importance of critical thinking skills for academic achievement (particularly long term outcomes), this has not been assessed in VET in Australia. Additionally critical thinking ability was associated with fewer misconception in exercise science students and professionals in Chapter 4, though critical thinking ability was not significantly better in professionals than in students. It is possible that critical thinking ability will play a similar role in the misconceptions of VET students.

While critical thinking skills have been repeatedly identified as highly desirable by employers (Jackson & Chapman, 2012; Sheldon & Thornthwaite, 2005), they are not a major component of competency-based training. It is not clear to what extent VET fitness students possess critical thinking ability prior to commencing their course, or develop it during their course. It is also not clear how the critical thinking ability, or misconceptions in the knowledge of VET fitness students, or VET qualified personal trainers, compares to their higher education counterparts.

Additionally, it is possible that critical thinking ability may influence the sources of information chosen by students and personal trainers. The aims of this study were therefore to:

1. Assess the change in knowledge, misconceptions, and critical thinking ability in students during a VET fitness course, and compare these findings with VET qualified personal trainers.
2. Determine whether the presence of misconceptions was related to lower critical thinking ability, knowledge, or level of education.
3. Explore the relationship between participants' confidence in their answers, their knowledge, and the presence of misconceptions.
4. Identify the sources of information used by VET students and personal trainers, the amount of trust placed in these sources, and whether the use or trust of particular sources was associated with knowledge, critical thinking ability, or the presence of misconceptions.

- Compare the critical thinking ability, knowledge, misconceptions, and sources of information of VET fitness students and graduates with higher education exercise science students and graduates.

5.2 Method

5.2.1 Design

This was a prospective cohort study of students undertaking a vocational fitness course. Students were surveyed in the first week of their course, then again in the final week, within an academic year (February to December). Practicing personal trainers were also surveyed once within the same period.

5.2.2 Participants

Students completing the vocational qualification Certificate IV in Fitness (SIS40215), and either the Certificate III in Fitness (SIS30315) or prerequisite units for the Certificate IV, were recruited from three Registered Training Organisations in Perth, Western Australia. These certificates are completed back-to-back in order to qualify as a personal trainer. One hundred and eleven students enrolled full-time, and completing face-to-face (rather than online) courses, consented to participate in the study. Sixty-six complete sets of pre- and post-course responses were obtained.

The personal trainer group (PT) consisted of 70 Certificate III and IV qualified personal trainers, currently working in the delivery of exercise to adults, and registered with Fitness Australia. The demographic characteristics of each group are shown in Table 5.1.

Table 5.1. Mean (*SD*) group demographic characteristics, for VET fitness students ($n = 66$) and personal trainers ($n = 70$)

	VET fitness students	Personal trainers
Gender	Male	38 (58%)
	Female	28 (42%)
Age in years (<i>SD</i>)	24.15 (8.59)	33.17 (9.81)*
Median highest education achieved (AQF level)	3	4.5
Industry experience (years)		6.10 (5.94)
Exercise AQF level		4.10 (0.30)

* significantly different to VET fitness students ($p < .05$)

A power analysis using G*Power 3.1 (Faul et al., 2007) determined that a total sample size of 40 was required to yield an actual power of .8 for a paired samples t-test to assess differences in the student group before and after course completion. This was based on an estimated effect size of 0.46, calculated from results reported by Ahopelto et al. (2011). One hundred and twenty-eight participants were required to yield an actual power of .8 for an independent samples t-test to assess differences between the student group and personal trainers. This was based on an estimated effect size of 1.55, based on the magnitude of the difference in Misconceptions between first year students and degree qualified professional reported in Chapter 4. Eighty-one participants were required for a multiple linear regression yielding a power of .8, based on six predictors of misconceptions (group, critical thinking ability, highest education, and trust ratings for three categories of sources of information). This was based on a Cohen's f^2 effect size of .10, reported by Gardner and Brown (2013).

5.2.3 Procedure

Ethics approval was granted by the Curtin University Human Research Ethics Committee (HRE2016-0292). All participants were volunteers, and informed consent was gained prior to completing the survey. All responses were anonymous, with each participant generating a unique code that allowed matching of pre- and post-course survey data. The pre-course survey (pre-VET) was completed in the first week of study, and the post-course survey (post-VET) was completed in the final week of the Certificate IV course. Students were recruited via the RTO delivering their course and surveyed during class time. The mean response rate was 85%.

Personal trainers were recruited via convenience snowball sampling using the author's fitness industry contacts, emails to Australian gyms, and postings on relevant private social media groups.

The survey was completed in person on a provided tablet device, without using reference material, and took approximately 15 minutes.

5.2.4 Measures

The Exercise Science Knowledge Survey (described in Chapter 4), was used to assess participants' knowledge of basic exercise and nutrition concepts, and their endorsement of common misconceptions. Cronbach's alpha for the Knowledge and Misconception scores with this group of participants were .64 and .77. The reliability

of the Knowledge subscale, while slightly below commonly accepted standards, (Ponterotto & Ruckdeschel, 2007), was considered adequate as discussed in Chapter 4.

Critical thinking ability was assessed using Frederick's (2005) three-item Cognitive Reflection Test. Cronbach's alpha for the internal consistency of the Cognitive Reflection Test in the present sample was $\alpha = .59$. This was comparable to the internal consistency of the scale observed in the sample reported in Chapter 4. Whilst it is lower than the generally accepted value of .70 (Ponterotto & Ruckdeschel, 2007), this was considered acceptable given the size of the sample in this study, the fact that the test only has three items, and its previously demonstrated ability to predict performance in cognitive skills related to critical thinking (Toplak et al., 2011; Oechssler et al., 2009; Pennycook et al., 2012).

Demographic information and highest prior educational achievement (AQF level) were collected, as well as the length of time personal trainers had worked in the fitness industry, and their highest exercise qualification (exercise AQF level).

Participants also identified what sources of exercise or nutrition information they had accessed in the previous 12 months, and rated the trustworthiness of each source (regardless of whether or not they accessed this source) on a five-point Likert-type scale (1 = not at all trustworthy, 5 = very trustworthy).

5.2.5 Data Analysis

Chi-square tests for independence were used to examine differences between the PT and VET groups in individual Exercise Science Knowledge Survey responses. Cramér's V was used to measure the strength of the association between participants' group, and the use of sources. McNemar's test was used to assess changes in individual Exercise Science Knowledge Survey item responses within the VET group. Differences between pre-VET and PT, and post-VET and PT groups in Knowledge, Misconceptions, critical thinking ability and Confidence (in both KNOW and MISC responses) were examined using independent samples t -tests. Differences between pre-VET and post-VET were assessed using paired samples t -tests. Cohen's d effect sizes were calculated to assess the practical significance of differences between groups.

Pearson's bivariate correlations were used to examine the association between trust scores and Knowledge, Misconceptions, critical thinking ability, age, and highest educational achievement.

A hierarchical multiple linear regression analysis was used to examine the relationship between prior education, critical thinking ability, knowledge, and sources, and the presence of misconceptions.

Sources of information were combined into broad categories for analysis, as described in Chapter 4. The trust score for each category was the mean for items in the category. Use of the sources in each category was coded as either zero (did not access this source in the previous 12 months) or one (did access this source). The modal response in each category was used to classify whether a participant was a user of these sources.

Chi-square tests for independence were used to examine differences between PT, and the VET groups in the sources of information used. Cramér's V was used to measure the strength of the association between participants' group, and the use of sources. McNemar's test was used to assess changes in the use of sources within the VET group. Differences between those using and not using sources were examined using an independent samples t -test. Differences between groups in trust measurements were examined using paired samples t -test (pre-VET & post-VET), and independent samples t -test (PT and both VET groups).

Significance for all tests was accepted at $p < .05$, except where stated.

5.3 Results

5.3.1 Dropouts

Forty-five participants surveyed in the pre-VET group did not complete the post-VET survey. This may be because they had withdrawn from the course, did not attend on the day the post-VET responses were collected, or declined to participate in the post-VET survey. Pre-VET results were examined to explore differences between those who completed the study, and those who did not. Dropouts scored higher in Misconceptions (4.96 ± 1.79 compared with 4.08 ± 1.65 , 95% CI [0.23, 1.53]) than those who repeated the survey ($t(110) = -2.69, p = .008$), but there were no significant differences in Knowledge. Dropouts also scored lower in critical thinking ability (0.13 ± 0.40 , compared with 0.38 ± 0.74 , 95% CI [0.01, 0.49]; $t(104.5) = 2.29, p = .02$), had achieved a lower level of education prior to beginning

their course (2.36 ± 1.84 compared with 3.42 ± 1.76 , 95% CI [0.38, 1.76]; $t(109) = 3.06$, $p = .003$), and reported using fewer sources (4.20 ± 3.35 compared with 6.06 ± 4.20 , 95% CI [0.56, 3.17]; $t(110) = 2.84$, $p = .005$), than those who repeated the survey.

5.3.2 Knowledge and Misconceptions

The percentage of participants in each group who possessed individual misconceptions is illustrated in Table 5.2. Only two misconceptions were relatively uncommon in pre-VET students, with less than 20% of participants from this group agreeing that ‘low intensity cardio burns more fat than high intensity’, and ‘a high protein, high fat diet is healthier than recommended healthy eating guidelines’. Three misconceptions were observed at higher counts than expected when compared to personal trainers: ‘static stretching reduces injury risk’, ‘if a part of your body is exercised hard, you will lose body fat from that area’, and ‘women get too muscular if they lift heavy weights’.

Comparing pre-VET and post-VET results using McNemar’s test showed that agreement with four misconception statements was significantly less common in the post-VET survey: ‘static stretching reduces injury risk’ ($p < .001$), ‘a high protein, high fat diet is healthier than recommended healthy eating guidelines’ ($p = .006$), ‘if a part of your body is exercised hard, you will lose body fat from that area’ ($p = .013$), and ‘women get too muscular if they lift heavy weights’ ($p = .008$).

Three misconceptions were relatively uncommon in personal trainers, with 13% of participants agreeing that ‘low intensity cardio burns more fat than high intensity’, 1% that ‘if a part of your body is exercised hard, you will lose body fat from that area’, and 6% that ‘women get too muscular if they lift heavy weights’.

Differences between personal trainers and each of the student groups were examined using chi-square tests for independence. Cramér’s V was used to measure the strength of the association between participants’ group, and possession of each misconception. Significant differences to expected counts were observed in all misconceptions when PTs and pre-VET students were compared, though only in three misconceptions did PTs record significantly less than the expected count in agreement with each misconception: ‘static stretching reduces injury risk’, ‘if a part of your body is exercised hard, you will lose body fat from that area’, and ‘women get too muscular if they lift heavy weights’. In others the observed differences were

due to pre-VET participants recording more ‘don’t know’ responses, or a trend towards more ‘don’t know’ responses and agreement with misconceptions that did not reach statistical significance in individual counts.

Table 5.2. The presence of misconceptions in personal trainers (PT) ($n = 70$) and students ($n = 66$) pre- and post-VET fitness course.

Misconception	PT		Pre-VET		Post-VET	
	Observed	Observed	χ^2	p	V	V
Static stretching reduces injury risk	37.1%**	75.8%*	24.55	<.001	.42	.18
The more protein, the better	40%	51.5%	7.40	.03	.23	.14
Low intensity cardio burns more fat than high intensity	12.9%	7.6%	10.75	.005	.28	.18
A high protein, high fat diet is healthier than recommended healthy eating guidelines	20%**	19.7%	23.18	<.001	.41	.28
If a part of your body is exercised hard, you will lose body fat from that area	1.4%*	25.8%*	24.66	<.001	.43	.22
A short term fast flushes out toxins and helps weight loss	21.4%	25.8%	7.36	.03	.23	.11
Lactic acid causes fatigue	67.1%	62.1%	25.66	<.001	.43	.15
A vitamin supplement can improve your well-being, energy levels, and performance	50%	62.1%	17.44	<.001	.36	.23
No pain, no gain	38.6%	51.5%	11.05	.004	.28	.24
Women get too muscular if they lift heavy weights	5.7%*	25.8%*	17.39	<.001	.36	.09

* significantly different to expected count when PT and pre-VET compared ($p < .008$). ** significantly different to expected count when PT and post-VET compared ($p < .008$).

Agreement with a misconception only differed from expected counts in one instance when personal trainers and post-VET students were compared. The observed agreement with ‘a high protein, high fat diet is healthier than recommended healthy eating guidelines’ was 4% in post-VET students (significantly less than the expected count), and 20% in personal trainers (significantly more than the expected count). In three other instances where significant chi-square test for independence results were observed (‘if a part of your body is exercised hard, you will lose body fat from that area’, a vitamin supplement can improve your well-being, energy levels, and performance,’ and ‘no pain, no gain’) individual results did not reach statistical significance.

The percentage of participants in each group agreeing with knowledge statements is shown in Table 5.3. McNemar’s tests showed there was a significant increase in agreement with three statements from pre-VET to post-VET: ‘a healthy diet should be generally consistent with healthy eating guidelines’ ($p = .007$), ‘fat metabolism is not a local process’ ($p = .001$), and vitamin supplements are unnecessary for most people ($p = .02$). Personal trainers agreed with three knowledge statements more than the expected count when compared to pre-VET students; ‘fat metabolism is not a local process’, ‘the weight loss from a fast will return once the fast finishes’, and ‘fatigue during high intensity exercise occurs for several reasons’.

When post-VET students and personal trainers were compared, significant differences to expected counts were only observed on two items. While 83% of personal trainers agreed that ‘the weight loss from a fast will return once the fast finishes’, only 61% of post-VET students agreed. Conversely agreement with ‘a healthy diet should be generally consistent with healthy eating guidelines’ was significantly higher than expected in post-VET students (94%), and less than expected in personal trainers (76%).

Knowledge, Misconception, and critical thinking ability results for the student group are shown in Table 5.4. Knowledge increased significantly from pre-VET to post-VET, and Misconceptions decreased significantly, with moderate effect sizes observed for both. There was no significant change in critical thinking ability scores.

Table 5.3. Agreement with knowledge statements in personal trainers (PT) ($n = 70$) and students ($n = 66$) pre- and post-VET fitness course.

Knowledge statement	PT		Pre-VET		Post-VET	
	Observed	Expected	Observed	χ^2	V	p
A progressive increase in exercise intensity is a good warm up	100%	92.4%	92.4%	5.50	.06	.06
Very large quantities of protein are not necessary	78.6%	66.7%	66.7%	7.51	.02	.14
Higher intensity exercise uses more energy than lower intensities	84.3%	81.8%	81.8%	10.28	.006	.25
A healthy diet should be generally consistent with healthy eating guidelines	75.7%**	77.3%	77.3%	1.20	.55	.01
Fat metabolism is not a local process	87.1%*	53%*	53%*	19.27	<.001	.46
The weight loss from a fast will return once the fast finishes	82.9%**	50%*	50%*	17.11	<.001	.01
Fatigue during high intensity exercise occurs for several reasons	94.3%*	72.7%*	72.7%*	11.65	.003	.11
Vitamin supplements are unnecessary for most people	84.3%	66.7%	66.7%	12.27	.002	.62
It is possible to get stronger without feeling significant pain	77.1%	62.1%	62.1%	7.81	.02	.16
Women can lift heavy weights for improved strength and health, and not get too muscular	91.4%	81.8%	81.8%	4.40	.11	.74

* significantly different to expected values ($p < .008$). ** significantly different to expected count when PT and post-VET compared ($p < .008$).

Table 5.4. Mean (*SD*) critical thinking ability, Knowledge, and Misconception scores for pre- and post-VET fitness students ($n = 66$).

	Pre-VET	Post-VET	95% CI	<i>t</i>	<i>df</i>	<i>d</i>
Critical thinking ability	0.38 (0.74)	0.42 (0.79)	[-1.46, 0.55]	-0.91	65	0.05
Knowledge	7.05 (2.12)	8.09 (1.50)	[-1.59, -0.50]	-3.86*	65	0.57
Misconceptions	4.08 (1.69)	3.00 (1.57)	[0.68, 1.47]	5.43*	65	0.66

* $p < .05$

Results for the PT group are shown in Table 5.5, and compared to the student group using independent samples *t*-tests. PT differed to pre-VET in all measures, with large effect sizes for Knowledge, moderate effect sizes for Misconceptions, and small effects for critical thinking ability. No significant differences were seen between PT and post-VET in any measure, though small effect sizes were seen in critical thinking ability and Knowledge.

Table 5.5. Mean (*SD*) critical thinking ability (CTA), Knowledge (KNOW), and Misconception (MISC) scores for personal trainers (PT) ($n = 70$), and comparison to pre- and post-VET fitness students ($n = 66$).

	PT	pre-VET			post-VET				
		95% CI	<i>t</i>	<i>df</i>	<i>d</i>	95% CI	<i>t</i>	<i>df</i>	<i>d</i>
CTA	0.69 (0.92)	[-0.59, -0.02]	-2.13*	134	0.37	[-0.55, 0.03]	-1.77	134	0.31
KNOW	8.56 (1.44)	[-2.13, -0.89]	-4.83*	113.56	0.82	[-0.96, 0.03]	-1.85	134	0.32
MISC	2.94 (1.63)	[0.58, 1.69]	4.03*	134	0.69	[-0.49, 0.60]	0.21	134	0.04

* $p < .05$

Correlations between Knowledge, Misconceptions, critical thinking ability, and sources used for pre-VET and PT are shown in Table 5.6. Post-VET responses were excluded, as these are not independent values. There was no association between critical thinking ability and either Knowledge or Misconceptions. In the PT group years of industry experience showed no association with Knowledge ($r = -.10$, $p = .40$), or Misconceptions ($r = -.02$, $p = .90$).

Table 5.6. Correlation between study variables ($N = 136$)

	CTA	KNOW	MISC	Sources				
				No.	DQP	OTH	REL	MIX
CTA	-	.21	-.18	.19	-.20	-.19	.10	-.26
KNOW		-	-.08	.25	.04	.01	.30*	-.23
MISC			-	-.08	.23	.15	-.19	.29*
No.				-	-.08	-.07	.16	-.10
DQP					-	.48*	.30*	.39*
OTH						-	.28*	.43*
REL							-	.13
MIX								-

Note: critical thinking ability (CTA), Knowledge (KNOW), Misconceptions (MISC), number of sources used (No.), and trust in categories of sources (degree qualified professionals [DQP], other professionals [OTH], reliable [REL], mixed/unknown reliability [MIX])

* $p < .001$ (Bonferroni adjusted).

A hierarchical multiple regression was conducted to predict Misconceptions scores based on participants' group, highest educational achievement (AQF level), critical thinking ability, and trust in three of the four categories of sources of information (DQP, REL, and MIX) (see Table 5.7). Post-VET results were excluded from this, as they were repeated measurements. Prior to conducting the analysis, a number of assumptions were tested. Stem-and-leaf plots indicated critical thinking ability was positively skewed, though all other variables were normal. An inspection of the normal probability plot of standardised residuals and scatterplot of standardised residuals against standardised predicted values indicated that assumptions of normality, linearity, and homoscedasticity of residuals were met. Box plots identified univariate outliers in critical thinking ability, trust in reliable sources, and trust in sources of mixed and unknown reliability. These outliers were adjusted so they were consistent with the nearest non-outlier. The maximum Mahalanobis distance did not exceed the critical χ^2 for $df = 6$ (at $\alpha = .001$) of 22.45, indicating no multivariate outliers.

Table 5.7. Unstandardised (B) and standardised (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor variable on each step of a hierarchical multiple linear regression predicting Misconceptions ($N = 136$)

Predictor	B [95% CI]	β	sr^2
Block 1			
Group	-1.13 [-1.69, -0.58]**	-.33	.11
Block 2			
Group	-1.05 [-1.88, -0.23]*	-.04	.04
AQF level 9	0.8 [-1.85, 3.46]	.10	.00
AQF level 8	-0.47 [-3.36, 2.41]	-.05	.00
AQF level 7	0.16 [-2.29, 2.6]	.03	.00
AQF level 6	0.18 [-2.83, 3.18]	.02	.00
AQF level 5	0.43 [-2.09, 2.95]	.07	.00
AQF level 4	0.67 [-1.72, 3.07]	.18	.00
AQF level 3	0.41 [-2.02, 2.85]	.10	.00
AQF level 2	1.14 [-1.89, 4.18]	.10	.00
AQF level 1	1.22 [-1.41, 3.86]	.17	.01
Block 3			
Group	-1.01 [-1.83, -0.18]*	-.29	.04
AQF level 9	0.96 [-1.7, 3.63]	.12	.00
AQF level 8	-0.19 [-3.11, 2.74]	-.02	.00
AQF level 7	0.34 [-2.13, 2.8]	.07	.00
AQF level 6	0.51 [-2.55, 3.58]	.04	.00
AQF level 5	0.43 [-2.09, 2.96]	.07	.00
AQF level 4	0.76 [-1.63, 3.16]	.21	.00
AQF level 3	0.52 [-1.92, 2.96]	.13	.00
AQF level 2	1.16 [-1.87, 4.19]	.10	.00
AQF level 1	1.3 [-1.34, 3.94]	.18	.00
Critical thinking ability	-0.21 [-0.57, 0.16]	-.10	.01
Block 4			
Group	-0.42 [-1.33, 0.49]	1.12	.00
AQF level 9	0.59 [-2.04, 3.21]	.08	.00
AQF level 8	-0.20 [-3.06, 2.66]	-.02	.00
AQF level 7	0.06 [-2.36, 2.48]	.01	.00
AQF level 6	0.06 [-2.95, 3.07]	.00	.00
AQF level 5	-0.01 [-2.51, 2.5]	.00	.00
AQF level 4	0.47 [-1.88, 2.82]	.13	.00
AQF level 3	0.19 [-2.21, 2.60]	.05	.00
AQF level 2	0.79 [-2.18, 3.77]	.07	.00
AQF level 1	0.75 [-1.86, 3.36]	.10	.00
Critical thinking ability	-0.08 [-0.45, 0.29]	-.04	.00
Trust in degree qualified professionals	0.39 [-0.17, 0.95]	.15	.01
Trust in reliable sources	-0.6 [-1.11, -0.08]*	-.22	.03
Trust in sources of mixed/unknown reliability	0.59 [-0.00 - 1.18]	.20	.02

* $p < .05$. ** $p < .001$. Note: AQF levels 1-4 = certificates 1-4, level 5 = diploma, level 6 = advanced diploma, level 7 = bachelor degree, level 8 = honours degree or graduate certificate, level 9 = masters, level 10 = doctorate. High school graduation was considered equivalent to AQF level 3.

Variables were entered into the hierarchical multiple linear regression in order of their causal priority (Petrocellli, 2003), beginning with the most general and unchanging variables (Group, then AQF level, then critical thinking ability), and finishing with the most specific and changeable (trust). The trust scores were entered into the final block together as it was anticipated they would be closely related, as shown by the correlation matrix in Table 5.6.

Group membership was dummy coded (pre-VET students as zero, and PT as one), and when entered in the first step accounted for 10.8% of the variance in misconceptions ($R^2 = .108$, $F(1, 134) = 16.21$, $p < .001$). In step two highest educational achievement was dummy coded (into variables for each AQF level), and accounted for a non-significant additional 3.6% of the variance in misconceptions ($\Delta R^2 = .036$, $\Delta F(9, 125) = 0.58$, $p = .81$). In step three critical thinking ability accounted for a non-significant 0.9% of the variance in misconceptions ($\Delta R^2 = .009$, $\Delta F(1, 124) = 1.25$, $p = .27$). In step four trust in degree qualified professionals, reliable sources, and sources of mixed and unknown reliability were added together. These accounted for 5.8% of the variance in misconceptions ($\Delta R^2 = .058$, $\Delta F(3, 121) = 2.89$, $p = .03$).

Together the set of variables accounted for approximately 21% of variance in Misconceptions scores ($F(14, 121) = 2.31$, $p = .008$). By Cohen's (1988) conventions, a combined effect of this magnitude is considered moderate ($f^2 = .26$).

5.3.3 Confidence in Knowledge and Misconceptions

Changes in Confidence in both Knowledge and Misconceptions in VET students were assessed using a paired samples *t*-test, as reported in Table 5.8. Significant increases were observed from pre-VET to post-VET in both Knowledge Confidence and Misconceptions Confidence, with large effect sizes for both.

Table 5.8. Mean (*SD*) Confidence scores in student group pre- and post-VET fitness course ($n = 66$)

	Pre-VET	Post-VET	95% CI	<i>t</i>	<i>df</i>	<i>d</i>
Knowledge Confidence	18.87 (6.92)	24.56 (4.64)	[-7.61, -4.56]	-7.99*	58	0.97
Misconceptions Confidence	18.53 (6.21)	24.33 (4.15)	[-7.25, -4.68]	-7.25*	58	1.10

* $p < .05$.

Results for the personal trainer group are shown in Table 5.9 and compared to the student groups using independent samples t-tests. Personal trainers differed significantly to students pre-VET, but not post-VET, in both confidence measures. Both Confidence measures were positively associated with age, educational achievement, critical thinking ability and Knowledge, but not Misconceptions. These associations are shown in Table 5.10. In personal trainers, the level of exercise education (KNOW CON: $r = .04, p = .76$; MISC CON: $r = .04, p = .77$) and years of practice (KNOW CON: $r = .14, p = .25$; MISC CON: $r = .12, p = .31$) were not significantly correlated with Confidence measures.

Table 5.9. Mean (*SD*) Knowledge (KNOW CON) and Misconception (MISC CON) Confidence scores for personal trainers (PT) ($n = 70$), and comparison to pre- and post-VET fitness students ($n = 66$)

	PT	pre-VET				post-VET			
		95% CI	<i>t</i>	<i>df</i>	<i>d</i>	95% CI	<i>t</i>	<i>df</i>	<i>d</i>
KNOW CON	25.96 (3.91)	[-9.10, -5.16]	-7.02*	90.21	1.26	[-2.86, 0.74]	-1.88	131	0.40
MISC CON	25.25 (4.01)	[-8.57, -4.86]	-7.17*	98.28	1.29	[-2.32, 0.48]	-1.30	131	0.22

* significantly different to PT group ($p < .05$).

Table 5.10. Correlation between Confidence measures and demographic variables, critical thinking ability (CTA), Knowledge (KNOW) and Misconceptions (MISC) in all participants ($N = 136$)

	Age	AQF level	CTA	KNOW	MISC
Knowledge Confidence	.38**	.24**	.24**	.70**	-.17
Misconceptions Confidence	.38**	.26**	.20*	.55*	-.13

* $p < .05$. ** $p < .01$.

5.3.4 Sources of Information

Almost all participants reported having searched for exercise or nutrition information in the last 12 months (pre-VET 95%, post-VET, 97%, PT 96%).

Personal trainers were found to use significantly more types of resources (8.69 ± 3.98) than pre-VET (6.06 ± 3.35 , 95% CI [1.37, 3.88]; $t(134) = 4.15, p < .001, d =$

0.71) and post-VET (6.32 ± 3.54 , 95% CI [1.09, 3.65]; $t(134) = 3.66$, $p < .001$, $d = 0.63$) students, with moderate effect sizes for both. There was no difference between pre-VET and post-VET in the number of sources used (95% CI [-1.03, 0.52], $t(65) = -0.66$, $p = .51$, $d = 0.08$).

The use, and trust, of sources in each group is described in Table 5.11. McNemar’s test revealed no differences in the use of any source from pre-VET to post-VET. However, trust in other health professionals increased from pre-VET to post-VET (95% CI [0.51, 0.52], $t(65) = 2.45$, $p = .02$, $d = 0.32$), and trust in sources of mixed and unknown reliability decreased (95% CI [0.08, 0.31], $t(65) = 3.37$, $p = .001$, $d = 0.44$).

Table 5.11. Percentage of pre- and post-VET fitness students ($n = 66$), and personal trainers (PT) ($n = 70$) accessing each source and mean (SD) trust in each source.

	pre-VET		post-VET		PT	
	Use (%)	Trust	Use (%)	Trust	Use (%)	Trust
Exercise & nutrition professionals	37.87	4.18 (0.56)	37.87	4.11 (0.53)	65.71***	3.59* (0.62)
Other health professionals	0	3.78* (0.85)	1.75	4.06* (0.92)	5.56	3.13* (1.03)
Reliable sources	6.06	3.49 (0.66)	12.12	3.55 (0.77)	48.57***	3.73** (0.59)
Mixed/unknown reliability	15.15	2.94* (0.47)	16.67	2.74* (0.43)	28.57	2.42* (0.61)

* significantly different to all other groups ($p < .05$). ** significantly different to pre-VET only ($p < .05$). *** significantly different to expected count ($p < .05$).

Comparison of personal trainers to pre-VET students showed observed counts significantly higher than expected for the use of exercise and nutrition professionals ($\chi^2(1) = 10.55$, $p = .001$, $V = 0.28$), and reliable sources ($\chi^2(1) = 30.49$, $p < .001$, $V = 0.47$). Personal trainers also reported significantly more trust in reliable sources (95% CI [-0.45, -0.03], $t(134) = -2.23$, $p = .03$, $d = 0.38$), and less trust in all other sources (PRO: 95% CI [0.38, 0.79], $t(134) = 5.80$, $p < .001$, $d = 1.00$, OTH: 95% CI [0.33, 0.97], $t(134) = 4.01$, $p < .001$, $d = 0.69$, MIX: 95% CI [0.33, 0.70], $t(134) = 5.56$, $p < .001$, $d = 0.95$), with moderate or large effect sizes. Comparison to post-VET students similarly showed personal trainers had higher than expected counts for the use of exercise and nutrition professionals ($\chi^2(1) = 10.55$, p

= .001, $V = 0.28$), and reliable sources ($\chi^2(1) = 21.14, p < .001, V = 0.39$). Trust in reliable sources was not significantly different (95% CI [-0.42, 0.05], $t(134) = -1.55, p = .12$), while personal trainers had less trust than post-VET students in all other sources (PRO: 95% CI [0.32, 0.72], $t(134) = 5.24, p < .001, d = 0.90$, OTH: 95% CI [0.60, 1.26], $t(134) = 5.54, p < .001, d = 0.95$, MIX: 95% CI [0.15, 0.50], $t(134) = 3.59, p < .001, d = 0.61$), again with moderate or large effect sizes.

Personal trainers using exercise and nutrition professionals as a source had more years of experience (7.26 ± 6.56 compared to 3.83 ± 3.80 , 95% CI [-6.39, -0.48]; $t(67) = -2.32, p = .02, d = 0.64$) than those that did not, as did those using sources of mixed or unknown reliability (8.85 ± 8.54 compared to 5.00 ± 4.19 , 95% CI [-6.90, -0.80]; $t(67) = -2.52, p = .01, d = 0.57$). Personal trainers using reliable sources had higher Knowledge scores than those that did not (8.94 ± 1.18 compared to 8.19 ± 1.58 , 95% CI [-1.42, -0.08]; $t(68) = -2.23, p = .03, d = 0.54$), while post-VET students who used sources of mixed or unknown reliability had lower Knowledge scores (7.27 ± 2.10 compared to 8.25 ± 1.31 , 95% CI [0.02, 1.95]; $t(64) = 2.04, p = .04, d = 0.56$), and higher Misconception scores (4.09 ± 1.58 compared to 2.78 ± 1.49 , 95% CI [-2.30, -0.32]; $t(64) = -2.64, p = .01, d = 0.85$).

In personal trainers Knowledge significantly correlated with trust in exercise and nutrition professionals ($r = .30, p = .01$), other health professionals ($r = .30, p = .02$), and reliable sources ($r = .29, p = .02$). Misconceptions did not significantly correlate with any trust score in personal trainers, but was positively associated with trust in mixed or unreliable sources ($r = .28, p = .02$) in pre-VET students. There were no correlations between trust and Knowledge, or Misconceptions, in post-VET students.

5.3.5 Differences between VET and Higher Education Students and Graduates

Students at the beginning of their qualifications (pre-VET and first year students) and graduates of each qualification (personal trainers and degree qualified professionals) were compared for differences in demographic variables, Knowledge, Misconceptions, confidence, critical thinking ability, and the use and trust of sources of information. Post-VET results were not compared to third year students, as the post-VET assessment was a repeated test, while the third year group was not.

Chi-square tests for independence showed no differences in gender between pre-VET and first year students ($\chi^2(1) = 0.42, p = .52, V = 0.04$), or between personal trainers and degree qualified professionals ($\chi^2(1) = 0.99, p = .32, V = 0.09$). Independent samples *t*-tests showed pre-VET students were significantly older than first year students (24.15 ± 8.59 compared to 19.54 ± 3.69 years, 95% CI [2.42, 6.80]; $t(75.13) = 4.20, p < .001, d = 0.70$). There was no difference in age between personal trainers and degree qualified professionals (33.17 ± 9.81 compared to 30.90 ± 8.87 years, 95% CI [-1.17, 5.71]; $t(119) = 1.31, p = .19, d = 0.24$).

Pre-VET and first year students did not differ in either Misconceptions (4.08 ± 1.65 compared to 4.43 ± 1.71 , 95% CI [-0.84, 0.14]; $t(223) = -1.42, p = .16, d = 0.21$), or Knowledge (7.05 ± 2.12 compared to 7.27 ± 1.74 , 95% CI [-0.76, 0.31]; $t(223) = -0.83, p = .41, d = 0.11$). However, first year students scored significantly higher in critical thinking ability (0.72 ± 0.93 compared to 0.38 ± 0.74 , 95% CI [-0.58, -0.11]; $t(151.08) = -2.94, p = .004, d = 0.40$). In contrast, degree qualified professionals had both lower Misconception scores (2.31 ± 1.57 compared to 2.94 ± 1.63 , 95% CI [0.04, 1.21]; $t(119) = 2.13, p = .04, d = 0.39$), and higher Knowledge scores (9.37 ± 0.82 compared to 8.56 ± 1.44 , 95% CI [-1.23, -0.37]; $t(113.32) = -3.93, p < .001, d = 0.69$), than personal trainers, though there was not a significant difference in critical thinking ability (0.92 ± 0.99 compared to 0.69 ± 0.92 , 95% CI [-0.58, 0.11]; $t(119) = -1.34, p = .18, d = 0.24$).

There were no difference in either Confidence measure between pre-VET and first year students (KNOW CON: 18.87 ± 6.92 compared to 18.61 ± 5.40 , 95% CI [-1.51, 2.03]; $t(89.43) = 0.26, p = .80, d = 0.04$; MISC CON: 18.53 ± 6.21 compared to 18.22 ± 5.33 , 95% CI [-1.37, 2.01]; $t(206) = 0.37, p = .71, d = 0.05$). There was also no difference between personal trainers and degree qualified professionals (KNOW CON: 26.67 ± 3.29 compared to 25.96 ± 3.91 , 95% CI [-2.02, 0.59]; $t(115.95) = -1.08, p = .28, d = 0.20$; MISC CON: 25.41 ± 3.33 compared to 25.25 ± 4.01 , 95% CI [-1.53, 1.20]; $t(118) = -0.24, p = .81, d = 0.04$), despite the difference in Knowledge and Misconceptions scores between these groups of professionals.

A chi-square test for independence showed that a significantly higher proportion of pre-VET than first year students had accessed sources of exercise and nutrition information in the previous 12 months (95% compared to 84%; $\chi^2(1) = 5.79, p = .02, V = 0.16$). Pre-VET students accessed a greater number of different

sources (6.06 ± 3.35 compared to 4.48 ± 3.09 , 95% CI [0.66, 2.49]; $t(223) = 3.40$, $p = .001$, $d = 0.49$) were more likely to access sources of mixed or unknown reliability (15% compared to 5%; $\chi^2(1) = 6.49$, $p = .01$, $V = 0.17$). There was no difference between the student groups in accessing exercise and nutrition professionals ($\chi^2(1) = 1.73$, $p = .19$, $V = 0.09$), other professionals ($\chi^2(1) = 0.42$, $p = .52$, $V = 0.05$), or reliable sources ($\chi^2(1) = 0.01$, $p = .91$, $V = 0.01$).

There were significant differences between groups in the trust of sources, with pre-VET students finding other professionals and reliable sources less trustworthy than first year students (OTH: 3.78 ± 0.85 compared to 4.01 ± 0.70 , 95% CI [-0.47, -0.01]; $t(103.81) = -2.01$, $p = .03$, $d = 0.29$; REL: 3.49 ± 0.66 compared to 3.84 ± 0.53 , 95% CI [-0.54, -0.17]; $t(102.52) = -3.82$, $p < .001$, $d = 0.58$), and sources of mixed and unknown reliability more trustworthy (2.94 ± 0.47 compared to 2.73 ± 0.38 , 95% CI [0.09, 0.32]; $t(223) = -4.18$, $p < .001$, $d = 0.58$).

There was no difference in the proportion of personal trainers or degree qualified professionals that had accessed information in the previous 12 months ($\chi^2(1) = 0.50$, $p = .48$, $V = 0.06$), though personal trainers accessed a greater number of sources (8.69 ± 3.98 compared to 7.27 ± 2.78 , 95% CI [0.19, 2.63]; $t(118.82) = 2.30$, $p = .02$, $d = 0.41$). There was no difference between these groups in the use of exercise and nutrition professionals ($\chi^2(1) = 0.32$, $p = .57$, $V = 0.05$), or other professionals ($\chi^2(1) = 2.24$, $p = .14$, $V = 0.16$), as a source of information. However degree qualified professionals were more likely to use reliable sources of information (71% compared to 49%; $\chi^2(1) = 5.86$, $p = .01$, $V = 0.22$), and less likely to access sources of mixed and unknown reliability (8%, compared to 29%; $\chi^2(1) = 7.97$, $p = .01$, $V = 0.26$). Personal trainers reported less trust in reliable sources (3.73 ± 0.59 compared to 4.00 ± 0.59 , 95% CI [-0.51, -0.08]; $t(119) = -2.69$, $p = .01$, $d = 0.46$), though there were no differences in trust in other categories of sources (PRO: 3.59 ± 0.62 compared to 3.76 ± 0.48 , 95% CI [-0.37, 0.04]; $t(119) = -1.60$, $p = .11$, $d = 0.31$; OTH: 3.13 ± 1.03 compared to 3.32 ± 0.93 , 95% CI [-0.56, 0.17]; $t(119) = -1.09$, $p = .29$, $d = 0.19$; MIX: 2.42 ± 0.61 compared to 2.27 ± 0.41 , 95% CI [-0.36, 0.33]; $t(118.03) = 1.59$, $p = .11$, $d = 0.29$).

5.4 Discussion

This study examined the presence of misconceptions, knowledge, and critical thinking ability in VET students and personal trainers, whether these misconceptions

were associated with critical thinking ability or knowledge and identified predictors of misconceptions. It also investigated the association of confidence with knowledge and the presence of misconceptions. The sources of information used by students and personal trainers, the trust placed in these sources, and the association of these variables with knowledge or the presence of misconceptions were also examined. Finally, VET students and personal trainers were compared to first year exercise science students, and degree qualified professionals.

Students were demonstrated to possess misconceptions prior to entering a VET fitness course. These were partially corrected during the course, as Knowledge improved, and Misconceptions declined. However, there was no difference observed between personal trainers and students who completed the course in their knowledge or misconceptions scores, regardless of the experience of the trainer.

At least 25% of the student group agreed with eight misconception statements, suggesting that they are common misconceptions. The popularity of ‘a vitamin supplement can improve your wellbeing, energy levels, and performance’, and ‘lactic acid causes fatigue’ has been explored in prior literature (Herbold et al., 2004; Morton et al., 2008), and their popularity in all groups in the present investigation is consistent with this literature. A vocationally qualified personal trainer may not receive sufficiently detailed knowledge from their course to identify the flaws in underlying knowledge that led to these misconceptions. Thus the misconception can persist into professional practice. The fact that higher vocational qualifications (i.e. diplomas) or years of experience are not associated with fewer misconceptions suggests that the continuing education of personal trainers is insufficient to correct these fundamental misconceptions.

Additionally, ‘a high protein, high fat diet is healthier than recommended healthy eating guidelines’ was largely corrected during the VET fitness course, though was more commonly reported in personal trainers. This could suggest that advertising and marketing is affecting personal trainers (Bennie et al., 2017; Morton et al., 2008). It might also indicate that personal trainers are not equipped to make appropriate choices regarding the quality of information (consistent with the findings reported by Stacey et al., 2010) which may be presented to them in professional development. As personal trainers may uncritically accept poor information, a misconception that was previously corrected may return, or a new misconception may develop. Given that McKean et al. (2015) identified that many personal trainers

do not participate in adequate professional development, and the majority operate outside their scope of practice in terms of providing nutrition services, the public has a high risk of receiving inappropriate advice from personal trainers.

In contrast, the increase in Knowledge during the course was expected. While previous research has identified that personal trainers performed poorly in assessments of required knowledge (Malek et al., 2002; Zenko & Ekkekakis, 2015), more difficult survey questions could account for this. The statements in the Exercise Science Knowledge Survey were largely simple enough for the public to answer correctly, and some misconception statements contained obvious flaws in reasoning. However, the lack of differences between post-VET and PT groups is in contrast to the degree qualified professionals group in Chapter 4, who did score significantly higher than students about to graduate. This is further indication that the professional development of personal trainers is inadequate. Research in Switzerland (Kruseman et al., 2008) and the UK (De Lyon & Cushion, 2013) has identified that personal trainers may not seek professional development, or do not feel that professional development and formal qualifications are important to inform their practice. Neither of these studies involved Australian personal trainers, though the similarly voluntary (or in Switzerland, non-existent) nature of professional registration in all three countries, together with the findings of McKean et al. (2015), suggest similar issues will exist.

No relationship between Knowledge and Misconceptions was identified in the present study. This contrasts with the results of Chapter 4, when a small negative association between these variables was found. It is possible that there is a threshold of knowledge, above which misconceptions are more likely to be corrected, which the post-VET students did not reach. Though the post-VET survey results did not appear to differ much from third year students, due to the different conditions of this survey these results could not be compared.

Instead, it appears that the use of more reliable sources of information, rather than specific content knowledge, may be important in reducing misconceptions, as the trust of these sources, and lower trust in sources of mixed and unknown reliability, was a significant predictor of misconceptions. This ability to identify and critically appraise sources of information is in line with higher levels of qualification than the industry standard Certificate IV (Australian Qualifications Framework Council, 2013). These findings suggest that enhancing critical thinking skills by

providing instruction in appraising sources of information, for example, may lead to greater success correcting misconceptions than providing specific information.

There was no significant change in critical thinking ability observed in VET students, and a trivial effect size. Additionally, Cognitive Reflection Test scores observed were notably lower than previous research. The mean for personal trainers (the best performing group) in the present study was 0.69 ± 0.92 , whereas Frederick (2005) reported a mean of 1.24 from undergraduate students. Other research using the Cognitive Reflection Test demonstrates a range of scores from 0.7 ± 0.93 (Toplak et al., 2011) to 2.45 ± 0.64 (Alter, Oppenheimer, Epley & Eyre, 2007). While critical thinking ability did not change during the VET course, neither was there a significant difference between first and third year students in Chapter 4. There was, however, a difference between pre-VET students and first year students, though there was not a corresponding difference in Misconceptions in these groups. While it appears that critical thinking ability plays a role in preventing misconceptions, specific content knowledge has value in addition to general thinking skills.

From pre-VET to post-VET there was an increase in the number of sources of information was observed, with increased use of reliable sources, and exercise and nutrition professionals, with PTs using these sources more than students either pre- or post-VET. Further, trust in all sources, except reliable sources, correspondingly decreased. Fewer than half of personal trainers used reliable sources of information (consistent with Bennie et al., 2017), though those that did scored higher in Knowledge. This was in contrast to degree qualified professionals, who were more likely to use reliable sources, were more trusting of these sources, and had less trust in sources of mixed or unknown reliability. Since Stacey et al. (2010) highlighted the lack of research on the sources of information of personal trainers to that point, this has been a growing area of interest. The variety of sources identified here supports earlier qualitative findings (De Lyon & Cushion, 2013) that informal and self-directed learning was an important source of knowledge for personal trainers. But while Stacey et al. (2010) identified that personal trainers were not confident in assessing the quality of information, those interviewed by De Lyon and Cushion (2013) did not express the same reservations. The differences in trust between VET students and personal trainers in the present study suggest that personal trainers are more able to differentiate between reliable and unreliable sources, though the high

number of different sources used by personal trainers compared to degree qualified professionals, and the lower likelihood that reliable sources are accessed, suggests that this may not inform decisions about which sources to use.

The use of online sources has been a theme in recent research (Bennie et al., 2017, De Lyon and Cushion, 2013), and was a consistently popular source of information in the mixed and unknown reliability category of the present study. But the quality of health information from online sources is highly variable (Eysenbach et al., 2002; Miles et al., 2000, Zhang, Sun & Xie, 2015), and users have been shown to rely on heuristics to assess the quality of the information they are presented with, using strategies such as endorsements from others, and the extent a site conforms to expectations, to make decisions about trustworthiness (Metzger et al., 2010). It is highly likely personal trainers will rely on similar strategies to inform their decisions, so it is plausible that misconceptions are reinforced by poor choices of online content.

The differences in Knowledge and Misconceptions between degree qualified professionals and personal trainers is notable when considering the lack of difference in confidence measures between the two groups. This difference in Knowledge is consistent with previous research (Malek et al., 2002; Zenko & Ekkekakis, 2015) showing that more qualified professionals scored higher in knowledge assessments. Also consistent with previous research is the inconsistent use of reliable sources by personal trainers (Bennie et al., 2016; McKean et al., 2015). This combination of misconceptions in knowledge, high levels of confidence, and the use of unreliable sources which confirm existing biases, may therefore be more likely to occur in personal trainers than degree qualified professionals, leading to an increased risk of poor advice being provided to clients. Barnes, Ball and Desbrow (2016) identified that over 80% of the websites of fitness businesses examined either exceeded, or were at risk of exceeding, the scope of practice for fitness professionals to provide nutrition advice. The potential for inaccurate advice is clearly high when a professional relies on unreliable information, possesses high levels of confidence, and operates outside the scope of their qualification.

There are some limitations of the present findings to consider. Firstly, the methods of recruitment mean these findings may not be generalisable to all personal trainers, or VET fitness students. Only full time, face-to-face students were recruited, so it is possible that in online, or part time students, misconceptions may survive at a

different rate than was demonstrated here. Additionally, it was difficult to recruit personal trainers to participate. As a result, participating personal trainers may not be representative of the broader population.

Although participants were instructed not to guess while completing the Exercise Science Knowledge Survey, it is possible that Knowledge scores may over-represent the knowledge of those surveyed, as participants may decide to agree with statements that seem plausible. For a more detailed assessment of knowledge, multiple choice or short answer questions may be required.

Due to the rapidly changing nature of exercise and nutrition misconceptions, it is possible that repeating the Exercise Science Knowledge Survey with future student cohorts will yield different results. Though some misconceptions appear to be enduring, other misconceptions identified as common by higher education professionals and VET trainers in Chapter 3 were not common in this group. Future investigation of appropriate misconceptions may need to include other sources who are more familiar with current fitness trends.

5.4.1 Conclusions

Generic critical thinking skills, such as the ability to identify appropriate sources of information, are more important than industry experience for reducing the presence of misconceptions in practicing trainers. Personal trainers should be encouraged to pursue higher level (diploma or degree) qualifications where possible to increase their exposure to these skills. There is also a need to embed these skills into the current Certificate IV in Fitness course, or provide professional development focussing on critical thinking, as it appears that these skills are not being developed to a level that allows personal trainers to accurately assess information on their own, and manage their own professional development.

Chapter 6: An Online Critical Thinking Intervention for Fitness Professionals

6.1 Introduction

Personal trainers are a popular source of exercise advice and guidance for the public, with more than 20 000 registered with the peak body (Fitness Australia, 2016). There are significant benefits to be derived from employing the services of a personal trainer, with higher exercise intensities during training sessions (Ratamess, Faigenbaum, Hoffman & Kang, 2008), and improved exercise adherence (Jeffery, Wing, Thorson & Burton, 1998). Additionally, personal trainers are qualified to provide basic nutrition advice consistent with nationally endorsed guidelines, and assistance in goal setting and maintaining motivation to exercise (Fitness Australia, 2014).

The release of a scope of practice for personal trainers was an attempt by Fitness Australia (2014) to clarify the role. Though many of the tasks of a personal trainer are physical in nature, Gavin (1996) identified that many trainers perceive their role to be more holistic, involving significant psychological aspects. More recently, McKean et al. (2015) identified that personal trainers do not feel constrained by their scope of practice in the provision of nutrition advice, with the majority of trainers exceeding this scope.

It has been identified that personal trainers participate in varied (but typically minimal) amounts of continuing professional development after attaining their qualification (Kruseman et al. 2008; McKean et al., 2015). Additionally, De Lyon and Cushion (2013) found that trainers considered on-the-job training and industry experience very important but thought that formal qualifications were of limited relevance to their professional practice. Other research has found that this industry experience is not a reliable indicator of the knowledge of personal trainers (Malek et al., 2002). Given formal qualifications and professional development are not highly valued, and personal trainers may not feel bound by their scope of practice in restricting their advice to clients, there is the potential for misconceptions to develop when trainers rely on overly simplistic explanations of complex phenomena (Badenhorst et al., 2015; Michael, 2007).

Additionally, personal trainers are typically quite confident in their ability to provide advice (Barnes, Desbrow & Ball, 2016). This confidence was identified in Chapter 5 to be similar that of degree qualified professionals, despite differences in

the level of qualifications, and knowledge demonstrated, between these groups. This potentially unfounded confidence may make it difficult to identify and correct misconceptions. These misconceptions can then be disseminated to clients, and possibly have an adverse effect on exercise outcomes.

6.1.1 Misconceptions in Exercise Professionals

It is clear from the research to date that the knowledge of personal trainers is insufficient to justify the holistic practice identified above. And while personal trainers typically participate in limited continuing professional development (Kruseman et al. 2008; McKean et al., 2015), they also use sources of information of varying quality (Bennie et al., 2017), and place higher levels of trust in sources of mixed reliability than more qualified professionals (as seen in Chapter 5). This increases the risk of errors in the knowledge of personal trainers.

Errors in the knowledge of personal trainers has been clearly demonstrated. Malek et al. (2002) administered a test based on personal trainer certification exams by the major accreditation bodies in the US and observed average scores of less than 50%. Zenko and Ekkekakis (2015) similarly identified that personal trainers' awareness of exercise prescription guidelines was poor (the average score in this test was 43%), though also identified that participants' confidence that they selected correct answers was high. In both instances participants' years of experience was not associated with better performance, though participants with degree qualifications performed significantly better than those without. And results from Chapter 5 indicate that while VET students improved their Knowledge, and reduced Misconception scores throughout their course, practicing personal trainers were not significantly different in either measure to these students. Again, years of experience did not have an influence on Knowledge, or Misconceptions.

In the absence of formal, ongoing education, choices of professional development courses, and self-directed learning, become more important. But a meta-analysis by Stacey et al. (2010) identified that while some personal trainers used high quality information, others expressed difficulty in identifying the quality of sources. Consistent with this, Bennie et al. (2017) identified that only about half of personal trainers used high quality sources of information, and a similar finding was reported in Chapter 5. It is possible that in a learning environment with

unreliable sources of information, errors in knowledge can become persistent misconceptions, to be passed on to other trainers and clients.

Research is yet to examine how to improve the decisions that personal trainers make around sources of information. And while the presence of misconceptions in personal trainers has been examined in Chapter 5, the most effective way of correcting misconceptions has not been identified. As the direct correction of a person's knowledge has been shown to be ineffective in other contexts (Lewandowsky et al., 2012), it is necessary to explore other approaches.

6.1.2 Correcting Misconceptions

There is a growing body of research that demonstrates that active learning approaches are effective in learning physiology. Aholpelto et al. (2011) used a combination of direct instruction and problem-based learning to reduce medical students' misconceptions of cardiac physiology. And while there is no other research specifically examining misconceptions, Nybo and May (2015) showed that students who had to design, conduct, and report on their own experiments performed better in an exercise physiology class than those who followed a course manual with these steps prescribed for them.

A key component of these active learning tasks is critical thinking skills, including the ability to present evidence in support of ideas, engage in critical discussion with others on these ideas, and modify opinions as evidence changes or counterarguments are presented (Pithers & Soden, 2000). This can extend to "inquiry strategies" (Kuhn, 1999), which may include searching for, and assessing the quality of, new information.

Employers in a range of industries are increasingly looking for these critical thinking skills in new employees, as part of a suite of generic "soft" skills (Jackson & Chapman, 2012), in preference to formal qualifications or years of experience. This has previously been identified in the fitness industry (Lloyd, 2008), but recent evidence is lacking. The results of Chapter 5 suggest that vocational education does not enhance these skills in graduates, though other research in Australian institutions is lacking. Fong et al. (2017) identified in the first meta-analysis on the topic that critical thinking ability was associated with academic success in US community college students. However, these colleges offer higher level qualifications (such as

associate degrees) as well as vocational qualifications. They also did not examine whether critical thinking ability was improved in students during these courses.

Although a stated goal of qualifications within the AQF is to prepare students for further learning (Australian Qualifications Framework Council, 2013), at Certificate IV level there is limited opportunity to develop critical thinking skills in students. In fact, as VET in Australia is competency-based, students are assessed against industry specific outcomes (Gonczi & Hager, 2010), thus it is their ability to complete a series of tasks, rather than their understanding of key concepts, that is assessed. While there is some research examining changes to critical thinking in US community colleges (Fong et al., 2017), the research reported in Chapter 5 represents the first examination of critical thinking in Australian VET students and showed no change in critical thinking ability throughout a vocational fitness course.

Tiruneh et al. (2014) identified that instructors need to be skilled in critical thinking in order to improve student outcomes. As the majority of VET trainers are themselves vocationally trained, and have usually spent significant time in industry (Robertson, 2008), it cannot be assumed they have spent significant time in higher education, where these skills have been shown to develop (e.g. Hughes et al., 2015). And while evidence in Australia is lacking, VET institutions in the UK are not supportive of trainers upskilling in research methods (Gray, Turner, Sutton, Petersen, Swain, Esmond, et al., 2015), which is an important component of critical thinking ability, and VET trainers often need to gain these skills in their own time, with no opportunity to disseminate this knowledge within institutions. Offering this type of training directly to personal trainers may be a more effective approach.

Sufficient content knowledge is required to analyse an argument adequately, so critical thinking is usually considered to be a context specific skill (Abrami, et al., 2008). For that reason, content specific to the domain of learning has been shown to be effective (Abrami, et al., 2015; Tiruneh et al., 2014). Additionally, explicit instruction is more effective than implicit instruction in critical thinking (Marin & Halpern, 2011), when it is assumed that students will identify and retain the critical thinking skills displayed by the instructor or in the content without specific prompting.

6.1.3 Online Education

Due to the variable and unpredictable hours a personal trainer may work in order to meet the needs of their clients, face-to-face delivery of professional development may not be convenient. So, in order to provide accessible training to the fitness industry, online options are crucial. It appears as if online learners are not disadvantaged when compared to face-to-face learning (Cavanaugh & Jacquemin, 2015; Means, Toyama, Murphy & Baki, 2013), so the convenience and greater potential reach means that well-designed online education is an appropriate option for this population.

Chickering and Gamson (1987) proposed seven principles of undergraduate education, which informs much of the subsequent research into education. While it is argued that there are significant differences between pedagogy and andragogy (Forrest & Peterson, 2006), much of this difference is based on the assumption that adult learners are more capable of independent learning, with less structure and guidance, while younger learners require a teacher-centred approach (e.g. Muduli, Kaura & Quazi, 2018). Others argue that this is a false dichotomy (Holmes & Abington-Cooper, 2000), as demonstrated by the effectiveness of many active learning approaches discussed earlier, in which students may receive relatively little guidance. There are also limitations applying an ‘andragogic’ approach to VET, or VET qualified professionals, where learners may come from disadvantaged backgrounds, have less experience with education, and need greater levels of support (Griffin, 2014).

So it is reasonable to apply the principles described by Chickering and Gamson (1987) to VET when relevant, while allowing opportunities for more capable learners to extend themselves. And research following from Chickering and Gamson (1987) has identified that these principles are used by teaching professionals to guide the planning and delivery of online learning, even in vocational contexts (Bishoff, 2010; Tirrell & Quick, 2012).

Other research reveals how these principles can apply in online learning. Communication between teaching staff and students can be encouraged through the use of asynchronous communication like email, internal messages and forum discussion (Newlin & Wang, 2002; Wang & Newling, 2000), staff being readily available, through virtual office hours, and responding quickly to messages (Crews, Wilkinson & Neill, 2015; Grant & Thornton, 2007). Cooperation and rapport

between students can be enhanced through the use of forums and internal messaging (Clawson, Deen & Oxley, 2002, Crews et al., 2015; Newlin & Wang, 2002), and activities like group projects, and the peer review of work (Grant & Thornton, 2007). Prompt and effective feedback can be provided when teaching staff monitor the course rigorously, mark work quickly, and provide individual feedback (Grant & Thornton, 2007; Newlin & Wang, 2002). High expectations can be communicated through clearly stated and readily available learning objectives (Cheawjindakarn, Suwannatthachote & Theeraroungchaisri, 2012; Grant & Thornton, 2007; Newlin & Wang, 2002), and through establishing clear deadlines (Crews et al., 2015). Diverse learning preferences can be accommodated by providing a wide range of resources and links for students to select from (Crawford-Ferre & West, 2012; Newling & Wang, 2002), and provide content presented in multiple formats, such as narrated presentation slides, and text (Crawford-Ferre & West, 2012; Walker, 2006).

Time on tasks can be maximised by the progressive release of content, so practice is spread rather than massed (Newlin & Wang, 2002), and by permitting multiple attempts at activities (Crews et al., 2015). Increased time on task has been found to be associated with better student outcomes (Coldwell, Paterson & Mustard, 2008). Reminders about deadlines can also be useful in enhancing time spent on activities, as the online environment may be conducive to procrastination (Grant & Thornton, 2007).

Finally, active learning can be encouraged through the use of practice problems (Crews et al., 2015), and web-based research activities (Newlin & Wang, 2002). The online environment provides opportunities for research activities beyond existing course content, with students suggesting this improves critical thinking skills (Grant & Thornton, 2007). Online, asynchronous discussion has also been found to enhance critical thinking skills to a greater extent than face-to-face discussion tasks, possibly because students have more time to reflect on their contributions (Guiller et al., 2008).

It is also possible that the progressive release of content also contributes to enhancing critical thinking ability in online education. Mayeshiba, Jansen and Muhlbauer (2018) used a competency-based model of progressing students through an online course. Rather than unlocking material on a regular (i.e. weekly) basis, material was released when students achieved competent performance on earlier activities. This way students could progress at a pace comfortable for them, and

these students performed significantly better than those who received traditional online delivery when assessed against a critical thinking rubric.

However, online learning presents some challenges. Firstly, teachers consider the preparation of content, grading, and responding to question online to be more time-consuming (Keengwe & Kidd, 2010). Online learning may disadvantage younger students, or those from cultures where learning is traditionally more strictly structured (Coldwell et al., 2008). Women may also have an advantage over male participants. Coldwell et al. (2008) identified that female students in a final year Bachelor of Technology Information online unit participated in provided activities significantly more than men. High achievers in the course spent significantly more time online in the course, viewed more content, and were more active in discussion forums. A similar pattern of activity was observed when genders were compared, and women scored more highly than men in the unit (72%, compared to 63%).

6.1.4 Objectives

Given the demonstrated errors in the knowledge of personal trainers, and the lack of adequate ongoing, formal education to support their professional development and practice, explicit instruction in critical thinking may allow personal trainers to make better choices of sources of information and continuing professional development activities. This may result in personal trainers holding fewer misconceptions, improving evidence-based practice, and disseminating more accurate information to clients. The aims of this study were therefore to:

1. Assess the impact of an online, domain specific, critical thinking intervention on the presence of misconceptions, knowledge, and critical thinking ability of personal trainers.
2. Assess any changes in the sources of information used, and the trust of sources, as a result of this intervention.

6.2 Method

6.2.1 Design

This was a randomised, staggered entry intervention study of personal trainers registered with the peak body (Fitness Australia). Participants were allocated into either an Immediate (IMM) or Delayed (DEL) start group. Participants were surveyed before being allocated into a group, again at the end of the delay period

(DEL only), and upon completion of the critical thinking intervention. This retest following the delay period allowed comparison of the intervention to the effect of time on performance on the Exercise Science Knowledge Survey.

6.2.2 Participants

Personal trainers with a minimum qualification of a Certificate IV were recruited via a promotional campaign by Fitness Australia. Three hundred and seventy-eight inquiries were received, with 180 participants recruited to participate. None of these participants had completed the Exercise Science Knowledge Survey as part of the studies described in previous chapters. The intervention was registered with Fitness Australia in order to provide continuing education credits (CECs) as an incentive to participate. Participants received a completion certificate and five CECs upon completion of the post-intervention survey, which is 25% of their required professional development commitment in a two-year registration period.

The flow of participants throughout the study is displayed in Figure 6.1. Ninety participants commenced in each group, though only 81 in the Immediate group, and 67 in the Delayed group, started the intervention. Forty-five participants (50%) in the Immediate start group, and 38 in the Delayed group (42%) completed the intervention and the post-intervention survey.

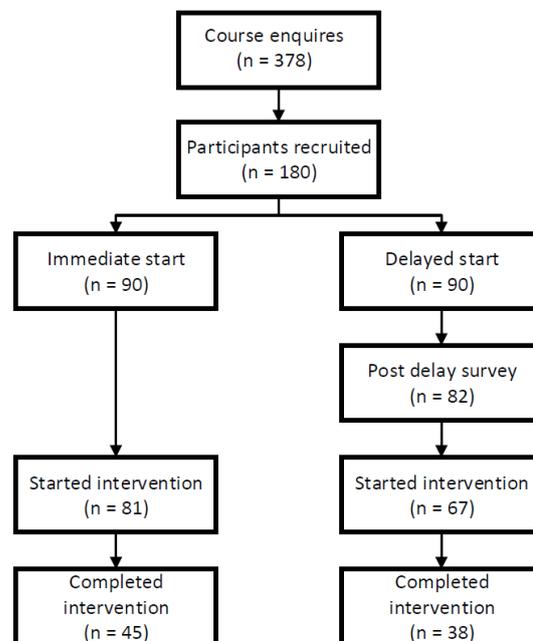


Figure 6.1. Attrition of participants in the immediate, and delayed start groups.

The demographic characteristics of each group are shown in Table 6.1. Independent samples *t*-tests revealed that there were no differences between groups in age (95% CI [-5.81, 4.72], $t(81) = -0.21, p = .84$), highest educational achievement (95% CI [-1.10, 0.55], $t(81) = -0.67, p = .84$), exercise education level (95% CI [-0.60, 0.40], $t(81) = -0.40, p = .60$), or years of industry experience (95% CI [-3.01, 4.46], $t(81) = -0.40, p = .69$). Women were over-represented in each group, but though a chi-square test of independence showed significant gender differences ($\chi^2(1) = 5.86, p = .02, V = -0.27$), post-hoc analysis showed no individual result was significantly different to expected values.

Table 6.1. Mean (*SD*) group demographic characteristics, for immediate ($n = 45$) and delayed ($n = 38$) start groups.

	Immediate	Delayed	
Gender	Male	9 (20%)	17 (45%)
	Female	36 (80%)	21 (55%)
Age in years (<i>SD</i>)	41.69 (11.75)	42.24 (12.31)	
Highest educational achievement (AQF level) (<i>SD</i>)	6.07 (1.75)	6.34 (2.02)	
Industry experience (years)	8.78 (9.28)	8.05 (7.50)	
Exercise AQF level	4.40 (0.99)	4.50 (1.31)	

The over-representation of women in the present sample is consistent with a recent industry profile, which identified that 56% of fitness instructors are female (Fitness Australia, 2016). The median exercise qualification was a Certificate IV, also consistent with the broader industry, although the median age of participants of 43 years was significantly higher than the industry-wide 32 years (Fitness Australia, 2016).

Seventy-three participants reported their level of registration with Fitness Australia, which indicates the length of their registration, and the minimum of CECs accumulated to maintain that registration. Twenty-three participants possessed a level one registration (less than two years registration), 38 were at level two (two to 10 years of registration, for a Certificate IV qualified trainer, gaining at least 20 CECs every two years) and 12 were registered at level three (10 or more years of registration, and additional CECs for a Certificate IV qualified trainer). There were

no significant differences in the numbers at each level of registration ($\chi^2 (2) = 1.22$, $p = .54$, $V = 0.13$).

A power analysis using G*Power 3.1 (Faul, et al., 2007) determined that a total sample size of 41 was required to yield an actual power of .8 for a paired samples *t*-test to assess differences in the participant group pre- and post-intervention. This was based on an estimated effect size of 0.45 reported by Blessing and Blessing (2010). Forty-two participants were required to yield an actual power of 0.8 for an independent samples *t*-test to assess differences between the Immediate and Delayed start groups. This was based on an estimated effect size of 0.92 reported by Blessing and Blessing (2010).

6.2.3 Material

All surveys (initial, post-delay, and post intervention) were completed using Qualtrics survey software (Qualtrics LLC, Utah, USA). The intervention was hosted using the Moodlecloud (Moodle Pty Ltd, Perth, Australia) online learning management system.

The critical thinking intervention was designed by the author to provide explicit, domain specific critical thinking instruction to personal trainers. It consisted of eight modules, which each took an average of 90 minutes to complete. The course was designed to require levels of analysis, autonomy, and cognitive skills appropriate for Certificate IV or diploma qualifications (levels four and five) in the Australian Qualifications Framework.

The course was also designed to comply with best practice for e-learning instructional design (Cheawjindakarn et al., 2012; Crawford-Ferre & Wiest, 2012). Within modules content was presented in a range of formats (including narrated PowerPoint videos, text, and links to relevant websites). Participants were given the autonomy to explore content and complete activities in their preferred order in each module where appropriate (Vrasida, 2004). A discussion forum was provided, and student interaction was encouraged. The course instructor (the author) was highly active in the course, marking work and providing written feedback within 24 hours in most cases, and was readily contactable, which are important components of online education (Crawford-Ferre & Wiest, 2012).

Each module concluded with a four-question reflection activity (modified from Dietz-Uhler & Lanter, 2009) requiring participants to identify key points of the

module, to identify how they could apply it to their professional practice, and identify areas for future learning. This has been shown to improve demonstration of critical thinking skills in online discussion (Alexander et al., 2010), and was released to participants once all other tasks within the module had been completed. Once the activities within a module were completed to the satisfaction of the researcher (including the four questions activity), the next module was released.

Modules One and Two covered arguments. Module One (after outlining course content, assessment criteria, contact information, etc.) introduced the concept of argument, as a well-structured argument, involving reflection about the world or events and commitment to analysing evidence to support a position, promotes critical thinking (Jiménez-Aleixandre & Erduran, 2007). It was stressed that in this instance the term ‘argument’ is used in a collaborative sense, and requires working together towards a common position, rather than a confrontation (Andriessen & Baker, 2014). The argument model in Module One was a simplified version of that proposed by Toulman (1958, cited in Andriessen & Baker, 2014). An expanded version was presented in Module Two that included counterarguments and rebuttals.

Modules Three and Four identified errors of argument, such as biases that can interfere with the interpretation of information (Stanovich, West & Toplak, 2013; Tversky & Kahneman, 1974), and fallacious arguments, where an argument or evidence is applied inappropriately (Boudry, Paglieri & Pigliucci, 2015). Boudry et al. (2015) claim that fallacies cannot be taught in a way that makes them clear, as the difference between a sound and a fallacious argument is sometimes dependant only on the quality of the supporting evidence, which may be interpreted subjectively. It is also asserted that instruction in these fallacies will not necessarily reduce their use (Mercier, Boudry, Paglieri & Trouche, 2017), though participants were presented with these fallacies and encouraged to look for them in their own arguments, as well as identify poor arguments presented by others.

Module Five introduced the concept that confidence can be unrelated to ability in many areas (Kruger & Dunning, 1999), then identified how the required skills and knowledge in Certificate III and IV qualifications compare to qualifications that may be possessed by other health professionals (Australian Qualifications Framework Council, 2013). Other characteristics of expertise were also identified, such as task characteristics and cognitive skills (Shanteau, 1992).

Previous literature has identified a lack of scientific literacy as contributing to misconceptions in other fields (Gleichgerrcht et al., 2015), as professionals reported accessing scientific literature, but lacked the skills to interpret it appropriately. Therefore, Module Six provided a basic introduction to the scientific method, to improve the appreciation of, and comprehension of, these resources. Module Seven extended this, by providing an outline of different research designs, the conclusions that may be drawn from each method, and recommendations on the efficient use of search engines to find high quality, evidence-based information online.

Module Eight was a culmination activity, in which participants were given a fitness product to research, then needed to independently search for information on this product, evaluate the quality of sources, interpret the findings of these sources, then form an opinion based on the volume, and quality, of evidence they found. Not only did this evidence need to be reliable, but participants needed to reach the correct conclusions about the efficacy of this product.

6.2.4 Measures

The Exercise Science Knowledge Survey (described in Chapter 3), was used to assess participants' knowledge of basic exercise and nutrition concepts, and their endorsement of common misconceptions. The survey produces a Knowledge (KNOW) score and a Misconceptions (MISC) score, described in Chapter 5. Corresponding Confidence scores (KNOW CON and MISC CON) from a three-point Likert-type scale were also collected (1 = slightly confident, 3 = very confident). Cronbach's alpha for the Knowledge and Misconception scores in the initial survey were .38 and .62. The reliability of the Misconception scale, while slightly below commonly accepted standards (Ponterotto & Ruckdeschel, 2007), is still acceptable to explore a new measure. The reliability of the Knowledge scale was consistent with the reliability observed in Chapter 4 and is not a concern when diverse knowledge is being assessed (Taber, 2017).

Critical thinking ability was assessed using Frederick's (2005) three-item Cognitive Reflection Test. A sub-optimal Cronbach's reliability was observed in the present sample ($\alpha = .66$), which was higher than observed with previous participant groups (Chapters 4 & 5) and was considered acceptable as discussed previously.

Demographic information, including highest prior educational achievement (AQF level) was collected. Participants were also asked to report the length of time

they had worked in the fitness industry, their highest exercise qualification (exercise AQF level), and their level of professional registration, which is a reflection of years of experience and participation in professional development.

Participants also identified what sources of exercise or nutrition information they had accessed in the previous 12 months, and rated the trustworthiness of each source (regardless of whether or not they accessed this source) on a five-point Likert-type scale (1 = not at all trustworthy, 5 = very trustworthy).

Performance in the critical thinking intervention was assessed using a series of marking keys prepared by the author. Activities that were multiple choice were scored according to participants identifying the correct response. Other activities required qualitative answers (usually short paragraphs). Participants would receive partial marks if they did not directly answer the question asked, or used poor quality sources, or inadequate reasoning. While the level of answer expected was broadly consistent with Certificate IV level, due to the critical analysis tasks required some activities may have been more in line with a higher AQF level. If a participant did not receive at least half the available score for a given activity, they were required to repeat the activity, after receiving written feedback from the assessor. Participants were able to repeat an activity as many times as necessary to demonstrate competent performance. This also served to increase students' time on task, and contribute to a better understanding of course content (Crews et al., 2015). Participants were deemed to have passed the course when all activities were completed.

6.2.5 Procedure

Ethics approval was granted by the Curtin University Human Research Ethics Committee (HRE2017-0807). All participants were volunteers who accessed the intervention free of charge. Identifying information was collected, so that CEC certificates could be issued to participants completing the course. Informed consent to participate in the research was obtained from all participants. Once informed consent was gained, participants were provided a link to complete the initial survey. Once the initial survey was complete, participants were assigned to either the Immediate start, or Delayed start group, using block randomisation. Participants were not given feedback about their survey performance.

The Immediate start group was then given access to the intervention and had six weeks to complete all activities. The Delayed group were informed that they

would gain access to the intervention after a six-week waiting period. They received weekly email communication during the waiting period to assist with retention. After this delay, this group repeated the survey, then was given access to the intervention, and had six weeks to complete all tasks.

At the conclusion of the intervention, a post-intervention survey was completed, then a CEC certificate was issued to the participant.

6.2.6 Data Analysis

Differences in Knowledge, Misconceptions, critical thinking ability, and Confidence (both KNOW CON and MISC CON scores) from pre- to post-intervention were examined using paired samples *t*-tests. Differences between groups were examined using independent samples *t*-tests. Cohen's *d* effect sizes were calculated to assess the practical significance of differences between groups, and between surveys within groups.

Sources of information were combined into the categories and scored as described in Chapter 4. Chi-square tests for independence was used to examine differences between immediate and delayed start groups in the sources of information used. Cramér's *V* was used to measure the strength of the association between participants' group, and the use of sources. McNemar's test was used to assess changes in the use of sources within groups. Results were recoded so "don't know" and "no" responses were combined, to allow this test to be used. Differences between those using and not using sources were examined using an independent samples *t*-test. Differences between groups in trust measurements were examined using independent samples *t*-test, and within groups using a paired samples *t*-test (Immediate start), and a repeated measures ANOVA (Delayed start).

Significance for all tests was accepted at $p < .05$, except where stated.

6.3 Results

6.3.1 Dropouts

Of the 90 participants allocated to each group, 45 completed the intervention in the Immediate start group, and 38 in the Delayed start group. Initial survey results were examined to explore differences between those who completed the study, and those who did not. Participants who completed the intervention were older than those that did not (42.06 ± 12.03 compared to 38.27 ± 11.61 , 95% CI [0.31, 7.28]; $t(178) = 2.15$, $p = .03$), and had achieved higher AQF levels (6.19 ± 1.90 compared to $5.34 \pm$

1.6, 95% CI [0.32, 1.37]; $t(156.84) = 3.19, p = .002$). There were no differences in Knowledge, Misconceptions, or critical thinking ability.

6.3.2 Critical thinking, Misconceptions and Knowledge

Critical thinking ability, and Knowledge and Misconception scores are shown in Table 6.2. Independent samples t -tests showed no significant differences between groups in the initial or post-intervention surveys in critical thinking ability (initial: 95% CI [-0.46, 0.54], $t(81) = 0.16, p = .88$; post-intervention: 95% CI [-0.57, 0.47], $t(81) = -0.20, p = .84$), Knowledge (initial: 95% CI [-0.60, 0.57], $t(81) = -0.05, p = .96$; post-intervention: 95% CI [-0.71, 0.62], $t(81) = -0.13, p = .90$), or Misconceptions (initial: 95% CI [-0.41, 0.91], $t(81) = 0.76, p = .45$; post-intervention: 95% CI [-0.61, 0.78], $t(81) = 0.24, p = .81$).

A paired samples t -test showed no significant difference in critical thinking ability from initial to post-delay survey in the Delayed start group (95% CI [-0.50, 0.13], $t(37) = -1.19, p = .24, d = 0.16$). Both groups' critical thinking scores increased significantly from the initial to the post-intervention survey (DEL: 95% CI [-0.77, -0.13], $t(37) = -2.82, p = .01, d = 0.38$; IMM: 95% CI [-0.62, -0.09], $t(44) = -2.70, p = .01, d = 0.29$), though the magnitude of the change was small.

There was no difference in Misconceptions from initial to post-delay surveys in the Delayed start group (95% CI [-0.55, 0.50], $t(37) = -.10, p = .92$). Post-intervention Misconceptions scores for both groups were significantly lower than the initial survey (DEL: 95% CI [0.10, 1.16], $t(37) = 2.43, p = .02, d = 0.42$); IMM: 95% CI [0.32, 1.28], $t(44) = 3.35, p = .002, d = 0.51$), and in the Delayed group significantly lower than the post-delay survey (95% CI [0.20, 1.11], $t(37) = 2.94, p = .01, d = 0.42$).

There was no significant change in Knowledge the Delayed group between initial and post-intervention survey (95% CI [-0.46, 0.41], $t(37) = -0.12, p = .90$), and no change at all in the Immediate start group (95% CI [-0.53, 0.53], $t(44) = 0.00, p = 1.00$). There were also no differences in the Delayed group from initial survey to post-delay (95% CI [-0.23, 0.34], $t(37) = 0.37, p = .71$), or post-delay to post-intervention (95% CI [-0.47, 0.31], $t(37) = -0.41, p = .69$).

Table 6.2. Mean (*SD*) critical thinking ability, Knowledge, and Misconception scores for Delayed (DEL) (*n* = 38) and Immediate (IMM) (*n* = 45) start groups.

	Initial survey		Post-delay	Post-intervention	
	DEL	IMM	DEL	DEL	IMM
Critical thinking ability	1.32 (1.14)	1.36 (1.15)	1.50 (1.13)	1.76 (1.15)*	1.71 (1.22)*
Knowledge	8.82 (1.45)	8.80 (1.22)	8.76 (1.46)	8.84 (1.17)	8.80 (1.75)
Misconceptions	2.53 (1.50)	2.78 (1.52)	2.55 (1.54)	1.89 (1.54)**	1.98 (1.63)*

* significantly different to initial survey ($p < .05$). ** significantly different to both initial and post-delay survey ($p < .05$).

The percentage of participants in each group who demonstrated individual misconceptions in the initial survey is illustrated in Table 6.3. Chi-square tests for independence showed there were no significant differences from expected values in either group for any individual misconception in the initial survey. Five misconceptions were relatively common among participants. At least 50% of participants in each group agreed that “lactic acid causes fatigue”, and “a vitamin can improve your well-being, energy levels, and exercise performance”, while at least 30% in each group agreed “static stretching reduces injury risk”, “the more protein the better”, and “no pain, no gain”.

McNemar’s test was used to assess changes in participants’ agreement with misconception statements. The only significant change of agreement with any statement from initial survey to post-delay survey was “a high protein, high fat diet is healthier than recommended healthy eating guidelines”, which had increased agreement ($p = .02$). While there were no differences in the delayed group from initial survey to post-intervention, in the immediate group significant reductions in agreement were observed for “static stretching reduces injury risk” ($p = .003$), and “the more protein, the better” ($p = .003$).

The percentage of participants in each group agreeing with knowledge statements is shown in Table 6.4. Chi-square tests of independence showed neither group was significantly different to expected values. Participants overwhelmingly agreed with all knowledge statements, with only “very large quantities of protein are not necessary”, and “it is possible to get stronger without feeling significant pain” having less than 80% of participants agreeing.

Table 6.3. Percentage of participants observed to possess individual misconceptions in the delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups

Misconception	Initial Survey		Post Delay		Post Intervention		
	DEL	IMM	Total	DEL	DEL	IMM	Total
Static stretching reduces injury risk	41.4%	39.8%	40.6%	42.1%	34.2%	22.2%*	27.7%
The more protein, the better	33.3%	41.9%	37.8%	28.9%	26.3%	17.8%*	21.7%
Low intensity cardio burns more fat than high intensity	6.9%	16.1%	11.7%	2.6%	7.9%	17.8%	13.3%
A high protein, high fat diet is healthier than recommended healthy eating guidelines	13.8%	11.8%	12.8%	18.4%*	2.6%	6.7%	4.8%
If a part of your body is exercised hard, you will lose body fat from that area	2.3%	3.2%	2.8%	2.6%	2.6%	4.4%	3.6%
A short term fast flushes out toxins and helps weight loss	14.9%	9.7%	12.2%	7.9%	2.6%	0%	1.2%
Lactic acid causes fatigue	69%	65.6%	67.2%	68.4%	60.5%	62.2%	61.4%
A vitamin supplement can improve your well-being, energy levels, and performance	50.6%	57%	53.9%	44.7%	23.7%	37.8%	31.3%
No pain, no gain	40.2%	32%	36.1%	36.8%	23.7%	20%	21.7%
Women get too muscular if they lift heavy weights	5.7%	7.5%	6.7%	2.6%	5.3%	8.9%	7.2%

* significantly different to prior result ($p < .05$)

Table 6.4. Agreement with knowledge statements in the delayed (DEL) (n = 38) and immediate (IMM) (n = 45) start groups

Knowledge statement	Initial Survey		Post Delay		Post Intervention		
	DEL	IMM	Total	DEL	DEL	IMM	Total
A progressive increase in exercise intensity is a good warm up	97.4%	93.3%	95.2%	94.7%	97.4%	95.6%	96.4%
Very large quantities of protein are not necessary	76.3%	80%	78.3%	76.3%	65.8%	80%	73.5%
Higher intensity exercise uses more energy than lower intensities	94.7%	91.1%	92.8%	89.5%	92.1%	84.4%	88%
A healthy diet should be generally consistent with healthy eating guidelines	92.1%	93.3%	92.8%	89.5%	97.4%	95.6%	96.4%
Fat metabolism is not a local process	92.1%	84.4%	88%	89.5%	92.1%	84.4%	88%
The weight loss from a fast will return once the fast finishes	81.6%	84.4%	83.1%	81.6%	78.9%	84.4%	81.9%
Fatigue during high intensity exercise occurs for several reasons	92.1%	86.7%	89.2%	94.7%	100%	88.9%	94%
Vitamin supplements are unnecessary for most people	94.7%	91.1%	92.8%	89.5%	94.7%	93.3%	94%
It is possible to get stronger without feeling significant pain	71.1%	82.2%	77.1%	78.9%	81.6%	77.8%	79.5%
Women can lift heavy weights for improved strength and health, and not get too muscular	89.5%	93.3%	91.6%	92.1%	84.2%	95.6%	90.4%

McNemar's test was used to assess changes in participants' agreement with knowledge statements. No difference was seen in the delayed group from initial survey to post-delay, or in either group from initial survey to post-intervention.

6.3.3 Confidence in Knowledge and Misconceptions

Confidence in both Knowledge and Misconception responses are reported in Table 6.5. Differences between groups in the initial survey were assessed using an independent samples *t*-test. Changes within groups were assessed using a paired samples *t*-test. There was no difference between groups in the initial survey in either KNOW CON (95% CI [-1.99, 1.93], $t(79) = -0.03, p = .97$) or MISC CON (95% CI [-1.59, 2.35], $t(79) = .38, p = .70$). There were also no differences between the initial survey and the post-intervention survey for either group in either KNOW CON (DEL: 95% CI [-0.58, 2.47], $t(35) = 1.26, p = .22$; IMM: 95% CI [-0.46, 2.10], $t(43) = 1.28, p = .21$), or MISC CON (DEL: 95% CI [-1.11, 1.84], $t(35) = 0.50, p = .62$; IMM: 95% CI [-0.21, 2.62], $t(43) = 1.72, p = .09$). There was also no difference in the delayed group between the post-delay survey and the initial (KNOW CON: 95% CI [-0.86, 0.65], $t(36) = -0.29, p = .77$; MISC CON: 95% CI [-0.98, 1.69], $t(36) = 0.53, p = .60$), or the post-intervention survey (KNOW CON: 95% CI [-0.36, 2.58], $t(35) = 1.53, p = .14$; MISC CON: 95% CI [-1.05, 1.70], $t(36) = 0.48, p = .64$).

Table 6.5. Mean (*SD*) Confidence scores in delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups

	Initial survey		Post-delay	Post-intervention	
	DEL	IMM	DEL	DEL	IMM
Knowledge	24.49	24.45	24.59	23.64	23.64
Confidence	(4.49)	(4.36)	(4.69)	(4.68)	(5.35)
Misconceptions	22.76	23.14	22.41	22.11	21.93
Confidence	(4.60)	(4.31)	(5.04)	(5.16)	(5.50)

Knowledge Confidence was positively associated with Knowledge ($r = .41, p = .00$), but did not correlate with any demographic variable, including exercise AQF level and years of experience. Misconceptions Confidence did not correlate with Misconceptions ($r = .03, p = .80$), or any demographic variable.

6.3.4 Sources of Information

Almost all participants (98%) reported having searched for exercise or nutrition information in the 12 months prior to the initial survey. A chi-square test for independence showed there was no difference between groups ($\chi^2(1) = 0.02, p = .90$).

The use of sources in each group is presented in Table 6.6. There were no differences between the Delayed and Immediate start groups in the initial survey. McNemar’s test revealed no significant change from initial to post-delay survey, or post intervention survey, in the Delayed start group. There was a significant increase in the use of exercise and nutrition professionals ($p = .003$), and reliable sources ($p = .006$), in the Immediate start group.

Table 6.6. Participants from delayed (DEL) ($n = 38$) and immediate (IMM) ($n = 45$) start groups who reported accessing each category of sources

	Initial survey		Post-	Post-	
	DEL	IMM	delay	DEL	IMM
Exercise & nutrition professionals	52.6%	40%	60.5%	60.5%	71.1%*
Other health professionals	6.9%	6.1%	6.7%	11.5%	2.9%
Reliable sources	36.8%	24.4%	47.4%	50%	46.7%*
Mixed/unknown reliability	18.4%	13.3%	15.8%	13.2%	22.2%

* significantly different to initial survey ($p < .05$)

The trust participants expressed in categories of sources is shown in Table 6.7. There were no differences between Delayed and Immediate start groups in the initial survey, or between the initial, and post-delay surveys in the delayed group. Both groups increased significantly in their trust of other health professionals (DEL: 95% CI [-0.76, -0.32], $t(37) = -4.88, p < .001, d = 0.72$; IMM: 95% CI [-0.78, -0.31], $t(44) = -4.71, p < .001, d = 0.75$), with moderate effect sizes for both. Both groups also reported higher trust in reliable sources (DEL: 95% CI [-0.42, -0.07], $t(37) = -2.80, p = .01$; IMM: 95% CI [-0.54, -0.21], $t(44) = -4.62, p = .00$), with a small effect size for the Delayed start group ($d = 0.42$), and a moderate effect for the Immediate start group ($d = 0.70$). Trust in sources of mixed and unknown reliability decreased significantly in both groups (DEL: 95% CI [0.11, 0.33], $t(37) = 3.94, p = .00, d =$

0.49; IMM: 95% CI [0.05, 0.32], $t(44) = 2.82$, $p = .01$, $d = 0.44$), with small effect sizes for both.

Table 6.7. Mean (*SD*) trust in categories of sources of information reported by participants from Delayed (DEL) ($n = 38$) and Immediate (IMM) ($n = 45$) start groups.

	Initial survey		Post-	Post-intervention	
	DEL	IMM	delay	DEL	IMM
Exercise & nutrition professionals	3.86 (0.52)	3.89 (0.49)	3.97 (0.50)	3.92 (0.56)	3.91 (0.48)
Other health professionals	3.58 (0.69)	3.42 (0.76)	3.67 (0.70)	4.12 (0.79)*	3.97 (0.71)*
Reliable sources	3.88 (0.49)	3.81 (0.55)	3.91 (0.56)	4.12 (0.63)*	4.19 (0.54)*
Mixed/unknown reliability	2.63 (0.40)	2.68 (0.33)	2.73 (0.51)	2.41 (0.48)*	2.50 (0.48)*

* significantly different to initial survey ($p < .05$)

6.4 Discussion

The aim of this study was to assess the impact of an online, domain specific critical thinking intervention on the presence of misconceptions, knowledge, and critical thinking ability of personal trainers, using a randomised, staggered entry intervention. For both the Immediate start and Delayed start groups, there was an increase in critical thinking ability, and a decrease in Misconceptions scores, from pre-intervention to post-intervention. Given there was no change in these scores during the time delay for the Delayed start group, it can be concluded that the intervention was effective at improving these scores. Similarly, there was an increase in both the trust, and use, of trustworthy sources of information, also indicative of an improvement in critical thinking ability.

In spite of the reduction in Misconception scores, and a trend towards the reduced prevalence of individual misconceptions, only two of these changes were significant (“static stretching reduces injury risk”, and “the more protein, the better”), and only in the immediate start group. This was possibly due to the nature

of the intervention, which did not address individual misconceptions of the Exercise Science Knowledge Survey specifically, in order to assess the change in critical thinking ability only, rather than improved content knowledge. Highly prevalent individual misconceptions were consistent with those identified in Chapter 5, and previous research (Jacobson, Sobonya & Ransone, 2001; Morton, et al., 2008).

The reduction in Misconception scores shows that explicit, domain specific, online instruction in critical thinking could reduce the presence of misconceptions in personal trainers. While other research had identified the poor sources of information used by personal trainers (Bennie et al., 2017), an inability to discern the quality of sources (Stacey et al., 2010), and a lack of inhibition by their scope of practice (McKean et al., 2015), the present study is the first attempt to correct these issues. Additionally, the correction of misconceptions in other areas has focussed on pedagogical issues around presenting information (Badenhorst et al., 2015; Michael, 2007). Bennie et al. (2017) proposed the need for a resource to provide high quality information for personal trainers, though it is not clear if personal trainers suffer from a lack of sources of information. In fact, the present study shows that trainers are willing to use a wide variety of sources. Therefore, improving the ability of personal trainers to find, and discern the quality of, reliable sources may be a useful strategy.

In contrast to the change observed in Misconception scores, there was no change in Knowledge scores in either group post-intervention. This may be due to a ceiling effect. As the agreement with all factual statements was quite high, and the items all concerned fundamental knowledge, this scale may not have been sensitive enough to capture changes in knowledge. But a similar floor effect was not seen with misconceptions statements. This suggests that Misconceptions are distinct from a lack of knowledge on a topic, but rather an alternate understanding. Given that there were high levels of agreement with all knowledge statements, despite the prevalence of the corresponding misconception, it seems likely these alternate understandings can co-exist with the correct understanding of the content. This is consistent with the durable nature of misconceptions.

The intervention led to a small improvement in critical thinking ability. Performance on the Cognitive Reflection Test improved in both groups from pre- to post-intervention, and the lack of a significant change in the Cognitive Reflection Test score in the delayed start group over the initial delay period supports the

interpretation that the improvement can be attributed to the intervention. It is possible that this result does not reflect the actual magnitude of change in critical thinking ability, as more than one-third of participants got all three items in the CRT correct in the post-intervention survey (i.e., there was a ceiling effect on the measure). Previous research has also demonstrated the effectiveness of explicit critical thinking interventions using domain specific content (Abrami, et al., 2015; Tiruneh et al., 2014), but this is the first instance of this approach being used to improve these skills in personal trainers, and in participants who are largely vocationally trained. This suggests that embedding critical thinking instruction in vocational qualifications could also be an effective approach to improving these skills, and preventing the formation of misconceptions, in personal trainers.

Confidence in either Knowledge or Misconceptions did not change following the critical thinking intervention. Given the high levels of confidence identified by previous research (Barnes, Desbrow & Ball, 2016; Zenko & Ekkekakis, 2015), it is reasonable to expect that gaps in knowledge and expertise identified by the critical thinking intervention may have led to a reduction in confidence. That it did not may indicate this confidence is especially resilient. Zenko and Ekkekakis (2015) identified that personal trainers' confidence in their knowledge was strongly associated with their actual knowledge of exercise prescription guidelines, and confidence and knowledge were also strongly associated in the seminal research on the topic of overconfidence by Kruger and Dunning (1999), their key finding to the contrary only evident when quartiles were compared. However, research in nursing has found a negative association between critical thinking ability and confidence (Hoffman & Elwin, 2004). It is possible that a more challenging assessment of knowledge and misconceptions in the present research could have better explored this relationship, as the fundamental nature of the items in the Exercise Science Knowledge Survey could have led to elevated confidence levels.

An increased preference for high quality sources of information was demonstrated by higher use, and trust, of reliable sources of information following the critical thinking intervention. There was also a decrease in the trust of sources of mixed or unknown reliability, although no corresponding change in the use of these sources. As personal trainers are varied in their use of high quality information (Bennie et al., 2017; McKean et al., 2015), this suggests that some personal trainers using unreliable sources could be doing so with caution. But whether this means they

are rejecting poor information, or information which conflicts with their biases, is not clear. Further caution should be exercised when examining the change in the use of sources, as this question specified a timeframe of the prior twelve months. The question was not reworded following the critical thinking intervention, so it is possible that any change in the use of sources was due to accessing information to complete activities in the intervention, rather than a change in the participants' behaviour. It is also highly likely that a source of information accessed prior to the intervention could still be identified as a source following the six week intervention. While a shorter time period could be used (less than six weeks) this may not be a representative period of time for participants.

Overall, it appears that the online, domain specific, critical thinking intervention was successful in reducing the presence of misconceptions in personal trainers, increased their critical thinking ability, and led to an increased preference for high quality sources of information. However, the present investigation has several limitations which means these results should be interpreted with caution.

While it may have been possible to recruit more participants if the intervention had been made available for longer, given the vigorous promotion of the intervention by Fitness Australia to its members via email and social media posts, this seems unlikely. The time-consuming nature of the course may have reduced its attractiveness to prospective participants, and it is possible that a greater incentive would have been required to increase the participation rate. Given that CECs were allocated according to Fitness Australia's course registration procedures, this was not possible.

Rather than being a random sample of personal trainers registered with Fitness Australia, the sample was self-selected, with participants being notably older than the typical personal trainer (Fitness Australia, 2016), and having higher educational achievement than personal trainer participants in Chapter 5. It is possible given the relatively high education levels of participants that the critical thinking ability of personal trainers was overestimated in the present study, and that a more representative sample of personal trainers may have responded differently to the critical thinking intervention.

It is not possible to compare these results to those of Chapter 5, due to the different delivery of the Exercise Science Knowledge Survey in this study. While participants were instructed to not refer to reference material when completing the

survey online, this cannot be ruled out. As a result, it is also possible that the actual prevalence of individual misconceptions scores may be higher than what was identified here. It is also possible, however, that certain misconceptions are overrepresented here, and that participants accessing reference material may have made poor choices in the sources they used. Additionally, participants may have searched online for answers to the Cognitive Reflection Test following the initial survey, as these items are in the public domain.

6.4.1 Conclusions

This study provides evidence that an online, domain specific critical thinking course can successfully improve critical thinking ability and reduce the presence of misconceptions in personal trainers. Given these skills may not be adequately fostered in VET, access to training in critical thinking skills is important for personal trainers, who often need to independently search for and assess information relevant to the safe and successful exercise of their clients.

While this intervention was successful in improving critical thinking ability in the sample of personal trainers participating, given the flexibility personal trainers have in choosing their professional development, this kind of training is likely to appeal to those who are more academically inclined. It is therefore unclear whether this would also be effective with a more representative sample of personal trainers.

Chapter 7: Discussion

7.1 Introduction

Misconceptions of exercise and nutrition information are common and persistent in exercise science students, exercise professionals, and the public. While teaching interventions have attempted to reduce the presence of misconceptions, and had some success, the research into the role of critical thinking ability in reducing the presence of misconceptions is more limited. Neither the presence of misconceptions, nor the critical thinking ability, of vocational fitness students and vocationally qualified personal trainers has been assessed until now.

There were three major aims of this research. Firstly, to assess the presence of misconceptions in exercise science students, exercise professionals, and the public. Secondly, to assess whether misconceptions survived a VET fitness course, and if they were present in VET trained fitness professionals. Findings from these two areas could identify if misconceptions survive education and persist into professional practice, where they could affect outcomes for clients.

The final major aim was to identify whether domain specific, explicit instruction in critical thinking could reduce the presence of misconceptions, and improve the critical thinking ability of exercise professionals. This could provide the tools for exercise professionals to identify and correct misconceptions held by themselves and others. Additional aims were to identify the sources, and potential methods of correction of misconceptions in the classroom, and to examine the sources of information used, and trusted, by each group, and changes to these as a result of the instruction in critical thinking.

As no standard measure of general exercise and nutrition knowledge and misconceptions existed, one was developed for use in this research. Given the changing nature of popular misconceptions, and the evolving nature of knowledge in this area, items in the Exercise Science Knowledge Survey were written based on the current scientific evidence, and guided by the opinions of educators. Items were designed to be relevant to students, professionals, and the general population based on what was observed by these experienced educators.

Among higher education students, and degree qualified professionals, higher levels of education and critical thinking ability were associated with fewer misconceptions, and increased levels of knowledge. While similar associations

existed in VET fitness students, the same differences between groups was not observed: VET qualified trainers had similar levels of knowledge and misconceptions to students at the end of their course. In both higher education and VET, students' and graduates' self-reported trust in reliable sources of information, such as academic journal articles, textbooks, and public health promotion campaigns, was associated with fewer misconceptions.

The domain specific, explicit critical thinking intervention led to improvements in critical thinking ability, reductions in the number of misconceptions possessed, and increased trust, and use, of reliable sources of information. This suggests that critical thinking ability has an important role to play in correcting misconceptions, and could be included in the training, and professional development, of VET qualified fitness professionals.

7.2 Sources of Misconceptions

A number of ontological and pedagogical sources of misconceptions were identified by the higher education professionals and VET trainers, described in Chapter 3. Abrahamson et al. (2008) identified that the increasing popularity of the public seeking health information via online resources was bypassing the opportunity for an appropriately qualified 'gatekeeper' to interpret relevant information. Others have hypothesized that accessing isolated, incorrect knowledge from informal sources could lead to the formation of misconceptions (Bensley & Lilienfield, 2015), as this may not form a coherent body of knowledge. Both inaccurate information, and an inaccurate interpretation of a source, are therefore potential sources of misconceptions. Participants identified a number of potential sources of misconceptions that are consistent with this.

The lack of detail, or depth, in the understanding of students was identified repeatedly by educators in both the higher education and VET sectors. This was consistently evident in misconceptions which required knowledge of metabolism to correct or prevent, with participants also identifying the importance of appreciating the interaction of physiological systems. This is consistent with previously reported opinions of higher education professionals (Badenhorst et al., 2015; Michael, 2007). There are some theoretical explanations for these misconceptions persisting. In this case, the misconception "the more protein, the better" has characteristics in common with misconceptions of diffusion described by Chi (2005). Chi explained

that students considering emergent processes (such as diffusion) as direct processes may have difficulty with the conceptual change required to change their understanding adequately, as a very different mental model is required. Students may understand the role of protein metabolism in the synthesis of muscle fibres, but not appreciate the role of the nature of the training stimulus and carbohydrate in that training and recovery or consider the myriad other uses of dietary protein. Thus students may equate intake of protein with muscle hypertrophy, as a simple cause and effect relationship. Similarly, correcting the misconception ‘if a part of your body is exercised hard, you will lose body fat from that area’ may also have a conceptual change component, as students often struggle to understand the concept of energy (Mann, 2003; Yalçinkaya, Taştan & Boz, 2009), so may not immediately appreciate the impact of a person’s energy balance on their body composition.

If the appropriate depth of knowledge is not achieved during education, it is possible that these misconceptions may persist into professional practice. This may be more likely in VET graduates, as VET trainers in the present investigation tended to rely on simpler explanations and analogies to explain these concepts, as described in Chapter 3. This misconception could then be reinforced if graduates rely on unreliable sources (such as social media, health and fitness magazines, friends, or alternative health practitioners), which has been identified as a characteristic of the ongoing education of many personal trainers (Bennie et al., 2017; McKean et al., 2015). Both this recent body of research and the present results could be used to inform the development of future VET fitness training packages.

Multiple educators identified that the incorrect understanding that leads to a misconception could be a result of exposure to outdated knowledge, as more up-to-date scientific literature has not yet received widespread attention in public discussion. But given the lack of popularity of the use of reliable sources of information in the VET and first year higher education students surveyed, it is unlikely primary sources are being used. Rather, popular media sources may be perpetuating these long-held conceptions without the authors, who may lack technical expertise, updating their understanding.

For the misconception ‘static stretching reduces injury risk’, the status of this statement as a misconception is controversial among even higher education professionals. Systematic reviews examining the issue are conflicting (Behm et al., 2013; McHugh & Cosgrave, 2010; Shrier, 1999; Thacker et al., 2004), and the more

recent reviews call for further research on the topic. However, only one higher education participant acknowledged this controversy, while most did not include static stretching in classes involving physical activity. When participants interviewed did agree with the misconception statement, it appeared to be due to their own personal experience or preferences, rather than the state of the research. These outdated understandings could therefore be spread by educators as well as the popular media, highlighting the need to regularly update content knowledge, particularly for VET trainers without easy access to scientific research.

7.2.1 Informal Sources

While the opinions of educators that informal sources of information lead to misconceptions developing is consistent with previous research, the mode of this information has changed. While early research talked about media sources without elaborating (Michael, 2007; Morton et al., 2008), other research has identified the shortcomings of online sources of health information (Eysenbach, et al., 2002; Miles et al., 2000; Zhang, Sun & Xie, 2015). These media sources were most commonly cited as the source of misconceptions ‘a short term fast flushes out toxins and helps weight loss’ and ‘a vitamin can improve your well-being, energy levels, and exercise performance’.

Educators also identified social media as a source of information. In this research social media was grouped with other online and popular media sources as a source of mixed and unknown reliability for analysis based on the categories identified by Bennie et al. (2017). This category of information was shown to be more popular in VET students and graduates, with sources of mixed and unknown reliability both used more frequently, and more trusted, than in first year exercise science students and degree qualified professionals. While the accuracy of online sources of health information has been examined (Eysenbach, et al., 2002; Miles et al., 2000), as well as the heuristics used to make decisions about the reliability of these sources (Lederman, Fan, Smith & Chang, 2014; Metzger et al., 2010), social media sources of exercise and nutrition information have not been specifically assessed, a notable gap in the research given the popularity of these platforms.

The role of exercising subcultures in the presence of misconceptions is also a factor that has not been examined in research to date. An example of the perceived nutritional preferences of Crossfit enthusiasts was identified by one interviewee.

While the unique culture of Crossfit has been described in research (e.g., Dawson, 2017), it was also noted that this culture extended to the encouragement of alternative eating patterns, similar to the misconception ‘a high fat, high protein diet is healthier than recommended healthy eating guidelines’. Most of the research into this form of exercise has focussed on injury rates (Klimek, Ashbeck, Brook & Durall, 2018; Mehrab, de Vos, Kraan & Mathijssen, 2017; Weisenthal, Beck, Maloney, DeHaven & Giordano, 2014), though it has also been noted that many fundamentals of exercise prescription are ignored in Crossfit workouts (Mullins, 2015). Whether this approach to exercise prescription is a result of misconceptions, convenience for managing large groups of diverse exercisers, or the low education standards of instructors (Mullins, 2015) is not clear.

7.2.2 Sources of Misconceptions in Professionals

The opinions of higher education professionals and VET trainers described in Chapter 3 adds to a growing body of research identifying the use of poor quality evidence as a source of misconceptions, or errors in knowledge (Bennie et al., 2017; McKean et al., 2015; Stacey et al. 2010), and is also supported by the popularity of sources of unknown and mixed reliability identified in Chapter 5. Improving the ability of fitness professionals, particularly those without degree qualifications, to identify and appreciate appropriate sources, is required to achieve lasting improvement in this area.

Bennie et al. (2017) called for the creation of a resource that provided, and interpreted, high quality information for fitness professionals. While this approach is valuable, it is likely to become just another online resource, the popularity of which is not related to the quality of the content of the source (Lemire, Paré et al., 2008). Any resource may also require significant effort to maintain, or face a limited lifespan. In contrast, Barnes, Desbrow and Ball (2016) recommended education focussing on information sourcing and critical analysis of nutrition content, to increase the use of evidence-based information by personal trainers. The effectiveness of this approach was demonstrated in Chapter 7, though this could also be embedded into VET qualifications.

7.3 Measures

7.3.1. Exercise Science Knowledge Survey

When designing the Exercise Science Knowledge Survey the decision was made to include factual statements that correspond to each misconception statement. This was to avoid participants identifying that the survey was assessing misconceptions due to the nature of the statements, a possible result of using incorrect statements only, such as the survey administered in the early research into psychological misconceptions by Vaughan (1977). Bensley and Lilienfeld (2015) also identified the need for participants to identify ambiguity or uncertainty, and profess a lack of knowledge. For this reason a “don’t know” response was included, as forcing a “true” or “false” answer may lead to an inaccurate estimation of knowledge or misconceptions. Additionally, participants were asked to rate their confidence in each response (except “don’t know” responses), to reflect their level of certainty.

This decision to use both factual and incorrect statements was justified, as the Knowledge and Misconception scales had either a weak negative association, or no association at all. Knowledge also failed to predict Misconception scores in regression analyses in Chapters 4 and 5. The term misconceptions has been given varying definitions, with Taylor and Kowalski (2014, p.259) referring to misconceptions as “inaccurate prior knowledge”. However, if this was the case we would expect to see a strong negative association between misconceptions and knowledge, and that misconceptions could be readily corrected by knowledge. Other definitions refer to the enduring nature of misconceptions (Badenhorst et al., 2015; diSessa, 2006). The persistence of misconceptions identified by previous research (Hughes et al., 2015; Morton et al., 2008; Vaughan, 1977) suggests that this enduring quality is an important part of the definition. Misconceptions therefore need to be assessed separately to knowledge, as the presence of misconceptions appears to be a different phenomenon to a lack of knowledge.

The confidence measure produced by the Exercise Science Knowledge Survey differed from previous research that has asked participants to estimate their performance (e.g. Kruger & Dunning, 1999, Zenko & Ekkekakis, 2015). Instead, participants rated their confidence in their response to each item, and these were tallied to form total Misconceptions and Knowledge Confidence scores. This was

done in order to prevent participants identifying that there were incorrect items in the survey statements, which may have changed their responses. Direct comparison to earlier research is therefore not possible. The fact the Knowledge had a strong positive association with the corresponding Confidence score, while Misconceptions had at best a weak negative association, provides further support for the notion that these are different constructs.

Further highlighting the differences between Knowledge and Misconceptions were the different reliability coefficients observed for these scales. While the Misconceptions scale was adequate for a new measure as discussed in earlier chapters, the reliability of the Knowledge scale was consistently low. While this is considered below acceptable standards in psychological research (Ponterotto & Ruckdeschel, 2007), it is possibly more acceptable in a test of knowledge, particularly when multiple capacities of knowledge are assessed (Taber, 2017). This is also consistent with the explanation that Knowledge and Misconception scores measure different constructs. The broad nature of the misconceptions mean that the knowledge statements required a strong understanding of a range of areas of physiology and exercise science. The misconceptions, on the other hand, were usually based on an overly simplified understanding of correct knowledge, or a flaw in reasoning, so it is possible that these could be identified as misconceptions by participants without the need for significant content knowledge.

Reliability was also highest for both Knowledge and Misconception scales in Chapter 5, in a more homogenous population of VET students and graduates, without degrees in relevant fields. The study reported in Chapter 4, on the other hand, included a general population group, while the research reported in Chapter 6 involved a sample that included both VET trained and degree qualified participants. It appears therefore that the Exercise Science Knowledge Survey is not a test of exercise science knowledge that could be used across a varied population, though there is some use in the Misconception measure. However, keeping factual statements in the survey is recommended, to disguise which statements are misconceptions.

In order to maintain the relevance of the Exercise Science Knowledge Survey, misconceptions, and their corresponding factual statements, need to be updated on a regular basis. It is clear from the results presented in Chapters 4 and 5 that some misconceptions considered common by higher education professionals and

VET trainers are in fact not popular in their students, or even in the public. The misconception statements “low intensity cardio burns more fat than high intensity” and “a high protein, high fat diet is healthier than recommended healthy eating guidelines” were not agreed with by more than 20% of participants in any group surveyed, though educators interviewed considered them relatively popular misconceptions. While the perceptions of popular misconceptions by higher education professionals and VET trainers will necessarily lag behind their actual popularity in students and the public, a survey that is not updated regularly may quickly lose relevance. However, this comes at the expense of being able to easily compare subsequent research to the present findings.

The sources of information to be assessed were initially selected from a range of formal and informal sources identified by previous research, participants of the qualitative component of this research (see Chapter 4), and the fitness industry experience of the author. Subsequent research (Bennie et al., 2017) categorised these (and similar) sources into high quality, and low quality sources, as outlined in Chapter 2. Consistent with this, the sources previously identified were grouped into these categories, with extra categories for appropriate professionals, which were not part of the analysis for Bennie et al. (2017). Future research should maintain these categories, to allow for comparison with previous results.

7.3.2. Cognitive Reflection Test

The Cognitive Reflection Test (Frederick, 2005) has been widely used as a measure of critical thinking ability. It has been shown to be positively associated with patience (Frederick, 2005) and the Need for Cognition scale (Frederick, 2005; Liberali et al., 2012; Pennycook, Cheyne, Koehler & Fugelsang, 2016), which measures the tendency for an individual to engage in and enjoy thinking. It also predicts performance in the assessment of biases and heuristics (Toplak, et al., 2011). These are all elements of critical thinking consistent with the definitions described in Chapter 2. The Cognitive Reflection Test is usually considered valid (Toplak et al., 2011; Pennycook et al., 2016), though others have found that numeracy contributes to performance (Campitelli & Gerrans, 2013).

The Cognitive Reflection Test has also been demonstrated to be reliable (Liberali et al., 2012; Toplak, et al., 2011), though this was not seen during the present investigations, with poor reliability observed in all three instances. It is

possible that the mode of administration, and the instructions provided, may have affected results. In the present research the survey was administered electronically, and participants were not permitted to write notes. Research does not provide clear direction in this regard. While Pennycook et al. (2016) reported electronic administration, reliability was not reported, and others do not specify how the test was administered (Liberali et al., 2012; Toplak, et al., 2011). However given the strong performance of the Cognitive Reflection Test in recent research it was considered appropriate to continue to use it as a test of critical thinking ability.

An advantage of the Cognitive Reflection Test over other assessments of critical thinking is that it assesses the participant's ability to think critically, rather than asking them to self-report on their inclination to think critically, while being very short, and simple to conduct. Self-reporting is a feature of other popular assessments of critical thinking, such as the Need for Cognition scale (Cacioppo & Petty, 1982), and the California Measure of Mental Motivation (Giancarlo, Blohm & Urdan, 2004). As the ability to think critically is a socially desirable characteristic, and those who lack this ability may be unaware of this deficit in their thinking, an assessment of ability is more useful. Yet others assess critical thinking ability using essay comprehension and analysis skills, which are time consuming (Liu, Frankel, Roohr, 2014).

It has been suggested that the ubiquity of the items in the Cognitive Reflection Test has led to less accurate results when research participants recognise the items (Toplak, Stanovich & West, 2014). That is, it has become a victim of its own success. As a result, Toplak et al. (2014) proposed an expanded version, consisting of seven items, three of which were provided from communication with Frederick. There was a strong correlation with the original three-item version, and the expanded version was a strong predictor of performance on rational thinking tasks. Future assessments of critical thinking ability should consider the use of this expanded test, though the convenience of the original test means it still has value, such as use in a larger battery of questions when time is an issue. The use of the expanded test could also be used to minimise the ceiling effect that was proposed to influence the results in Chapter 6.

7.4 Misconceptions in Exercise Science Students & Graduates

Consistent with previous research examining the knowledge of exercise science students and professionals (Ekkekakis et al., 2016), Knowledge scores were higher in degree qualified professionals than students. Additionally, Misconception scores were lower. It appears as if the qualifications of participants are key to preventing misconceptions forming, rather than industry experience, because while years of practice was not associated with fewer misconceptions, also consistent with previous research (Malek et al., 2002; Zenko & Ekkekakis, 2015), the group status of participants was.

Notably, Misconception scores were significantly higher in first year students than the public group, despite both possessing similarly low levels of instruction in exercise and nutrition topics. A possible explanation for this is the highly qualified nature of the public group recruited for this study. Participants were obtained via snowball recruitment, so some highly educated early participants may have led to a group that did not accurately represent the general population. As a result, they had high levels of education, were older than other groups recruited, and scored highly in critical thinking ability. There were few differences between the groups in the sources of information used, and trusted, between first year students and the public. So the difference in Misconception scores between these groups suggests that information they are exposed to is interpreted differently, given the negative association between Misconceptions scores, and educational achievement and critical thinking ability.

The role of general education in the presence of misconceptions is not entirely clear in the research. While Hughes et al. (2015) found that higher levels of education resulted in fewer misconceptions of psychology, Dekker et al. (2012) found that misconceptions of neuroscience were not associated with education. While this could be explored further, it is plausible that the skills gained during higher levels of education, particularly critical analysis and drawing sound conclusions from a broad body of evidence, have a role to play in reducing misconceptions.

But while critical thinking ability was negatively associated with Misconceptions, and was also a significant predictor of Misconceptions, only 20% of the variance in Misconception scores was explained. Other significant predictors were trust in reliable sources, and trust in sources of mixed and unknown reliability.

While low, this is consistent with earlier research, which only accounted for about 30% of the variation in the endorsement of misconception statements (Bensley et al., 2014). While improving the reliability of the Exercise Science Knowledge Survey may improve this, it appears that a number of factors contribute to the formation of misconceptions which were not captured in this research. It is proposed that metacognitive ability contributes to misconceptions developing (Dole & Sinatra, 1998), but outside of poor sources of information and cognitive factors, both assessed in the present thesis, few other explanations have been identified in the research to date (Hughes, Lyddy & Lambe, 2013).

As mentioned above, it is well established that years of professional practice in exercise does not result in increased knowledge (Malek et al., 2002; Zenko & Ekkekakis, 2015), while the present study showed this is also the case with Misconceptions. And given that misconceptions have been shown to persist throughout degree programs in exercise science and other health related degrees (Innes et al., 2018; Morton et al., 2008; Richardson et al., 2015), it appears that these misconceptions will persist, maybe even throughout the career of the professional. Given the focus on depth of knowledge in correcting misconceptions identified in Chapter 3, and an appreciation of complexity and interaction of systems that have been a theme of this, and previous research (Badenhorst et al., 2016), it may be difficult to maintain this detailed understanding in professional practice. As this knowledge is not called upon in day-to-day interactions with clients it is even possible that misconceptions could emerge that were not present in the degree program. An example here is degree qualified exercise professionals possessing the misconception ‘the more protein, the better’ at higher rates than third year students. While professional development opportunities may focus on how information can be applied for the benefit of clients, a renewed focus on the underlying concepts of this knowledge is required.

7.5 Misconceptions in Vocational Fitness Students & Personal Trainers

While VET qualified personal trainers were similar in some ways to the degree qualified professionals discussed above, there were notable differences. Personal trainers with more years of experience did not possess fewer misconceptions than those less experienced, similar to the degree qualified professionals surveyed. But while Misconception scores were reduced in students by

the end of their VET course, personal trainers did not score any higher in Knowledge, or lower in Misconceptions, than post-VET students. While the knowledge of fitness professionals has been examined previously, most of these have included a range of different education levels, and often international professionals (Kruseman et al., 2008; Malek et al., 2002; Zenko & Ekkekakis, 2015). This research is the first to specifically compare VET fitness students and graduates, and is part of an emerging body of research examining Australian fitness professionals (Barnes, Desbrow & Ball, 2016; Bennie et al., 2017; McKean et al., 2015).

That the knowledge of degree qualified professionals increased after graduation, while that of personal trainers did not, is worthy of investigation. It is possible that those with degrees participate in higher quality professional development. Alternatively, the critical thinking skills presumably developed during a degree program could also be a factor.

However, while personal trainers did not score significantly higher in Knowledge than post-VET students, nor does Knowledge increase with years of experience, the system of registration administered by Fitness Australia recognises a personal trainer's length of experience as a factor in their knowledge. The length of time a personal trainer has been registered (and presumably participated in professional development) allows admission to varying "levels" of registration, with higher levels claimed to be able to assume leadership and mentoring roles, and possessing "a more progressed level of knowledge and skill" (fitness.org.au/articles/registration-levels/84). While more experienced trainers likely possess a wealth of knowledge about the industry itself, this does not necessarily equate to technical or theoretical knowledge.

Across all participants in this study, higher Misconception scores were associated with lower levels of educational achievement, lower critical thinking ability, lower trust in reliable sources, and higher trust in sources of mixed or unknown reliability. Interestingly, trust in degree qualified professionals was also associated with higher Misconceptions scores, while degree qualified professionals were also more frequently referred to than reliable sources among the public and first year student groups, and in both VET students and VET qualified personal trainers. It was only in third year students and degree qualified professionals that reliable sources were as prevalent a source as other professionals. This increase in prevalence

may be explained by the accessibility of lecturers (in the case of students) and colleagues.

The sources used by personal trainers has been examined widely in recent literature, with about half of trainers self-reporting the use of unscientific sources (Bennie et al., 2017; McKean et al., 2015). Some also expressed difficulty identifying high quality information (Stacey et al., 2010), though this is in contrast to the findings of De Lyon and Cushion (2013), when personal trainers reported more confidence in this. While the results from Chapter 5 and 6 are associations only, it is plausible that better critical thinking ability will result in the ability to discern the quality of sources of information in exercise and nutrition contexts, and enable the prevention, or correction, of misconceptions. It is well established that education at higher AQF levels requires a higher level of critical analysis and interpretation (Australian Qualifications Framework, 2013) in all fields of education. It stands to reason therefore, that even if a professional is highly qualified in an unrelated area, their ability in critical analysis (given adequate content knowledge) will be more apparent.

There was a significant decrease in Misconception scores in students from the beginning to the end of the VET course, and higher levels of critical thinking ability in personal trainers than either pre- or post-VET students. While this improvement is encouraging, personal trainers reported high levels of use of sources of mixed or unknown reliability, to an extent not seen in degree qualified professionals in Chapter 4. Trust in these sources was a significant predictor of Misconception scores in VET students and graduates, though critical thinking ability was not, despite this presumably contributing to trust judgements. This highlights the importance of further education for personal trainers on their choice of sources of information, to reduce the risk of new misconceptions emerging later.

This higher use of unreliable sources, together with high levels of confidence in their knowledge (Barnes, Desbrow & Ball, 2016), and demonstrated bias against interventions such as medication and surgery for weight loss (Lobb et al., 2008) present conditions ripe for the development of misconceptions during professional practice. In the example of Barnes, Desbrow and Ball (2016), participants were surveyed on their confidence in their nutrition knowledge, and changes have already been made to the fitness training package that may improve trainers' awareness of their limitations. In 2015, when Barnes and colleagues were collecting survey

responses, the Certificate III in Fitness training package (SIS30313) contained one nutrition unit of competency, while there were none in the Certificate IV. The current Certificate III in Fitness training package (SIS30315) contains one unit of competency regarding the provision of healthy eating advice. However the current Certificate IV in Fitness (SIS40215) now contains two additional nutrition units of competency. One of these specifically addresses the limitations of a personal trainer's scope of practice, and the dangers of providing advice outside of this. Despite this, and the fitness professionals' scope of practice directly referring to "nationally endorsed nutrition standards and guidelines" (Fitness Australia, 2014), the low use of reliable sources of information suggests personal trainers need more education in choosing appropriate sources.

7.6 Confidence

In the present research, performance in the Knowledge scale had a strong positive association with Confidence, and confidence scores for both Knowledge and Misconceptions were very high. These high levels of confidence may have been due to the simple nature of the misconceptions. Comparison with other research on personal trainers is difficult however, as participants in prior research have been asked to estimate their scores (Zenko & Ekkekakis, 2015). In this case the Exercise Science Knowledge Survey meant participants could not be asked to predict their Knowledge or Misconception scores, as this would have identified the misconceptions in the statements they were presented with, and revealed the nature of the survey.

While Knowledge was strongly associated with confidence in all three quantitative studies in this research, Misconceptions was only weakly associated with confidence, and then only in VET students and graduates. This again reinforces the point made above that these are difference constructs. Participants are not aware of their misconceptions, of course, but this disconnection from confidence suggests they may not even be aware that their opinions are controversial. If a participant was aware that their understanding of a topic is incomplete, or differs from others, given adequate critical thinking ability we could reasonably expect to see lower confidence in their knowledge.

These findings are consistent with a body of literature, using a variety of topics and assessments of confidence, which show a strong positive association

between test performance and confidence, including for personal trainers. De Lyon and Cushion (2013) found that trainers feel they are capable of making good decisions about sources of information, and further considered that on-the-job training and experience was more important than formal qualifications. Barnes, Desbrow and Ball (2016) found trainers felt confident in their nutrition knowledge, while Zenko and Ekkekakis (2015) found that professionals overestimated their performance in an assessment of exercise prescription. These findings are consistent with the seminal work on perceived and actual knowledge (Kruger & Dunning, 1999) which proposed that poor metacognitive ability led to higher levels of confidence, and found participants who scored worse in tests of humour, grammar, and logical reasoning tended to overestimate their scores, while high performing participants underestimated their scores.

But inconsistencies in the way confidence is measured makes comparison of these results difficult. Kruger and Dunning (1999) compared the gap in perceived and actual scores between the lowest and highest scoring quartiles. Zenko and Ekkekakis (2015) reported a difference between perceived and actual scores averaged 13%, with a larger difference observed in men than women. In the present study, asking participants to predict their own scores on the Misconception scale was not possible for the reasons discussed above, and participants were kept unaware of these separate scales. Instead, a three-point rating of confidence was used for each item.

The independent nature of personal trainers' employment makes the correction of misconceptions difficult, as they may lack the means for correction through immediate, accurate feedback when they make an error. These misconceptions could also be strengthened if the information they have ready access to is inaccurate, leading to the high levels of confidence seen here. The lack of any association between Confidence and Misconceptions suggests a significant proportion of personal trainers possess a poor awareness of the boundaries of their knowledge. That is, they don't know what they don't know. It is possible that exposure to more reliable sources of information, or improved critical thinking ability, will result in lower, and possibly more appropriate, levels of confidence.

7.7 The Correction of Misconceptions

Though direct instruction was frequently proposed by educators in Chapter 3 as a strategy to correct individual misconceptions, some shortcomings of this approach were identified by higher education professionals and VET trainers interviewed. Although the research is unclear about the effectiveness of this approach (Kowalski & Taylor, 2009; Lewandowsky et al., 2012), clearly elements of instruction are required to increase students' depth of understanding of complex concepts, a point identified by almost all higher education professionals interviewed.

But, while research evidence that underpins this knowledge was considered very important in ensuring students understood concepts, it was also acknowledged that this evidence was not compelling to students. There are, however, some examples in research of more engaging approaches, such as the use of a "classic paper" to teach skeletal muscle adaptations to aerobic exercise (Brown, 2006) and Berkley and Berkley's (2009) use of episodes of the popular science show "Mythbusters" to teach research methods to psychology students. In this latter case students performed significantly better on assessment questions that had been the topic of a video, compared to those that had not. Both these examples demonstrate the importance of enhancing students' appreciation of research evidence.

In contrast, some of the other methods proposed by educators may serve to reinforce students' trust of less reliable evidence. The use of case study data and personal anecdote was considered very effective by some participants. While this was often used in conjunction with more reliable data by higher education professionals, VET trainers often relied on this evidence. They also relied heavily on simple analogies and visual representations, though generally considered misconceptions corrected when students left the course. While Posner et al. (1982) encouraged the use of analogies to facilitate conceptual change, these need to be used judiciously, as other authors suggest they may contribute to a misconception forming if they are relied on too heavily (Badenhorst et al., 2015; Michael et al., 1999).

This is at odds with the depth of knowledge that higher education professionals require of their students, which has been repeatedly identified in research (Ahopelto et al., 2011; Badenhorst et al., 2015; Michael, 2007). Two educators (one higher education and one VET) advocated modelling appropriate behaviour as a method of correcting misconceptions, but it is not clear if students

gained an understanding of these concepts or were just producing the desired behaviour. This approach, if relied upon, could leave students on the wrong side of a concept threshold (Meyer & Land, 2003), where they may be able to mimic competent behaviour, without necessarily understanding the reasons behind these actions, and disadvantaging them for further learning related to this concept.

An added complication could be the limited depth of understanding of VET trainers themselves. Given that the current industry standard qualification is a Certificate IV in Workplace Training and Assessment, of which considerable concern has been raised (Guthrie, 2010; Halliday-Wynes & Misko, 2012), VET trainers may lack the required pedagogical skill to reliably correct more complex misconceptions. Smith, Hodge and Yasukawa (2015) argue that the role of a VET trainer is highly challenging, requiring knowledge and skills more in line with a bachelor's degree, rather than a Certificate IV. And given that VET trainers only need to possess the qualification above the AQF level they are teaching, high levels of technical knowledge may not be present.

The lack of differences in Knowledge and Misconception scores between post-VET students and personal trainers (in contrast to the differences between third year exercise science students and degree qualified professionals) suggest that the professional development of personal trainers needs further attention, as a more experienced personal trainer is not necessarily a more knowledgeable one (Malek et al., 2002; Zenko & Ekkekakis, 2015), and may not necessarily provide better advice. Recent research has presented some strategies for this. While Bennie et al. (2017) recommended a resource for personal trainers which interpreted scientific research to provide evidence-based information for fitness professionals, Barnes, Desbrow & Ball (2016) recommended education should focus on information sourcing and critical analysis. This is consistent with the recommendations of those educators interviewed in Chapter 3, confirming the need for developing critical thinking skills in personal trainers.

7.7.1 Critical Thinking in the Correction of Misconceptions

An advantage of using simpler items than previous assessments of exercise and nutrition knowledge in the Exercise Science Knowledge Survey is that it permits the use of critical thinking ability in identifying incorrect statements, rather than relying on highly developed content knowledge. This is not only an issue in the

public and VET qualified professionals, as degree qualified exercise professionals have also been shown to hold biases that could influence their professional practice (Richardson et al., 2015). Similarly, biases leading to the rejection of scientific research in favour of personal experience and anecdote have been identified in chiropractic students (Innes et al., 2018). This builds on prior research identifying the non-scientific beliefs of chiropractic students and graduates (Gliedt et al., 2012; Puhl, Reinhart, Doan, McGregor & Injeyan, 2014). While not assessed in these previous studies, improved critical thinking ability could play a significant role in reducing these biases, as the negative association between Misconceptions and critical thinking ability demonstrated in Chapters 4 and 5 shows. The present research represents the first time the critical thinking ability of exercise professionals has been assessed.

It is well established that new information will be interpreted in a way that supports an existing bias (Nickerson, 1988), and this effect is strong enough to withstand correction (Tversky & Kahnemann, 1974). The present research showed that trust in sources of mixed or unknown reliability is not only positively associated with Misconception scores, it is also negatively associated with critical thinking ability. It has been established that many personal trainers rely on unreliable sources of information (Bennie et al., 2017; McKean et al., 2015), but while other research promoted the need to provide better information for personal trainers, the intervention in this research differed in that the aim was to help personal trainers make better decisions about the information they are exposed to. Given that the volume of inaccurate information cannot be controlled, this approach may lead to more sustainable, long-term improvements in the information personal trainers rely on.

Critical thinking skills were key components of many of the strategies outlined by educators in Chapter 3, such as the active learning, research, and guided discussion tasks proposed. However in VET there are fewer opportunities to develop these skills, as the competence based training model of training and assessment used in Australia usually requires adequate task performance (Wheelahan & Moodie, 2011), and generic research and reasoning skills may not be relevant to the task involved. Additionally, rather than merely embedding these skills into an assessment of other skills, the explicit approach to instruction appears to be most effective. But teaching critical thinking explicitly, within the context of a domain is a complex

task, involving the interaction of domain knowledge, critical thinking knowledge, and the pedagogical knowledge specific to both (Ab Kadir, 2017).

VET trainers face the same challenges as VET qualified personal trainers, in that they may lack access to high quality sources of information like academic journals (Barnes, Desbrow & Ball, 2016), and the skills to interpret that information accurately. Qualitative research of VET trainers and students has identified that professional and pedagogical expertise of VET trainers is highly regarded by both educators and students (Smith & Yasukawa, 2017), as is further education beyond the minimum requirements for the role. So it is reasonable to suggest that instruction in critical thinking would not only improve the knowledge of, and sources of information used by, personal trainers, but would be welcomed by students in VET training.

7.7.2 Critical Thinking Interventions

Previous research has identified that online interventions can be effective at improving critical thinking skills (Abrami et al., 2015; Alexander et al., 2010), and this was supported by the present research. In addition to improvements in critical thinking ability assessed by the Cognitive Reflection Test, participants also reported increased trust of reliable sources, decreased trust of sources of mixed and unknown reliability, and reduced their Misconception scores, which are all indicative of improved critical thinking skills.

A range of approaches has been demonstrated to improve critical thinking ability, with research suggesting explicit instruction is more effective than embedding critical thinking into other content (Marin & Halpern, 2011; Tiruneh et al., 2014). In addition to explicit instruction, domain specific content was designed in order to appeal to personal trainers, as well as achieve the best possible results. Despite the relevance of the program, and the need for personal trainers to complete professional development training, a dropout rate of just over 50% was observed. This was notable given that the professional development program was offered to participants free of charge, in contrast to other forms of professional development that might have significant registration fees attached. Although financial incentives have been reported to significantly improve retention rates in research (O'Neil, Penrod & Bornstein, 2003), it may be that the incentive of the free course was not a significant motivator, given the volume of work required. Given the self-selected

nature of the participant group to start with, it is possible that with this dropout rate the critical thinking intervention is ‘preaching to the choir’ and retaining the personal trainers that already favour higher quality evidence. A more representative sample of personal trainers could also result in higher dropout rates, as this sample was older, more highly qualified, and scored higher in critical thinking ability, than the personal trainers recruited in Chapter 5. Whether personal trainers recognise the need for well-developed critical thinking skills is unknown.

The approach taken to correcting misconceptions here was different to the recommendations of Bennie et al. (2017), as the critical thinking instruction should improve the choices of information personal trainers make, rather than providing another source among many. While the findings of research examining personal trainers’ expressed confidence in finding and interpreting information is mixed (De Lyon & Cushion, 2013; Stacey et al., 2010), it is possible that some of this confidence came from a lack of critical thinking ability. But while the reported use of degree qualified exercise and nutrition professionals increased following the intervention, the use of reliable sources (a category consisting of academic articles, textbooks, or public health promotion campaigns) did not, nor did trust in these sources improve. While increases in the reported trust of degree qualified professionals is encouraging, they may be less reliable than written academic sources. In spite of the improvements seen in the intervention, a large proportion of personal trainers still rely on less reliable sources. It is possible that industry wide change in the preferred sources of personal trainers will require a sustained effort, including changes to both VET and professional development.

7.8 Limitations

The Exercise Science Knowledge Survey was designed to assess the exercise science knowledge of a broad range of participants, with highly varied levels and fields of education. As a result, survey items needed to be simple, and some nuance may have been lost as a result. It is possible that professionals may have interpreted statements differently, or identified exceptions to general rules, which would lead them to a different answer than what was expected.

Additionally, popular misconceptions may change or evolve over time, leading some survey items to lose relevance. Anecdotally, it was observed even during the time that this research was conducted that the misconception ‘high

protein, high fat diet' became less popular, while the ketogenic diet (another low carb, high protein, high fat diet), initially popularised by Robert Atkins (1972), re-emerged.

Although far slower, evolving scientific evidence may lead to misconceptions needing to be modified as our understanding changes, such as the example of the changing research on the efficacy of static stretching for injury prevention, discussed in Chapter 3.

The voluntary nature of research participation, and the 'snowball' recruitment method used to gather participants for professional and public groups means that it is likely that representative samples of populations were not obtained. There were also limitations to groups which make applying these findings to broad populations difficult. VET students were limited to full time students in face-to-face delivery, which excluded those undertaking other modes of study. Participation in the intervention was limited to personal trainers who were registered with the peak body. It is possible that those who choose not to register with Fitness Australia would respond to the survey and the intervention differently.

When repeated surveys were collected, and with participation in the intervention, motivation was an extra factor, and participants may not have applied the same amount of effort in each survey completion. While it was considered that the opportunity to gain CEC points for free would be an attractive incentive for participation in the intervention, the dropout rate suggests that this may not have been enough to ensure commitment to the program.

Finally, although some longitudinal results were gathered, it was not possible to follow VET students into professional practice, or to assess the changes in exercise science students over the course of the degree. Instead, cross-sectional methods were relied on, limiting the ability to draw conclusions about changes in Misconceptions or critical thinking ability in individuals over time. Due to time constraints long-term follow up on participants, to assess the impact of professional practice on Knowledge or Misconceptions, or whether the effect of the critical thinking interventions was maintained, was not possible. This also means that changes in the sources of information used by participants may not have been identified in this short timeframe, as the questions regarding sources ask about sources accessed in the previous 12 months. Therefore participants may have

benefitted quite significantly from the critical thinking intervention, but any changes in their use of sources would not be identified in the current survey.

7.9 Directions for Future Research

The changing nature of misconceptions was discussed in the limitations to this research. Previous research has examined the popularity of misconceptions in students, but there is little research examining the change in misconceptions over time. Doing so could inform the practice of educators in both VET and higher education, as they could present information to meet the needs of correcting changing misconceptions.

This research presents the first time VET students and graduates in Australia have been assessed for critical thinking ability. For a personal trainer to provide a high quality, individualised service for a client can be a complex problem solving and planning exercise, and personal trainers are taking responsibility for increasingly diverse and complex clients. Further investigation is required to determine the process personal trainers undertake to identify, and use, the information required to perform these tasks.

The context of these findings is clearly the fitness industry, but there is no reason they could not be applied more widely, with different interventions using the same strategy. Future research could examine whether the approach used in the present research could be applied to other vocationally qualified professions, or other areas where misconceptions are common, such as education, medicine, or examining nutrition more specifically.

There was limited opportunity for longitudinal data to be collected in this research. Longer term research examining the change in misconceptions or critical thinking ability throughout a degree would be helpful, as most of the prior research is also cross-sectional. Also, longitudinal assessment of the misconceptions and critical thinking ability of VET qualified personal trainers may better identify the effectiveness of the current system for professional development in Australia. Repeated, long term follow-up on the effectiveness of critical thinking interventions in this group could also identify whether the short term, explicit instruction of critical thinking (such as the present research), has a lasting effect on critical thinking ability, or merely a short-term benefit that reverses over time.

This research also identified a significant gap in knowledge in the critical thinking ability of VET students, and VET trainers. Identifying the level of scientific and information literacy, and critical analysis skills of these groups, could assist with identifying mismatches with the requirements of job roles, and inform the development of future training packages, and content of lower levels of the AQF framework.

7.10 Conclusions

This research presents the first known investigation into the critical thinking ability of exercise professionals, and VET students, the first assessment of misconceptions in VET students, and the first attempt at improving the critical thinking ability of exercise professionals. A summary of the key research aims, findings, and recommendations is provided in Table 7.1. The results highlight that Misconceptions were lower in more progressed higher education students and professionals, and critical thinking ability was better. VET students scored lower in Misconceptions as a result of their course, and were no different to experienced personal trainers. Lastly, an online, domain specific critical thinking intervention was effective in reducing Misconceptions, and improving critical thinking ability. The possession of misconceptions, and trust in less reliable sources, of VET students and graduates presents a significant failing in the skills of personal trainers, who need to be highly autonomous in their work, and may lack exposure to more qualified professionals to help them with their selection, and interpretation, of information.

The success of the critical thinking intervention suggests that explicit instruction in critical thinking can lead to improvements in the sources of information personal trainers use, and their knowledge. This could lead to improvements in personal trainers' professional practice, potentially improving client outcomes and safety. This could also be applied to VET students, potentially through explicit instruction, or embedding these skills into an updated fitness training package. This is particularly important given that the professional development vocationally qualified personal trainers are exposed to does not appear to reduce the presence of misconceptions.

Improvements in critical thinking skills are a valuable outcome, and should be encouraged in all areas of education to enhance independent, lifelong learning.

Where Ausubel (1968) encouraged educators to identify the gaps in knowledge of their students, these critical thinking skills allow us to do this for ourselves, and direct our own learning, while avoiding misconceptions.

Table 7.1. Summary of research aims, key findings, and recommendations.

Chapter	Research Aim	Finding	Recommendations
	To identify fundamental exercise and nutrition misconceptions prevalent in students and graduates	10 out of 13 examined misconceptions (MISC) were thought to be present in students or graduates, and were included in development of the survey	n/a
3	To identify the potential methods of correcting misconceptions	Both direct instruction and active learning strategies were identified, as well as improving critical thinking ability (CTA)	An appreciation of the complexity of physiological systems should be fostered, to prevent MISC developing
	To explore pedagogical and ontological sources of misconceptions	Incomplete or shallow understanding was the main pedagogical source, while poor sources were identified as sources outside the classroom	Instruction in critical thinking, and the quality of sources in vocational education (VET) could reduce the use of poor sources of information
	To assess the presence of misconceptions in exercise science students, professionals, and the public	MISC were present in students entering the course, but less so in the public. They were reduced at the end of the course, and were lower again in professionals	Students may bring MISC into their course through their own reading – greater emphasis on CTA in the public is needed
	To determine if misconceptions were related to lower critical thinking ability	Higher critical thinking ability was associated with, and predicted, misconceptions	The role of explicit instruction in CTA in correcting MISC should be examined further
4	To explore relationships between confidence, knowledge, and misconceptions	Confidence and knowledge were higher, and MISC lower, in more qualified groups	Direct instruction to improve exercise and nutrition knowledge in the public can be used to reduce MISC
	To identify if sources of information were associated with misconceptions	Trust in less reliable sources was associated with MISC. Professionals had more trust in reliable sources, and less trust in unreliable sources	Improving the ability to find, and appreciation of, high quality sources could be used to reduce the presence of MISC
	To assess changes in misconceptions and critical thinking ability over a vocational fitness course, and compare this to practicing personal trainers	Knowledge increased, and MISC decreased, during a VET fitness course. Personal trainers were not significantly better in these scores than students	Personal trainers should be encouraged to pursue higher level qualifications (i.e. diplomas) to further reduce MISC
	To determine if misconceptions were related to lower critical thinking ability	Higher critical thinking ability was not associated with, and did not predict, misconceptions	The role of explicit instruction in CTA in correcting MISC should be examined further
5	To explore the relationship between confidence, knowledge, and misconceptions	Knowledge was not associated with MISC. Confidence was associated with knowledge, but not MISC. Trainers do not have the skills to assess errors in their knowledge	The role of explicit instruction in CTA in correcting MISC should be examined further
	To identify if sources of information were associated with misconceptions	Trust in less reliable sources was associated with MISC, but only half of personal trainers used reliable sources	Greater instruction in finding and appraising sources should be included in VET fitness training
	To assess the impact of an online, domain specific critical thinking intervention on misconceptions and critical thinking ability	This intervention improved CTA, and reduced MISC. Knowledge did not change	Embedding instruction in CTA in vocational training and professional development could reduce MISC in personal trainers
6	To assess changes in the sources of information used as a result of this intervention	Trust in reliable sources increased, and trust in unreliable sources decreased, due to the intervention	Instruction in CTA is required to help personal trainers choose appropriate sources

References

- Ab Kadir, M.A. (2017). What teacher knowledge matters in effectively developing critical thinkers in the 21st century curriculum? *Thinking Skills and Creativity*, 23, 79-90. doi:10.1016/j.tsc.2016.10.011
- Abdel-Hamid, T., Ankel, F., Battle-Fisher, M., Gibson, B., Gonzalez-Parra, G., Jalali, M., ... & Murphy, P. (2014). Public and health professionals' misconceptions about the dynamics of body weight gain/loss. *System Dynamics Review*, 30, 58-74. doi:10.1002/sdr.1517
- Abe, T., DeHoyos, D.V., Pollock, M.L., & Garzarella, L. (2000). Time course for strength and muscle thickness changes following upper and lower body resistance training in men and women. *European Journal of Applied Physiology and Occupational Physiology*, 81, 174-180. doi:10.1007/s004210050027
- Abrahamson, J.A., Fisher, K.E., Turner, A.G., Durrance, J.C., & Combs Turner, T. (2008). Lay information intermediary behaviour uncovered: exploring how nonprofessionals seek health information for themselves and others online. *Journal of the Medical Library Association*, 96, 310-323. doi: 10.3163/1536-5050.96.4.006
- Abrami, P.C., Bernard, R.M., Borokhovski, E., Waddington, D.I., Wade, C.A., & Persson, T. (2015). Strategies for teaching students to think critically: a meta-analysis. *Review of Educational Research*, 85, 275-314. doi:10.3102/0034654314551063
- Abrami, P.C., Bernard, R.M., Borokhovski, E., Wade, A., Surkes, M.A., Tamim, R., & Zhang, D. (2008). Instructional interventions affecting critical thinking skills and dispositions: a stage 1 meta-analysis. *Review of Educational Research*, 78, 1102-1134. doi: 10.3102/0034654308326084
- Adam, A., & Manson, T.M. (2014). Using a pseudoscience activity to teach critical thinking. *Teaching of Psychology*, 41, 130-134. doi:10.1177/0098628314530343
- Ahopelto, I., Mikkilä-Erdmann, M., Olkinuora, E., & Käätä, P. (2011). A follow up of medical students' biomedical understanding and clinical reasoning

concerning the cardiovascular system. *Advances in Health Sciences Education: Theory & Practice*, 16, 655-668. doi:10.1007/s10459-011-9286-3

- Alexander, M.E., Commander, N., Greenberg, D., & Ward, T. (2010). Using the Four-Questions technique to enhance critical thinking in online discussion. *Journal of Online Learning and Teaching*, 6, 409-415. Retrieved from http://jolt.merlot.org/vol6no2/alexander_0610.pdf
- Allen, J., Montalto, M., Lovejoy, J., & Weber, W. (2011). Detoxification in naturopathic medicine: a survey. *The Journal of Alternative and Complementary Medicine*, 17, 1175-1180. doi:10.1089/acm.2010.0572
- Alter, A.L., Oppenheimer, D.M., Epley, N., & Eyre, R.N. (2007). Overcoming intuition: metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology*, 136, 569-576. doi:10.1037/0096-3445.136.4.569
- Ambrose, I., Bonne, M., Chanock, K., Cunnington, C., Jardine, S., & Muller, J. (2013). "Like catching smoke": easing the transition from TAFE to university. *Journal of Academic Language and Learning*, 7, A120-131. Retrieved from <http://www.journal.aall.org.au/index.php/jall/article/viewArticle/257>
- American College of Sports Medicine, American Dietetic Association, Dietitians of Canada. (2009). Nutrition and athletic performance. *Medicine and Science in Sports and Exercise*, 41, 709-731. doi:10.1249/MSS.0b013e318190eb86
- Anderson, G., Elliot, B., & Woods, N. (2010). The Canadian personal training survey. *Journal of Exercise Physiology*, 13, 19-28. Retrieved from https://www.researchgate.net/profile/Gregory_Anderson5/publication/281391863_The_Canadian_Personal_Training_Survey/links/55e5260308aede0b57358c9c/The-Canadian-Personal-Training-Survey.pdf
- Andriessen, J., & Baker, M. (2016). Arguing to Learn. In: Sawyer, R.K. (Ed). *The Cambridge Handbook of the Learning Sciences* (pp. 439-460). Cambridge: Cambridge University Press

- Askew, E.W., & Hecker, A.L. (1976). Adipose tissue cell size and lipolysis in the rat: response to exercise intensity and food restriction. *The Journal of Nutrition*, *106*, 1351-1360. doi:10.1093/jn/106.9.1351
- Åstrand, I., Åstrand, P., Christensen, E.H., & Hedman, R. (1960). Intermittent muscular work. *Acta Physiologica Scandinavica*, *48*, 448-453. doi:10.1111/j.1748-1716.1960.tb01879.x
- Australian Bureau of Statistics. (2014). *Australian Health Survey: Nutrition First Results – Food and Nutrients, 2011-12*. Retrieved from <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.008~2011-12~Main%20Features~Preface~1>
- Australian Qualifications Framework Council. (2013). *Australian Qualifications Framework* (Second Edition). Retrieved from <https://www.aqf.edu.au/sites/aqf/files/aqf-2nd-edition-january-2013.pdf>
- Ausubel, D.P. (1968). *Educational Psychology: a Cognitive View*. New York, USA: Holt, Rinehart & Winston, Inc.
- Badenhorst, E., Mamede, S., Hartman, N., & Schmidt, H.G. (2015). Exploring lecturers' views of first-year students' misconceptions in biomedical domains. *Advances in Health Sciences Education*, *20*, 403-420. doi:10.1007/s10459-014-9535-3
- Badenhorst, E., Mamade, S., Abrahams, A., Bugarith, K., Friedling, J., Gunston, G., ... & Schmidt, H.G. (2016). First year medical students' naïve beliefs about respiratory physiology. *Advances in Physiology Education*, *40*, 342-348. doi:10.1152/advan.00193.2015
- Baechle, T.R., & Boyce, M. (1974). Resistance training for women. *Journal of Health, Physical Education, Recreation*, *45*, 28-29. doi:10.1080/00221473.1974.10622203
- Bandias, S., Fuller, D., & Pfitzner, D. (2011). Vocational and higher education in Australia: a need for closer collaboration. *Journal of Higher Education Policy and Management*, *33*, 583-94. doi:10.1080/1360080X.2011.621185

- Banting, W. (1864). *Letter on corpulence: addressed to the public*. Mohun, Ebbs & Hough: New York.
- Barnes, K., Ball, L., & Desbrow, B. (2016). Promotion of nutrition care by Australian fitness business: a website analysis. *Public Health, 140*, 45-49. doi:10.1016/j.puhe.2016.08.026
- Barnes, K., Desbrow, B., & Ball, L. (2016). Personal trainers are confident in their ability to provide nutrition care: a cross sectional investigation. *Public Health, 140*, 39-44. doi:10.1016/j.puhe.2016.08.020
- Baylor, A.L. (2001). A U-shaped model for the development of intuition by level of expertise. *New Ideas in Psychology, 19*, 237-244. doi:10.1016/S0732-118X(01)00005-8
- Behm, D.G., Blazeovich, A.J., Key, A.D., & McHugh, M. (2013). Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. *Applied Physiology, Nutrition and Metabolism, 41*, 1-11. doi:10.1139/apnm-2015-0235
- Bennie, J.A., Wiesner, G.H., van Uffelen, J.G.Z., Harvey, J.T., & Biddle, S.J.H. (2017). Sources of practice knowledge among Australian fitness trainers. *Translational Behavioral Medicine, 7*, 741-750. doi:10.1007/s13142-017-0482-4
- Bennie, J.A., Thomas, G., Wiesner, G.H., van Uffelen, J.G.Z., Khan, A., Kolbe-Alexander, T. ... & Biddle, S.J.H. (2018). Australian fitness professionals' level of interest in engaging with high health-risk population subgroups: findings from a national survey. *Public Health, 160*, 108-115. doi:10.1016/j.puhe.2018.03.035
- Bensley, D.A., & Lilienfeld, S.O. (2015). What is a psychological misconception? Moving towards an empirical answer. *Teaching of Psychology, 42*, 282-292. doi:10.1177/0098628315603059
- Bensley, D.A., Lilienfeld, S.O., & Powell, L.A. (2014). A new measure of psychological misconceptions: relations with academic background, critical

thinking, and acceptance of paranormal and pseudoscientific claims.

Learning and Individual Differences, 36, 9-18.

doi:10.1016/j.lindif.2014.07.009

Biemans, H., Nieuwenhuis, L., Poell, R., Mulder, M., & Wesselink, R. (2004).

Competence-based VET in the Netherlands: background and pitfalls. *Journal of Vocational Education and Training*, 56, 523-528.

doi:10.1080/13636820400200268

Bird, S.P., Tarpenning, K.M., & Marino, F.E. (2005). Designing resistance training programmes to enhance muscular fitness. *Sports Medicine*, 35, 841-851.

doi:10.2165/00007256-200535100-00002

Bishoff, J.P. (2010). *Utilization of the seven principles for good practice in undergraduate education in general chemistry by community college instructors*. (Doctoral dissertation). Retrieved from

<https://www.researchrepository.wvu.edu/cgi/viewcontent.cgi?article=3959&context=etd>

Bishop, D. (2003). Warm up I: potential mechanisms and the effects of passive warm up on exercise performance. *Sports Medicine*, 33, 439-454.

doi:10.2165/00007256-200333060-00005

Bjelakovic, G., Nikolaya, D., Gluud, L.L., Simonetti, R.G., & Gluud, C. (2007).

Mortality in randomized trials of antioxidant supplements for primary and secondary prevention. *Journal of the American Medical Association*, 297, 842-857. doi:10.1001/jama.297.8.842

Blessing, S.B. & Blessing, J.S. (2010). PsychBusters: a means of fostering critical thinking in the introductory course. *Teaching of Psychology*, 37, 178-182.

doi: 10.1080/00986283.2010.488540

Bloom, P., & Weisberg, D.S. (2007). Childhood origins to adult resistance to science. *Science*, 316, 996-997. doi:10.1126/science.1133398

Borglin, G., & Fagerström, C. (2012). Nursing students' understanding of critical thinking and appraisal and academic writing: a descriptive, qualitative study.

Nurse Education in Practice, 12, 356-360. doi:10.1016/j.nepr.2012.04.009

- Børsheim, E., & Bahr, R. (2003). Effect of exercise intensity, duration, and mode on post-exercise oxygen consumption. *Sports Medicine*, *33*, 1037-1060.
doi:10.2165/00007256-200333140-00002
- Boudry, M., Paglieri, F., & Pigliucci, M. (2015). The fake, the flimsy, and the fallacious: demarcating arguments in real life. *Argumentation*, *29*, 431-456.
doi:10.1007/s10503-015-9359-1
- Boutcher, S.H. (2011). High-intensity intermittent exercise and fat loss. *Journal of Obesity*, *2011*, 1-10. doi:10.1155/2011/868305
- Brown, G.A. (2006). Teaching skeletal muscle adaptations to aerobic exercise using an American Physiological Society classic paper by Dr. Phillip Gollnick and colleagues. *Advances in Physiology Education*, *30*, 113-118.
doi:10.1152/advan.00054.2005
- Brunner-Zielger, S., Strasser, B., & Haber, P. (2011). Comparison of metabolic and biomechanic responses to active vs. passive warm-up procedures before physical exercise. *Journal of Strength & Conditioning Research*, *25*, 909-914. doi:10.1519/JSC.0b013e3181d640da
- Buchwald, K.W. & Cori, C.F. (1931). Influence of repeated contraction of muscle on its lipid content. *Proceedings of the Society for Experimental Biology & Medicine*, *28*, 737-43. doi:10.3181/00379727-28-5508
- Burkley, E., & Burkley, M. (2009). Mythbusters: a tool for teaching research methods in psychology. *Teaching of Psychology*, *36*, 179-184.
doi:10.1080/00986280902739586
- Burnett, A.J., Livingstone, K.M., Woods, J.L., & McNaughton, S.A. (2017). Dietary supplement use among Australian adults: findings from the 2011-2012 National Nutrition and Physical Activity Survey. *Nutrients*, *9*, 1248-1259.
doi:10.3390/nu9111248
- Burns, R.D., Schiller, M.S., Merrick, M.A., & Wolf, K.N. (2004). Intercollegiate student athlete use of nutritional supplements and the role of athletic trainers and dietitians in nutrition counseling. *Journal of the American Dietetic Association*, *104*, 246-249. doi:10.1016/j.jada.2003.11.013

- Cacioppo, J.T., & Petty, R.E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, 42, 116-131. doi:10.1037/0022-3514.42.1.116
- Caldwell, J.E., Ahonen, E., & Nousiainen, U. (1984). Differential effects of sauna-, diuretic-, and exercise-induced hypohydration. *Journal of Applied Physiology*, 57, 1018-1023. doi:10.1152/jappl.1984.57.4.1018
- Campitelli, G., & Gerrans, P. (2013). Does the cognitive reflection test measure cognitive reflection? A mathematical modelling approach. *Memory & Cognition*, 42, 434-447. doi:10.3758/s13421-013-0367-9
- Cavanaugh, J.K., & Jacquemin, S.J. (2015). A large sample comparison of grade based student learning outcomes in online vs. face-to-face courses. *Online Learning*, 19, 1-8. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.875.9734&rep=rep1&type=pdf>
- Central YMCA Qualifications (2014). *Tomorrow's exercise professionals*. Central YMCA Qualifications. Retrieved from: <http://www.spectrum-fit.co.uk/docs/cyq-tomorrows-exercise-professionals-report-oct-2014.pdf>
- Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: analysis of a new learning management model for Thai high schools. *Journal of International Studies*, 11, 37-48. doi: 10.14254/2071-8033.2018/11-2/3
- Cheawjindakarn, B., Suwannatthachote, P., & Theeraroungchaisri, A. (2012). Critical success factors for online distance learning in higher education: a review of the literature. *Creative Education*, 3, 61-66. doi:10.4236/ce.2012.38B014
- Checkley, E. (1890). *A natural method of physical training: making muscle and reducing flesh without dieting or apparatus*. (10th Ed). Brooklyn, NY: William C. Bryant & Co. Retrieved from: <https://archive.org/details/naturalmethodofp01chec>

- Cheung, K., Hume, P.A., & Maxwell, L. (2003). Delayed onset muscle soreness: treatment strategies and performance factors. *Sports Medicine*, 33, 145-164. doi:10.2165/00007256-200333020-00005
- Chi, M.T.H. (2005). Commonsense conceptions of emergent processes: why some misconceptions are robust. *The Journal of the Learning Sciences*, 14, 161-199. doi:10.1207/s15327809jls1402_1
- Chi, M.T.H. (2013). Two kinds and four sub-types of misconceived knowledge, ways to change it, and the learning outcomes. In S. Vosniadou (Ed.), *International Handbook on Conceptual Change* (pp. 49-70). Routledge.
- Chi, M.T.H., & Slotta, J.D. (1993). The ontological coherence of intuitive physics. *Cognition and Instruction*, 10, 249-260. doi:10.1080/07370008.1985.9649011
- Chickering, A.W. & Gamson, Z.F. (1987, March). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 3-7. Retrieved from <https://files.eric.ed.gov/fulltext/ED282491.pdf>
- Clawson, R.A., Deen, R.E., & Oxley, Z.M. (2002). Online discussions across three universities: student participation and pedagogy. *PS: Political Science & Politics*, 35, 713-718. doi:10.1017/S1049096502001233
- Cleak, M.J., & Eston, R.G. (1992). Delayed onset muscle soreness: mechanisms and management. *Journal of Sports Sciences*, 10, 325-341. doi:10.1080/02640419208729932
- Clement, D.B., & Taunton, J.E. (1980). A guide to the prevention of running injuries. *Canadian Family Physician*, 26, 543-548. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2383477/>
- Cliff, W.H. (2006). Case study analysis and the remediation of misconceptions about respiratory physiology. *Advances in Physiology Education*, 30, 215-223. doi:10.1152/advan.00002.2006
- Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

- Coldwell, J., Paterson, P.T., & Mustard, J. (2008). Online students: relationships between participation, demographics and academic performance. *Electronic Journal of e-Learning*, 6, 19-30. Retrieved from <http://dro.deakin.edu.au/view/DU:30017242>
- Crawford-Ferre, H.G., & Wiest, L.R. (2012). Effective online instruction in higher education. *Quarterly Review of Distance Education*, 13, 11-14. Retrieved from: http://www.siue.edu/~lmillio/IT598/Resources/04_assessment/Effective%20Online%20Instruction.pdf
- Crews, T.B., Wilkinson, K., & Neill, J.K. (2015). Principles for good practice in undergraduate education: effective online course design to assist students' success. *Journal of Online Learning and Teaching*, 11, 87-103. Retrieved from https://sc.edu/about/offices_and_divisions/cte/distributed_learning/docs/principles_good_practice_undergraduate_education_crews.pdf
- CrossFit (n.d.). About affiliation. Retrieved from <https://www.crossfit.com/affiliate>
- Cureton, K.J., Collins, M.A., Hill, D.W., & McElhannon, F.M. (1988). Muscle hypertrophy in men and women. *Medicine and Science in Sports and Exercise*, 20, 338-344. Retrieved from <https://journals.lww.com/acsm-msse/pages/articleviewer.aspx?year=1988&issue=08000&article=00003&type=abstract>
- Cuthbertson, D.P. (1925). The distribution of phosphorus and fat in the resting and fatigued muscle of the cat, with a note on the partition of phosphorus in the blood. *Biochemical Journal*, 19, 896-910. doi:10.1042/bj0190896
- Davies, M. (2013). Critical thinking and the disciplines reconsidered. *Higher Education Research and Development*, 32, 529-544. doi:10.1080/07294360.2012.697878
- Dawson, M.C. (2017). CrossFit: fitness cult or reinventive institution? *International Review for the Sociology of Sport*, 52, 361-379. doi:10.1177/1012690215591793

- DeGolier, T.F. (2010). Using critical-thinking skills to substantiate or challenge controversial claims endorsing a myriad of weight-loss products. *The American Biology Teacher*, 72, 545-550. doi:10.1525/abt.2010.72.9.5
- De Lyon, A.T.C., & Cushion, C.J. (2013). The acquisition and development of fitness trainers' professional knowledge. *Journal of Strength and Conditioning Research*, 27, 1407-1422. doi:10.1519/JSC.0b013e3182653cc1
- Dietrich, J., Keyzer, P., Coyle, I.R., Norton, K., Sekendiz, B., Jones, V., & Finch, C.F. (2013). Train the trainers: maintaining standards to minimise injuries and avoid legal liability in the fitness industry. *Australian and New Zealand Sports Law Journal*, 8, 89-106. doi: 10.1016/j.jsams.2014.11.017
- Dekker, S., Lee, N.C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology*, 3, 1-8. doi:10.3389/fpsyg.2012.00429
- Diviani, N., van den Putte, B., Giani, S., & van Weert, J.C.M. (2015). Low health literacy and evaluation of online health information: a systematic review of the literature. *Journal of Medical Internet Research*, 17. doi: 10.2196/jmir.4018
- Dietz-Uhler, B., & Lanter, J.R. (2009). Using the Four-Questions Technique to enhance learning. *Teaching of Psychology*, 36, 38-41. doi:10.1080/00986280802529327
- diSessa, A.A. (2006). A history of conceptual change research: threads and fault lines. In Sawyer, R.K. (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 88-108). Cambridge University Press.
- Dole, J.A., & Sinatra, G.M. (1998). Reconceptualizing change in the cognitive construct of knowledge. *Educational Psychologist*, 33, 109-129. doi:10.1080/00461520.1998.9653294
- Duellman, M.C., Lukaszuk, J.M., Prawitz, A.D., & Brandenburg, J.P. (2008). Protein supplement users among high school athletes and misconceptions about effectiveness. *Journal of Strength & Conditioning Research*, 22, 1124-1129. doi:10.1519/JSC.0b013e31817394b9

- Duscha, B.D., Johnson, J.L., Huffman, K., Houmard, J., & Krause, W.E. (2012). Exercise dose response in muscle. *International Journal of Sports Medicine*, 33, 218-223. doi:10.1055/s-0031-1291323
- Ebben, W.P. & Jenson, R.L. (1998). Strength training for women. *The Physician and Sportsmedicine*, 26, 86-97. doi:10.3810/psm.1998.05.1020
- Ecker, U.K.H., Lewandowsky, S., Fenton, O., & Martin, K. (2014). Do people keep believing because they want to? Preexisting attitudes and the continued influence of misinformation. *Memory and Cognition*, 42, 292-304. doi: 10.3758/s13421-013-0358-x
- Ekkekakis, P., Albee, M.J., & Zenko, Z. (2016). Knowledge of exercise prescription guidelines across one 4-year kinesiology curriculum. *Research Quarterly for Exercise and Sport*, 87, 124-130. doi:10.1080/02701367.2015.1083524
- Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, 62, 107-115. doi: 10.1111/j.1365-2648.2007.04569.x
- Ennis, R.H. (1993). Critical thinking assessment. *Theory Into Practice*, 32, 179-186. doi:10.1080/00405849309543594
- Ernst, E. (2008). Chiropractic: a critical evaluation. *Journal of Pain and Symptom Management*, 35, 544-562. doi: 10.1016/j.jpainsymman.2007.07.004
- Ernst, E. (2012). Alternative detox. *British Medical Bulletin*, 101, 33-38. doi:10.1093/bmb/lds002
- Evans, J. St B. T. (1984). Heuristic and analytic processes in reasoning. *British Journal of Psychology*, 75, 451-468. doi:10.1111/j.2044-295.1984.tb01915.x
- Eysenbach, G., Powell, J., Kuss, O., & Sa, E. (2002). Empirical studies assessing the quality of health information for consumers on the World Wide Web. *Journal of the American Medical Association*, 287, 2691-2700. doi:10.1001/jama.287.20.2691
- Fabriger, L.R., Wegener, D.T., MacCallum, R.C., & Strahan, E.J. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods*, 4, 272-299. Retrieved from <http://personal.psu.edu/jxb14/M554/articles/Fabrigaretal1999.pdf>

- Facione, P.A. (1990). *Critical thinking: a statement of expert consensus for purposes of educational assessment and instruction*. Retrieved from American Philosophical Association, <https://philarchive.org/archive/FACCTA>
- Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioural, and biomedical sciences. *Behavior Research Methods*, 39, 175-191.
doi:10.3758/BF03193146
- Fitness Australia (2014). *Position Statement: Scope of Practice for Registered Exercise Professionals*. Retrieved from <https://fitness.org.au/articles/policies-guidelines/scope-of-practice-for-ausreps/4/38/20>
- Fitness Australia (2016). *Profile of the Fitness Industry in Australia: Fitness Industry Workforce 2016*. Retrieved from <https://fitness.org.au/articles/category/profile-of-the-australian-fitness-industry-2016/108/19>
- Flann, K.L., LaStayo, P.C., McClain, D.A., Hazel, M., & Lindstedt, S.L. (2011). Muscle damage and muscle remodelling: no pain, no gain? *The Journal of Experimental Biology*, 214, 674-679. doi:10.1242/jeb.050112
- Fong, C.J., Kim, Y., Davis, C.W., Hoang, T., & Kim, Y.W. (2017). A meta-analysis on critical thinking and community college student achievement. *Thinking Skills and Creativity*, 26, 71-83. doi:10.1016/j.tsc.2017.06.002
- Forrest, S.P., & Peterson, T.O. (2006). It's called andragogy. *Academy of Management Learning & Education*, 5, 113-122.
doi:10.5465/amle.2006.20388390
- Fortmann, S.P., Burda, B.U., Senger, C.A., Lin, J.S., & Whitlock, E.P. (2013). Vitamin and mineral supplements in the primary prevention of cardiovascular disease and cancer. *Annals of Internal Medicine*, 159, 824-838.
doi:10.7326/0003-4819-159-12-201312170-00729
- Fox, S., & Duggan, M. (2013). *Health online 2013*. Retrieved from Pew Research Centre <http://www.pewinternet.org/2013/01/15/health-online-2013/>

- Frantz, T.L., & Ruiz, M.D. (2011). Effects of dynamic warm-up on lower body explosiveness among collegiate baseball players. *Journal of Strength & Conditioning Research*, 25, 2985-2990. doi:10.1519/JSC.0b013e31820f509b
- Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19, 25-42. doi:10.1257/089533005775196732
- Freedman, M.R., King, J., & Kennedy, E. (2001). Popular diets: a scientific review. *Obesity Research*, 9, 1S-40S. doi:10.1038/oby.2001.113
- Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism*, 14, 104-120. doi:10.1123/ijsnem.14.1.104
- Gardner, R.M., & Brown, D.L. (2013). A test of contemporary misconceptions in psychology. *Learning and Individual Differences*, 24, 211-215. doi:10.1016/j.lindif.2012.12.008
- Gardner, R.M., & Dalsing, S. (1986). Misconceptions about psychology among college students. *Teaching in Psychology*, 13, 32-34. doi:10.1207/s15328023top1301_9
- Gavin, J. (1996). Personal trainers' perceptions of role responsibilities, conflicts, and boundaries. *Ethics and Behavior*, 6, 55-69. doi:10.1207/s15327019eb0601_4
- Geer, E.B., & Shen, W. (2009) Gender difference in insulin resistance, body composition, and energy balance. *Gender Medicine*, 6, 60-75. doi:10.1016/j.genm.2009.02.002
- Genoni, A., Lo, J., Lyons-Wall, P., & Devine, A. (2016). Compliance, palatability and feasibility of Palaeolithic and Australian Guide to Healthy Eating diets in healthy women: a 4-week intervention. *Nutrients*, 8, 4-9. doi:10.3390/nu8080481
- Giancarlo, C.A., Blohm, S.W., & Urdan, T. (2004). Assessing secondary students' disposition toward critical thinking: development of the California Measure of Mental Motivation. *Educational and Psychological Measurement*, 64, 347-364. doi:10.1177/0013164403258464

- Gleichgerrcht, E., Luttges, B.L., Salvarezza, F., & Campos, A.L. (2015). Educational neuromyths among teachers in Latin America. *Mind, Brain and Education, 9*, 170-178. doi:10.1111/mbe.12086
- Gliedt, J.A., Briggs, S., Williams, J.S.M., Smith, D.P., & Blampied, J. (2012). Background, expectations and beliefs of a chiropractic student population: a cross-sectional survey. *Journal of Chiropractic Education, 26*, 146-160. doi:10.7899/JCE-11-031
- Gonczi, A., & Hager, P. (2010). The competency model. *International Encyclopedia of Education, 8*, 403-410. doi:10.1016/B978-0-08-044894-7.00790-9
- Goop (n.d.). The power of infrared saunas. Retrieved from <https://goop.com/wellness/detox/the-power-of-infrared-saunas/>
- Goston, J.L., & Correia, M.I.T.D. (2010). Intake of nutritional supplements among people exercising in gyms and influencing factors. *Nutrition, 26*, 604-611. doi:10.1016/j.nut.2009.06.021
- Gowlett, J.A.J. (2003). What actually was the Stone Age Diet? *Journal of Nutritional and Environmental Medicine, 13*, 143-147. doi:10.1080/13590840310001619338
- Grant, M.R. & Thornton, H.R. (2007). Best practices in undergraduate adult-centred online learning: mechanisms for course design and delivery. *Journal of Online Learning and Teaching, 3*, 346-356. Retrieved from <http://jolt.merlot.org/documents/grant.pdf>
- Gray, C., Turner, R., Sutton, C., Petersen, C., Stevens, S., Swain, J., ... & Thackeray, D. (2015). Research methods teaching in vocational environments: developing critical engagement with knowledge? *Journal of Vocational Education and Training, 67*, 274-293. doi:10.1080/13636820.2015.1050443
- Griffin, T. (2014). *Disadvantaged learners and VET to higher education transitions*. Retrieved from National Centre for Vocational Education Research <https://www.ncver.edu.au/research-and-statistics/publications/all-publications/disadvantaged-learners-and-vet-to-higher-education-transitions>

- Grodstein, F., O'Brien, J., Kang, J.H., Dushkes, R., Cook, N.R., Okereke, O., ... & Sesso, H.D. (2013). Long-term multivitamin supplementation and cognitive function in men. *Annals of Internal Medicine*, *159*, 806-814.
doi:10.7326/0003-4819-159-12-201312170-00006
- Gruber, A., Knefe, M., Waelchli, P., & Schreyer, J. (2008). Modeling scholarly inquiry: one article at a time. *College and Undergraduate Libraries*, *15*, 99-125. doi:10.1080/10691310802177085
- Guiller, J., Durndell, A., & Ross, A. (2008). Peer interaction and critical thinking: face-to-face or online discussion? *Learning and Instruction*, *18*, 187-200.
doi:10.1016/j.learninstruc.2007.03.001
- Guthrie, H. (2010). *Professional development in the vocational education and training workplace*. Retrieved from National Centre for Vocational Education Research <https://www.ncver.edu.au/research-and-statistics/publications/all-publications/professional-development-in-the-vocational-education-and-training-workforce>
- Gwinup, G., Chelvam, R., & Steinburg, T. (1971). Thickness of subcutaneous fat and activity of underlying muscles. *Annals of Internal Medicine*, *74*, 408-411.
doi:10.7326/0003-4819-74-3-408
- Hall, A.K., Bernhardt, J.M., Dodd, V., & Vollrath, M.W. (2015). The digital health divide: evaluating online health information access and use among older adults. *Health Education and Behaviour*, *42*, 202-209.
doi:10.1177/1090198114547815
- Halliday-Wynes, S., & Misko, J. (2012). *Assessment issues in VET: minimising the level of risk*. Retrieved from National Centre for Vocational Education Research https://www.ncver.edu.au/_data/assets/file/0019/9019/assessment-issues-in-vet-2620.docx
- Halton, T.L., & Hu, F.B. (2004). The effects of high protein diets on thermogenesis, satiety and weight loss: a critical review. *Journal of the American College of Nutrition*, *23*, 373-385. doi:10.1080/07315724.2004.10719381

- Hammarström, A., Wiklund, A.F., Lindhal, B., Larsson, C., & Ahlgren, C. (2014). Experiences of barriers and facilitators to weight-loss in a diet intervention – a qualitative study of women in Northern Sweden. *BMC Women's Health*, *14*, 59. doi:10.1186/1472-6874-14-59
- Hannust, T., & Kikas, E. (2006). Children's knowledge of astronomy and its change in the course of learning. *Early Childhood Research Quarterly*, *22*, 89-104. doi: 10.1016/j.ecresq.2006.11.001
- Herbold, N.H., Vazquez, I.M., Goodman, E., & Emans, S.J. (2004). Vitamin, mineral, herbal, and other supplement use by adolescents. *Topics in Clinical Nutrition*, *19*, 266-272. Retrieved from https://journals.lww.com/topicsinclinicalnutrition/Abstract/2004/10000/Vitamin_Mineral_Herbal_and_Other_Supplement_Use.2.aspx
- Hoffman, K., & Elwin, C. (2004). The relationship between critical thinking and confidence in decision-making. *Australian Journal of Advanced Nursing*, *22*, 8-12. Retrieved from: <https://search-proquest-com.dbgw.lis.curtin.edu.au/docview/236160617?accountid=10382>
- Holloway, J.B., & Baechle, T.R. (1990). Strength training for female athletes. *Sports Medicine*, *9*, 216-228. doi:10.2165/00007256-199009040-00003
- Holmes, G., & Abington-Cooper, M. (2000). Pedagogy vs. andragogy: a false dichotomy? *The Journal of Technology Studies*, *26*, 51-55. Retrieved from <https://scholar.lib.vt.edu/ejournals/JTS/Summer-Fall-2000/pdf/holmes.pdf>
- Hooper, L., Martin, N., Abdelhamid, A., & Davey Smith, G. (2015). Reduction in saturated fat intake for cardiovascular disease. *Cochrane Database of Systematic Reviews*, *2015*, 1-150. doi:10.1002/14651858.CD011737
- Horn, L., Nevill, S., & Griffith, J. (2006). *Profile of undergraduates in US postsecondary education institutions: 2003-04*. Retrieved from National Center for Education Statistics <https://eric.ed.gov/?id=ED491908>
- Horswill, C.A., Stofan, J.R., Lacambra, M., Toriscelli, T.A., Eichner, E.R., Murray, R. (2009). Sodium balance during US football training in the heat: cramp-

prone vs. reference players. *International Journal of Sports Medicine*, 30, 789-794. doi:10.1055/s-0029-1234056

Horvath, J.C., Donoghue, G.M., Horton, A.J., Lodge, J.M., & Hattie, J.A.C. (2018). On the irrelevance of neuromyths to teacher effectiveness: comparing neuro-literacy levels amongst award-winning and non-award winning teachers. *Frontiers in Psychology*, 9, 1-5. doi:10.3389/fpsyg.2018.01666

Hsieh, H., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15, 1277-1288. doi:10.1177/1049732305276687

Hughes, S., Lyddy, F., Kaplan, R., Nichols, A.L., Miller, H., Saad, C.G., ... & Lynch, A. (2015). Highly prevalent but not always persistent: undergraduate and graduate students' misconceptions about psychology. *Teaching of Psychology*, 42, 34-42. doi:10.1177/0098628314562677

Hughes, S., Lyddy, F., & Lambe, S. (2013). Misconceptions about psychological science: a review. *Psychology Learning & Teaching*, 12, 20-31. doi:10.2304/plat.2013.12.1.20

Hussain, J., & Cohen, M. (2018). Clinical effects of regular dry sauna bathing: a systematic review. *Evidence-Based Complementary and Alternative Medicine*, 2018, 1-30. doi:10.1155/2018/1857413

Hyman, M., Quinn, S., Marshall, L.A., & Snyder, S. (2007). *Managing biotransformation: the metabolic, genomic, and detoxification balance points. The proceedings from the 13th International Symposium of the Institute for Functional Medicine*. Retrieved from: http://www.alternative-therapies.com/at/web_pdfs/ifm_proceedings_low.pdf

Ikuenobe, P. (2001). Teaching and assessing critical thinking abilities as outcomes in an informal logic course. *Teaching in Higher Education*, 6, 19-32. doi:10.1080/13562510020029572

Innes, S.I., Leboeuf-Yve, C., & Walker, B.F. (2018). How frequent are non-evidence-based health care beliefs in chiropractic students and do they vary

across the pre-professional educational years. *Chiropractic and Manual Therapies*, 26, 1-9. doi:10.1186/s12998-018-0178-y

Innovex (2018). Work it out: lose weight or gain muscle with a sauna. Retrieved from <https://www.poolsource.com/work-out-lose-weight-or-gain-muscle-with-sauna/>

Jackson, D., & Chapman, E. (2012). Non-technical competencies in undergraduate business degree programs: Australian and UK perspectives. *Studies in Higher Education*, 37, 541-567. doi:10.1080/03075079.2010.527935

Jacobson, B.H., & Aldana, S.G. (1992). Current nutrition practice and knowledge of varsity athletes. *Journal of Applied Sport Science Research*, 6, 232-238. Retrieved from https://journals.lww.com/nsca-jscr/abstract/1992/11000/current_nutrition_practice_and_knowledge_of.7.aspx

Jacobson, B.H., Sobonya, C., & Ransone, J. (2001). Nutrition practices and knowledge of college varsity athletes: a follow-up. *Journal of Strength and Conditioning Research*, 15, 63-68. doi:10.1519/00124278-200102000-00011

Jeffery, R.W., Wing, R.R., Thorson, C., & Burton, L.R. (1998). Use of personal trainers and financial incentives to increase exercise in a behavioral weight-loss program. *Journal of Consulting and Clinical Psychology*, 66, 777-783. doi:10.1037/0022-006X.66.5.777

Jiménez-Aleixandre, M.J. & Erduran, S. (2007). In Erduran, S., & Jiménez-Aleixandre, M.J. (Eds). *Argumentation in Science Education* (pp. 3-28) Springer.

Jung, A.P., Bishop, P.A., Al-Nawwas, A., Dale, R.B. (2005). Influence of hydration and electrolyte supplementation on incidence and time to onset of exercise-associated muscle cramps. *Journal of Athletic Training*, 40, 71-75. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1150229/>

Kahnemann, D., & Klein, G. (2009). Conditions for intuitive expertise. *American Psychologist*, 64, 515-526. doi:10.1037/a0016755

- Kalelioğlu, F., & Gülbahar, Y. (2014). The effect of instructional techniques on critical thinking and critical thinking dispositions in online discussion. *Educational Technology and Society, 17*, 248-258. Retrieved from <http://www.jstor.org/stable/jeductechsoci.17.1.248>
- Kauppinen, K. (1997). Facts and fables about sauna. *Annals of the New York Academy of Sciences, 813*, 654-662. doi:10.1111/j.1749-6632.1997.tb51764.x
- Keengwe, J. & Kidd, T.T. (2010). Towards best practices in online learning and teaching in higher education. *Journal of Online Learning and Teaching, 6*, 533-541. Retrieved from http://jolt.merlot.org/vol6no2/keengwe_0610.pdf
- Kieffer, H.S. (2008). Myths and truths from exercise physiology. *Journal of Physical Education, Recreation & Dance, 79*, 23-25. doi:10.1080/07303084.2008.10598227
- Klaczynski, P.A. & Lavalley, K.L. (2005). Domain-specific identity, epistemic regulation, and intellectual ability as predictors of belief-based reasoning: a dual process perspective. *Journal of Experimental Child Psychology, 92*, 1-24. doi:10.1016/j.jecp.2005.05.001
- Klein, A.V., & Kiat, H. (2014). Detox diets of toxin elimination and weight management: a critical review of the evidence. *Journal of Human Nutrition and Dietetics, 28*, 675-686. doi:10.1111/jhn.12286
- Klimek, C., Ashbeck, C., Brook, A.J., & Durall, C. (2018). Are injuries more common with CrossFit training than other forms of exercise? *Journal of Sport Rehabilitation, 27*, 295-299. doi:10.1123/jsr.2016-0040
- Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory, 6*, 107-118. doi:10.1037/0278-7393.6.2.107
- Kostek, M.A., Pescatello, L.S., Seip, R.L., Angelopoulos, T.J., Clarkson, P.M., Gordon, P.M., ... Price, T.B. (2007). Subcutaneous fat alterations resulting from an upper-body resistance training program. *Medicine and Science in Sports and Exercise, 39*, 1177-1185. doi:10.1249/mss.0b0138058a5cb

- Kowalski, P. & Taylor, A.K. (2009). The effect of refuting misconceptions in the introductory psychology class. *Teaching of Psychology, 36*, 153-159. doi:10.1080/00986280902959986
- Kraemer, W.J., & Ratamess, N.A. (2004). Fundamentals of resistance training: progression and exercise prescription. *Medicine and Science in Sports and Exercise, 36*, 674-688. doi:10.1249/01.MSS.0000121945.36635.61
- Kreider, R.B., Wilborn, C.D., Taylor, L., Campbell, B., Almada, A.L., Collins, R., ... & Antonio, J. (2010). ISSN exercise and sport nutrition review: research and recommendations. *Journal of the International Society of Sports Nutrition, 7*, 1-43. doi:10.1186/1550-2783-1-1-1
- Krotkiewski, M., Aniansson, A., Grimby, G., Björntorp, P., & Sjöström, L. (1979). The effect of unilateral isokinetic strength training on adipose and muscle tissue morphology, thickness, and enzymes. *European Journal of Applied Physiology & Occupational Physiology, 42*, 271-281. doi:10.1007/BF00423297
- Krueger, J., & Mueller, R.A. (2002). Unskilled, unaware, or both? The better-than-average heuristic and statistical regression predict errors in estimates of own performance. *Journal of Personality and Social Psychology, 82*, 180-188. doi:10.1037//0022-3514.82.2.180
- Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: how difficulties recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*, 1121-1134. doi:10.1037/0022-3514.77.6.1121
- Kruseman, M., Misarez, V., & Kayser, B. (2008). Knowledge about nutrition and weight loss among fitness instructors: a cross-sectional study in Geneva, Switzerland. *Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie, 56*, 156-160. Retrieved from: http://www.sgsm.ch/fileadmin/user_upload/Zeitschrift/56-2008-4/Nutrition_Krusemann.pdf
- Kuhn, D. (1989). Children and adults as intuitive scientists. *Psychological Review, 96*, 674-689. doi:10.1037//0033-295X.96.4.674

- Kuhn, D. (1991). *The Skills of Argument*. Cambridge University Press: Cambridge
- Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, 28, 16-25. doi:10.3102/0013189X028002016
- Kuhn, D. (2010). Teaching and learning science as argument. *Science Education*, 94, 810-824. doi:10.1002/sce.20395
- Kukkonen-Harjula, K., & Kauppinen, K. (2012). Health effects and risks of sauna bathing. *International Journal of Circumpolar Health*, 65, 195-205. doi:10.3402/ijch.v65i3.18102
- Lamar, S., & Lodge, J. (2014). Making sense of how I learn: metacognitive capital and the first year university student. *The International Journal of the First Year in Higher Education*, 5, 93-105. doi:10.5204/intjfyhe.v5i1.193
- Langdon, J., Rukavina, P., & Greenleaf, C. (2016). Predictors of obesity bias among exercise science students. *Advances in Physiology Education*, 40, 157-164. doi:10.1152/advan.00185.2015
- Larkin, D. (2012). Misconceptions about “misconceptions”: preservice secondary science teachers’ views on the value and role of student ideas. *Science Education*, 96, 927-959. doi:10.1002/sce.21022
- Larson, A.A., Britt, M.A., & Kurby, C.A. (2009). Improving students’ evaluation of informal arguments. *The Journal of Experimental Education*, 77, 339-366. doi:10.3200/JEXE.77.4.339-366
- Lazer, D.M.J., Baum, M.A., Benkler, Y., Berinsky, A.J., Greenhill, K.M., Menczer, F., ... & Zittrain, J.L. (2018). The science of fake news. *Science*, 359, 1094-1096. doi: 10.1126/science.aao2998
- Lederman, R., Fan, H., Smith, S., & Chang, S. (2014). Who can you trust? Credibility assessment in online health forums. *Health Policy & Technology*, 3, 13-25. doi:10.1016/j.hlpt.2013.11.003
- Lemire, M., Sicotte, C., & Paré, G. (2008). Internet use and the logics of personal empowerment in health. *Health Policy*, 88, 130-140. doi:10.1016/j.healthpol.2008.03.006

- Lemire, M., Paré, G., Sicotte, C., & Harvey, C. (2008). Determinants of Internet use as a preferred source of information on personal health. *International Journal of Medical Informatics*, *77*, 723-734. doi:10.1016/j.ijmedinf.2008.03.002
- Lewandowsky, S., Ecker, U.K.H., Seifert, C.M., Schwarz, N., & Cook, J. (2012). Misinformation and its correction: continued influence and successful debiasing. *Psychological Science in the Public Interest*, *13*, 106-131. doi:10.1177/1529100612451018
- Liberali, J.M., Reyna, V.F., Furlan, S., Stein, L.M., & Pardo, S.T. (2012). Individual differences in numeracy and cognitive reflection, with implications for biases and fallacies in probability judgment. *Journal of Behavioral Decision Making*, *25*, 361-381. doi:10.1002/bdm.752
- Lloyd, C. (2008). Recruiting for fitness: qualifications and the challenges of an employer-led system. *Journal of Education and Work*, *21*, 175-195. doi:10.1080/13639080802214019
- Lobb, L.R., Lobb, W.B., & Hallam, J.S. (2008). Perceptions of anti-obesity medications among personal trainers. *Journal of Strength and Conditioning Research*, *22*, 485-489. doi:10.1519/JSC.0b013e31816607e5
- MacCallum, R.C., Widaman, R.C., Zhang, K.F., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, *4*, 84-99. Retrieved from <https://pdfs.semanticscholar.org/21c2/bd08b2111dcf957567b98e1c8dcad652e3dd.pdf>
- Mair, S.D., Seaber, A.V., Glisson, R.R., & Garrett, W.E. (1996). The role of fatigue in susceptibility to acute muscle strain injury. *The American Journal of Sports Medicine*, *24*, 137-143. doi:10.1177/036354659602400203
- Malek, M.H., Nalbone, D.P., Berger, D.E., & Coburn, J.W. (2002). Importance of health science information for personal fitness trainers. *Journal of Strength and Conditioning Research*, *16*, 19-24. doi:10.1519/1533-4287(2002)016<0019:IOHSEF>2.0.CO;2

- Manheimer, E.W., van Zuuren, E.J., Fedorowicz, Z., & Pijl, H. (2015). Paleolithic nutrition for metabolic syndrome. *American Journal of Clinical Nutrition*, *102*, 922-932. doi:10.3945/ajcn.115.113613
- Mann, M.F. (2003). *Students' use of formal and informal knowledge about energy and the human body*. (Doctoral dissertation). Retrieved from http://espace.library.curtin.edu.au/R?func=dbin-jump-full&local_base=gen01-era02&object_id=14733
- Manore, M.M., Hand, R.K., Liguori, G., Bayles, M., Dolins, K., Steinmuller, P., Cotton, R., & Smith-Edge, M. (2017). Knowledge and beliefs that promote or hinder collaboration among Registered Dietitian Nutritionists and Certified Exercise Professionals – results of a survey. *Journal of the Academy of Nutrition and Dietetics*, *117*, 280-296. doi:10.1016/j.jand.2016.05.007
- Margaria, R., Edwards, H.T., & Bill, D.B. (1933). The possible mechanisms of contracting and paying the oxygen debt and the role of lactic acid in muscular contraction. *American Journal of Physiology*, *106*, 689-715. doi:10.1152/ajplegacy.1933.106.3.689
- Marin, L.M., & Halpern, D.F. (2011). Pedagogy for developing critical thinking in adolescents: explicit instruction produces greatest gains. *Thinking Skills and Creativity*, *6*, 1-13. doi:10.1016/j.tsc.2010.08.002
- Maughan, R.J. (1986). Exercise-induced muscle cramp: a prospective biochemical study in marathon runners. *Journal of Sports Sciences*, *4*, 31-34. doi:10.1080/02640418608732095
- Mayeshiba, M., Jansen, K.R., & Muhlbauer, L. (2018). An evaluation of critical thinking in competency-based and traditional online learning environments. *Online Learning Journal*, *22*, 77-89. doi:10.24059/olj.v22i2.1365
- McGregor, M., Puhl, A.A., Reinhart, C., Injeyan, H.S., & Soave, D. (2014). Differentiating intraprofessional attitudes towards paradigms in health care delivery among chiropractic factions: results from a randomly sampled survey. *BMC Complementary and Alternative Medicine*, *14*, 1-8. doi:10.1186/1472-6882-14-51

- McHugh, M.P., & Cosgrave, C.H. (2010). To stretch or not to stretch: the role of stretching in injury prevention and performance. *Scandinavian Journal of Medicine and Science in Sports*, 20, 169-181. doi:10.1111/j.1600-0838.2009.01058.x
- McKean, M.R., Slater, G., Oprescu, F., & Burkett, B.J. (2015). Do the nutrition qualifications and professional practices of Registered Exercise Professionals align? *International Journal of Sport Nutrition and Exercise Metabolism*, 25, 154-162. doi:10.1123/ijsnem.2014-0051
- Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning: a meta-analysis of the empirical literature. *Teachers College Record*, 115, 1-47. Retrieved from https://www.sri.com/sites/default/files/publications/effectiveness_of_online_and_blended_learning.pdf
- Mehrab, M., de Vos, R., Kraan, G.A., & Mathijssen, N.M.C. (2017). Injury incidence and patterns among Dutch CrossFit athletes. *Orthopaedic Journal of Sports Medicine*, 5, 1-13. doi:10.1177/2325967117745263
- Melton, D.I., Katula, J.A., & Mustain, K.M. (2008). The current state of personal training: an industry perspective of personal trainers in a small Southeast community. *Journal of Strength & Conditioning Research*, 22, 883-889. doi:10.1519/JSC.0b013e3181660dab
- Mercier, H., Boudry, M., Paglieri, F., & Trouche, E. (2017). Natural-born arguers: teaching how to make the best of our reasoning abilities. *Educational Psychologist*, 52, 1-16. doi:10.1080/00461520.2016.1207537
- Metzger, M.J. (2007). Making sense of credibility on the Web: models for evaluating online information and recommendations for future research. *Journal of the American Society for Information Science and Technology*, 13, 2078-2091. doi:10.1002/asi.20672
- Metzger, M.J., Flanagin, A.J., & Medders, R.B. (2010). Social and heuristic approaches to credibility evaluation online. *Journal of Communication*, 60, 413-439. doi:10.1111/j.1460-2466.2010.01488.x

- Meyer, J., & Land, R. (2003). *Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising within the disciplines*. Retrieved from:
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.476.3389&rep=rep1&type=pdf>
- Michael, J.A. (1998). Students' misconceptions about perceived physiological responses. *Advances in Physiology Education*, 19, S90-S98.
doi:10.1152/advances.1998.274.6.S90
- Michael, J.A. (2006). Where's the evidence that active learning works? *Advances in Physiology Education*, 30, 159-167. doi:10.1152/advan.00053.2006
- Michael, J.A. (2007). What makes physiology hard for students to learn? Results of a faculty survey. *Advances in Physiology Education*, 31, 34-40.
doi:10.1152/advan.00057.2006
- Michael, J.A., Richardson, D., Rovick, A., Modell, H., Horwitz, B., Hudson, M., ... & Williams, S. (1999). Undergrad students' misconceptions about respiratory physiology. *Advances in Physiology Education*, 22, S127-S135.
doi:10.1152/advances.1999.277.6.S127
- Miles, J., Petrie, C., & Steel M. (2000). Slimming on the Internet. *Journal of the Royal Society of Medicine*, 93, 254-257. doi:10.1177/014107680009300510
- Miller, K.C. (2015). Rethinking the cause of exercise-associated muscle cramping: moving beyond dehydration and electrolyte losses. *Current Sports Medicine Reports*, 14, 353-354. doi:10.1249/JSR.0000000000000183
- Modell, H.I., Michael, J.A., Adamson, T., Goldberg, J., Horwitz, B.A., Bruce, D.S., ... & Williams, S. (2000). Helping undergraduates repair faulty mental models in the student laboratory. *Advances in Physiology Education*, 23, 82-90. doi:10.1152/advances.2000.23.1.S82
- Modell, H.I., Michael, J.A., Adamson, T., & Horwitz, B. (2004). Enhancing active learning in the student laboratory. *Advances in Physiology Education*, 28, 107-111. doi:10.1152/advan.00049.2003

- Mohr, D.R. (1965). Changes in waistline and abdominal girth and subcutaneous fat following isometric exercises. *Research Quarterly for Exercise and Sport*, 36, 168-173. doi:10.1080/10671188.1965.10614676
- Morton, J.P., Doran, D.A., & Maclaren, D.P.M. (2008). Common student misconceptions in exercise physiology and biochemistry. *Advances in Physiology Education*, 32, 142-146. doi:10.1152/advan.00095.2007
- Muduli, A., Kaura, V., & Quazi, A. (2018). Pedagogy or andragogy? Views of Indian postgraduate business students. *IIMB Management Review*, 30, 168-178. doi:10.1016/j.iimb.2018.01.008
- Mullins, N.M. (2015) CrossFit: remember what you have learned; apply what you know. *Journal of Exercise Physiology Online*, 18, 32-44. Retrieved from: https://www.researchgate.net/profile/Nicole_Mullins2/publication/290123696_CrossFit_Remember_what_you_have_learned_apply_what_you_know/links/56feed5708aee995dde73b6f.pdf
- Mundfrom, D.J., Shaw, D.G., & Lu Ke, T. (2005). Minimum sample size recommendations for conducting factor analyses. *International Journal of Testing*, 5, 159-168. doi:10.1207/s15327574ijt0502_4
- National Health & Medical Research Council (2003). *Dietary Guidelines for Australian Adults*. Retrieved from: <https://www.nhmrc.gov.au/guidelines-publications/n29-n30-n31-n32-n33-n34>
- National Health & Medical Research Council (2013). *Dietary Guidelines for Australian Adults*. Retrieved from <https://www.nhmrc.gov.au/about-us/publications/australian-dietary-guidelines>
- Nelson, A.G., Kokkonen, J., & Arnell, D.A. (2005). Acute muscle stretching inhibits muscle strength endurance performance. *Journal of Strength and Conditioning Research*, 19, 338-343. doi:10.1519/R-15894.1
- Newlin, M.H., & Wang, A.Y. (2002). Predictors of web-student performance: the role of self-efficacy and reasons for taking an on-line class. *Computers in Human Behaviour*, 18, 151-163. doi:10.1016/S0747-5632(01)00042-5

- Newton, P.M. (2015). The learning styles myth is thriving in higher education. *Frontiers in Psychology, 6*, 1908. doi:10.3389/fpsyg.2015.01908
- Newton, P.M., & Miah, M. (2017). Evidence-based higher education – is the learning styles ‘myth’ important? *Frontiers in Psychology, 8*, 1-9. doi:10.3389/fpsyg.2017.00444
- Nickerson, R.S. (1998). Confirmation bias: a ubiquitous phenomenon in many guises. *Review of General Psychology, 2*, 175-220. doi:10.1037/1089-2680.2.2.175
- Noakes, T.D. (2000). Physiological models to understand exercise fatigue and the adaptations that predict or enhance athletic performance. *Scandinavian Journal of Medicine and Science in Sports, 10*, 123-145. doi:10.1034/j.1600-0838.2000.010003123.x
- Noland, M., & Kearney, J.T. (1978). Anthropometric and densitometric responses of women to specific and general exercise. *Research Quarterly for Exercise and Sport, 49*, 322-328. doi:10.1080/10671315.1978.10615541
- Nosaka, K., Newton, M., & Sacco, P. (2002). Delayed-onset muscle soreness does not reflect the magnitude of eccentric exercise-induced muscle damage. *Scandinavian Journal of Medicine and Science in Sports, 12*, 337-346. doi:10.1034/j.1600-0838.2002.10178.x
- Nybo, L., & May, M. (2015). Effectiveness of inquiry-based learning in an undergraduate exercise physiology course. *Advances in Physiology Education, 39*, 76-80. doi:10.1152/advan.00161.2014
- Nybo, L., Sundstrup, E., Jakobsen, M.D., Mohr, M., Honstrup, T., Simonsen, L., ... & Krstrup, P. (2010). High-intensity training versus traditional exercise interventions for promoting health. *Medicine and Science in Sports and Exercise, 42*, 1951-1958. doi:10.1249/MSS.0b013e3181d99203
- O’Dea, J. (2003). Consumption of nutritional supplements among adolescents: usage and perceived benefits. *Health Education Research, 18*, 98-107. doi:10.1093/her/18.1.98

- O'Dea, J., & Rawstorne, P.R. (2001). Male adolescents identify their weight gain practices, reasons for desired weight gain, and sources of weight gain information. *Journal of the American Dietetic Association, 101*, 105-107. Retrieved from <https://search-proquest-com.dbgw.lis.curtin.edu.au/docview/218453942/fulltext/B9828BBFA9449F2PQ/1?accountid=10382>
- O'Neil, K.M., Penrod, S.D., & Hornstein, B.H. (2003). Web-based research: methodological variables' effects on dropout and sample characteristics. *Behavior Research Methods, Instruments, and Computers, 35*, 217-226. doi:10.3758/BF03202544
- Oechssler, J., Roider, A., & Schmitz, P.W. (2009). Cognitive abilities and behavioural biases. *Journal of Economic Behaviour and Organization, 72*, 147-152. doi:10.1016/j.jebo.2009.04.018
- Olson, A.L., & Edelstein, E. (1968). Spot reduction of subcutaneous adipose tissue. *Research Quarterly for Exercise and Sport, 39*, 647-652. doi:10.1080/10671188.1968.10616592
- Osborne, J. (2010). Arguing to learn in science: the role of collaborative, critical discourse. *Science, 328*, 463-466. doi:10.1126/science.1183944
- Pankevich, D.E., Teegarden, S.L., Hedin, A.D., Jensen, C.L., & Bale, T.L. (2010). Calorie restriction experience reprograms stress and orexigenic pathways and promotes binge eating. *Journal of Neuroscience, 30*, 16399-16407. doi:10.1523/JNEUROSCI.1955-10.2010
- Parker, W., Steyn, N.P., Levitt, N.S., & Lombard, C.J. (2011). They think they know but do they? Misalignment of perceptions of lifestyle modification knowledge among health professionals. *Public Health Nutrition, 14*, 1429-1438. doi:10.1017/S1368980009993272
- Pedersen, T.H., Nielsen, O.B., Lamb, G.D., & Stephenson, D.G. (2004). Intracellular acidosis enhances the excitability of working muscle. *Science, 305*, 1144-1147. doi:10.1126/science.1101141

- Pennycook, G., Cheyne, J.A., Seli, P., Koehler, D.J., & Fugelsang, J.A. (2012). Analytic cognitive style predicts religious and paranormal belief. *Cognition*, *123*, 335-346. doi:10.1016/j.cognition.2012.03.003
- Pennycook, G., Cheyne, J.A., Koehler, D.J., & Fugelsang, J.A. (2016). Is the cognitive reflection test a measure of both reflection and intuition? *Behavioural Research*, *48*, 341-348. doi:10.3758/s13428-015-0576-1
- Perrier, E.T., Pavol, M.J., & Hoffman, M.A. (2011). The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility. *Journal of Strength and Conditioning Research*, *25*, 1925-1931. doi:10.1519/JSC.0b013e3181e73959
- Petrocelli, J.V. (2003). Hierarchical multiple regression in counseling research: common problems and possible remedies. *Measurement and Evaluation in Counseling and Development*, *36*, 9-22. Retrieved from http://www.datapsyc.com/petrocelli_2003.pdf
- Phillips, S.M. (2011). The science of muscle hypertrophy: making dietary protein count. *Proceedings of the Nutrition Society*, *70*, 100-103. doi:10.1017/S002966511000399X
- Pithers, R.T., & Soden, R. (2000). Critical thinking in education: a review. *Educational Research*, *42*, 237-249. doi:10.1080/001318800440579
- Ponterotto, J.G., & Ruckdeschel, D.E. (2007). An overview of coefficient alpha and a reliability matrix for estimating adequacy of internal consistency coefficients with psychological research measures. *Perceptual and Motor Skills*, *105*, 997-1014. doi:10.2466/pms.105.3.997-1014
- Pope, R.P., Herbert, R.D., Kirwan, J.D., & Graham, B.J. (2000). A randomized trial of preexercise stretching for prevention of lower-limb injury. *Medicine and Science in Sports and Exercise*, *32*, 271-277. doi:10.1097/00005768-200002000-00004
- Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education*, *66*, 211-227. doi:10.1002/sce.3730660207

- Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 93, 223-231. doi:10.1002/j.2168-9830.2004.tb00809.x
- Puhl, A.A., Reinhart, C.J., Doan, J.B., McGregor, M., & Injeyan, H.S. (2014). Relationship between chiropractic teaching institutions and practice characteristics among Canadian doctors of chiropractic: a random sample survey. *Journal of Manipulative and Physiological Therapeutics*, 37, 709-718. doi:10.1016/j.jmpt.2014.09.005
- Ramírez-Campillo, R., Andrade, D.C., Campos-Jara, C., Henríquez-Olguín, C., Alvarez-Lepín, C., & Izquierdo, M. (2013). Regional fat changes induced by localized muscle endurance resistance training. *Journal of Strength and Conditioning Research*, 27, 2219-2224. doi:10.1519/JSC.0b013e31827e8681
- Ratamess, N.A., Faigenbaum, A.D., Hoffman, J.R., & Kang, J. (2008). Self-selected resistance training intensity in healthy women: the influence of a personal trainer. *Journal of Strength and Conditioning Research*, 22, 103-111. doi:10.1519/JSC.0b013e31815f29cc
- Reise, S.P., Waller, N.G., & Comrey, A.L. (2000). Factor analysis and scale revision. *Psychological Assessment*, 12, 287-297. doi:10.1037/1040-3590.12.3.287
- Richardson, L.A., Fister, C.L., & Ramlo, S.E. (2015). Effect of an exercise and weight control curriculum: views of obesity among exercise science students. *Advances in Physiology Education*, 39, 43-48. doi:10.1152/advan.00154.2014
- Robergs, R.A., Ghiasvand, F., & Parker, D. (2004). Biochemistry of exercise-induced metabolic acidosis. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology*, 287, R502-R516. doi:10.1152/ajpregu.00114.2004
- Robertson, I. (2008). VET teachers' knowledge and expertise. *International Journal of Training Research*, 6, 1-22. doi:10.5172/ijtr.6.1.1

- Rodriguez, N.R., Di Marco, N.M., & Langley, S. (2009). American College of Sports Medicine position stand. Nutrition and athletic performance. *Medicine and Science in Sports and Exercise*, *41*, 709-732.
doi:10.1249/MSS.0b013e31890eb86
- Rosenbloom, C.A., Jonnalagadda, S.S., & Skinner, R. (2002). Nutrition knowledge of collegiate athletes in a division I National Collegiate Athletic Association institution. *Journal of the American Dietetic Association*, *3*, 418-420.
doi:10.1016/S0002-8223(02)90098-2
- Ross, L., Greene, D., & House, P. (1977). The “false consensus effect”: an egocentric bias in social perception and attribution processes. *Journal of Experimental Social Psychology*, *13*, 279-301. doi:10.1016/0022-1031(77)90049-X
- Rovick, A.A., Michael, J.A., Modell, H.I., Bruce, D.S., Horwitz, B., Adamson, T., ... & Whitescarver, S.A. (1999). How accurate are our assumptions about our students' background knowledge? *Advances in Physiology Education*, *21*, 93-101. doi:10.1152/advances.1999.276.6.S93
- Sainsbury, A., & Zhang, L. (2010). Role of the arcuate nucleus of the hypothalamus in regulation of body weight during energy deficit. *Molecular and Cellular Endocrinology*, *316*, 109-119. doi:10.1016/j.mce.2009.09.025
- Saper, R.B., Eisenberg, D.M., & Phillips, R.S. (2004). Common dietary supplements for weight loss. *American Family Physician*, *70*, 1731-1738. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/15554492>
- Sass, C., Eickhoff-Shemek, J.M., Manore, M.M., & Kruskall, L.J. (2007). Crossing the line: understanding the scope of practice between registered dietitians and health/fitness professionals. *ACSM's Health & Fitness Journal*, *11*, 12-19.
doi: 10.1249/01.FIT.0000269059.95841.3e
- Schade, M., Helledrandt, F.A., Waterland, J.C., & Carns, M.L. (1962). Spot reducing in overweight college women: its influence on fat distribution as determined by photography. *Research Quarterly for Exercise and Sport*, *33*, 461-471.
doi:10.1080/10671188.1962.10616478

- Schoenfeld, B.J. (2010). The mechanisms of muscle hypertrophy and their application to resistance training. *Journal of Strength and Conditioning Research*, 24, 2857-2872. doi:10.1519/JSC.0b013e3181e840f3
- Schwellnus, M.P., Drew, N., & Collins, M. (2008). Muscle cramping in athletes – risk factors, clinical assessment, and management. *Clinics in Sports Medicine*, 27, 183-194. doi:10.1016/j.csm.2007.09.006
- Schwellnus, M.P., Nicol, J., Laubscher, R., & Noakes, T.D. (2004). Serum electrolyte concentrations and hydration status are not associated with exercise associated muscle cramping (EAMC) in distance runners. *British Journal of Sports Medicine*, 38, 488-492. doi:10.1136/bjism.2003.007021
- Sealey, R.M., & Crowe, M.J. (2014). Debating the issue: using university student debates to facilitate active student engagement in sport and exercise science. *Focus on Health Professional Education*, 16, 102-104. doi:10.11157/fohpe.v16i1.50
- Shanteau, J. (1992). Competence in experts: the role of task characteristics. *Organizational Behaviour and Human Decision Processes*, 53, 252-266. doi:10.1016/0749-5978(92)90064-E
- Sharp, J.G., Bowker, R., & Byrne, J. (2008). VAK or VAK-uous? Towards the trivialisation of learning and the death of scholarship. *Research Papers in Education*, 23, 293-314. doi:10.1080/02671520701755416
- Sheldon, P., & Thornthwaite, L. (2005). Employability skills and vocational education and training policy in Australia: an analysis of employer association agendas. *Asia Pacific Journal of Human Resources*, 43, 404-425. doi:10.1177/1038411105059100
- Sheppard, J.M., & Triplett, N.T. (2016). Program design for resistance training. In Haff, G.G., & Triplett, N.T. (Eds.), *Essentials of Strength Training and Conditioning* (4th ed., pp. 439-469). Champaign, IL: Human Kinetics
- Sherman, S.J., Zehner, K.S., Johnson, J., & Hirt, E.R. (1983). Social explanation: the role of timing, set, and recall on subjective likelihood estimates. *Journal of*

Personality and Social Psychology, 44, 1127-1143. doi:10.1037/0022-3514.44.6.1127

- Shrier (1999). Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. *Clinical Journal of Sports Medicine*, 9, 221-227. Retrieved from <https://ovidsp-tx-ovid-com.dbgw.lis.curtin.edu.au/sp-3.31.1b/ovidweb.cgi?&S=BEHAFPIFBADDDHCJNCEKMGDCKFKFAA00&Complete+Reference=S.sh.22.23.27.31%7c7%7c1>
- Siegal, M., Butterworth, G., & Newcombe, P.A. (2004). Culture and children's cosmology. *Developmental Science*, 7, 308-324. doi:10.1111/j.1467-7687.2004.00350.x
- Sillence, E., Briggs, P., Harris, P., & Fishwick, L. (2007). Going online for health advice: changes in usage and trust practices over the last five years. *Interacting with Computers*, 19, 397-406. doi:10.1016/j.intcom.2006.10.002
- Smith, E., Hodge, S., & Yasukawa, K. (2015). VET teacher education in Australian universities: who are the students and what are their views about their courses? *Research in Post-Compulsory Education*, 20, 419-433. doi:10.1080/13596748.2015.1081752
- Smith, E. & Yasukawa, K. (2017). What makes a good VET teacher? Views of Australian VET teachers and students. *International Journal of Training Research*, 15, 23-40. doi:10.1080/14480220.2017.1355301
- Spriet, L.L. (2014). New insights into the interaction of carbohydrate and fat metabolism during exercise. *Sports Medicine*, 44, 87-96. doi:10.1007/s40279-014-0154-1
- Stacey, D., Hopkins, M., Adamo, K.B., & Prud'homme, D. (2010). Knowledge translation to fitness trainers: a systematic review. *Implementation Science*, 5, 28. doi:10.1186/1748-5908-5-28
- Stanovich, K.E., Toplak, M.E., & West, R.F. (2008). The development of rational thought: a taxonomy of heuristics and biases. *Advances in Child Development and Behavior*, 36, 251-285. doi:10.1016/S0065-2407(08)00006-2

- Stanovich, K.E., West, R.F., & Toplak, M.E. (2013). Myside bias, rational thinking, and intelligence. *Current Directions in Psychological Science*, 22, 259-264. doi:10.1177/0963721413480174
- Steinhaus, A.H. (1934). Why exercise. *The Journal of Health and Physical Education*, 5, 5-43. doi:10.1080/23267240.1934.10619650
- Stofan, J.R., Zachwieja, J.J., Horswill, C.A., Murray, R., Anderson, S.A., & Eichner, E.R. (2005). Sweat and sodium losses in NCAA football players: a precursor to heat cramps. *International Journal of Sport Nutrition and Exercise Metabolism*, 15, 641-652. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.662.5876&rep=rep1&type=pdf>
- Stone, M.B., Edwards, J.E., Stemmans, C.L., Ingersoll, C.D., Palmieri, R.M., & Krause, B.A. (2003). Certified athletic trainers' perceptions of exercise-associated muscle cramps. *Journal of Sport Rehabilitation*, 12, 333-342. doi: 10.1123/jsr.12.4.333
- Sulzer, N.U., Schweltnus, M.P., & Noakes, T.D. (2005). Serum electrolytes in ironman triathletes with exercise-associated muscle cramping. *Medicine and Science in Sports and Exercise*, 37, 1081-1085. doi:10.1249/01.mss.0000169723.79558.cf
- Sunstein, C.R., & Vermeule, A. (2009). Conspiracy theories: causes and cures. *The Journal of Political Philosophy*, 17, 202-227. doi: 10.1111/j.1467-9760.2008.00325.x
- Swain, D.P., & Franklin, B.A. (2006). Comparison of cardioprotective benefits of vigorous versus moderate intensity aerobic exercise. *The American Journal of Cardiology*, 97, 141-147. doi:10.1016/j.amjcard.2005.07.130
- Tabachnick, B.G. & Fidell, L.S. (1989). *Using multivariate statistic* (5th ed). Boston, MA: Allyn & Bacon
- Taber, K.S. (2001). The mismatch between assumed prior knowledge and the learner's conceptions: a typology of learning impediments. *Educational Studies*, 27, 159-171. doi:10.1080/03055690125159

- Taber, K.S. (2017). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48, 1273-1296. doi:10.1007/s11165-016-9602-2
- Tardif, E., Doudin, P., & Meylan, N. (2015). Neuromyths among teachers and student teachers. *Mind, Brain and Education*, 9, 50-59.
doi:10.1111/mbe.12070
- Taylor, A.K., & Kowalski, P. (2004). Naïve psychological science: the prevalence, strength, and sources of misconceptions. *The Psychological Record*, 54, 15-25. doi:10.1007/BF03395459
- Taylor, A. K., & Kowalski, P. (2014). Student misconceptions: Where do they come from and what can we do? In Benassi, V.A., Overson, C.E., & Hakala, C.M. (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum* (pp. 259-273). Washington, DC: Society for the Teaching of Psychology.
- Tetlock, P.E. (1985). Accountability: the neglected social context of judgement and choice. In Staw, B., & Cummings, L. (Eds.), *Research in Organizational Behaviour, Vol 1* (pp. 297-332). Greenwich, CT: JAI Press.
- Thaker, S.B., Gilchrist, J., Stroup, D.F., & Kimsey, C.D. (2004). The impact of stretching on sports injury risk: a systematic review of the literature. *Medicine and Science in Sports and Exercise*, 36, 371-378.
doi:10.1249/01.MSS.0000117134.83018.F7
- Thompson, J.K., Jarvie, G.J., & Lahey, B.B. (1982). Exercise and obesity: etiology, physiology, and intervention. *Psychological Bulletin*, 91, 55-79.
doi:10.1037/0033-2909.91.1.55
- Thompson, F., & Logue, S. (2006). An exploration of common student misconceptions in science. *International Education Journal*, 7, 553-559.
Retrieved from
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.577.3355&rep=rep1&type=pdf>

- Tipton, K.D. (2008). Protein for adaptations to exercise training. *European Journal of Sport Science*, 8, 107-118. doi:10.1080/17461390801919102
- Tirrell, T., & Quick, D. (2012). Chickering's seven principles of good practice: student attrition in community college online courses. *Community College Journal of Research and Practice*, 36, 580-590.
doi:10.1080/10668920903054907
- Tiruneh, D.T., Verburgh, A., & Elen, J. (2014). Effectiveness of critical thinking instruction in higher education: a systematic review of intervention studies. *Higher Education Studies*, 4, 1-17. doi:10.5539/hes.v4n1p1
- Todd, J. (1992). The origins of weights training for female athletes in North America. *Iron Game History*, 2, 4-14. Retrieved from https://www.researchgate.net/publication/298437860_Origins_of_Weight_Training_for_Female_Athletes_in_North_America
- Toplak, M.E., West, R.F., & Stanovich, K.E. (2011). The Cognitive Reflection Test as a predictor of performance on heuristics-and-biases tasks. *Memory and Cognition*, 39, 1275-1289. doi:10.3758/s13421-011-0104-1
- Toplak, M.E., West, R.F., & Stanovich, K.E. (2014). Assessing miserly information processing: an expansion of the Cognitive Reflection Test. *Thinking and Reasoning*, 20, 147-168. doi:10.1080/13546783.2013.844729
- Torres-McGehee, T.M., Pritchett, K.L., Zippel, D., Minton, D.M., Cellamare, A., & Sibilia, M. (2012). Sports nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists. *Journal of Athletic Training*, 47, 205-211. doi:10.4085/1062-6050-47.2.205
- Tortora, G.J., & Grabowski, S.R. (1996). *Principles of anatomy and physiology*. HarperCollins: New York.
- Tsui, L. (1999). Courses and instruction affecting critical thinking. *Research in Higher Education*, 40, 185-200. doi:10.1023/A:1018734630124
- Tsui, L. (2002). Fostering critical thinking through effective pedagogy: evidence from four institutional case studies. *The Journal of Higher Education*, 73, 740-763. doi:10.1353/jhe.2002.0056

- Tversky, A., & Kahneman, D. (1974). Judgement under uncertainty: heuristics and biases. *Science*, *185*, 1124-1131. doi:10.1126/science.185.4157.1124
- Van Gelder, L.H., & Bartz, S.D. (2011). The effect of acute stretching on agility performance. *Journal of Strength and Conditioning Research*, *25*, 3014-3021. doi:10.1519/JSC.0b013e318212e42b
- Vaughan, E.D. (1977). Misconceptions about psychology among introductory psychology students. *Teaching of Psychology*, *4*, 138-141. doi:10.1207/s15328023top0403_9
- Vispute, S.S., Smith, J.D., LeCheminant, J.D., & Hurley, K.S. (2011). The effect of abdominal exercise on abdominal fat. *Journal of Strength & Conditioning Research*, *25*, 2559-2564. doi:10.1519/JSC.0b013e3181fb4a46
- Vrasidas, C. (2004). Issues of pedagogy and design in e-learning systems. *Proceedings of the 2004 Symposium on Applied Computing* (pp. 911-915). doi:10.1145/967900.968086
- Walker, L. (2006). Narrated PowerPoint as a self-learning resource. *International Journal of Learning*, *13*, 1-5. Retrieved from <https://researchbank.swinburne.edu.au/items/cb23d414-6b54-4620-9677-f39a04973789/1/PDF%20%28Published%20version%29.pdf?.vi=save>
- Wang, A.Y., & Newlin, M.H. (2000). Characteristics of students who enrol and succeed in psychology Web-based classes. *Journal of Educational Psychology*, *92*, 137-143. doi:10.1037/0022-0663.92.1.137
- Wang, S. (2017). An exploration into research on critical thinking and its cultivation. *Theory and Practice in Language Studies*, *7*, 1266-1280. doi:10.17507/tpls.0712.14
- Weisenthal, B.M., Beck, C.A., Maloney, M.D., DeHaven, K.E., & Giordano, B.D. (2014). Injury rate and patterns among CrossFit athletes. *Orthopaedic Journal of Sports Medicine*, *2*, 1-7. doi:10.1177/2325967114531177
- Wewege, M., van den Berg, R., Ward, R.E., & Keech, A. (2017). The effects of high-intensity interval training vs. moderate-intensity continuous training on

body composition in overweight and obese adults: a systematic review and meta-analysis. *Obesity Reviews*, 18, 635-646. doi:10.1111/obr.12532

Wheelehan, L., & Moodie, G. (2011). *Rethinking skills in vocational education and training: from competencies to capabilities*. NSW Department of Education and Communities. Retrieved from:
<https://www.voced.edu.au/content/ngv%3A48914>

Wichadee, S. (2014). Students' learning behavior, motivation and critical thinking in learning management systems. *Journal of Educators Online*, 11, 1-20.
Retrieved from <https://eric.ed.gov/?id=EJ1033317>

Whitney, E., Rolfes, S.R., Crowe, T., Cameron-Smith, D., & Walsh, A. (2011). *Understanding nutrition: Australia and New Zealand edition*. South Melbourne, Victoria. Cengage Learning

Yalçinkaya, E., Taştan, Ö., & Boz, Y. (2009). High school students' conceptions about energy in chemical reactions. *Pamukkale University Journal of Education*, 26, 1-11. Retrieved from:
http://pauegitimdergi.pau.edu.tr/Makaleler/710882739_Eylem%20Yal%C3%A7%20Yal%C3%96zgecan%20Ta%C5%9Ftan2,%20Yezdan%20Boz3.pdf

Zelasko, C.J. (1995). Exercise for weight loss: what are the facts? *Journal of the American Dietetic Association*, 95, 1414-1417. doi:10.1016/S0002-8223(95)00371-1

Zenko, Z., & Ekkekakis, P. (2015). Knowledge of exercise prescription guidelines among certified exercise professionals. *Journal of Strength and Conditioning Research*, 29, 1422-1432. doi: 10.1519/JSC.0000000000000771

Zhang, Y., Sun, Y., & Xie, B. (2015). Quality of health information for consumers on the web: A systematic review of indicators, criteria, tools, and evaluation results. *Journal of the Association for Information Science and Technology*, 66, 2071-84. doi: 10.1002/asi.23311

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39, 35-62. doi:10.1002/tea.10008

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendix A: Participant Information Sheets

A.1 Participant Information Statement – Interview

HREC Project Number:	HRE2016-0292
Project Title:	Exercise Science Knowledge in Students & Professionals
Principal Investigator:	Dr Melissa Davis, Senior Lecturer, School of Psychology & Speech Pathology
Student researcher:	Dan Jolley
Version Number:	1.01
Version Date:	13/AUG/2016

What is the project about?

Research has shown that students can have errors in their knowledge of exercise science, which can last throughout an education, and into professional practice. Previous research has looked at the exercise science knowledge of students, personal trainers, and the public, separately, but not compared these groups to see what differences in knowledge, exercise habits, and sources of information exist.

This project aims to directly compare the exercise science knowledge, habits, and sources of information of these different groups, and the extent to which misconception can endure throughout an exercise science education. This will help TAFEs and universities identify gaps in the knowledge of students and graduates. This project also aims to create and implement an intervention for fitness professionals to improve their critical thinking ability, to better identify gaps in their knowledge and prevent further misconceptions forming.

Five exercise science lecturers are being asked to participate in interviews to create a relevant survey to assess the misconceptions in the target groups. About 300 people are being invited to participate in the survey.

Who is doing the research?

This project is being conducted by Dan Jolley. The results from this research will be used by Dan Jolley to obtain a Doctor of Philosophy at Curtin University, and is funded by the University. There will be no costs to you, and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

We are looking for experienced exercise science lecturers. You will be required to take part in an interview that will take approximately 45 minutes. This interview will take place at a mutually convenient location and time. It will involve questions regarding a series of exercise science misconceptions commonly held by the general public, and you will be asked to comment on the frequency the misconception is seen in students, if it has an impact on learning, and the relevant course content that should correct the misconception. You will also be encouraged to suggest other, frequently occurring misconceptions that were not raised.

We will make an audio recording so we can concentrate on what you have to say and not distract ourselves with taking notes.

There will be no cost to you for taking part in this research, and you will not be paid for taking part.

Are there any benefits to being in this research project?

There may be no direct benefit to you from participating. You will be informed about the results of the research, which may assist in the development of course content and resources to help clarify student understanding.

It is also hoped that this research will assist with developing education programs for exercise professionals and the general public, and improve the way that exercise science information is communicated. This may help people get better results from their exercise programs.

Are there any risks from being in this research project?

There are no risks from participating in this research.

Who will have access to my information?

The information collected in this interview will be identifiable. This means that any information we collect that can identify you will stay on the information we collect. It will be treated as confidential and used only in the project unless otherwise stated. We can let others know this information only if you say so, or if the law says we need to. Only the research team and the Curtin University Ethics Committee will have access to the information we collect in this research.

All information will be stored in a secure network at Curtin University. The data will be password-protected. No hard copy data will be collected. The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information in accordance with relevant privacy laws.

The results of this research will form part of a Doctor of Philosophy thesis. It may also be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented, but may be identified in acknowledgements in the thesis or published papers. Please let the research know if you do not wish to be acknowledged.

Will you tell me the results of the research?

We will write to you once the data from the survey have been analysed (early 2018) and let you know the results of the research.

Do I have to take part in the research project?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to stop so we can make sure you are aware of anything that needs to be done so you can withdraw safely. If you choose not to take part or start and then stop the study, it will not affect your relationship with the University, staff or colleagues. If you chose to leave the study, we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you would like more information about this research you can contact:

Dr Melissa Davis: (08) 9266 2601

If you would like more information about the content of the survey, you can contact:

Mr Dan Jolley: 0402 381 532, or email:

daniel.j.jolley@postgrad.curtin.edu.au

If you decide to take part in this research we will ask you to signal your consent.

There is a consent form that you will be asked to read, and sign. Signing this form indicates that you agree to be in the research project and have your information used as described. Please take your time and ask any questions you have before you decide what to do. You will be emailed copy of this information sheet and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2016-0292). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

A.2 Participant Information Statement – Survey

HREC Project Number:	HRE2016-0292
Project Title:	Exercise Science Knowledge in Students & Professionals
Principal Investigator:	Dr Melissa Davis, Senior Lecturer, School of Psychology & Speech Pathology
Student researcher:	Dan Jolley
Version Number:	1.04
Version Date:	16/SEP/2016

What is the project about?

Research has shown that students can have errors in their knowledge of exercise science, which can last throughout an education, and into professional practice. Previous research has looked at the exercise science knowledge of students, personal trainers, and the public, separately, but not compared these groups to see what differences in knowledge, exercise habits, and sources of information exist.

This project aims to directly compare the exercise science knowledge, habits, and sources of information of these different groups. This will help fitness professionals identify where education is needed for the general public, and help TAFEs and universities identify gaps in the knowledge of students and graduates.

About 300 people are being invited to participate in this survey.

Who is doing the research?

This project is being conducted by Dan Jolley. The results from this research will be used by Dan Jolley to obtain a Doctor of Philosophy at Curtin University, and is funded by the University. There will be no costs to you, and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

We are looking for volunteers with a variety of exercise backgrounds and exercise science knowledge (from untrained to highly qualified). You will be required to complete a survey that will take approximately 25 minutes. It will involve a series of statements about exercise science, and you will be required to rate your agreement with the statements. There will also be questions about your background, exercise levels, and your sources of exercise information (if any).

This survey is to be completed in the presence of the researcher. You are asked not to look at any websites or reference material when you answer these questions. Please do not guess – if you do not know an answer, please select the “don’t know” option when available.

There will be no cost to you for taking part in this research, and you will not be paid for taking part. You have the chance to go into a draw to win one of 6 \$50 gift vouchers. Please provide your email address where requested if you wish to be entered, so we can contact you if you win.

Are there any benefits to being in this research project?

There may be no direct benefit to you from participating. Once the survey is completed, you will be provided with exercise science information to clarify any confusion you may have about the topics covered. This information can be provided immediately by the researcher, or more detailed information can be sent to you if you are interested in further reading.

It is hoped that this research will assist with developing education programs for exercise professionals and the general public, and improve the way that exercise science information is communicated. This may help people get better results from their exercise programs.

Are there any risks from being in this research project?

There is a risk you may be confused about some of the statements in the survey. At the conclusion of the survey, please feel free to ask the researcher about the correct answers, or request more information.

Who will have access to my information?

The information collected in this research will be non-identifiable (anonymous). This means that we do not need to collect individual names. No one, not even the research team, will be able to identify your information. Any information we collect and use during this research will be treated as confidential. Only the research team and the Curtin University Ethics Committee will have access to the information we collect in this research.

All information will be stored in a secure network at Curtin University. The data will be password-protected. No hard copy data will be collected. The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information in accordance with relevant privacy laws.

The results of this research will form part of a Doctor of Philosophy thesis. It may also be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

We will write to you at the end of the research (early 2018) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research project?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to stop so we can make sure you are aware of anything that needs to be done so you can withdraw safely. If you choose not to take part or start and then stop the study, it will not affect your relationship with the University, staff or colleagues.

If you chose to leave the study we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you would like more information about this research you can contact:

Dr Melissa Davis: (08) 9266 2601

If you would like more information about the content of the survey, you can contact:

Mr Dan Jolley: 0402 381 532, or email:

daniel.j.jolley@postgrad.curtin.edu.au

If you decide to take part in this research we will ask you to signal your consent.

There is a consent form that you will be asked to read, and sign. Signing this form indicates that you agree to be in the research project and have your information used as described. Please take your time and ask any questions you have before you decide what to do. You will be emailed copy of this information sheet and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2016-0292). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

A.3 Participant Information Statement – Intervention

HREC Project Number:	HRE2016-0807
Project Title:	Critical Thinking for Fitness Professionals
Principal Investigator:	Dr Melissa Davis, Senior Lecturer, School of Psychology & Speech Pathology
Student researcher:	Dan Jolley
Version Number:	1.01
Version Date:	20/NOV/2017

What is the project about?

Research has shown that exercise professionals can have errors in their knowledge of exercise science, which can persist in spite of professional development and years of experience. While education can be used to improve this knowledge, this is not always effective. It is possible that providing instruction in critical thinking and research skills can improve the ability of personal trainers to search for, and assess the quality of, information for themselves.

This project aims to improve the critical thinking ability of fitness professionals by providing an online intervention, using industry-specific content. This will help improve the quality of training and information that trainers are able to provide to their clients.

About 60 people are being invited to participate in this program.

Who is doing the research?

This project is being conducted by Dan Jolley. The results from this research will be used by Dan Jolley to obtain a Doctor of Philosophy at Curtin University and is funded by the University.

Why have I been asked to take part, and what will I have to do?

We are looking for personal trainers, with a minimum qualification of a Certificate IV in Fitness, who would like to gain extra continuing education credits (CECs) towards their Fitness Australia re-registration.

Prior to commencing the course, you will be required to complete a survey that will take approximately 20 minutes. It will involve a series of statements about exercise science, and you will be required to rate your agreement with the statements. There will also be questions about your background, exercise levels, and your sources of exercise information (if any). Though this will be completed online, you are asked not to look at any websites or reference material when you answer these questions. Please do not guess – if you do not know an answer, please select the “don’t know” option when available.

You will then be assigned to either an immediate-start, or a delayed-start group. The immediate-start group will be able to commence the course straight away. The delayed-start group will need to wait for 6 weeks, at which point you will repeat the survey. After this second survey, you will be allowed to start the course.

There will be no cost to you for taking part in this research, and you will not be paid for taking part. You will be awarded CECs upon successful completion of all course activities.

Are there any benefits to being in this research project?

You have the opportunity to earn CECs towards to Fitness Australia registration, at no cost to you. Additionally, you will learn skills that will allow you to better develop your knowledge in exercise related fields, which will have an ongoing benefit to your professional practice.

It is hoped that this research will assist with developing education programs for personal trainers, as well as providing the skills for trainers to improve their own knowledge, and provide better quality information to clients. Ultimately, this will lead to improved exercise outcomes for clients.

Are there any risks from being in this research project?

There is minimal risk from being associated with this research. When working at a computer for long periods of time it is possible to develop soreness in your lower back, shoulder, elbow, or wrist. Make sure you take regular breaks throughout the course, and adjust your workstation so you can read, type, and use a mouse comfortably.

Who will have access to my information?

You will be able to be identified from your participation in the online course, in order to provide support for the course. But no one, other than the research team, will be able to identify your information. Any information we collect and use during this research will be treated as confidential. Only the research team and the Curtin University Ethics Committee will have access to the information we collect in this research.

All information will be stored in a secure network at Curtin University. The data will be password-protected. No hard copy data will be collected. The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information in accordance with relevant privacy laws.

The results of this research will form part of a Doctor of Philosophy thesis. It may also be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

We will write to you at the end of the research (early 2019) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research project?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to

stop so we can make sure you are aware of anything that needs to be done so you can withdraw safely. If you choose not to take part or start and then stop the study, it will not affect your relationship with the University, staff or colleagues.

If you chose to leave the study we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you would like more information about this research you can contact:

Dr Melissa Davis: (08) 9266 2601

If you would like more information about the content of the survey, you can contact:

Mr Dan Jolley: 0402 381 532, or email:

daniel.j.jolley@postgrad.curtin.edu.au

If you decide to take part in this research we will ask you to signal your consent below. There is a checkbox at the end of the consent statement to indicate that you understand what you have read and what has been discussed. Checking this box indicates that you agree to be in the research project and have your information used as described. Please take your time and ask any questions you have before you decide what to do. You will be emailed a copy of this information and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2017-0807). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix B: Consent Forms

B.1 Consent Form - Interview

HREC Project Number:	HRE2016-0292
Project Title:	Exercise Science Knowledge in Students & Professionals
Principal Investigator:	Dr Melissa Davis, Senior Lecturer, School of Psychology and Speech Pathology
Student Researcher:	Dan Jolley
Version Number:	Version 1.04
Version Date:	23/SEP/2016

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I consent to being recorded during this interview
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive an electronic copy of this Information Statement and Consent Form.

I agree with the above statements, and understand that I can choose not to participate:

Participant Name	
Signature	
Date	

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

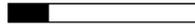
Researcher Name	Dan Jolley
Signature	
Date	

B.2 Consent Statement – Survey & Intervention

CONSENT STATEMENT

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive an electronic copy of this Information Statement and Consent Form.
- I understand that I may be allocated to a delayed start group, and not be able to access course content immediately.

Yes, I understand



Appendix C: Ethics Approvals



14-Sep-2016

Name: Melissa Davis
Department/School: School of Psychology and Speech Pathology
Email: M.Davis@exchange.curtin.edu.au

Dear Melissa Davis

RE: Ethics approval
Approval number: HRE2016-0292

Thank you for submitting your application to the Human Research Ethics Office for the project **The Prevalence and Strength of Misconceptions Among Undergraduate Exercise Science Students, Vocational Fitness Students, and Exercise Professionals**.

Your application was reviewed through the Curtin University low risk ethics review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **14-Sep-2016** to **13-Sep-2017**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Davis, Melissa	CI
Jolley, Daniel	Student
Lavender, Andrew	Supervisor

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
 - proposed changes to the approved proposal or conduct of the study
 - unanticipated problems that might affect continued ethical acceptability of the project
 - major deviations from the approved proposal and/or regulatory guidelines

- serious adverse events
- 3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
- 4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
- 5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
- 6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
- 7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
- 8. Data and primary materials must be retained and stored in accordance with the [Western Australian University Sector Disposal Authority \(WAUSDA\)](#) and the [Curtin University Research Data and Primary Materials policy](#)
- 9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
- 10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
- 11. Ethics approval is dependent upon ongoing compliance of the research with the [Australian Code for the Responsible Conduct of Research](#), the [National Statement on Ethical Conduct in Human Research](#), applicable legal requirements, and with Curtin University policies, procedures and governance requirements
- 12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

None.

This letter constitutes ethical approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely



Dr Catherine Gangell
Manager, Research Integrity



Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

17-Nov-2017

Name: Melissa Davis
Department/School: School of Psychology and Speech Pathology
Email: M.Davis@exchange.curtin.edu.au

Dear Melissa Davis

RE: Ethics Office approval
Approval number: HRE2017-0807

Thank you for submitting your application to the Human Research Ethics Office for the project **An online intervention to improve the critical thinking skills of fitness professionals**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **17-Nov-2017 to 16-Nov-2018**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Davis, Melissa	CI
Jolley, Daniel	Student
Lavender, Andrew	Supervisor

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:

- proposed changes to the approved proposal or conduct of the study
 - unanticipated problems that might affect continued ethical acceptability of the project
 - major deviations from the approved proposal and/or regulatory guidelines
 - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
 4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
 5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
 6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
 7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
 8. Data and primary materials must be retained and stored in accordance with the [Western Australian University Sector Disposal Authority \(WAUSDA\)](#) and the [Curtin University Research Data and Primary Materials policy](#)
 9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
 10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
 11. Approval is dependent upon ongoing compliance of the research with the [Australian Code for the Responsible Conduct of Research](#), the [National Statement on Ethical Conduct in Human Research](#), applicable legal requirements, and with Curtin University policies, procedures and governance requirements
 12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

None.

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely



Amy Bowater
Acting Manager, Research Integrity

Appendix D: Exercise Science Knowledge Survey



1. **Unique Identifier Code:** this is so we can identify your responses without needing to collect personal information that may identify you. Please provide the requested information in the boxes below:

The month of your birth (2 digits, i.e. August is 08):

The last letter of your first name:

The first number of your street address:

The first letter of your father's first name:

The last 3 digits of your phone number:

2. **Email Address (optional):** by completing this survey you may be eligible for a prize (drawn at random once all responses have been collected). Please enter your email address if you would like to be entered in this draw, so we can contact you if you win. If you enter your email address, we will also send you a copy of the information and consent forms for this research. Your email address will not be used for any other purpose.

(terms and conditions of prize draw are available on request)

3. How old are you? years
4. What is your gender?
5. What is your highest level of education? (select one)
- No qualification
- Certificate I or Yr. 10 graduation
- Certificate II
- Certificate III or Yr. 12 graduation
- Certificate IV
- Diploma
- Advanced Diploma, Associate Degree
- Bachelor Degree
- Honours Degree, Grad Cert., Grad Dip.
- Master's Degree
- Doctoral/Medical Degree

6. Are you currently employed in a fitness/exercise related role (such as personal trainer, exercise physiologist, strength & conditioning coach)? (yes/no)

If yes, how long have you worked in the exercise industry? (total number of years, not including breaks)

years

7. What is your highest level of exercise qualification? (select one)

- No qualification
- Certificate I or Yr. 10 graduation
- Certificate II
- Certificate III or Yr. 12 graduation
- Certificate IV
- Diploma
- Advanced Diploma, Associate Degree
- Bachelor Degree
- Honours Degree, Grad Cert., Grad Dip.
- Master's Degree
- Doctoral/Degree

8. Exercise Frequency. Select one statement that best describes your exercise frequency. Include all forms of exercise & sport.

- I have never exercised
- I have exercised in the past (> 12 months ago)
- I have exercised regularly, but not currently (stopped in the last 12 months)
- I currently exercise 1-2 times per week
- I currently exercise 3-5 times per week
- I exercise 6 or more times per week

9. How long have you exercised? State the length of time (to the nearest year) you have been regularly exercising, without a break of longer than 3 months.

years

10. Exercise Type. Select all types of exercise that you would participate in on a regular basis (at least once per week).

- | | | | |
|------------------------------------|--------------------------|---------------------------------|--------------------------|
| Walking/running | <input type="checkbox"/> | Group fitness classes | <input type="checkbox"/> |
| Cycling | <input type="checkbox"/> | Bodybuilding/figure competition | <input type="checkbox"/> |
| Swimming | <input type="checkbox"/> | Powerlifting | <input type="checkbox"/> |
| Cardio machines (e.g. rower, bike) | <input type="checkbox"/> | CrossFit | <input type="checkbox"/> |
| Team sport | <input type="checkbox"/> | Aqua aerobics | <input type="checkbox"/> |
| Individual sport | <input type="checkbox"/> | Yoga | <input type="checkbox"/> |
| Weights training | <input type="checkbox"/> | Martial arts/Combat sports | <input type="checkbox"/> |
| Golf | <input type="checkbox"/> | Pilates | <input type="checkbox"/> |
| Other (please state) | <input type="text"/> | | |

11. In the last 12 months, have you looked for information on exercise or nutrition?

yes no

12. Select all sources of exercise or nutrition information you have accessed in the last 12 months. (select all that apply)

Degree qualified exercise/nutrition professionals	<input type="checkbox"/>	Doctor (general practitioner)	<input type="checkbox"/>
Personal trainers/gym instructors	<input type="checkbox"/>	Pharmacist	<input type="checkbox"/>
General interest magazines	<input type="checkbox"/>	Chiropractor	<input type="checkbox"/>
Health/fitness magazines	<input type="checkbox"/>	Nutritionist (not degree qualified)	<input type="checkbox"/>
Exercise or nutrition textbooks	<input type="checkbox"/>	Celebrities	<input type="checkbox"/>
Academic (peer reviewed) journals	<input type="checkbox"/>	Alternative/natural health expert, i.e. naturopath,	<input type="checkbox"/>
Health/fitness/nutrition websites (privately owned)	<input type="checkbox"/>	Chinese medicine practitioner	<input type="checkbox"/>
Internet forums	<input type="checkbox"/>	Team mates	<input type="checkbox"/>
Social media pages	<input type="checkbox"/>	Public health promotion campaigns (i.e. Find 30, Live Lighter)	<input type="checkbox"/>
Friends	<input type="checkbox"/>	Physiotherapist	<input type="checkbox"/>
People you meet in the gym	<input type="checkbox"/>	Other (please state)	<input type="text"/>
Co-workers	<input type="checkbox"/>		

13. Rate the trustworthiness of the following sources for exercise or nutrition information.

Source	Not at all trustworthy	Not usually trustworthy	Sometimes trustworthy	Usually trustworthy	Very trustworthy
Degree qualified exercise/nutrition professionals	1	2	3	4	5
Personal trainers & gym instructors	1	2	3	4	5
General interest magazines	1	2	3	4	5
Health & fitness magazines	1	2	3	4	5
Exercise or nutrition textbooks	1	2	3	4	5
Academic (peer reviewed) journals	1	2	3	4	5
Health/fitness/nutrition websites (privately owned)	1	2	3	4	5
Internet forums	1	2	3	4	5
Social media pages	1	2	3	4	5
Friends	1	2	3	4	5
People you meet in the gym	1	2	3	4	5
Co-workers	1	2	3	4	5
Doctor (general practitioner)	1	2	3	4	5
Pharmacist	1	2	3	4	5
Chiropractor	1	2	3	4	5

Nutritionist	1	2	3	4	5
Celebrities	1	2	3	4	5
Alternative/natural health expert, i.e. naturopath, Chinese medicine practitioner	1	2	3	4	5
Team mates	1	2	3	4	5
Public health promotion campaigns (i.e. Find 30, Live Lighter)	1	2	3	4	5
Physiotherapist	1	2	3	4	5

14. A bat and ball cost \$1.10 in total. The bat costs \$1.00 more than the ball. How much does the ball cost? cents

15. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? minutes

16. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake? days

17. Exercise Science Knowledge. Decide whether each of the following statements is correct or not. If you don't know the answer, select 'don't know'. Please do not guess.

Then on the right-hand side rate your confidence in your answer. If you answered 'don't know' on the left, please also answer 'don't know' on the right. If you answered either 'yes' or 'no', then you must rate your level of confidence.

Statement	Don't Know	True	False		Slightly	Moderately	Very
Very large quantities of protein are not necessary to improve your response to training. Your body only uses as much protein as it needs to, and extra protein gets broken down and excreted in your urine.	0	1	2	How confident are you in this answer?	1	2	3
Gentle, static stretching before exercising is a good way to reduce your risk of getting injured.	0	1	2	How confident are you in this answer?	1	2	3
Higher intensity exercise uses more energy than lower intensities. Increased energy expenditure is a key part of successful weight loss programs, so this is encouraged when safe to do so.	0	1	2	How confident are you in this answer?	1	2	3



An hour of low intensity cardio training will burn more fat than an hour at high intensity. Therefore, you will lose weight faster doing low intensity cardio training.	0	1	2	How confident are you in this answer?	1	2	3
A healthy diet should be generally consistent with the Australian Dietary Guidelines, contain food from all the major food groups (including grains & dairy), and contain moderate amounts of carbohydrate, fat, and protein.	0	1	2	How confident are you in this answer?	1	2	3
Fat metabolism is not a local process. You can't pick where you lose body fat from by exercising specific parts of the body.	0	1	2	How confident are you in this answer?	1	2	3
Protein is the most crucial nutrient for muscle growth. If you want to get bigger or stronger, the more you can eat, the better.	0	1	2	How confident are you in this answer?	1	2	3
If you want to start losing weight, then a short term fast or juice cleanse to flush toxins out of your system is a good way to get things started.	0	1	2	How confident are you in this answer?	1	2	3
If a part of your body is exercised hard, you will lose body fat from that area. For example, stomach crunches will help to flatten your stomach.	0	1	2	How confident are you in this answer?	1	2	3
You get tired when you exercise at high intensity for several reasons, including (but not limited to): depleted muscle glycogen, accumulated muscle damage, increased acidity in the muscle, and psychological fatigue	0	1	2	How confident are you in this answer?	1	2	3
A healthy, balanced diet provides most of the micronutrients you need. Vitamin supplements are unnecessary for most people	0	1	2	How confident are you in this answer?	1	2	3
A diet high in protein and fats, with little or no dairy or grains, is healthier than what is recommended in the Australian Dietary Guidelines	0	1	2	How confident are you in this answer?	1	2	3
When we exercise hard lactic acid builds up in our muscles. This is the cause of fatigue	0	1	2	How confident are you in this answer?	1	2	3
A gradual, progressive increase in the intensity of exercise is a good way to warm up and prevent injury.	0	1	2	How confident are you in this answer?	1	2	3

<p>It is possible for people to get stronger without feeling significant pain. Muscle damage (and resulting pain) is largely caused by eccentric muscle contractions, and you can still get stronger while keeping soreness to a minimum</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3
<p>Women have a risk of getting too muscular if they lift heavy weights. To avoid this, use lighter weights, and perform more repetitions.</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3
<p>A vitamin supplement (like a multivitamin) can improve your wellbeing, energy levels, and exercise performance.</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3
<p>Most people can lift heavy weights for improved strength and health, and not get too muscular. Women will generally find gaining muscle much harder than men, due to hormonal differences between the genders.</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3
<p>"No pain, no gain." To get stronger or fitter, you need to endure some pain. This is necessary to make your body adapt to exercise</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3
<p>The weight loss result from a short term fast or juice cleanse is usually a result of reduced muscle glycogen storage, and less water retention. This weight will return once the fast finishes.</p>	0	1	2	<p>How confident are you in this answer?</p>	1	2	3

Appendix E: Online Critical Thinking Intervention



CRITICAL THINKING FOR FITNESS PROFESSIONALS

Training Details	
Course Start & Duration	The start date of the course is flexible. Once access to the course has been provided, you will have 6 weeks to complete all modules.
Mode of Delivery	This course is delivered entirely online. To access content and complete activities, you will need access to a computer and an internet connection. Most of the content will be presented within a Moodle course, but occasionally external links will be used. You may also be required to access other sites to research topics in the course.

Facilitator Contact Information
Dan Jolley: daniel.j.jolley@postgrad.curtin.edu.au

Required Resources
Provided: <ul style="list-style-type: none">• Access to Moodle for course content (participants need to register to use the site)• Access via email to an assessor to mark work and provide clarification and reasonable adjustment as needed• Background reading material, and external links and resources as appropriate Participants are required to arrange access to: <ul style="list-style-type: none">• A computer with internet access• Writing materials as necessary

Recognition of Prior Learning / Credit
There is no recognition of prior learning available for this course

Assessment Process
<p>To complete a module, you need to answer all questions satisfactorily. If any of your answers require more work, you will receive email communication from the assessor outlining what extra work is required.</p> <p>Once all questions in a module are answered, and a passing mark is received, then next module will be opened for you to attempt. It may take up to 48 hours for the next module to be opened, so please allow for this delay when planning when you will complete modules.</p> <p>If a passing mark is not received, you will receive feedback from the assessor, and be able to attempt the questions again. You can attempt questions as many times as you like, within the 6 week duration of the course. If you wish to appeal an assessment decision, contact the assessor at daniel.j.jolley@postgrad.curtin.edu.au. If you are not satisfied with the outcome of this appeal, you can contact the Principal Investigator at m.davis@exchange.curtin.edu.au.</p> <p>In order to gain CECs from this course, you must successfully complete all eight (8) modules.</p>



CRITICAL THINKING FOR FITNESS PROFESSIONALS

Reasonable Adjustment

Adjustment to assessment in the course is possible, provided no major changes to the presentation of course content is required. If you require support for literacy and numeracy issues; support for hearing, sight or mobility issues; considerations relating to age, gender & cultural beliefs; or format of assessment materials, you need to contact the assessor.

Necessary adjustments should be discussed with the assessor *prior to* completing Module 1.

Other Information

This course has been designed by Dan Jolley as progress towards a PhD at Curtin University. Should you have any further questions about this course, the content, or the research it is part of, please contact Dan at daniel.j.jolley@postgrad.curtin.edu.au.

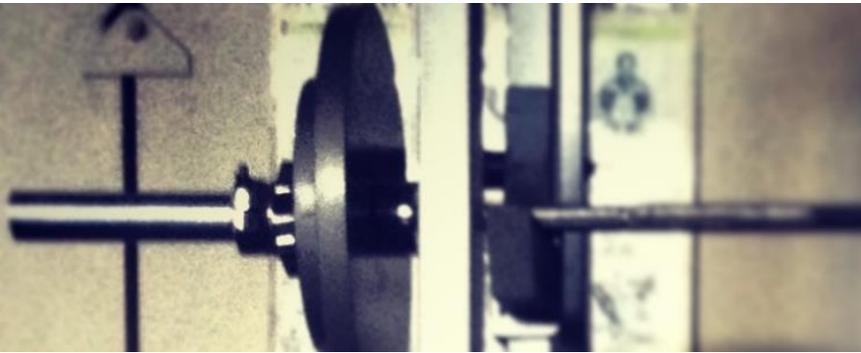
If there are any further questions or concerns that cannot be addressed by the researcher, please contact the Principal Investigator for this project, Dr. Melissa Davis, at m.davis@exchange.curtin.edu.au.

Module Details

Number	Title	Content
1	Introduction to Argument	<ul style="list-style-type: none">• Introduction: critical thinking in the fitness industry• Argument structure• Use of qualifiers
2	Argument Continued: Opposing Views	<ul style="list-style-type: none">• Revision of argument basics• Why does someone hold an opposing view?• Identifying a poor argument
3	Biases	<ul style="list-style-type: none">• What is a cognitive bias?• Do you hold any biases?• Identifying bias in others
4	Logical Fallacies	<ul style="list-style-type: none">• What is a logical fallacy?• Identifying relevant fallacies
5	Confidence & Qualifications	<ul style="list-style-type: none">• How much of an expert are you?• Why are some people overconfident?• Who can we turn to when we need to know more?
6	Scientific Method	<ul style="list-style-type: none">• The scientific method for personal trainers• The placebo effect• Burden of proof
7	Sources of Information	<ul style="list-style-type: none">• Hierarchy of evidence• How much to trust sources of varying quality• Online searching for better evidence
8	Putting it all Together	<ul style="list-style-type: none">• Culmination activities: research a claim, present evidence, draw conclusions• Course reflection

CRITICAL THINKING FOR FITNESS PROFESSIONALS

Topic	Description & Relevant Skills
Argument	<p>Argument is the ability to engage in discussion with someone holding a different opinion, and arrive at a conclusion that both parties can agree with – not an argument as you traditionally use the term! As personal trainers, sometimes you need to argue with clients or colleagues. To be skilful at argument, you need to be able to:</p> <ul style="list-style-type: none"> • Identify the important information to support your own position • Demonstrate an appropriate level of conviction (that is, not overstate the strength of your argument) • Identify strengths and weaknesses of the opposing position • Provide relevant counterarguments • Be willing and able to adjust your position if compelling evidence is presented that contradicts it
Biases/Logical Fallacies	<p>Biases are shortcuts in thinking, that can help you process information and arrive at decisions more quickly. But this can often cause you to interpret information incorrectly. To limit the negative impact of biases:</p> <ul style="list-style-type: none"> • Have an awareness of the different mistakes of logic we make as a result of our biases (logical fallacies) • Identify biases in your own thinking • Attempt to control for biases by questioning your own conclusions. • Identify biases in others, which may be presented when the interpret information in an incorrect way, or draw poor conclusions
Epistemology	<p>Epistemology can be a complicated topic, but can be summarized as the way we think about thinking. For example, do you consider that your thoughts about a topic can change or adapt over time, or do you consider knowledge to be final and unchanging? If you have a sophisticated epistemology you will display:</p> <ul style="list-style-type: none"> • Opinions that evolve or adapt when presented with changing evidence • A strong awareness of your scope of practice • An awareness of those more qualified in a field than yourself
Evidence	<p>To be a good fitness professional, you need to be able to assess the strength of evidence for a claim (such as a diet or exercise program promising a certain result). To do this effectively you should be able to:</p> <ul style="list-style-type: none"> • Identify whether evidence is strong or weak • Identify the emotional appeal of personal stories, and not let your objective opinions be influenced by these stories • Decide whether a conclusion is useful based on the strength of the evidence
Metacognition	<p>Metacognition is an awareness of your own thinking. If you have good awareness, then you can identify the strengths and weaknesses of your knowledge, and identify areas in which you need to improve. A good understanding of your knowledge will mean you are more capable of operating within your scope of practice, even as it changes and expands during your time in the fitness industry</p>
Scientific Method	<p>This is an extension of gauging the strength of evidence discussed above. While you are not a scientist, fitness professionals are sometimes asked to form judgements about science that may support (or contradict) an opinion. To have an informed opinion, you will need to:</p> <ul style="list-style-type: none"> • Understand basic research methods, and why certain methods are selected for different research • Judge whether evidence presented is strong or weak, and whether the conclusions drawn are appropriate • Identify gaps in the evidence (what the research did NOT demonstrate), and propose in general terms how these gaps can be addressed



Module 1: Introduction to Argument

Module 1 Learning Outcomes

At the end of this module, you should be able to:

- Understand the need for fitness professionals to possess critical thinking skills
- Understand basic argument structure
- Identify whether or not evidence cited supports an argument
- Choose an appropriate qualifier to suit the quality of the evidence

Part 1: Getting Started

Welcome to your "Critical Thinking for Fitness Professionals" course. Over the next eight modules you will be exposed to different ways of thinking about knowledge in a fitness setting. You will learn to make decisions about how accurate information is, or how fair the conclusions drawn from that information are. You will also learn to examine your own thinking about this evidence, and the thinking of others. Finally, you will be given tips on how to search for good information for yourself, and find reliable sources.

Although we will be using fitness, nutrition, and weight loss content for examples and activities throughout this course, our goal is not to teach you anything new about these topics. Instead, we want to give you the skills to examine your own understanding, and draw your own conclusions. You may adjust your opinion slightly on one or two of these topics, or even change your mind entirely after reflecting on this information.

But more on that later.



Critical Thinking for Fitness Professionals

Module 1: Introduction to Argument

"Thinking at Hell's gate" (CC BY 2.0) by [innoxius](#)



Module 1: Introduction to Argument

What is critical thinking?

Firstly, what do you think about when we use the term "critical thinking?"

It's not a term that is thrown around a lot in the fitness industry. Usually, we are much more concerned about what we can learn about resistance and cardio training. Or we want to know about new findings in nutrition, or psychology. Or we want business, sales, or management advice.

But arguably, critical thinking is more important than all of these. The ability to think critically is the most important skill we can gain from an education. With this skill, we become much better at identifying and interpreting information for ourselves.

Critical thinking can be defined as engaged, skilful, and judgemental assessment of one's beliefs, or those of others. More simply, it is being able to think about our own thinking. Are our decisions reasonable? Are we interpreting information fairly? Are we ignoring information that contradicts our opinion?

Are we willing to change our opinions in the light of changing information or evidence, or do we stick with what we believe to be true, no matter what?

What is critical thinking?



JUMPING HOPE.
They play should strive to end with caution. It is a healthy exercise, and tends to make the form graceful; but it should be used with moderation. I have known instances of blood vessels burst by young ladies, who, in a silly attempt to jump a certain number of hundred times, have persevered in jumping after their strength was exhausted.



What is critical thinking?

Engaged, skilful, and judgemental assessment of one's beliefs, or those of others



If we lack the ability to think critically, we will find it hard to develop our knowledge. At an extreme, we can be stuck doing what we have always done, while the world, and the industry, continues to move on around us. To get the most out of ourselves in the rapidly changing fitness industry, we need to be able to think critically.

One more point on that definition. A key issue is that word "engaged". While many people will possess some critical thinking skills, if they are unwilling, or unable, to apply them to a particular topic, they will not benefit from them. In order to think critically we need to want to apply these skills to all our knowledge.



Module 1: Introduction to Argument

We need to accept that it is ok to change your mind as we learn more about a topic. Or that our opinion can change or evolve over time. It can be very hard to admit that we are wrong sometimes. It happens to all of us, even though not all of us can admit it when it occurs. A good critical thinker can accept that this is an inevitable part of learning, and developing, as a professional. And a good critical thinker *never stops* learning.

Critical thinking in the fitness industry

Hopefully you see how critical thinking can benefit you as a fitness professional.



Consider the claims for the product you see here. This product purports to remove toxins from drinking water, with quite an impressive array of benefits. Customers have reported increased energy, reduced inflammation, and improved skin & sleep. What would you say if a client asked you about this product? Or told you they were using it? Do you think this sounds reasonable, or that the claims are a bit too ambitious?

It is not necessarily the place of a critical thinker to say that something definitively does, or does not work. But we can make decisions on the plausibility of a claim, and whether the evidence provided supports the claim. In this case, the evidence provided is quite weak. In later modules, you will find out why testimonials (such as those offered on the banner), are not useful when deciding if this product works, or doesn't work.

There are always people looking to promote a particular diet, exercise program, or healthy living philosophy. Some of these may be useful for our clients, some may be dangerous. Some of the



people promoting these are well qualified, others are not. Just go to a health and fitness expo to see the amazing range of diet and exercise advice on offer. Much of it is contradictory. So how do we know what is correct?

Our clients may not have the expertise to tell the difference. Unfortunately, many fitness professionals don't either. We don't need to address each of these claims individually, if you possess the skills to investigate them yourself. That's what we hope to achieve with this course.



Module 1: Introduction to Argument

Course details

Before we get into the nuts and bolts of the course, a little housekeeping. You would have noticed a document in the introduction to the Moodle course. Please take a minute to have a look at this. This is a course outline, and contains some information about the course content, how we will assess you, and some contact details in case you need to get in touch with us.

Included in this module, is a simple outline of the skills we are aiming to help you develop. On the left you can see the broad categories of critical thinking ability included in this course. Next to each category you can see a brief definition, and a description of these abilities. Feel free to refer back to this list throughout the course to see how you are going. If you want to have a closer look now, you can pause on this screen, or look at the document.

Topic	Description & Relevant Skills
Argument	Argument is the ability to engage in discussion with someone holding a different opinion, and arrive at a conclusion that both parties can agree with – not an argument as you traditionally use the term! As personal trainers, sometimes you need to argue with clients or colleagues. To be skilful at argument, you need to be able to: <ul style="list-style-type: none">• Identify the important information to support your own position• Demonstrate an appropriate level of conviction (that is, not overstate the strength of your argument)• Identify strengths and weaknesses of the opposing position• Provide relevant counterarguments• Be willing and able to adjust your position if compelling evidence is presented that contradicts it
Biases/Logical Fallacies	Biases are shortcuts in thinking, that can help you process information and arrive at decisions more quickly. But this can often cause you to interpret information incorrectly. To limit the negative impact of biases: <ul style="list-style-type: none">• Have an awareness of the different mistakes of logic we make as a result of our biases (logical fallacies)• Identify biases in your own thinking• Attempt to control for biases by questioning your own conclusions.• Identify biases in others, which may be presented when the interpret information in an incorrect way, or draw poor conclusions
Epistemology	Epistemology can be a complicated topic, but can be summarized as the way we think about thinking. For example, do you consider that your thoughts about a topic can change or adapt over time, or do you consider knowledge to be final and unchanging? If you have a sophisticated epistemology you will display: <ul style="list-style-type: none">• Opinions that evolve or adapt when presented with changing evidence• A strong awareness of your scope of practice• An awareness of those more qualified in a field than yourself
Evidence	To be a good fitness professional, you need to be able to assess the strength of evidence for a claim (such as a diet or exercise program promising a certain result). To do this effectively you should be able to: <ul style="list-style-type: none">• Identify whether evidence is strong or weak• Identify the emotional appeal of personal stories, and not let your objective opinions be influenced by these stories• Make a decision on whether or not a conclusion is useful based on the strength of the evidence
Metacognition	Metacognition is an awareness of your own thinking. If you have good awareness, then you are able to identify the strengths and weaknesses of your knowledge, and identify areas in which you need to improve. A good understanding of your knowledge will mean you are more capable of operating within your scope of practice, even as it changes and expands during your time in the fitness industry
Scientific Method	This is an extension of gauging the strength of evidence discussed above. While you are not a scientist, fitness professionals are sometimes asked to form judgements about science that may support (or contradict) an opinion. To have an informed opinion, you will need to: <ul style="list-style-type: none">• Understand basic research methods, and why certain methods are selected for different research• Judge whether evidence presented is strong or weak, and whether the conclusions drawn are appropriate• Identify gaps in the evidence (what the research did NOT demonstrate), and propose in general terms how these gaps can be addressed

Each module is divided up into smaller sections, so you don't need to complete a module all at once if you don't want to. You can do some extra reading, then come back to the rest of the module later, or stop for a break or some work. Allow about an hour for each module, though they might take longer if you decide to spend more time on extra reading and activities.

We hope you enjoy the course, and find what you learn a useful addition to the normal skill set of a fitness professional. That's it for the introduction. When you are ready, start the video for Part 2 to begin learning about some of the details of critical thinking.



Module 1: Introduction to Argument

Part 2: What is an Argument?

Critical Thinking for Fitness Professionals

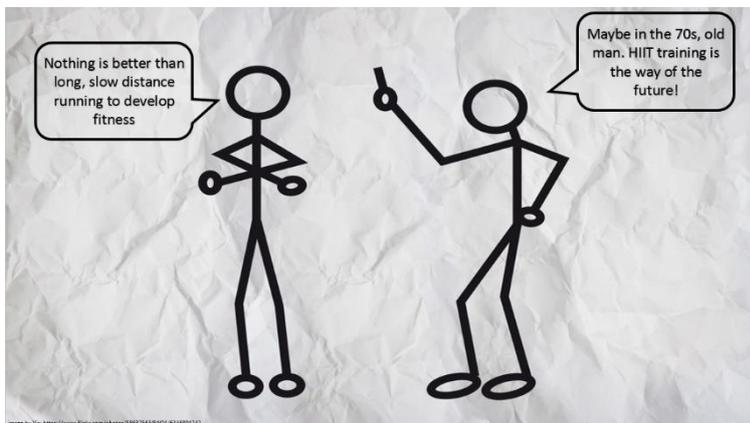
Module 1: Introduction to Argument
Part 2: What is an Argument?



When we use the term argument in a critical thinking setting, we are not using it in the way that it is commonly understood. Usually, when we think about an argument, we think about two people disagreeing, perhaps heatedly. We also usually don't think about these two people finding some common ground, or a position they can agree on. An argument is something most of us want to avoid when possible.

It's not what you think it is!

Instead, it is helpful to think about argument in a more cooperative manner. Rather than trying to convince someone at all costs that you are right, the aim of an argument in this form is to reach agreement. Two people may observe, and interpret something, in quite different ways. Both may be incorrect! Or both may be correct, but have an incomplete understanding of what they have observed. This argument can help both parties improve their understanding of a topic. While not everyone will be willing, or able, to participate in this sort of discussion, it can be a powerful way to learn, or clarify your thinking.



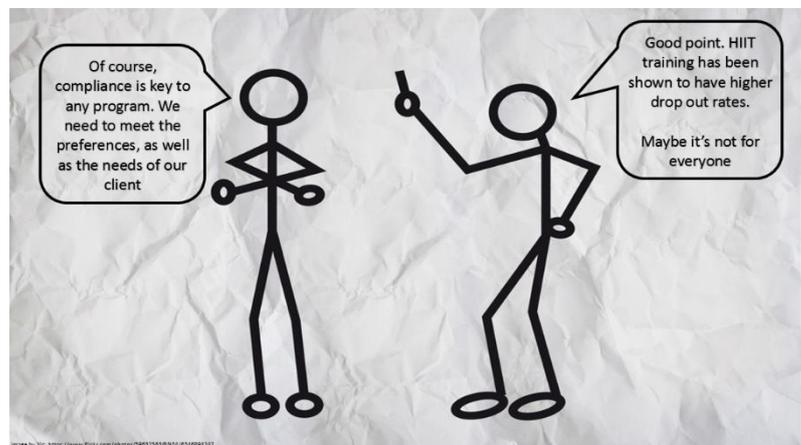
Consider this example: a trainer is discussing with a colleague the benefits of interval training. They may have quite different views about this type of training, and may strongly disagree with the other's position. One may have achieved great results for their clients using steady state cardio training. The other may have a strong personal preference towards interval training.



Module 1: Introduction to Argument

And while these two opinions seem to be contrasting, there are many different factors to consider in both of these statements. The reality may not be black and white. In the fitness industry, we often need to consider the needs, expectations, goals, and abilities of the clients we work with. Often, this will influence how we program exercise far more than our own thoughts about what is the ideal approach.

When considering the use of intervals, we need to consider, for example, if the client is able to exercise safely at the required intensity. Their injury and medical history needs to be taken into account. Their preferences need to be considered - do they *enjoy* this type of training? If not, will they complete the training at the intensity required? We also need to consider the goals of the client, and the type of training adaptation they require.



In short, it's a discussion that can't be summed up with one statement. The argument in this case may be used to identify how & when it is appropriate to use HIIT, not whether or not it should be used at all.

Argument structure

For an argument to be successful, we may need to overcome the habit of aggressively opposing another's opinion. This can be hard, particularly when we are confident in our knowledge and experience. But there are many benefits of well-structured argument:

- We learn to elaborate on what we know, and reason logically;
- We learn how to structure our argument properly, so we avoid making claims we cannot support;
- And we improve our ability to collaborate with others

To have a valid argument, we need:

- A claim
- Evidence that the claim is based on
- The justification for using that data





Module 1: Introduction to Argument

We may also use a qualifier, to indicate how certain we think our argument is. The person we are presenting the argument to may then assess the quality of our argument. Do they accept our data, and that it supports our claim? Do they agree with the level on confidence implied in our claim?

Example: arguments for intervals

Consider the following two arguments for using interval training. In the example on the left, a trainer makes a claim about high intensity interval training. As you can see, he is very confident. But the evidence he provides is only his personal experience, which he wants to apply to all his clients. While personal experience can be important in informing our own training, it is a weak form of evidence to apply to your clients, who do not have the same exercise history, injury history, goals, needs, likes and dislikes as you do.

	Argument 1	Argument 2
Claim	High intensity interval training (HIIT) is the best way to get fit	High intensity interval training (HIIT) probably improves aerobic capacity quicker than steady state exercise in those who can tolerate it
Evidence	I do HIIT all the time, and I'm fit	A review of research into the effectiveness of HIIT training showed benefits from sessions only 15 minutes long, in as little as two weeks
Justification	Because I'm a personal trainer and I can get myself fit with HIIT, I can help my clients too	This article showed the benefits of HIIT are gained quickly, but high levels of motivation are required. For my enthusiastic clients, this could be a great option

This argument itself is also invalid, as the trainer in this case doesn't **know** that he would not have received a better training effect from a different type of training at that time. And he never will know, as he can't go back in time to find out!

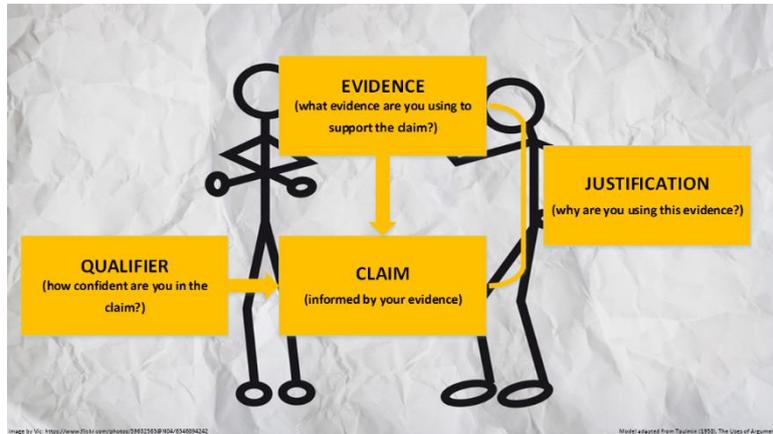
On the right, we see another argument in favour of HIIT training, but

it is more cautious. This trainer claims that HIIT training **probably** leads to better fitness gains than steady state training. This is the qualifier we mentioned earlier. He is also more specific than the first trainer, stating what type of fitness is improved, and who HIIT is suitable for. He presents evidence from an article that he has read, then goes on to justify his use of this article as evidence by stating what group of clients he will consider this training for.

We will expand on this model next time, but for now, keep in mind what we need to be able to present a valid argument to someone. If your evidence is weak or not relevant, should you be presenting this argument? Or should you be using a different qualifier?



Module 1: Introduction to Argument



At its best, argument can be a great tool for learning. Even if you are not shown to be wrong, you may end up making subtle changes to your position based on a well-reasoned counterargument. You may also learn something new, as other people bring new information to the discussion. The process of having this discussion help you reflect on your own opinion, and may help you understand it better (e.g. teaching being a great way to learn something). And the old adage of "practice makes perfect" holds true here. You can become better at explaining your reasons, ask better questions, and provide clearer explanations to clients.

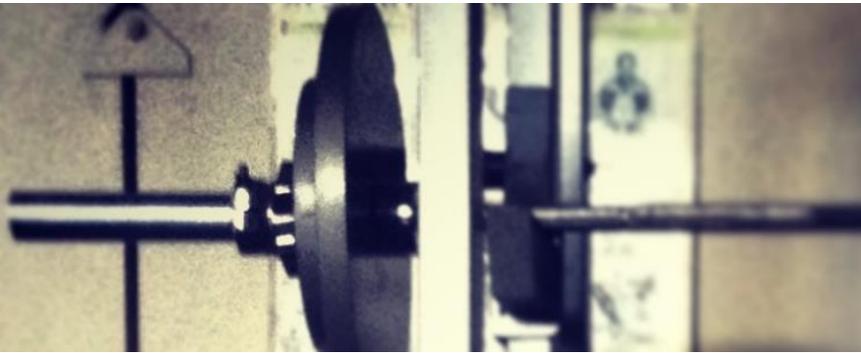
We need to keep an open mind. Do not discount the information of another just because it is not yours. Rather, assess their information on its merits. We also need to avoid getting too carried away, or excited in our argument, as this may lead people to dig in against your position, or may damage relationships.

It can be very difficult to explore an argument from a side you disagree with. Try it, and see how you go.

That's it for Part 2

When you're ready proceed to Part 3:
Argument Qualifiers





Module 1: Introduction to Argument

Part 3: Argument Qualifiers

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

Fitness Professionals Scope of Practice

Often in the fitness industry we see people making claims which are unsupported by evidence. This often occurs when fitness professionals are discussing concepts that are beyond the extent of their qualifications. Fitness Australia has prepared a document that clearly outlines what services and advice a fitness professional is qualified to provide. Make sure you read, and are familiar with, this document.

If someone asks you about a topic that is outside this scope of practice, the safest and most practical source of action is to refer the person to a professional with the appropriate qualification. If you are discussing topics outside of this scope of practice, you should be aware of the limits of your expertise. If you are arguing a point with someone, if the point is outside your scope of practice your qualifier should be very different than if you are comfortably within your expertise!

A copy of this document is available for download in this course, and can also be downloaded at <http://fitness.org.au/articles/policies-guidelines/scope-of-practice-for-registered-exercise-professionals/4/38/20>

Pick the Qualifier Activity

Consider the argument example we used in the previous section. The statement is:

"High intensity interval training ____ improves aerobic capacity quicker than steady state exercise in those who can tolerate it."

Without doing any further research on the topic, I may have a strong opinion on the topic, and may choose "always" or "never". But, having read the article provide which examined the research on the topic, the qualifier you choose may change.

In this case, the evidence is fairly clear that interval training is more effective at improving aerobic capacity. We may avoid using the qualifier "always", as there are gaps in this research, such as whether this is true over longer training programs than the research has examined. So we settle on "probably", to allow for times when this might **not** be true, or for the evidence to change over time (this is why scientists usually avoid these types of definitive qualifiers - it can be hard to say that something is absolutely true under **all** circumstances).





Module 1: Introduction to Argument

Now try it for yourself with the two exercises below. You will need to read the statements, and pick a qualifier. Then you will be given some reading. After finishing the reading, pick your qualifier again. Has it changed? Tell us why it changed (or why it hasn't), and what information in the article helped you reach this decision

Exercise 1: Consider the following statement: "CrossFit _____ injuries at a higher rate than other types of exercise."

Now consider what your personal opinion of this statement is, knowing what you do about CrossFit. It's ok to have a strong opinion about CrossFit, and it's ok not to - there's no right or wrong answer here. Now pick the qualifier that best fits this sentence, and your opinion.

- invariably causes
- often causes
- probably doesn't cause
- absolutely doesn't cause

Next, click the two links below and read the articles. Both are reviews of CrossFit written by exercise physiologists. Once completed, pick your qualifier again. You can change qualifiers, or keep the same one.

- a. <http://www.afr.com/lifestyle/health/highintensity-workouts--for-our-highspeed-times-20160615-qpk0mh>
- b. <https://www.drillsukala.com.au/exercise/crossfit-unbiased-review/>

Now select your qualifier again. Justify your decision to change/keep qualifiers. Explain what information provided help to change your opinion. If you did not change your opinion, explain why the information you read supported your view.





Module 1: Introduction to Argument

Exercise 2: Consider the following statement. "Vitamin supplements are _____ safe, and _____ be used by the average person as part of a healthy diet."

Consider your personal opinion of this statement, given your current knowledge about nutrition. Pick the two qualifiers that best fit the sentence, and your opinion.

- totally; need to
- often; probably should
- are not always; don't need to
- not; should not

Next, click the two links below and read the articles. Both are discussions of vitamin supplements by university researchers (one in nutrition, the other in pharmacy practice). Once completed, pick your qualifiers again. You can change qualifiers, or keep the same one.

- a) <https://theconversation.com/health-check-can-vitamins-supplement-a-poor-diet-62291>
- b) <https://theconversation.com/vitamins-myths-facts-use-and-misuse-4135>

Justify your decision to change/keep qualifiers. Explain what information provided help to change your opinion. If you did not change your opinion, explain why the information you read supported your view.





Module 1: Introduction to Argument

Part 4: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

At the end of each module you will be asked a series of four questions that are designed to help you reflect on what you have studied, and encourage you to think about what you might want to learn in the future. You can answer these questions using what you have learnt about critical thinking (argument, for example), or the exercise and nutrition content of the module. Take your time, and give your answers some thought.

This is an important part of the critical thinking process - how we apply what we learn, and where it leads us in the future, is almost as important as **what** we learn.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 1. Once your responses have been checked, Module 2 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.



Module 2: Opposing Views & Counterargument

Module 2 Learning Outcomes

At the end of this module, you should be able to:

- Understand why someone may disagree with you
- Identify weak arguments, and provide appropriate counterarguments
- Critically analyse an argument, and come up with counterarguments, even when you agree with the argument

Part 1: Introduction

Last time you were introduced to arguments. Not the ranting and raving type that we commonly think about, but a discussion of two points of view, that allow us to more clearly understand the other party's position, or reach agreement if one or both parties alters their position.

Our focus last time was on the claim being made, the strength of the evidence supporting the claim, and qualifiers that can be used to indicate how certain the claim is. To jog your memory, our argument structure is shown here. These are the crucial first steps of an argument, and help us to make sure our position is reasonable.

We can see the different components of the argument we discussed last time: the claim and the supporting evidence, connected by our justification. We can also see the qualifier we discussed previously, which can change the strength of the claim. But this isn't where an argument ends.



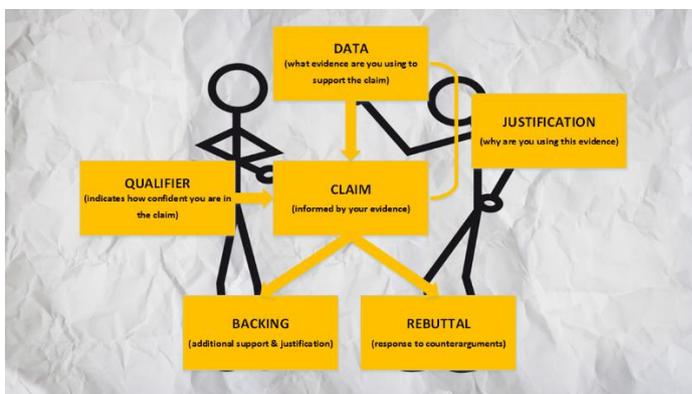
"Humanoids Arguing" (CC BY 2.0) by [hang in there](#)



Module 2: Opposing Views & Counterargument

Counterarguments

The person we are presenting our argument to may need more convincing, so we may need additional support for our claim, and further justifications. This is our **backing**. We may also find someone presents counterarguments - their own arguments **against** your claim, which you will need to respond too. These are called **rebuttals**.



In some jobs it is quite common for our decisions or reasoning to be challenged by clients, managers, or co-workers, and we will need to defend this position against counterarguments. That's assuming we are right, of course! And if we are proven to be wrong, we need to be able to accept that we are wrong.

An effective arguer is willing to change their opinion when required. If the other

person correctly shows that your claim is not supported by the evidence, or your justification is weak, you may need to accept that you were wrong. Counterarguments will be discussed in more detail next time, but keep in mind we are not looking to defend our position under all circumstances.

At the heart of this type of back and forth argument, is the strength of your evidence to support your claim. If you cannot answer "how do you know?", and defend your claim, then the argument should not have been made. Consider this fairly obvious example in the discussion between two characters from the show *The Simpsons* below, when discussing the effectiveness of the newly introduced "Bear Patrol" in Springfield:

Homer: Ah, not a bear in sight. The Bear Patrol must be working like a charm.

Lisa: that's specious reasoning, Dad.

Homer: thank you, honey.

Lisa (picks up a rock from the ground): By your logic, I could claim this rock keeps tigers away.



Module 2: Opposing Views & Counterargument

Homer (looking thoughtful): How does it work?

Lisa: It doesn't work.

Homer: Uh-huh.

Lisa: It's just a stupid rock.

Homer: Uh-huh.

Lisa: But I don't see any tigers around here, do you?



Homer (pulling money from his pocket): Lisa, I want to buy your rock.

A claim is made by Homer about the effectiveness of the "Bear Patrol" at keeping away bears. As a counterargument, Lisa attacks the quality of Homer's evidence (the lack of bears) by pointing out the problem with this assumption: an absence of bears in an urban area is due to a number of reasons, so the "Bear Patrol" cannot get the credit for this! In this case, the two parties were not able to find agreement on this issue, but for anyone watching the flaw in the argument should be obvious.

In this module, we are going to examine arguments in more detail than last time. We will look at the opposing side of an argument, and how to make (or rebut) counterarguments. Many people find it difficult to examine the other side of an argument, but if we learn how to do this, then we can learn more about our own argument and its weaknesses, and maybe learn more about some of the people we are trying to help.



Module 2: Opposing Views & Counterargument

Part 2: Why Does Someone Hold An Opposing View?

Critical Thinking for Fitness Professionals

Module 2: Opposing Views & Counterargument
Part 2: Why Does Someone Hold An Opposing View?



It can be difficult to imagine why someone could hold a different opinion to yours, particularly when you consider your education, experience, and the results you achieve for your clients. How could someone disagree with you?! But sometimes it happens, and gaining an appreciation of why this person disagrees with you might help you understand them better. For a trainer this could mean keeping your boss happy, or your clients!

"Thinking at Hell's gate" (CC BY 2.0) by [innoxius](#)

So let's examine some of the reasons why this might happen, and offer some potential explanations.

Different knowledge, or education

Within the fitness industry we sometimes work with clients who are very well informed, and have a good understanding of basic exercise principles. We also sometimes work with clients who don't even understand the most basic of exercise or weight loss concepts. We need to be able to communicate effectively with both. Something we see as undisputable fact may not make any sense at all to the client.

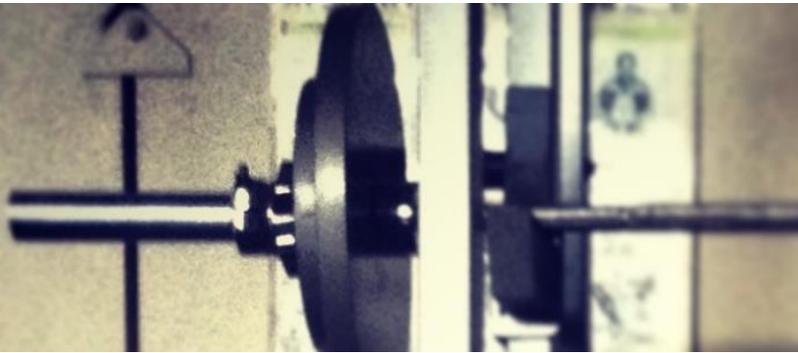


Why does someone hold a different opinion to you?

- Knowledge/education
- Personal experience
- Standards of evidence
- Motivation to hold their opinion
- Inability to examine their opinions

Let's look at an example. When designing training sessions to assist a client reach their weight loss goal, you decide that resistance training should form part of their training. Your client is appalled, as she considers resistance training something that footballers and bodybuilders do to get larger. She is trying to get smaller, so isn't impressed!





Module 2: Opposing Views & Counterargument

Most of us have encountered this in our fitness careers. We can usually help our clients understand the effect resistance training can have on our resting metabolism, and its place in weight loss programming. But what if this was another fitness professional, and you both had different opinions on just **how much** resistance training can contribute to weight loss? Where did these differing opinions come from?



For a start, you may have different qualifications - a Certificate III, Certificate IV, Diploma, or Bachelor's degree. So you may have been exposed to different information, which may place a different priority on resistance training as a weight loss intervention. They may have had lecturers with strong opinions one way or the other, and this may have influenced the way information was presented to them. They may

have been to different professional development courses, and read different articles. Be aware that much of this we select for ourselves, and without realising we can reinforce the opinion we already hold, even as we think we are expanding the boundaries of our knowledge. We'll spend more time on that in Module 3.

Depending on what you read, you can probably find information both in favour of, and against, resistance training for weight loss. Even the scientific literature may disagree on some of the benefits of resistance training. In this case, the argument may be an opportunity to compare sources of knowledge, and learn more, rather than simply defend your position, no matter what is said.

Personal experience

New information is interpreted through the lens of your experiences. If your client or your colleague has previously had success with resistance training as part of a weight loss program, then they will be more likely to have a positive opinion about it. But if they were unsuccessful with resistance training, of course they will be reluctant to try something again that, as far as they know, doesn't work.



Module 2: Opposing Views & Counterargument

Personal experience has a powerful influence on how we interpret new information. So if you want to encourage your client to be open to the idea of using resistance training, **any** information you provide may be less persuasive. Someone without this negative experience, on the other hand, could be convinced by the same evidence. For some, personal experience will be more powerful than any evidence that you can provide.

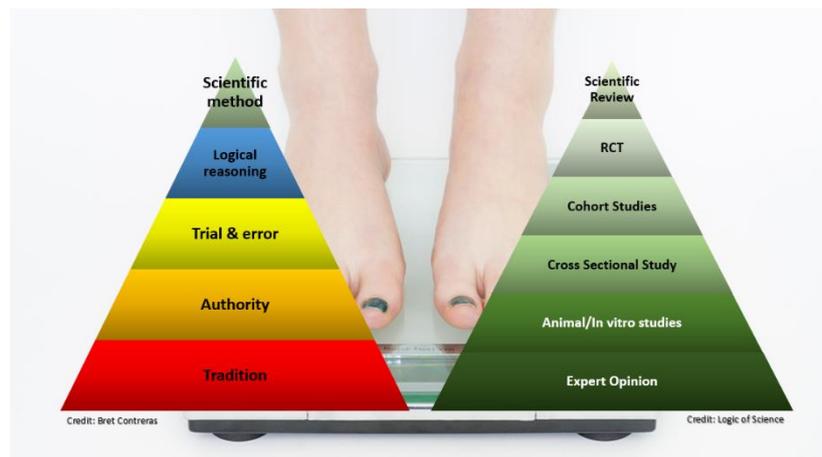
Different standards of evidence

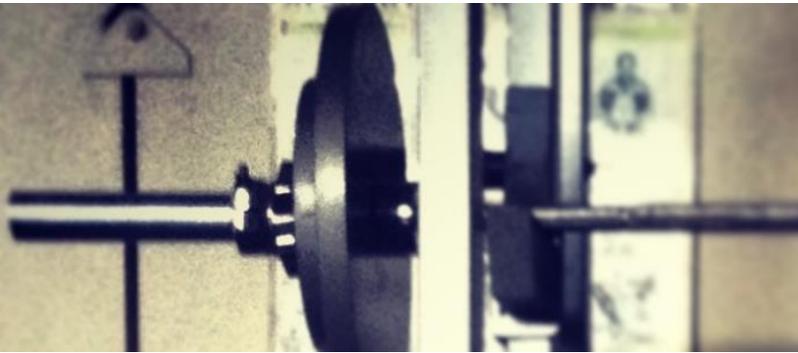
This is something we will cover more in later modules, but for now, it's important to understand that some of us may be convinced by different types of evidence. Your personal experience may not be relevant to other people, as everyone's circumstances are a little different. But for many of us, personal stories are more compelling than a textbook or an article. Your clients, particularly, will usually like to hear personal stories about the successes you have had with other clients, rather than a long lecture on the theory of weight loss.

The reasons for our choices in professional practice can be quite varied. On the left, you can see a pyramid showing some of the different ways we may arrive at our choices. The bottom of the pyramid shows

the less rigorous reasons. For some, it's enough to say that you do something "because that's the way it is always done" (tradition), or "my boss told me to do it that way" (authority). But for others, that's pretty unsatisfying. They may want to know that you have identified your best approach from trial and error, either in your own training or with previous clients. Still others may want to know that your methods are informed by thoughtfully applying the knowledge you have learnt during your education (logical reasoning). For each of these the justification is harder than "I've always done it that way." But we can go even further. We can even inform our practices by what the research evidence tells us, though this gets a little more complicated, as many of us are not qualified to interpret this information correctly.

The pyramid on the right shows that even when looking at scientific evidence, there are differences. Much of this is beyond the scope of qualification of a personal trainer, so we often need to rely on experts to interpret this information for us, and communicate it clearly. This is why we attend conferences and professional development courses. We will look at some of these in more detail in a later module, to improve your understanding of research.





Module 2: Opposing Views & Counterargument

If another trainer is satisfied by a different standard of evidence, then they may look at the same evidence as you, but arrive at a different conclusion. This is why we can sometimes get personal trainers disagreeing on fundamental issues. Both are convinced they are right, as both have evidence they think is compelling.

Often, the first step towards reaching agreement is determining how, and why, your opinions differ. Can you agree on what evidence is most compelling? If so, then it is possible to reach agreement. This may be when one of you is convinced by the other, or you agree that neither of you was 100% correct. Then a compromise position may be reached.

Of course, sometimes it's not possible to reach an agreement.

Motivation to hold their opinion

Someone may have a motivation to hold an opinion which may prevent them from changing their mind. This may not be intentional! Another trainer may have a huge investment in a certain style of training. This may be a financial investment, through their business and advertising, or a personal investment.

What do we mean by a personal investment? A trainer may have a strong preference towards resistance training. They enjoy doing this training themselves, and enjoy training their clients this way. They've been doing it for a long time, and read everything they can about its' benefits. They may even have had significant weight loss success (for themselves or their clients) using resistance training exclusively. To be able to honestly consider that there may be a more efficient way of achieving the results they are looking for could be very confronting.

This motivation is probably subconscious! We will examine this more in the next module, but it is entirely probable that the person we are talking to in this instance is convinced that they are looking at the topic in a fair, even-handed way. And it's very likely we hold our own biases, which are much harder to identify than biases we see in others.



Module 2: Opposing Views & Counterargument

Inability to examine their own opinion

This ability, or willingness, to examine your own opinion is the most challenging part of an effective, collaborative argument. When presented with a counterargument, do you examine your opinion? Or do you immediately look for flaws in the counterargument? The ability to weigh up both your argument, and the counterargument, at the same time, is very useful. If you can then show that the counterargument is weaker than your argument, you are in a much stronger position. This is called an "integrative rebuttal." Of course, if the counterargument is stronger, than your position may have to change.



Integrative rebuttal: criticizes the counterargument by referring back to the original argument, showing that it is more correct

Non-integrative rebuttal: criticizing the counterargument without examining the original argument. This is not a collaborative approach!

Most rebuttals, however, are "non-integrative", meaning that we attack the counterargument without considering the possibility that it is stronger than our argument.

Someone taking a non-integrative approach is merely interested in attacking the argument of the other party - they aren't open to the possibility of changing their opinion.

If their argument is weak, they may

retreat to holding onto their own position, and use a line you've probably heard before: "that's just my opinion." At this point, it should be clear that this argument is not going to be a constructive one!

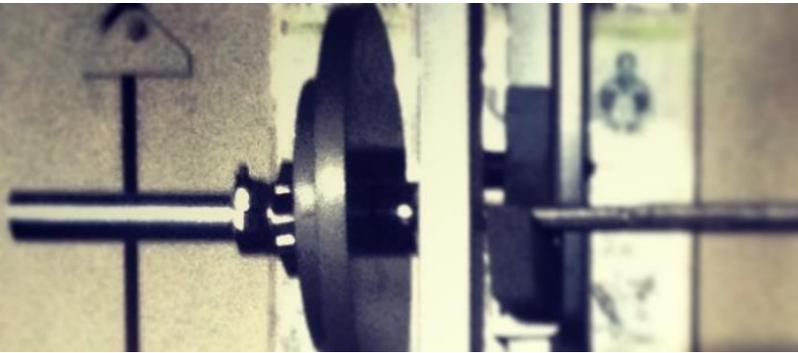
If the person you are talking to cannot see any reason to change their opinion, and can't provide a compelling counterargument to your position, then what is the point in the discussion? At some point you will need to agree to disagree, as any further discussion may result in one, or both of you, getting frustrated.

Rhetorical argument



To avoid potential arguments with others, it's worth considering that we don't have to be talking to another person to go through the argument process. In fact, it's often useful to go through this process on your own when examining a new idea, before presenting it to others. That way you identify much earlier if the idea is a bad one, and save everyone the effort of the argument.





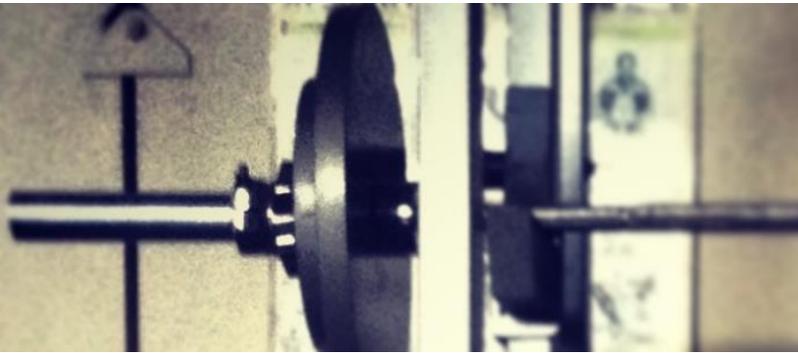
Module 2: Opposing Views & Counterargument

This is called a rhetorical argument. Using rhetorical arguments you can identify for yourself whether something is true or not, without having to rely on other people, and without needing the extra skills that go along with having this discussion with a colleague. By this we mean a strong memory and knowledge of the content, and communication skills to respond quickly and reasonably to the counterarguments. Using the process of rhetorical argument, we can propose an idea, identify supporting evidence and counterarguments, and then take our time to examine each of them. We can spread this out over days if we want to, before then forming our opinion.



In part 3 of this module you are going to construct a rhetorical argument. Remember, it's important that you are open to the possibility of your position being wrong. You need to come up with strong counterarguments, then honestly and fairly examine them. Don't just reject counterarguments, look for evidence that rejects them, then examine the strength of that evidence. If the counterargument is stronger than your rebuttal, then maybe you are wrong in this case! Good luck!





Module 2: Opposing Views & Counterargument

Part 3: Rhetorical Arguments

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

For this activity we are going to use the example we looked at in Part 2 - is resistance training or cardio training a better choice for helping our clients lose weight? It doesn't matter what your opinion is on the topic. Whether you strongly feel that one or the other is the best approach, or if you feel a moderate approach that uses a little of both works best, you can still have a go.

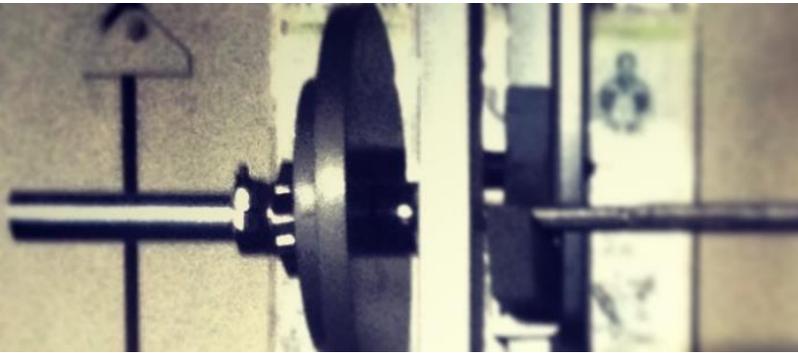
The object of this activity is for you to construct an argument. If you are feeling adventurous, you can even choose a position you disagree with, to get a completely different perspective on the issue.

Step 1: choose your argument. Is resistance training or cardio training better for helping our clients lose weight? You have to choose one or the other!

Step 2: identify the best reason (in your opinion) that this argument may be correct. This should include your evidence, and your justification. Your answer should be a short paragraph.

Step 3: now put yourself on the side of someone who disagrees with your argument. Take some time to find reasons why this argument may be wrong (for example, if you chose resistance training earlier, now you are taking the side of cardio training). You can do a Google search to get an idea of what some of these counterarguments are if you aren't sure. Your counterarguments could attack the evidence and justification you have provided, or attack the argument itself. When providing your counterarguments, provide your evidence as well. This could be a link to your supporting evidence, or a reference.





Module 2: Opposing Views & Counterargument

a. First counterargument:

b. Evidence for this counterargument:

c. Counterargument 2:

d. Evidence for counterargument:

Step 4: now weigh up the argument and counterarguments. Has your opinion changed? Have you developed a better understanding of why someone might disagree with you? Do you think that the real answer isn't as simple as one or the other? Provide a brief summary of your thoughts now that you've completed a rhetorical argument.

Going through this process may not change your mind. In fact, it may confirm your opinion. But you have to be open to the possibility of your mind being changed. Otherwise, you are just finding token counterarguments that are not convincing or looking for evidence that supports you, without being critical of the evidence.

We haven't yet told you which of these positions - if either - are correct. And we won't now, either. But we will provide some more evidence for you to look at if you want to. Included in this section is a review article looking at different physical activity strategies for weight loss. You can read the summary here (<https://www.ncbi.nlm.nih.gov/pubmed/19127177>). This is a pretty good standard of evidence, as it reviews the current state of scientific research, though you might find it quite technical.





Module 2: Opposing Views & Counterargument

Part 4: Identifying Poor Arguments

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

I'm sure you've heard the saying "everyone has the right to their own opinion" before. It's a saying that is used often by someone to justify an opinion when someone is disagreeing with them, especially if they want to avoid the discussion. And while they have a right to avoid a discussion, if someone's opinion (i.e. their claim) is not supported by evidence, then that opinion can be dismissed pretty quickly.

Does everyone have the equal right to an opinion? Absolutely. Is everyone's opinion equally right? Absolutely not. Poor arguments should be identified, then dismissed. While we wouldn't recommend being this ruthless in casual conversation, as personal trainers we have a duty of care to provide safe, effective services to our clients. When results or safety are compromised because another trainer is using poor methods, or is operating outside their scope of practice, it is reasonable to challenge them to justify their position. In a nice, friendly manner, of course!

In Part 3 we looked at a rhetorical argument. This is a great exercise to do on your own, so you don't find yourself in the position of having a claim challenged, and not being able to support your claim. Now, we are going to have a look at arguments others might present. You will be presented with three arguments for some different approaches to weight loss. Read the summary of each argument, then identify why it is a weak argument.

The argument may be weak because the evidence is poor, or does not support the claim. Or you may think that a counterargument is stronger. Knowledge of the area is helpful in identifying a weak argument, so you will need to use your knowledge as a personal trainer here, as well as what you have learnt about argument so far. Again, if you need to do a quick search for good information, please do so.

Exercise 1: a great way of losing weight is by using vibration platforms. You don't even need to exercise! When you sit or stand on these machines, the vibrations break fat cells apart, and you lose weight. If you want to target a specific part of the body, then you place that part of the body directly on the machine. My sister used one (and started exercising, and changed her diet) when she was trying to lose weight for her wedding and lost about 15 kg.





Module 2: Opposing Views & Counterargument

Exercise 2: chillies are a superfood, and can help you lose weight! A chemical in chillies (capsaicin) causes a large boost to your metabolism, resulting in massive weight loss when taken in high doses.

Exercise 3: the power of the mind is totally forgotten by personal trainers when planning weight loss strategies. You know how we only use 10% of our brain? All the barriers that stop us from being successful are nothing once we unleash the potential of the other 90%. Weight loss is largely about self-control. It takes a lot of discipline to maintain this control when you only use 10% of your brain - when you use all of it of course you are going to be successful!





Module 2: Opposing Views & Counterargument

Part 5: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in Module 1. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional. As mentioned last time, learning how to apply what we learn is as important as **what** we learn.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 2. Once your responses have been checked, Module 3 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.





Module 3: Biases

Module 3 Learning Outcomes

At the end of this module, you should be able to:

- Appreciate the impact of confirmation bias on your thinking
- Recognize a range of cognitive biases
- Identify a cognitive bias when demonstrated in the reasoning of others

Part 1: An Introduction to Bias

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

Read the statement below, and tell us whether or not you agree with the statement. If you aren't entirely sure, then pick the option that you agree with the most - it doesn't matter if you have reservations about this.

"Crossfit causes more injuries than more traditional types of resistance training or cardio training, so should be avoided by most of our clients"

I Agree

I Disagree

We aren't going to tell you if this statement is correct or not (or only partially correct); it doesn't really matter for this activity. But next you will see some links to a number articles, reports, blogs, research findings, etc., that discuss this issue. Some will be more convincing than others. Spend a few minutes reading each one (you don't have to read each one in full, but can if you like), and look for information which might tell you how trustworthy the source is. Then rate the trustworthiness of that source. Provide a short comment on why you rated this article as you did.

1. <http://journals.sagepub.com/doi/full/10.1177/2325967114531177>

- Not at all trustworthy
- Generally not trustworthy
- Somewhat trustworthy
- Generally trustworthy
- Very trustworthy

Explain your rating:





Module 3: Biases

2. http://www.huffingtonpost.com/erin-simmons/why-i-dont-do-crossfit_b_5411771.html

- Not at all trustworthy
- Generally not trustworthy
- Somewhat trustworthy
- Generally trustworthy
- Very trustworthy

Explain your rating:

3. <https://therussells.crossfit.com/2015/06/15/the-truth-hurts-part-1/>

- Not at all trustworthy
- Generally not trustworthy
- Somewhat trustworthy
- Generally trustworthy
- Very trustworthy

Explain your rating:

4. http://www.letsrun.com/forum/flat_read.php?board=1&id=5684611&thread=5684538

- Not at all trustworthy
- Generally not trustworthy
- Somewhat trustworthy
- Generally trustworthy
- Very trustworthy

Explain your rating:

5. <http://www.coachmag.co.uk/exercises/4182/is-crossfit-safe>

- Not at all trustworthy
- Generally not trustworthy
- Somewhat trustworthy
- Quite trustworthy
- Very trustworthy

Explain your rating:

You'll remember that you were asked your opinion about CrossFit injury rates back in Module 1, and we presented some information to you about it, so your opinion may have evolved slightly. But you probably still had some preconceived thoughts about this issue as you read these articles. The opinions you possess when you read an article will influence what you think about it, even when you think you are being impartial and fair. This is called confirmation bias. You will generally interpret information as being more trustworthy if it agrees with your preconceived opinion. Likewise, if the article disagrees with your opinion, you will be more likely to identify the flaws in the article, and will be more critical of it.



Module 3: Biases

Confirmation bias goes a long way towards explaining why two people can view the same information, and take away very different opinions about it. And it affects all of us, to varying degrees. Being an expert in a particular topic doesn't necessarily help prevent this bias. In fact, even teaching someone about confirmation bias, how to recognize it, and how to avoid it (like we are doing here), doesn't prevent it completely. But we can examine our own thinking whenever possible, to make sure when we are reading an article, or watching a video, or listening to someone speak, we are treating their ideas and opinions as fairly as we can.

So, if you were trying to be fair when reading the information presented to you earlier, what might you have noticed about each one? And is there even a clear opinion we can reach on this topic? Below are some points about each article that we noticed:

1. Articles published in scientific journals are usually pretty reliable sources. Even within scientific literature though, there are good and bad articles. This one is fair, but has some limitations. It was a survey of CrossFit participants recruited via a website. While this gives you a lot of participants from a range of gyms, there may be differences between people who volunteer to complete a survey, and those who don't. Surveys are also self-reported, which tends to be less reliable than observational data. **Our Verdict: Generally Trustworthy.** ★★★★★

2. This is an opinion piece from someone who has a strong and varied exercise history. What she doesn't have, however, is an exercise qualification. While she is at least informed by personal experience with CrossFit (which others with strong opinions may not be), she has a narrative about CrossFit, then is presenting evidence (for sources of varying quality) to fit her narrative. As we know, this makes for a weaker argument, regardless of whether or not her conclusions are correct! **Our Verdict: Generally Not Trustworthy.** ★★☆☆☆

Injury Rate and Patterns Among CrossFit Athletes

Benjamin M. Weisenthal,¹ BA, Christopher A. Beck,¹ MA, PhD, Michael D. Maloney,² MD, Kenneth E. DeHaven,² MD, and Brian D. Giordano,^{1,3} MD
Investigation performed at the University of Rochester School of Medicine and Dentistry, Rochester, New York, USA

Background: CrossFit is a type of competitive exercise program that has gained widespread recognition. To date, there have been no studies that have formally examined injury rates among CrossFit participants or factors that may contribute to injury rates.

Purpose: To establish an injury rate among CrossFit participants and to identify trends and associations between injury rates and demographic categories, gym characteristics, and athletic abilities among CrossFit participants.

Study Design: Descriptive epidemiology study.

Methods: A survey was conducted, based on validated epidemiologic injury surveillance methods, to identify patterns of injury among CrossFit participants. It was sent to CrossFit gyms in Rochester, New York; New York City, New York; and Philadelphia, Pennsylvania, and made available via a posting on the main CrossFit website. Participants were encouraged to distribute it further, and as such, there were responses from a wide geographical location. Inclusion criteria included participating in CrossFit training at a CrossFit gym in the United States. Data were collected from October 2012 to February 2013. Data analysis was performed using Fisher exact tests and chi-square tests.

Results: A total of 486 CrossFit participants completed the survey, and 386 met the inclusion criteria. The overall injury rate was determined to be 19.4% (73/386). Males (53/221) were injured more frequently than females (21/150; $P = .03$). Across all exercises, injury rates were significantly different ($P < .001$), with shoulder (21/84), low back (12/84), and knee (11/84) being the most commonly injured overall. The shoulder was most commonly injured in gymnastic movements, and the low back was most commonly injured in power lifting movements. Most participants did not report prior injury (72/89; $P < .001$) or discomfort in the area (58/88; $P < .001$). Last, the injury rate was significantly decreased with trainer involvement ($P = .028$).

Conclusion: The injury rate in CrossFit was approximately 20%. Males were more likely to sustain an injury than females. The involvement of trainers in coaching participants on their form and guiding them through the workout correlates with a decreased injury rate. The shoulder and lower back were the most commonly injured in gymnastic and power lifting movements, respectively. Participants reported primarily acute and fairly mild injuries.

Keywords: competitive exercise; CrossFit; Olympic lifting; power lifting; injury rate; cross-sectional pilot study

THE BLOG 05/29/2014 04:24 pm ET | Updated Jul 29, 2014

Why I Don't Do CrossFit

By Erin Simmons



I get asked all the time if I've tried CrossFit, my friends text me without fail when the games are on and tell me I should be there, and I'm asked my opinion of it on a weekly if not daily basis. So I'm going to share that opinion with you. I know that a lot of people won't like it, and Crossfitters may react quite negatively, but the goal of my page is not to simply go along with what is popular or to avoid tough subjects so that people won't "unfollow" me. The goal of my page is to educate people about fitness and health and to warn against potentially harmful or unhealthy diet and exercise practices, and that's what I'm going to do in this article.



Module 3: Biases

3. This article presents a very forceful argument, but it is flawed! The authors state their goal of defending CrossFit upfront, and make no pretence of impartial analysis. As a result, they look for information that supports their opinion, and interpret information in a supportive, rather than critical way. **Our Verdict: Generally Not Trustworthy.** ★★☆☆☆

THE RUSSELLS

Defending the brand from junk science, yellow journalism, and invincible ignorance

ABOUT

RECENT POSTS

- Too Much Volume or Not Enough Fitness?
- Instagram's Lying to You About #Basic
- Did the PepsiCo Foundation Direct Donations to Fight Legislation?
- What UConn Internal Emails Reveal About The Korey Stringer Institute
- PubMed Begins Flagging Conflicted Research: Coke Science Now Searchable



Russ Greene



Russell Berger

The Truth Hurts: Part 1



One of the most pervasive and harmful myths about CrossFit is one that many of us have readily accepted- CrossFit is relatively safe, but only when its constituent movements are performed with correct technique. On the surface this seems totally reasonable, but it has become the false premise upon which many serious claims about the safety of CrossFit rest.

I believe that this myth is borne from an attempt to reconcile an apparent tension between two major concepts taught by CrossFit. For the sake of this article, I will use the common definition of technique as whatever movement an athlete uses to accomplish a task. Though less well defined, I will consider good technique to be the movement which optimizes the athlete's mechanical advantage, and bad technique can be considered any deviation from that.

4. Forums are the “Wild West” of argument. No evidence is required, and you don’t know who is commenting, what their background or qualifications are, and they generally don’t provide any evidence. This forum is either uninformed opinion or personal experience, so not a great source! Note that the last post linked to a research article – this is a much better source! **Our Verdict: Not At All Trustworthy.** ★☆☆☆☆

The screenshot shows a forum thread on LetsRun.com. The thread title is "CrossFit type workout injury rates?". The first post by Tommy2Nutz asks if anyone knows how many people get injured from these workouts, mentioning that it seems like a lot of people are being pushed to the extreme and that there have been studies, videos, etc. The second post by GaryB replies that the use of KT Tape and Rock Tape by CrossFitters is almost as high as what you'll see at any expo/packet pick up for marathons/half marathons, and that shitty training programs/coaches in all sports lead to injured athletes. The third post by no worries replies that they've been doing it for a year and haven't seen many injuries at all, only got hurt once and it was seriously an old running injury that came back when they decided to throw running back into their training. They mention that if you go to a crappy box where the coaches suck you can get hurt, but everyone is without injury free. The fourth post by GaryB replies that no worries wrote nothing.



Module 3: Biases

- 5. Another opinion piece, but the authors in this case have some relevant industry experience, and the article doesn't present an obvious bias. In fact, both the for, and against positions in this article demonstrate a degree of nuance that we don't always see in these pieces. **Our Verdict: Somewhat Trustworthy.**



Now we get to the point of this exercise. How did you rate the trustworthiness of these articles? Did you disagree significantly with our ratings? If so, was this because you didn't notice the same issues we did? If so, feel free to go back and look at the articles in your own time. You will get better at this with practice. Or, perhaps you noticed something we missed. If so, let us know, as this could help us improve the course for future participants.

Or, did your ratings reflect your own opinions on the statement about injury rates? Was the information that confirmed your opinion rated as more trustworthy? This is the effect of confirmation bias, and it's something we have to deal on a daily basis.

Provide a couple of thoughts on how your ratings varied from our ratings. Do you think you demonstrated confirmation bias - meaning, did you find evidence that supported your opinion more compelling, and were you more dismissive of evidence that contradicted you? Explain your answer.

ADVICE

Is CrossFit safe?

Two experts debate whether CrossFit poses a high injury risk



on 17 DEC 2014

Yes...

says Andy McTaggart, health and fitness manager at Fitness First, Tottenham Court Road, London

I joined a CrossFit box this year because I was no longer playing rugby and wanted something that would challenge me. It's been fun and at times addictive. I'm naturally competitive and found that it drives me to train harder and lift heavier, but also to do it



Module 3: Biases

Part 2: What Are Some Common Biases?

Critical Thinking for Fitness Professionals

Module 2: Bias
Part 2: What Are Some Common Biases?



"Thinking at Hell's gate" (CC BY 2.0) by [innoxius](#)

Last time when discussing argument, we introduced the idea that personal trainers may hold very different opinions on a topic. These opinions may depend on a range of factors, such as personal experience and education. Not only do these experiences influence our opinions, but they may also affect the way we receive and interpret further information. Usually we are unaware this is happening.

Furthermore, there are a series of mental shortcuts, called "heuristics" that we take in order to process information faster. Most of the time, these are very helpful. Without these heuristics, we wouldn't be able to apply what we learn from our experiences. From a professional standpoint, we would be starting from scratch every time we see a new piece of equipment, meet a new client, or are exposed to new information. You can imagine how slow this would be: every time we see a slightly different chest press machine, it would be as if we have never seen one before. But as we can learn from our experience, we can skip a few steps in the process of analysis: we quickly learn what the key characteristics of all chest press machines are, for example.



Heuristics

mental shortcuts that help us process information faster

While this speeds us up, it can result in us displaying biases - that is, preferences towards certain information, ideas, or viewpoints. All of us demonstrate these biases to some degree. We may also show

different levels of bias in different areas of knowledge, and even within our areas of expertise. And while it is possible to minimise the bias we demonstrate, it is impossible to eliminate it altogether.

The previous activity may have demonstrated some bias that you did not know you had, specifically confirmation bias. This is when we form an opinion based on early evidence that is available to us, then judge further information based on how much it agrees with this early evidence. Later evidence that is inconsistent with the position we have formed is dismissed, or considered less important.

Confirmation bias is very powerful, and affects all of us in some way. In fact, not only does it influence how you receive information, but also how you **seek out** the information in the first place. Though we didn't ask you to look for information in the previous activity, if you had a strong opinion either in favour of, or opposed to, the statement about Crossfit, you would probably work harder to



Module 3: Biases

seek out information confirming your opinion, without being aware of it, rather than testing your opinion against challenging evidence. When we engage in an argument, if we are unaware of this, our primary goal is usually to defend or justify our opinion. Being open-minded enough to genuinely consider the possibility that you are wrong, as discussed in previous modules, can help prevent this.



On the next few pages we're going to introduce some common biases, and explore how they might influence fitness professionals. While being informed about these is not enough to prevent us falling prey to them, it might at least help us start to question our own thinking.

Availability: we will think something is likely if we find it easy to imagine or recall the circumstances in which it is possible. For example, we may estimate the risk of suffering from a heart attack based on how frequently it occurs in our own family. We might rate the likelihood of certain injuries based on if we have seen them or suffered from them ourselves.

Availability

we think something is more likely if we can imagine it more easily



This can be useful, as more frequently occurring situations are usually recalled more easily. But we tend to be more influenced by events that are more recent, that involved us, or involved celebrities.

For another example, let's consider a trainer who doesn't ask their clients to do deep barbell squats, preferring half squats, machine options (such as a leg press) and single leg alternatives (like step ups and lunges). When asked why, he says the risk of severe injury is too high. This may be informed by an injury they observed in the gym, or due to an injury to a famous person they read about. These possible sources are far more memorable than what they might have learnt in a lecture during their Certificate IV, or in a professional development course.

Anchoring: while it is possible for us to change our opinions on topics, where our opinion on that topic ends up is dictated by where we start from. When we realise we are wrong, and change our opinion, we usually don't change it enough.



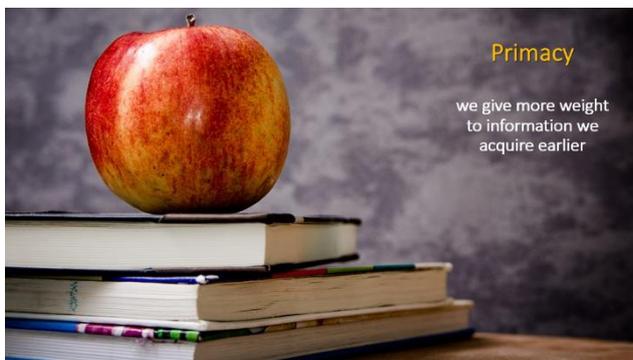
Module 3: Biases

For example, you may have recommended clients use green coffee bean extract as a weight loss supplement, and been convinced that the boost it provides to metabolism helps with weight loss. You may even have lost some weight while taking it yourself. Green coffee bean extract gained some popularity, or notoriety, when it was featured on the *Dr Oz Show*. But evidence was limited, and when we have a closer look, we find that green coffee bean extract has little, if any, effect.



The average person would find it pretty hard to reverse their opinion completely in this situation. Often, we will adjust our opinion, but not enough: "it works, but not as much as advertised", or "it doesn't work for everyone", or "they need to do more research to work out the full effects." We are anchored to our original opinion, and we can move away from it, but not as much as needed to be completely correct.

Primacy: when we draw conclusions based on information gathered over a length of time, the information we acquire early is given more weight than what comes later. In addition to confirmation bias, this helps explain why if we are presented with information that conflicts with our opinions, we tend to place much more trust in what we already know.



is wrong, or because you give undue weight to the course you did 10, 15, or even 20 years ago? Science can change a lot in this time, and exercise and health are rapidly developing fields. Our professional practice should be informed by this changing evidence.

Illusory Correlation: this means that when two things occur together, we are more likely to find evidence to confirm a relationship between the two. We will also tend to think that any relationship is stronger than it actually is. The tendency to find these relationships is how we come to form stereotypes about certain ethnic or religious groups, for example. We see one or two people from this group with a certain physical characteristic or personality trait, then assume that it is common in that population.



Module 3: Biases

In a health and fitness setting, this might extend to beliefs around modes of exercise, ways to eat, what stretching to do and when. If we experienced pain or discomfort after certain exercise, we may decide that the exercise caused our pain, rather than examining the other factors that may influence that pain (such as how we slept, our sitting position, other exercises, or the volume of exercise you've completed).

This effect can even extend to cures for the common cold. This is a great example, because we all get colds during our lifetime, some of us several a year. Doctors will tell you there is no reliable way to



"Cold Remedies" (CC BY-SA 2.0) by OctopusHat

treat or cure the common cold (other than time and rest) - at best we can reduce the severity of symptoms. But we have all heard of folk cures or home remedies that our family and friends have tried. Popular examples are chicken soup, vitamin C supplements, and Echinacea.

How do we form this association between these remedies and curing the cold? Well, when we get sick we start taking the remedy. After a couple of days of taking the remedy, we start to feel better.

What else could it be?! Of course, time is the key factor in recovering from a cold. We are always going to feel better at some point. So when we get sick, and start taking our remedy, we begin to feel better. So we start to associate the remedy with our recovery.

Just because things occur at the same time, it does not mean there is a relationship between them, but we will often think there is. We will discuss this more in the next module.

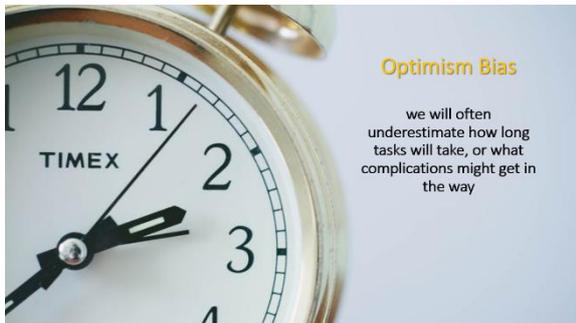
Bandwagon Effect: sometimes, in spite of all our knowledge and existing opinions, we come to hold a belief in part because large numbers of other people share this belief. This is called the bandwagon effect, and can be seen with every new fitness or diet trend that sweeps the globe.



Think about some of the recent fads in nutrition (such as the popularity of coconut oil) and exercise (remember how popular Zumba became in a very short space of time?). Without making any comment on whether these fads are good ideas or not, we are more likely to accept a popular opinion than an unpopular opinion. We also see this effect in action when we see fashion trends come and go, or when casual supporters get behind a successful sporting team.



Module 3: Biases



Optimism Bias: we have a tendency to be overly optimistic in many aspects of our daily lives - that is, we will overestimate the amount of control we have around our own circumstances, and underestimate the impact that others can have on us. An obvious example: do you have a friend that is always late for that coffee catch up? Or a client that is always late to appointments? Or is this you? This happens because we underestimate the impact of traffic, the wants and needs of our

children, or how long it will take to do that bit of cleaning or washing. We allow only 15 minutes for a 15 minute drive, rather than 20 minutes, just in case traffic is worse than we expected. Then we are late.

Like some of these other biases, the optimism bias affects us in many ways. When planning for a project most of us will underestimate how much work is involved, or will predict that problems are easier to solve than they actually are. While we may be accused of not thinking positively when we bring these sorts of issues up, it is often useful to plan extra time to handle these issues... the old business adage of "under promise, and over deliver" serves us well here. If we allow a bit of extra time to get something done, we may finish on time, or early. And we always look better to others when we are finishing work ahead of schedule.

Keep this in mind when you schedule your next coffee with a friend!

Backfire Effect: you are probably starting to work out by now that what we arrive at our knowledge via processes that are quite flawed. And once we've formed our opinion, it is not necessarily changed by evidence as it should be. In fact, sometimes when we are exposed to information which challenges our beliefs we double down, and are **even more** convinced that we are right. This is known as the backfire effect. Clearly, if we are trying to change someone's mind about their dearly held opinion (as some opinions in fitness are), we need to be quite cautious in how we go about it. Merely presenting facts to show that the other person is wrong is often not successful.





Module 3: Biases

So having been through all these biases, what can we do about them? Well, it might be slightly depressing, but the answer is: not much! It is easier to identify these biases on others than correct them in ourselves. But at the very least, we can be more aware of the factors that affect how we process information, and be more understanding of differences in opinion. This doesn't make the person holding the other opinion **correct** (as it doesn't make us correct), but we can aim to be congenial and polite when discussing these differences in opinion.

We're most likely to have success correcting an incorrect opinion in someone else when they are **willing** to be corrected. We may need to be content for someone to come to us when they want to discuss a topic, rather than actively trying to convert people to our way of thinking.

Links to Resources:

- a. <https://rd.springer.com/article/10.1007%2Fs40279-013-0073-6>. Abstract for an article reviewing squatting depth, for the discussion of the availability bias.
- b. <https://sciencebasedmedicine.org/lessons-from-the-dubious-rise-and-inevitable-fall-of-green-coffee-beans/>. An article outlining the issues associated with green coffee bean extract, for the discussion of anchoring. There are also other posts that update this, and comment more on Dr Oz specifically.
- c. http://theoatmeal.com/comics/believe_clean. A great cartoon by The Oatmeal that explains the backfire effect in a very simple, effective way. It's long, and the examples used are American, but it's worth the read.
- d. <https://sciencebasedmedicine.org/treating-the-common-cold/>. An article discussing possible treatments for the common cold, and what the evidence shows us.





Module 3: Biases

Part 3: Identify the Bias

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

In the next activity, you will need to read a series of scenarios that are relevant to the fitness industry. Look at each one, then decide what bias is represented here. Once you've answered, the correct answer will appear, along with an explanation. Sometimes more than one bias will be represented at one time, so your answer may not be quite the same as ours for one or two of these.

Scenarios:

1. You start to notice some people in the gym wearing black masks when you train. You don't pay much attention at first, but notice more and more people using them. You do some Googling, and find out that these are "altitude training masks", and claim to be able to improve your fitness levels by simulating the effects of high altitude when you exercise. These masks seem to be a pretty new innovation, and the guys that are wearing them look pretty fit, so you decide to give them a go. After all, they can only help your training!

What bias is represented here?

- | | |
|---------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> Anchoring | <input type="checkbox"/> Optimism |
| <input type="checkbox"/> Availability | <input type="checkbox"/> Confirmation |
| <input type="checkbox"/> Bandwagon | <input type="checkbox"/> Primacy |
| <input type="checkbox"/> Backfire | <input type="checkbox"/> Illusory Correlation |

2. When you warm up your clients, you always get them to do a few minutes on a cardio machine, followed by some gentle stretching, before getting in to the main body of the workout. This hasn't changed since you graduated from your Cert IV course a few years ago. Lately you've read an article talking about how injury risk is not reduced by static stretching, and how it may not be an effective part of a warm up. This contradicts what you learnt in your course, so you haven't paid too much attention to these articles, preferring to stick with what you know.

What bias is represented here?

- | | |
|---------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> Anchoring | <input type="checkbox"/> Optimism |
| <input type="checkbox"/> Availability | <input type="checkbox"/> Confirmation |
| <input type="checkbox"/> Bandwagon | <input type="checkbox"/> Primacy |
| <input type="checkbox"/> Backfire | <input type="checkbox"/> Illusory Correlation |





Module 3: Bias

3. When having a chat with another trainer you get onto the topic of nutrition. This trainer mentions that she is gluten-free, because she feels that this is a healthier way to eat than a regular diet. You disagree, and you debate it, but you can't change her mind with what you remember about the topic. When you get home that night, you jump online to try and prove her wrong. You type "why are gluten free diets stupid?" into the search bar, click on the first result you see, and start reading, so you can be more prepared for the discussion next time. The second article you read is in support of gluten free diets, but the argument it makes is obviously flawed, so you stop reading after a couple of sentences.

What bias is represented here?

- | | |
|---------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> Anchoring | <input type="checkbox"/> Optimism |
| <input type="checkbox"/> Availability | <input type="checkbox"/> Confirmation |
| <input type="checkbox"/> Bandwagon | <input type="checkbox"/> Primacy |
| <input type="checkbox"/> Backfire | <input type="checkbox"/> Illusory Correlation |

4. You are packing your bag in the morning to get ready for a game of footy, and throw in the lucky socks. You started playing footy about five years ago, and were pretty ordinary at first, but the first time you wore these socks (about three years ago) you had a great game. Since then, you've worn them every game, and the standard of your play has improved even more since then. You wouldn't dream of playing in any other socks now.

What bias is represented here?

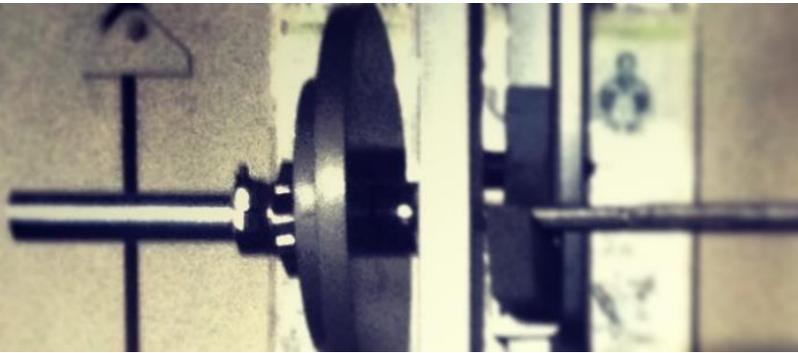
- | | |
|---------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> Anchoring | <input type="checkbox"/> Optimism |
| <input type="checkbox"/> Availability | <input type="checkbox"/> Confirmation |
| <input type="checkbox"/> Bandwagon | <input type="checkbox"/> Primacy |
| <input type="checkbox"/> Backfire | <input type="checkbox"/> Illusory Correlation |

5. When you plan training sessions for your clients, you often find that when you are delivering the session you run out of content before the hour of training is up, and you need to think on the run to finish the session. What usually happens is that some of the equipment you had planned to use is used by another gym member, so you need to skip that exercise. And despite your best efforts, the client always seems to get through the warm up activities a bit faster than you thought, and doesn't take the full amount of rest you want them to have during resistance training.

What bias is represented here?

- | | |
|---------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> Anchoring | <input type="checkbox"/> Optimism |
| <input type="checkbox"/> Availability | <input type="checkbox"/> Confirmation |
| <input type="checkbox"/> Bandwagon | <input type="checkbox"/> Primacy |
| <input type="checkbox"/> Backfire | <input type="checkbox"/> Illusory Correlation |





Module 3: Bias

6. Early in your personal training career you had a client hurt their back when doing a deadlift, although their technique was quite good. Afterwards, your client explained that they had been very physical that day at work, doing a lot of lifting, so they were fatigued going into the training session. You have also injured your back doing deadlifts, although in your case it was when you were still learning how to lift weights properly, and you were training without supervision or help from an instructor. You've since decided that the risk of injury in doing deadlifts (even with good technique) is high, so you won't program them at all, even for clients who are quite strong and well trained.

What bias is represented here?

- Anchoring
- Availability
- Bandwagon
- Backfire
- Optimism
- Confirmation
- Primacy
- Illusory Correlation

Part 4: Review

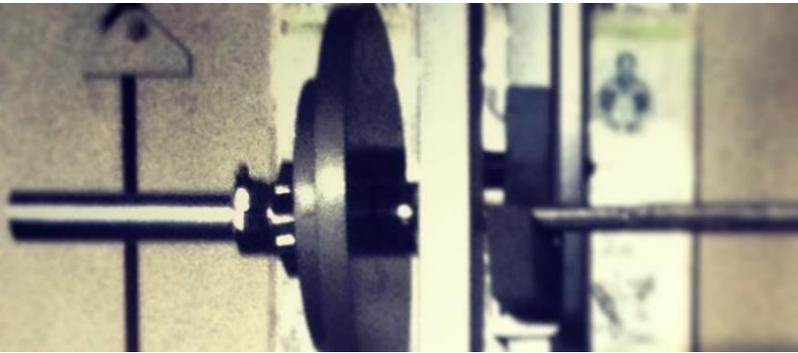
Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in the previous modules. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?





Module 3: Bias

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 3. Once your responses have been checked, Module 4 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.



Module 4: Logical Fallacies

Module 4 Learning Outcomes

At the end of this module, you should be able to:

- Recognize a range of common logical fallacies
- Identify common logical fallacies in a fitness context

Part 1: What Are Logical Fallacies?

Critical Thinking for Fitness Professionals

Module 4: Logical Fallacies
Part 1: What Are Logical Fallacies?



"Thinking at Hell's gate" (CC BY 2.0) by [innoksiuss](#)

So far you have been introduced to presenting an argument, counterarguments and rebuttal, and the biases which can affect our thinking. These biases influence not only the way information is received, but also how rigorously we examine our own arguments. We may be overly demanding of others when they are presenting information to us, and expect undisputable proof, but we may present quite poor evidence ourselves, or make weak justifications.

Invalid arguments are known as fallacies. On the next few slides we will present some of the more common fallacies, and provide some examples relevant to the fitness industry to demonstrate where you may have seen them before. In these fallacies you will be able to see the influence of the biases we discussed in the last module.

Fallacy

an invalid argument
or, an argument that is applied
inappropriately



Often these fallacies are not clear cut, and undisputable, themselves. But applying a blanket rule is impossible, as you will see - we will need to examine each argument on its merits. The difference between sound reasoning and a fallacy is not black and white, but rather a matter of degrees, and we may have very different opinions about whether an argument is sound, or a fallacy.



Module 4: Logical Fallacies

In fact, some philosophers define a fallacy as being nominally correct, but applied inappropriately (such as too aggressively).

Keep in mind that most arguments we encounter in real life do not resemble the collaborative types of argument we discussed previously. For example, in political debates the participants are often trying to highlight the differences between them, rather than reach a consensus. And when we disagree with a colleague, we are often not considering that our own position may be incorrect, but are instead focussing on the problems with our opponent's position. As a result, we could use fallacies to "win the argument" without considering whether or not we are correct.

Here are some of the common fallacies you may come across in your professional or personal life:

Appeal to ignorance: this is the error of assuming that something is true, only because it has not been proven false. Just because you are unaware of evidence that contradicts a statement, or even if evidence has not yet been found, this does not mean that you are correct. Often this is due to gaps in our own knowledge, and a little research, or consultation with an appropriate expert, can provide an answer.

We see this appeal to ignorance all the time in the nutrition fads that come and go. Currently coconut oil is having a moment in the sun, but previously it has been kale, goji berries, broccoli, and countless others. Let's say I'm promoting broccoli smoothies as a weight loss method. My claim is



Appeal to Ignorance

The error of assuming something is true, because it has not yet been proven false

that these result in faster weight loss than other diets. There may not be any research looking into the weight loss benefits of my broccoli smoothie diet (and there's not, from what I can tell!).

I could therefore make the claim that this diet is cutting edge, as research has yet to "catch up" with my breakthrough diet. This is the appeal to ignorance. But this does not mean the claim is correct. To properly research a new type of diet

can take years, and involve multiple scientists doing different research. Diet fads move much faster than this, so the evidence to disprove a specific claim may never exist.

However, there is a flipside to this argument. Sometimes, if something cannot be proven to be wrong, we may be able to accept it as true. A lot of science works this way. A hypothesis will be proposed (for example, drinking broccoli smoothies result in faster weight loss than other kilojoule restricted diets), then the researcher proposing it will attempt to disprove it (by comparing to other weight loss strategies). Then other scientists will attempt to disprove it, too (by trying similar experiments). If the hypothesis stands up to this scrutiny in multiple studies over a number of years, it may be considered correct.



Module 4: Logical Fallacies

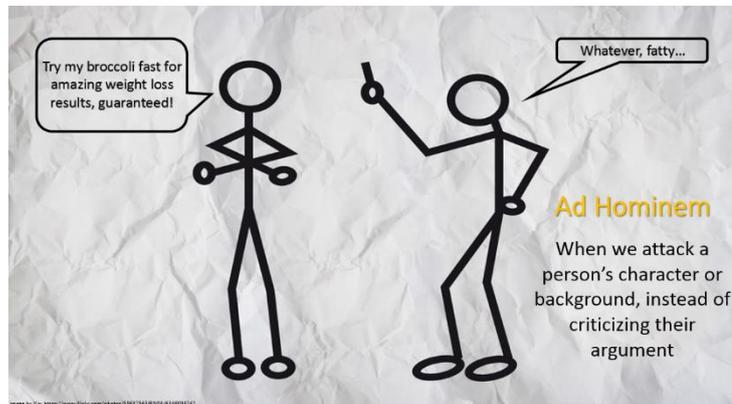
We will discuss the scientific method more in a later module, but as you can see in this case the structure of the sound and fallacious argument is the same, the difference is in the amount of scrutiny the idea has received, and who is trying to prove the idea wrong.

Ad hominem: an ad hominem fallacy is when instead of criticizing a person's argument, we attack the person, such as their character, background, or appearance instead. Most of us would like to think that we do not judge someone's ideas based on their appearance. In fact, we would be appalled if we were accused of that. But in the fitness industry it happens all the time. If you see a skinny person giving advice to someone about muscle hypertrophy, what do you think? Does his appearance influence what you think about his knowledge? What about if you see an overweight person providing weight loss advice to someone? For many of us, the first instinct is to assume that the person's appearance is a reflection of their knowledge. An ad hominem argument would be to say that their ideas are invalid because they do not look the way you think they should.

While another trainer's appearance may reflect their knowledge, it may also reflect their injury status, be the result of illness or genetic factors. The trainer may be very busy and successful, or have a young family, and not have the time to spend hours training themselves. We also need to be careful not to dismiss an argument because of the person's background. Just because one trainer has a degree, and the other did their Certificate IV online, we should not automatically side with the more qualified person, but examine the arguments on their merits.

Of course, there are some exceptions to this rule. If someone has a history of making extravagant claims without evidence, it is a very likely that they will do so again. If someone is providing advice outside their scope of practice, it is likely less reliable than advice from a professional in the field. It is reasonable, in these circumstances, that we don't spend a lot of time examining an argument from an unreliable source. This would be a waste of our time. But again, this is a matter of personal judgement.

Genetic fallacy: very closely related to the ad hominem fallacy is the genetic fallacy. This is when we discredit a point of view, or theory, based on its origin, or the character of the originator, rather than based on the idea itself. For example, it has been well known for many years that smoking is linked to a range of health problems, and there are restrictions on who can smoke, and where they can smoke. And most people agree that smoking is not good for us. But what if you knew that last century Nazi Germany led the modern world in discouraging smoking? And that Hitler was strongly opposed to smoking as well?



Module 4: Logical Fallacies

Some of the impetus for this was nationalistic ideals about smoking being "un-German", and concerns about German purity, but does this mean that restrictions on smoking are a bad idea? Of course not. Again, we should examine ideas on their merits.

But like the ad hominem attack, sometimes the origin of an idea gives us some context to decide whether or not we take it seriously. A less clear cut example would be to consider the history of chiropractic. When examining the origins of chiropractic, it is reasonable to develop some scepticism about the treatment. After all, the creator of the practice, Mr. D.D. Palmer, was not medically trained, but worked a variety of jobs, including beekeeper, and grocery store owner. He practiced "magnetic healing", and was vehemently anti-vaccine.

Genetic Fallacy

When we discredit an idea because of its origin, rather than its merits



But we want to avoid making a judgement on the basis of this history alone, though it may make us more cautious. There is a lot of debate about whether or not chiropractic is an effective treatment for back pain, or other conditions. But it is not because of these origins, it is because evidence is mixed, and suggests that this type of treatment has a fairly small effect.

Post hoc ergo propter hoc: this is a Latin phrase that means "after this, therefore because of this". This is the error of concluding an event is caused by another because it follows after it. For example, we start a new exercise program with an exercise we have never done before, and get injured. Therefore, the injury was caused by the new exercise, right? After all, everything else we have done before, and haven't been injured before.

Maybe, but we don't know for sure. We need to consider a host of other factors, such as any other training we were doing. Was the injury a result of overtraining, for example? Were we not paying attention to correct technique, or did we lift too much weight? Or did we have some muscle tightness from another training session, which led to the injury?



Module 4: Logical Fallacies

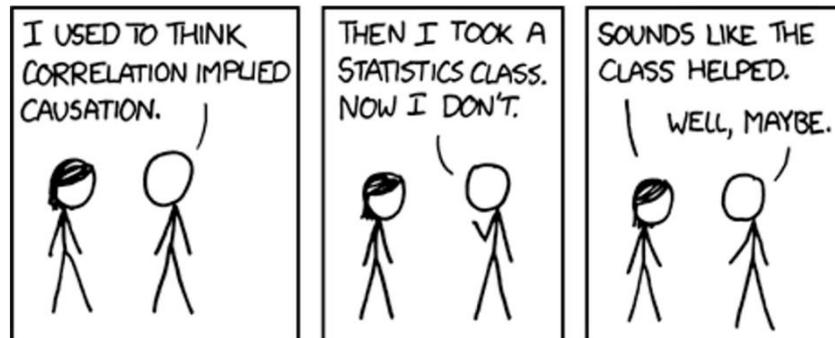


Image by [kxcd](#)

Another example is when we are sick. Think about the example of cold and flu remedies we used when discussing illusory correlation last time. We feel sick, we take a cold remedy, and we start to feel better. Did the cold remedy cure our cold? Probably not - we were going to improve no matter what, it was just a matter of time. But we have a bias towards drawing these associations. And when we use this justification in an argument, we are guilty of the *post hoc ergo propter hoc* fallacy.

Of course, there are instances where two events happen together because one does cause the other. How do we know if there is a causal link? Sometimes we don't! But we can be informed by our experience and knowledge. We also need to consider if there is a plausible reason for a link between the two events, and the probability of one causing the other. Your cold symptoms are always going to improve at some point, no matter what remedies you try.

Naturalistic fallacy: this is the error of assuming that something is good because it is "natural". This is a common assumption in nutrition. The idea is that a food that is natural is better for us, because it doesn't have artificial preservatives, flavours, or additives. This argument also gets used in exercise (think barefoot running) and health (such as a lot of alternative medicines).



The problem with this thinking is that there are a lot of examples of processing of food, and additives that help keep us healthy, and make our food safer. Examples are everywhere: fluoride is added to our water to reduce tooth decay, folate is added to bread to reduce the rate of birth defects, milk is pasteurised so it keeps fresh for longer, and soy products are fortified with vitamin B12, which vegetarians and vegans may be deficient in.



Module 4: Logical Fallacies

The other issue with this fallacy is determining what is "natural", and what is not. The above examples are all instances of substances being added to food, or food being treated. But none of them are "unnatural". Pasteurisation is simply the process of heating the milk to kill bacteria, then cooling it down quickly. Fluoride is found naturally in both fresh water and seawater, and folate is found in dark, leafy, green vegetables.

Furthermore, there are plenty of examples of things that are considered natural, which are quite dangerous. Australia is filled with poisonous (though natural) animals, and we have a high risk of skin cancer, as a result of exposure to the (natural) sun. We also have high rates of obesity and heart disease, which our consumption of (natural) sugars and fats contributes to. Like most things, the amount we consume is important. Sunlight, fats, and sugars are all necessary for good health, but the **quantity** is the key issue. There are very few things which are unequivocally "good" or "bad" for us. Usually it is the dose that determines this.

In summary, if we want to know if something is good for us or not, we cannot rely on subjective opinions on how natural it may be.

Straw man fallacy: this is the error of refuting an argument that another person has not provided. This may be when we ask a question in order to provide the answer we want to (a common political tactic), or exaggerating a part of another person's claim, in order to make it easier to refute. Again, we can look to nutrition to see many examples of this.

The Australian Dietary Guidelines come under a lot of criticism from some sources (a link is provided if you would like to read them for yourself), but is all of this criticism fair? Celebrity chef Pete Evans is a prominent critic of these guidelines, and has been quoted as saying "...[the guideline] suggests we consume a diet of mostly refined, highly processed carbohydrates and many of these foods contain huge amounts of sugar, which is proven to exacerbate modern-day chronic illnesses." While there is no doubt that excessive amounts of sugar will contribute to obesity, the guidelines actually talk about limiting added sugars, only eating enough to meet your energy needs, and eating from a variety of food groups, including grains - although mostly whole grains, rather than refined sugars.

Straw Man Fallacy

Misrepresenting another person's argument, to make it easier to refute



By creating an absurd caricature of the dietary guidelines, Evans finds it easier to prove his point, and may seem more convincing to someone uninformed about current healthy eating recommendations. For industry professionals, it weakens his argument, and makes it easier to refute.



Module 4: Logical Fallacies

Argument from popularity: This is the error of assuming a claim is more correct because it is more popular. In a fitness context, you may encounter this argument when someone is trying to convince you that a particular product, diet, or exercise program is effective by pointing to how many people believe that it is effective. How could that many people all be wrong?! But, there are countless examples of very popular opinions being incorrect.

Is there a vibration platform in your gym? What claims do people make about these? One supplier of these machines (<http://www.cardiotech.com.au/vibration-machines/lifeback>) claims that

metabolism is boosted by up to 18%, muscle mass is maintained, and the appearance of cellulite reduced! What should we make of these claims? Should we assume these machines have the claimed benefits because we see them in gyms a lot? Or because this supplier sells a lot of them? No. Just as we wouldn't trust an uninformed opinion, we also shouldn't trust thousands of uninformed opinions!

Argument From Popularity

Assuming an argument is correct, because it is popular



As an aside, when working out whether we can trust this source, examine the language used. The website states "it's **possible** your metabolism **may** increase... combined with a **cardio workout**". They've avoided making a claim that can be proven wrong! We know that someone who starts exercising may lose weight (depending on their nutrition and the intensity and duration of the exercise). But in this case we can't separate the effect of the platform from the effect of the exercise program.

Appeal to authority: This is the error of assuming that someone's opinion is correct, because they have a position of authority - such as a coach, teacher, or manager. Even though throughout this course we regularly defer to the knowledge and opinion of experts, their opinions are not beyond question. No one's ideas are too good to be questioned. If the expert is discussing something outside their expertise, or is contradicting established knowledge, we **should** ask questions, and be prepared to challenge them.

It is worth keeping in mind, however, that we consider someone an expert based on the length and quality of their education and experience. Given this, it is far more likely that they are going to be correct on the topic of their expertise than an untrained person. The best experts will also be very aware of the limits of their expertise, and will be willing to acknowledge when there is the possibility they are wrong. So there is a balance to be achieved. An expert should not be trusted blindly, but it is useful to acknowledge when they are able to make highly informed decisions.



Module 4: Logical Fallacies

Appeal to Authority

Assuming an argument is correct, because of the position the person making the argument holds.



We've gone through quite a few fallacies here, but this is not an exhaustive list. There are many more that you will encounter as you are exposed to the ideas of others. It is not necessary to be able to categorize them all, but it is important to be able to identify a weak argument. It's even more important to stop **ourselves** from making a weak argument. Examine your own thinking. When you are on solid ground, **then** you can have a look at the opinions of others!

Links to Resources:

- a. <https://sciencebasedmedicine.org/chiropractic-a-brief-overview-part-i/>. An article discussing the early origins of chiropractic.
- b. <https://www.ncbi.nlm.nih.gov/pubmed/21593658>. The abstract of a recent review of the evidence for chiropractic treatment in managing lower back pain. Back pain is notoriously difficult to manage anyway, but to date it has not been proven that chiropractic treatment is any better than a placebo.
- c. <http://www.bodyandsoul.com.au/health/health-news/pete-evans-on-why-he-thinks-were-living-by-outdated-nutritional-rules/news-story/cab5da8bfb2c732a7938b9ac5b88ab3f>. A link to an example of the straw man fallacy used in this module, from an interview with celebrity chef Pete Evans.
- d. <https://www.eatforhealth.gov.au/guidelines/australian-dietary-guidelines-1-5>. The 5 guidelines of the Australian Guide to Healthy Eating.
- e. <http://www.cardiotech.com.au/vibration-machines/lifeback>. A link to a website selling vibration platforms, so you can see the claims that are made.





Module 4: Logical Fallacies

Part 2: Identify the Logical Fallacy

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

In the next activity, you will need to read a series of scenarios that are relevant to the fitness industry. Look at each one, then decide what fallacy is represented here. Once you've answered, the correct answer will appear, along with an explanation. Sometimes more than one bias will be represented at one time, so your answer may not be quite the same as ours for one or two of these.

Scenarios:

1. A colleague of yours has watched a YouTube video of a prominent fitness professional, who runs several gyms, has a university degree, works with professional athletes, and promotes himself as an expert on improving sports performance. He requires most of his clients to squat to a box, and to have a band around their thighs, to improve glute activation, before progressing to more traditional squats. Your colleague has now criticized the way you teach a squat, as you do not follow this progression. You are wrong, he argues, because your approach differs to that of the prominent fitness professional, with a YouTube channel and four gyms!

Has your colleague committed a logical fallacy? **Yes** / **No**

What fallacy is represented here?

- | | |
|-----------------------------------------------------|---------------------------------------------------|
| <input type="checkbox"/> Appeal to ignorance | <input type="checkbox"/> Naturalistic fallacy |
| <input type="checkbox"/> Ad hominem | <input type="checkbox"/> Straw man fallacy |
| <input type="checkbox"/> Genetic fallacy | <input type="checkbox"/> Argument from popularity |
| <input type="checkbox"/> Post hoc, ergo propter hoc | <input type="checkbox"/> Appeal to authority |

2. A potential client is meeting with you to discuss personal training, and go through a pre-exercise screening. During the course of this screening, you identify that he has previously been diagnosed with high cholesterol. His GP prescribed a statin to help manage this condition, and recommended dietary changes and regular aerobic exercise. The client tells you he has decided not to take the medication, as he is concerned about the side effects of taking something that is unnatural. He has read that garlic is useful in managing cholesterol levels, and is trying this instead.

Has your client committed a logical fallacy? **Yes** / **No**





Module 4: Logical Fallacies

What fallacy is represented here?

- | | |
|-----------------------------------------------------|---------------------------------------------------|
| <input type="checkbox"/> Appeal to ignorance | <input type="checkbox"/> Naturalistic fallacy |
| <input type="checkbox"/> Ad hominem | <input type="checkbox"/> Straw man fallacy |
| <input type="checkbox"/> Genetic fallacy | <input type="checkbox"/> Argument from popularity |
| <input type="checkbox"/> Post hoc, ergo propter hoc | <input type="checkbox"/> Appeal to authority |

3. You notice that when you are running, in some circumstances you get knee pain, and others you don't. After some experimenting over a number of months, you think that you are more comfortable when running on a softer surface. When running on grass, you get no pain, but when running on bitumen you do. When your shoes are in good condition, you get no pain, but in bare feet or older shoes, your knees start to hurt again. Other factors (such as running speed, and other types of exercise), do not seem to contribute to this pain.

Have you committed a logical fallacy? **Yes** / **No**

What fallacy is represented here?

- | | |
|-----------------------------------------------------|---------------------------------------------------|
| <input type="checkbox"/> Appeal to ignorance | <input type="checkbox"/> Naturalistic fallacy |
| <input type="checkbox"/> Ad hominem | <input type="checkbox"/> Straw man fallacy |
| <input type="checkbox"/> Genetic fallacy | <input type="checkbox"/> Argument from popularity |
| <input type="checkbox"/> Post hoc, ergo propter hoc | <input type="checkbox"/> Appeal to authority |

4. You are watching a game of football with your father, who is a pretty passionate fan. The game is going badly for the team he supports, so he starts to get annoyed, and makes negative comments. An image of the team's coach is shown on the screen - a former player of no significance (at least, according to your father). He comments "what an idiot. He was a rubbish player, what does he know about football?"

Has your father committed a logical fallacy? **Yes** / **No**

What fallacy is represented here?

- | | |
|-----------------------------------------------------|---------------------------------------------------|
| <input type="checkbox"/> Appeal to ignorance | <input type="checkbox"/> Naturalistic fallacy |
| <input type="checkbox"/> Ad hominem | <input type="checkbox"/> Straw man fallacy |
| <input type="checkbox"/> Genetic fallacy | <input type="checkbox"/> Argument from popularity |
| <input type="checkbox"/> Post hoc, ergo propter hoc | <input type="checkbox"/> Appeal to authority |





Module 4: Logical Fallacies

Part 3: Find Your Own Logical Fallacy

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

Now that you are becoming more familiar with the types of logical fallacies we see in the fitness industry, you are probably starting to think of occasions when you have seen or heard these before. This may have been in discussions with colleagues or clients, or in advertising or articles you've read. In this activity, we would like you to show us an example of one of these.

1. Find an online example of a logical fallacy that is relevant to the fitness industry. This could be in the form of advertising, an article or blog post, or social media post (written or video). Provide a link.

2. Identify when the logical fallacy is used. If this is written, what is the exact text? If this is a video, at what point in the video does this occur?

3. What is the fallacy being used?

4. How could this mistake be corrected? Here you may suggest alternative wording for the statement, or some information that could be provided that would make the statement true





Module 4: Logical Fallacies

Part 4: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in the previous modules. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 4. Once your responses have been checked, Module 5 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.



Module 5: Confidence and Qualifications

Critical Thinking for Fitness Professionals

Module 5 - Knowledge & Confidence

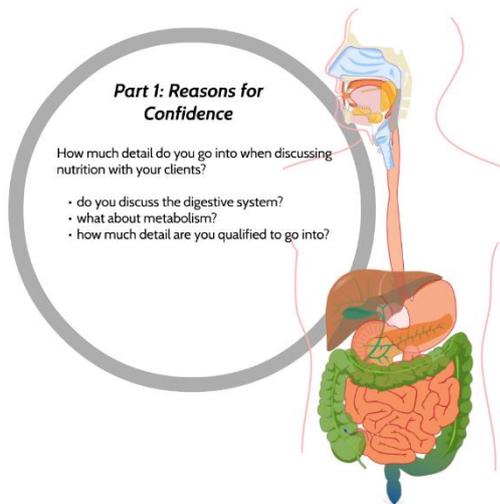


"Thinking at Hell's gate" (CC BY 2.0) by innoxius

Nutrition is a very important topic for many of our clients who are trying to lose body fat. But when you need to explain important concepts to your clients, how much detail could you, or would you want to, go into? This may depend on your level on knowledge of course, but the amount of detail we provide to our clients is often quite superficial.

We might outline the basics of digestion to explain why complex carbohydrates are often preferred to simple carbohydrates. We might also explain how carbohydrate can be stored, or used as energy, depending on our needs.

But if we had any more information, would we find it useful? Would there be a benefit in explaining how carbohydrates are broken down into monosaccharides, and the process that these go through to produce energy? Sometimes, yes. Those clients who are curious about eliminating sugar from their diet may benefit from an understanding of this process, as it would let them know that glucose and fructose are integral parts of the process of metabolism. We like to encourage moderation with all things for our clients, including sugars, fats, and even alcohol.

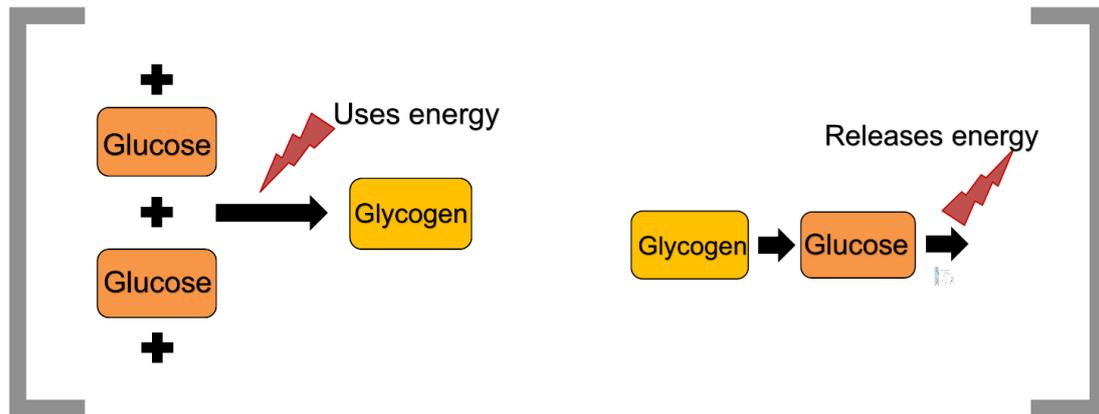


When we talk about the role of glucose in the body, how it is stored as glycogen, and how it provides energy, we usually only talk about it in the most general terms.

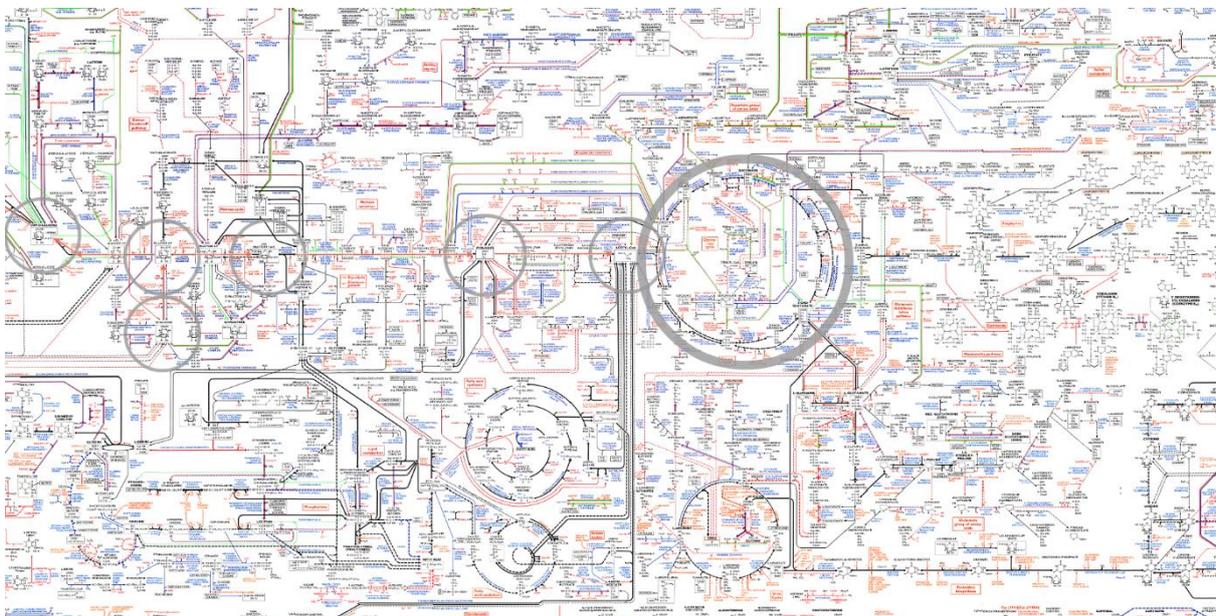


Module 5: Confidence and Qualifications

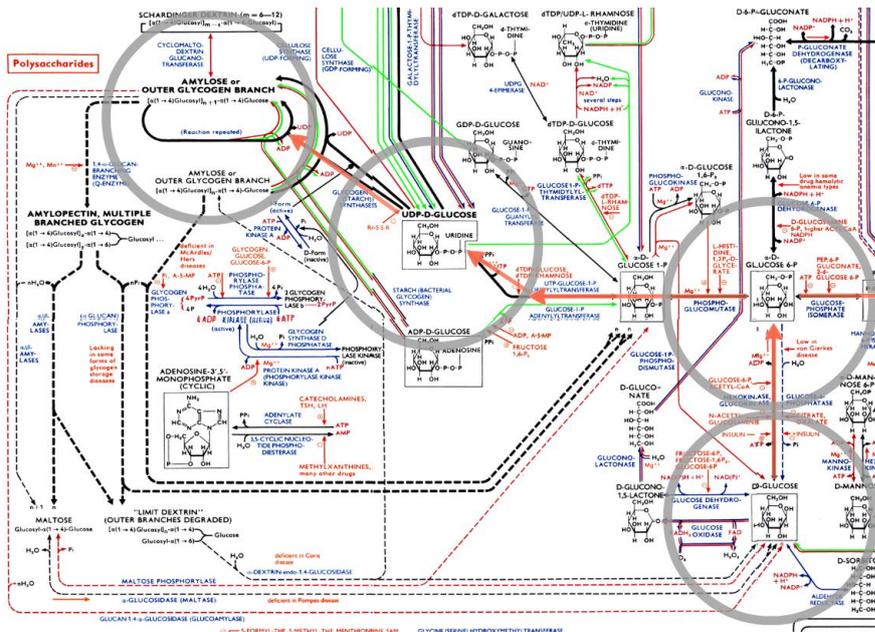
How confident are you talking a client through this? The level of detail you see here would be typical of a Certificate III nutrition course, and is about as complicated as most of us get.



More detail is provided in Certificate IV, and even more in an exercise science degree, where you will need to learn the different steps in this process, and an understanding of the Krebs Cycle. But that's *still* not the whole story...



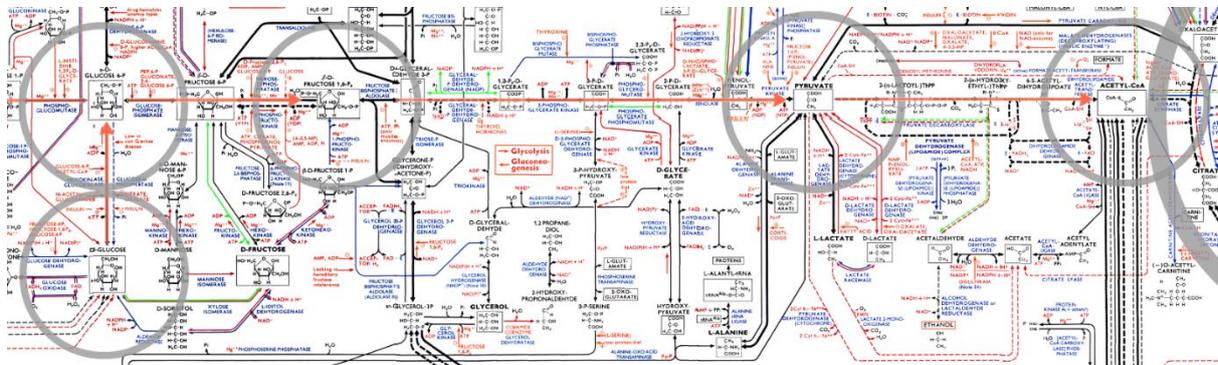
Module 5: Confidence and Qualifications



Above you can see represented all the different metabolic processes that occur when we consume carbohydrates, fats, and proteins. As you can see, there's a lot happening here - far more than you are taught in a Certificate IV nutrition class, or even a university degree. For example, under normal conditions glucose does not accumulate in the blood, but takes one of two paths, depending on energy demands.

First, here you can see here the process of glycogenolysis - the conversion of glucose to glycogen for storage in the muscles.

And here are the detailed steps of glycolysis - when glucose is broken down to acetyl-coenzyme A, before entering the Krebs Cycle. The mechanisms, enzymes and ions required for these processes to happen are well beyond what most of us need to know. The metabolism of fatty acids and amino acids are represented in this diagram as well.



Module 5: Confidence and Qualifications



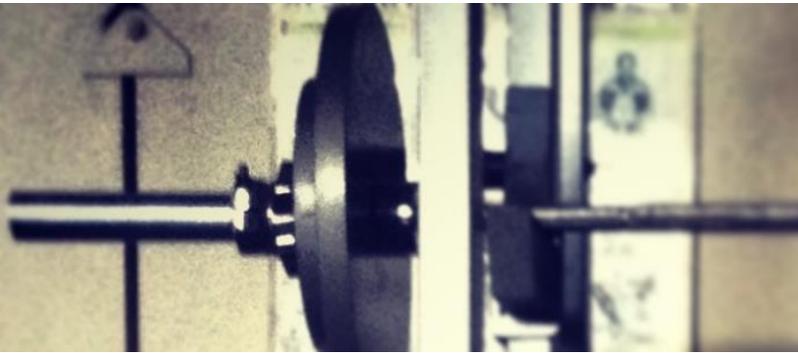
Image from <https://www.facebook.com/fatburnersonly/>

The fact is, personal trainers usually do not have the expertise to evaluate complicated nutrition or exercise claims, like the one we see above. Instead, we should look to people who are more qualified to interpret some of this information for us. But in the next section we will have a look at why we do not always do this.

Links to Resources:

- a. Metabolic chart by Roche Biomedical Pathways (<http://web.expasy.org/pathways/>), and Armand (<http://biochemicalpathwayswallchart.blogspot.com.au/2010/10/roche-biochemical-pathways-wall-chart.html>).
- b. For more information on carbohydrate metabolism: <http://cnx.org/contents/FPtK1zmh@8.26:nWir-Uwu@4/Carbohydrate-Metabolism>



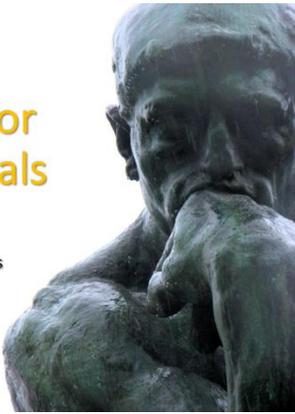


Module 5: Confidence and Qualifications

Part 2: Why Are We Overconfident?

It has been fairly well understood that people generally have inaccurate opinions of their own ability. That is, we tend to be poor at estimating our success in tasks, largely leaning towards overconfidence. When we form a judgement about our confidence, it is based initially on internal cues, or any feelings of doubt we may have. We then express these as a statement, or a number or phrase describing our confidence. The error can come from two sources: the internal judgement, or the expression of our confidence.

If we find ourselves overconfident on a topic, we can be corrected quickly if we receive **immediate** feedback - such as from a teacher or lecturer when in a classroom. But in a professional environment we often lack this feedback. Most personal trainers find themselves self-employed, and may not even have other trainers to discuss issues with. Our clients are certainly not in a position to provide the accurate feedback we need. As a result, our errors go uncorrected, and our confidence that we are correct can grow.



Critical Thinking for Fitness Professionals

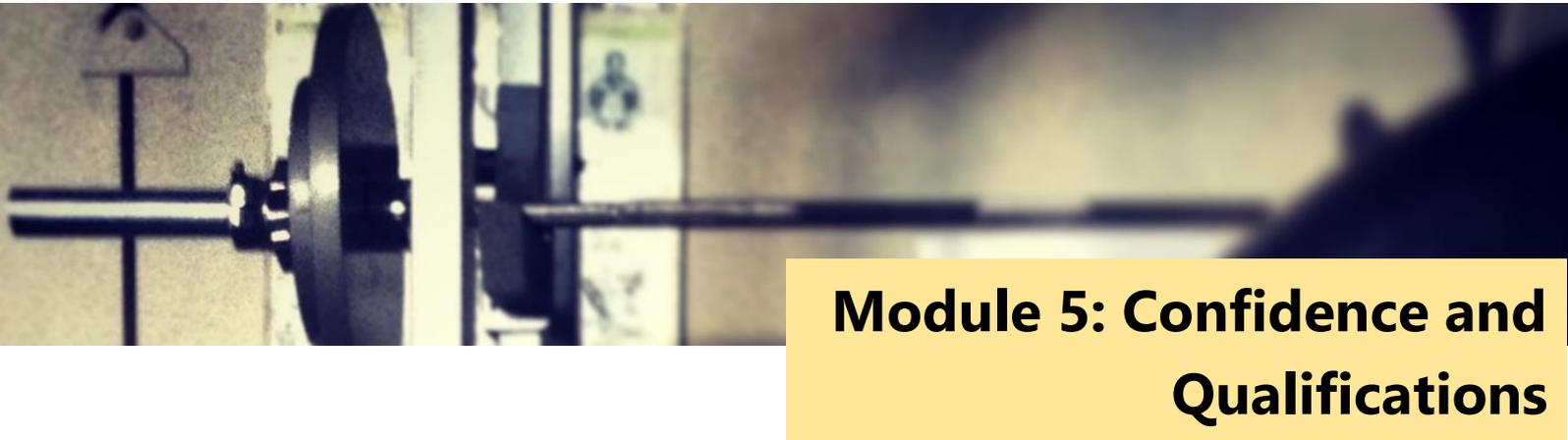
Module 5: Confidence & Qualifications
Part 2: Why Are We Overconfident?

"Thinking at Hell's gate" (CC BY 2.0) by [innoxius](#)



This overconfidence is not controversial - it has been shown again and again in research. The concept was popularized by David Dunning and Justin Kruger, in their paper *Unskilled and Unaware of it: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Opinion*. The paper starts with the apocryphal story of McArthur Wheeler, who committed a bank robbery after rubbing lemon juice on his face.





Module 5: Confidence and Qualifications

His theory was that because lemon juice is used as invisible ink, it would make his face invisible to security cameras. He was apparently shocked when this turned out not to be the case.

■ Lemon disguise was no help

PITTSBURGH — A middle-aged bank robber who rubbed lemon juice on his face because he thought it would prevent surveillance cameras from taking a clear picture of him was sentenced to 24½ years in prison.

Surveillance photos at the bank clearly showed MacArthur Wheeler and Clifton Earl Johnson taking \$5,200 from a Mellon Bank in Swissvale on Jan. 5, 1995.

U.S. District Judge Gary Lancaster sentenced Wheeler, 46, on Friday to the prison term and ordered that he serve three years on probation after that.

Johnson, 43, received a five-year sentence in April, in part because he testified against Wheeler. Johnson told him about the juice, Wheeler said.

The men didn't wear masks because they were sure the lemon juice would obscure their faces, according to Shaun Sweeney, who prosecuted Wheeler.

Image from <https://www.linkedin.com/pulse/aint-what-you-dont-know-dave-francis>

This paper led to the popularization of what is now known as the *Dunning-Kruger Effect*: that people who are less skilled not only commit errors, but lack the expertise to realise that they are committing an error. Poor performers in the tests the researchers conducted tended to overestimate their scores (i.e. possess excessive confidence), while strong performers underestimated their performance (low confidence).

Other researchers have found similar effects. Confirmation bias (as we discussed in a previous module) plays a significant role - we either are not exposed to, or neglect, evidence that will contradict our opinion, thus will be more confident in our expertise. In the case of McArthur Wheeler, he apparently took a photo of his own face in order to test his theory - which for whatever reason (an error on his part, perhaps) did not show his face. Thus, armed with very little experience, and some shaky supporting evidence, he robbed a bank!



Module 5: Confidence and Qualifications

THE DUNNING-KRUGER EFFECT

Designed by @YLMsportScience

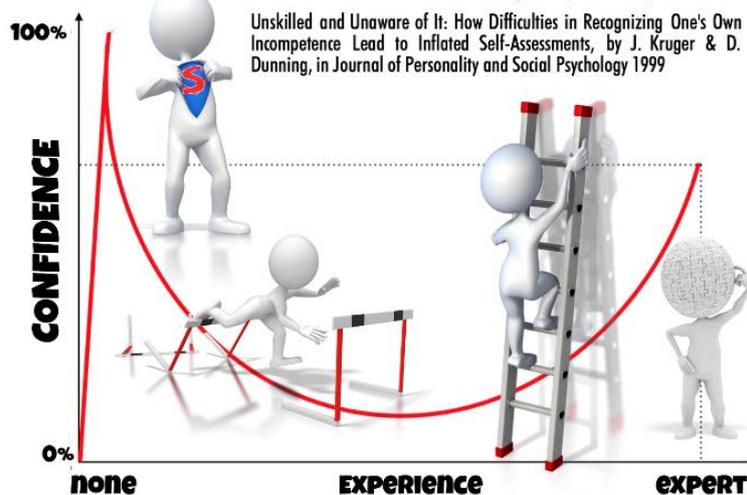
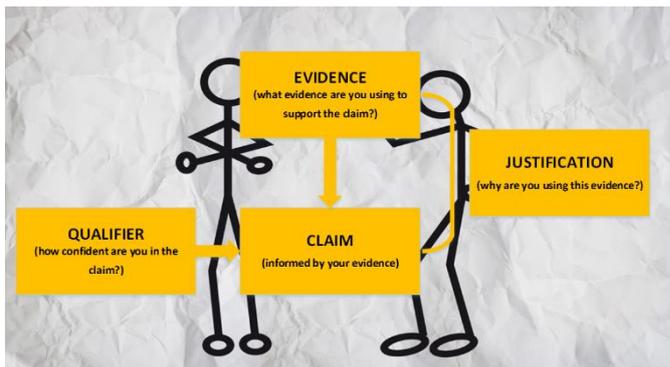


Image by Yann Le Meur. <https://ylmsportscience.com/>. Used with permission

As a way of countering this tendency towards poorly estimating our confidence, there are a few things we can do. When discussing argument in the first two modules we discussed make sure we had sound backing for our argument - strong evidence, and a solid justification for using the evidence in our argument. We can use the same principle here: take a piece of information that you



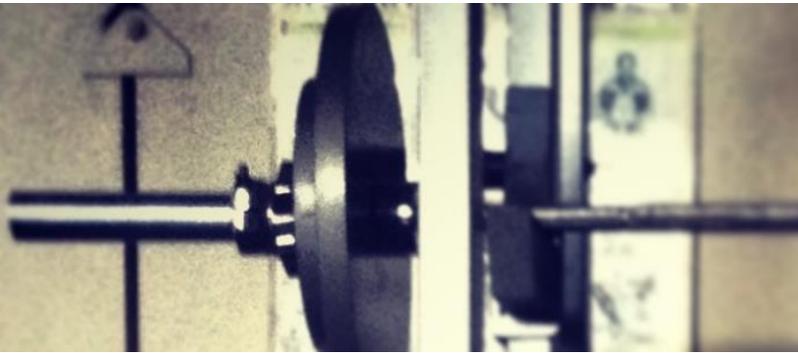
"Humanoids Arguing" (CC BY 2.0) by [hang in there](#)

regularly pass on to your clients - it might be about getting them to stretch either before or after a training session. Then ask yourself "how do you know?" Write down all the relevant evidence that you can think of that supports your statement.

Once you've done this, examine your evidence. Is it convincing? Were you able to provide plenty of detail in your explanation, or is it a little threadbare? Now, what does this do to your confidence? The more detail you have

been able to provide in your justification, the more confident you can be in your answer. Just like looking at metabolism in the previous section, an expert is going to be able to provide much more detail than is needed for a client, but this detail helps to inform the more basic advice they give.



A blurred background image of a gym setting, showing a barbell and weights.

Module 5: Confidence and Qualifications

Other research has shown that confidence in someone's knowledge or opinion decreases with the amount of effort they need to put into forming that opinion. Consistent with the Dunning-Kruger effect, if your knowledge is low, and you have reached your decision quickly (or even intuitively), you will be more confident than if you laboured over your decision - though this may be a better

decision. You might have seen an example of this when talking to gym members in the past. You will no doubt have encountered some interesting opinions in your time, often without strong evidence behind them. A response might be "that's just my opinion", or "that's what works for me". These types of responses are typical of someone who either lacks the capacity, or the inclination, to examine their opinions.



So having examined the relationship between confidence and knowledge, how do we know who we can trust? Clearly, the most confident people may not be the best sources of information. We will answer that in the next section.



Module 5: Confidence and Qualifications

Part 3: What Makes an Expert?

In the last section we had an entertaining look at the Dunning-Kruger effect. What we were trying to point out is that those who are the most confident in their own abilities and knowledge are not necessarily the most capable. It takes a certain level of knowledge to become aware of just how much more you need to learn, at which point your confidence may be quite low!

Critical Thinking for Fitness Professionals

Module 5: Confidence & Qualifications
Part 3: What Makes an Expert?



"Thinking at Hell's gate" (CC BY 2.0) by innoxius

On top of an awareness of how much there is to learn in their field, experts tend to exhibit the following characteristics:



- Content knowledge.** This is not limited to theoretical knowledge. It may include insights gained from experience and professional practice, so they can **apply** the knowledge appropriately.
- Mental skills to make tough decisions.** This requires highly focussed attention, the ability to disregard irrelevant information, the ability to identify exceptions to rules, and maintain performance under pressure.
- Psychological traits** such as self-confidence, strong communication skills (within their field), adaptability, and a clear sense of responsibility. In other words, acting like an expert is part of being one!
- Decision making strategies.** A systematic approach allows an expert to overcome their limitations. This includes using feedback, using decision making aids when necessary, deconstructing complex problems into smaller ones, and pre-thinking solutions to tough problems.

But expertise also requires a task with suitable characteristics. In some tasks it is not possible for experts to perform significantly better than novices. For example, with enough time with our clients, a good trainer should be able to make a significant difference to that person's strength or fitness. We should be able to tell the difference between expert trainers and novice trainers, because their decision making and practice directly impacts the benefit the client receives (through better programming, feedback, technique correction, etc.).



Module 5: Confidence and Qualifications

A nutrition expert, on the other hand, may not be as easily distinguished from novices based on the results of their clients. Why not? Because they rely on the clients to change their behaviour, and maintain this behaviour change, which is notoriously difficult. People relapse all the time, even when provided with the best advice.



On top of these characteristics of experts, we also need to examine the length, and quality, of their education. We often can't rely on the opinion of someone who professes to be an expert. Professional judgement and intuition are notoriously flawed. So when an "expert" relies on their instincts or subjective observations, we need to be cautious. In the fitness industry practical experience is often considered as a measure of someone's expertise, but the length of practice is poorly correlated with knowledge. In other words, it is entirely possible that someone could be a poor practitioner for a number of years, without learning or improving.



Module 5: Confidence and Qualifications



This education can include the professional development that the "expert" has completed. In order to maintain your Fitness Australia registration you are required to attain 20 Continuing Education Credits (CECs) over a two year period by attending short courses, seminars and conferences. But we choose these ourselves, so we can be very selective about the information we are exposed to. We could (and often do) end up choosing the professional development that best matches our pre-conceived

ideas, and avoid that which challenges us to consider the possibility we are wrong. Thus we become more convinced of our expertise, even though we may be wrong, or severely limited. Look back at Module 3 where we discussed confirmation bias for more information on this.

The one place we can't entirely control the information we are exposed to is during formal education. That is, our Certificate III and IV courses, exercise science degree, or other higher qualifications. In these a syllabus is set, and we need to complete the required subjects, regardless of what we think of them. We are also assessed to ensure we have understood the content. As discussed earlier in this module, a personal training qualification often does not provide enough detail to allow us to be considered "experts." So let's have a look at how personal training qualifications compare to others by examining the Australian Qualifications Framework (AQF), which identifies ten different levels of qualification.



How much education does a personal trainer have, and at what point can we be considered experts?



Certificate III - this will qualify you to be a ***gym instructor*** or possibly a ***group fitness instructor***. A certificate III requires factual, technical, and procedural knowledge, but limited theoretical knowledge. This allows them to complete routine activities (like fitness appraisals, programming, and client inductions), and provide solutions to some problems (like referring prospective members to a doctor for a medical clearance). A Cert III graduate is able to take limited responsibility in stable situations; in other words, should be closely supervised. This may take up to 6 months full time study.





Module 5: Confidence and Qualifications



Certificate IV - this is required to be a **personal trainer**. A Cert IV has broader factual and technical knowledge, but still has a limited theoretical base. More developed cognitive and communication skills are required, as well as the ability to deal with more unpredictable problems that might occur during a personal training session. A personal trainer may be entirely responsible for their own actions, and provide some limited direction for others. This may take another 6 months of full time study.



Bachelor Degree - this will qualify you to be an **exercise scientist**, or allow you to go on to postgraduate study (to practice as an exercise physiologist, for example). Typically, a degree takes 3-4 years. A graduate should have a broad, in depth, and coherent body of knowledge. They should be able to critically review information, be able to independently analyse and solve problems, and be able to communicate this knowledge clearly. They will also be accountable for their own learning, and be able to develop their knowledge independently, and work in collaboration with other disciplines. A degree qualified trainer may be dealing with some complex clients with injury or illness issues, and communicate with allied health professionals as needed.



Masters Degree - this may take up to 3-4 years, on top of a Bachelor Degree. Graduates may move into high level sport, or deal with clients with complex medical or injury histories. They should be up to date with recent advances in fitness, and understand the principles of scientific research. They should have mastery of theoretical knowledge in the field, be able to generate and evaluate complex ideas, and communicate technical information clearly. They should be highly independent, and be able to deal with complex, changing situations. As an example, think of the challenges involved in getting a sports team of individuals, with different needs, histories, and exercise tolerance in peak condition at the same time, in collaboration with a team of professionals from other fields. This is quite a complex task!



Doctoral Degree (Ph.D.) - a doctoral degree takes another 3-4 years, resulting in about 10 years of university study in total! Graduates of this degree are at the very frontier of our understanding of the science of fitness and nutrition. They are able to investigate and develop new knowledge, make a significant and original contribution to science, and are capable of the complex planning and communication that goes along with this. However their focus is on research rather than practical skills, and they may have a very narrow focus of expertise.

If you want more information, you are welcome to have a look at the AQF document included in this module - but it's quite a read. So where do you think personal trainers sit on the ladder of expertise when compared to some other allied health professionals?



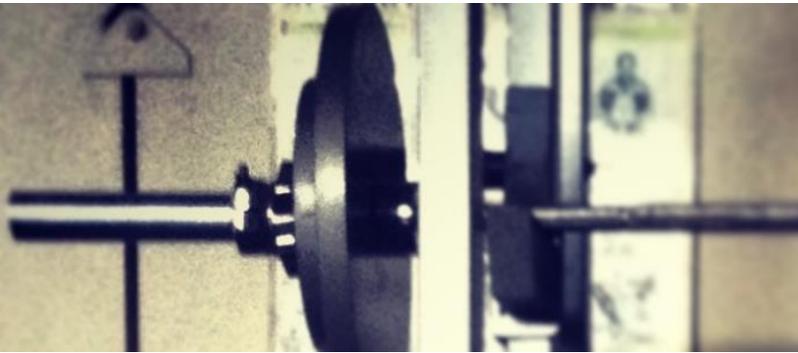
Module 5: Confidence and Qualifications



Many nutritionists have a Bachelor degree, while dietitians have either a Bachelor or a Masters degree, so we are far from nutrition experts. Exercise physiologists need at least a 4 year Bachelor degree before they can deal handle injury rehab and exercise for chronic illnesses. Physiotherapists similarly have a 4 year degree to be able to diagnose and treat musculoskeletal injuries and pain. Clinical psychologists need a Masters degree to practice psychology. Most strength and conditioning coaches working in professional sport have a Masters or a Doctoral degree, in addition to coaching qualifications.

Personal trainers may pick up pieces of knowledge in some, or all, of these fields populated by highly qualified professionals. But we are not experts in any of these fields. Let's not present ourselves to be something we are not. But, personal trainers can claim expertise within their scope of practice, which as we've discussed previously is focussed on exercise programming and delivery for healthy clients. We can excel at this, as we often have more contact time with our clients. As a result, we can have wonderful, productive relationships with these clients, and help them achieve lifelong goals. We can also work with these other professionals to achieve better outcomes for clients with more challenging circumstances. And, personal training can also be a great stepping stone to any of these other professions, if you choose to continue your education.

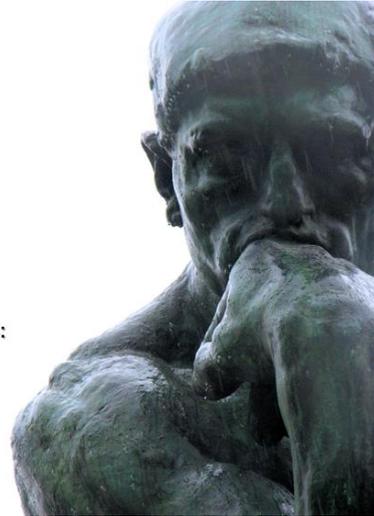




Module 5: Confidence and Qualifications

That's it for Part 3

When you're ready proceed to Part 4:
Review



"Thinking at Hell's gate" (CC BY 2.0) by innoxius

Part 4: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in the previous modules. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?





Module 5: Confidence and Qualifications

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 5. Once your responses have been checked, Module 6 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.



Module 6: The Scientific Method

Module 6 Learning Outcomes

At the end of this module, you should be able to:

- Understand the basic steps of the scientific method
- Appreciate the role of the placebo effect in products with proposed health and fitness effects
- Differentiate between evidence that uses the scientific method, and evidence that does not
- Identify with whom the burden of proof lies in an argument

Part 1: What is the Scientific Method?

Critical Thinking for Fitness Professionals

Module 6: Scientific Method
Part 1: What is the Scientific Method?



["Thinking at Hell's gate"](#) (CC BY 2.0) by [innoxius](#)

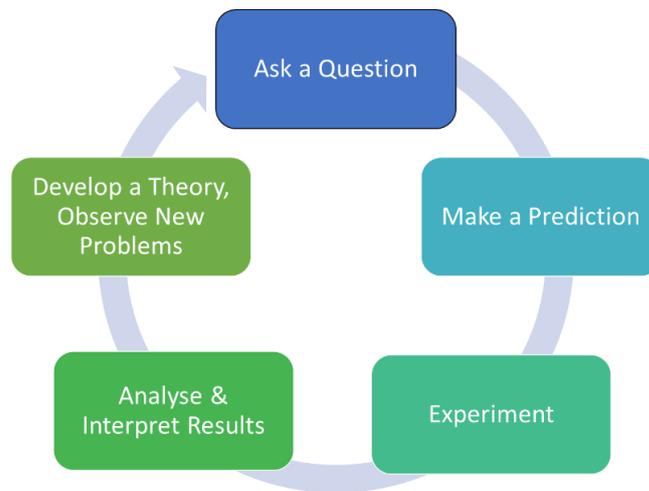
In the last module we discussed ideas of confidence and expertise. Often, the **confidence** a person has in their knowledge or abilities is not consistent with their **competence**. It is often once we are exposed to more information that we start to realise how much we don't know. We've also discussed the importance of formal education. While it is important to realise that education does not immediately make us a better personal trainer, it gives us tools that we can use to **become** a better trainer.

Knowledge is just one of these tools. One thing you might have noticed as we looked over the Australian Qualifications Framework is that at lower levels we need only some understanding of theory. We mostly require practical skills, and the ability to recall procedures and instructions. As we progress through the levels we need a deeper understanding of theory, research skills, and more advanced problem solving skills. At the very highest levels (Masters and doctoral degrees) we actually conduct the research which helps improve the understanding of our bodies, fitness, and nutrition.



Module 6: The Scientific Method

The ability to do scientific research is a skill not required by personal trainers. But if we understand some of the basics, it can help us evaluate new exercise products or claims, and decide if we need to learn more about them, or disregard them if the evidence is not convincing. So let's have a quick look at the steps of conducting scientific research.



Step 1: Observe a Problem, Ask a Question.

There's a lot we don't know about the human body. The effects of different types of training are constantly being studied in universities around the world. We look at the effect of different conditions, different diets, different clothing and equipment, and even different warm up and recovery strategies to find the safest, most effective ways to train. Sometimes these are big, important questions, but usually they are small problems, as we look to refine or improve existing knowledge.



As an example, let's look at the use of different types of warm ups. For years fitness students were taught that a static stretch was required prior to exercise. This has changed in recent years, but why? What is this the best way to warm up prior to sport, or vigorous exercise? This is our question.



Module 6: The Scientific Method

Step 2: Make a Prediction.

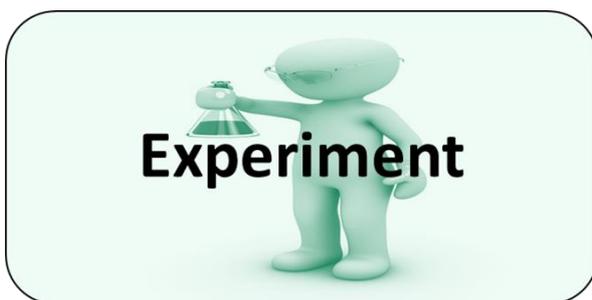


Here we propose a potential outcome that we are going to test. Using our current example, we could propose that a dynamic warm up before training (working the muscles that you are going to use for your exercise through their range of motion, progressively increasing intensity), will lead to better sprinting and jumping performance than a static stretch.

Step 3: Experiment.

The type of experiment used can vary greatly, depending on the question being asked. There may also be significant differences in how many people participate, the type of information collected, the length of the study, and the manner, and order, in which tests are conducted. All this also influences what conclusions can be drawn from the research.

For our warm up experiment, we have some options, but we want to pick one that will be practical and effective. We need to compare dynamic stretching to static stretching. So we will have two groups, one doing each type of warm up. Then we need to test their performance - a sprint test or vertical jump test will suit our needs. These tests should be performed by each participant, in each group, under identical conditions, so there are no other variables that impact performance.



We need to make sure that we have enough people in each group to reduce the impact of random chance on our results, such as if one participant responds unusually well to one type of warm up. We also need to make sure the groups are similar, as people of different exercise backgrounds or experience may respond differently. There may also be gender or age differences we need to account for.

Once we've designed our experiment, we carefully collect and record our results. One group does a static stretching warm up, while another does the dynamic warm up. They then perform the same tests, in the same order, and under the same conditions.



Module 6: The Scientific Method

Step 4: Analyse & Interpret Results

Once our experiment is conducted, we analyse our results. We use statistical software to test if there is enough of a difference between the groups to suggest that there was an effect from the different warm up, or whether this difference could be due to random chance. In this case, we've found that a dynamic warm up leads to better jumping and sprint performance than static stretching - an important finding for sports performance!



Scientists will tend to be quite conservative in their conclusions. They will usually not claim there is an effect unless their evidence is quite conclusive. In this case, we might conclude that a dynamic warm up is better than static stretching, but **only** for the tests that we performed, and with the group of participants we used. We wouldn't apply our results to different populations, or different types of exercise.

Sometimes the conclusions that unqualified commentators draw are quite different to what the researchers themselves state. They tend to assign certainty to findings that researchers do not, or extrapolate these findings beyond what is reasonable given the research that was conducted. Be wary of people who comment on scientific research that aren't qualified to conduct or interpret it!

Step 5: Develop a Theory / Observe New Problems



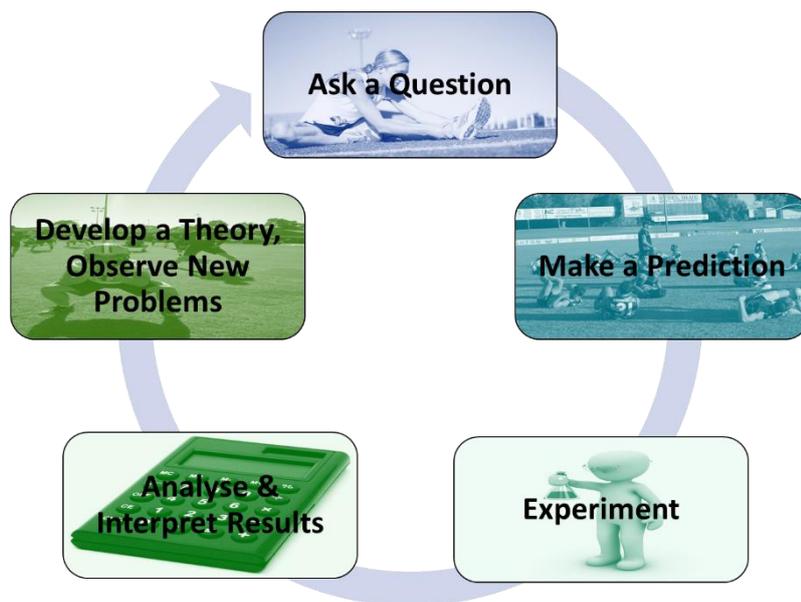
If the research is particularly ground-breaking, and makes a new discovery, this is pretty exciting. It's also very unlikely. Often nothing new is discovered. Sometimes, we can find out more about someone else's discovery. Or, we contradict their findings, so more research needs to be done to find out why this happened. This is helpful, but less newsworthy than the occasional "eureka" moment. Science is usually a slow, and incremental, process.

In our example, we've found that a particular type of warm up improves certain test results, for certain populations. Nothing else. We can't assume that dynamic warm ups are better than static stretching for all sports performance, or has an impact on injury rates, or is effective for any other population. But we can then ask these other questions, then do **more** research to find these answers. The body of research builds up over years, looking at different groups, and different types of exercise, and we build an overall picture of the effectiveness of these two warm ups.



Module 6: The Scientific Method

If you want to have a look at some good summaries of the evidence concerning types of warm up, some links are provided in this section of the module.

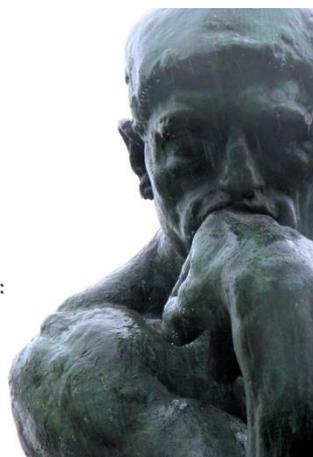


Hopefully you are developing an appreciation of what a slow, painstaking process science usually is. There are very few examples of "eureka" moments in modern science, when someone makes a discovery that completely changes what we know. In fact, this can often be an indication that someone is making an inappropriate claim. If someone is claiming to have invented/discovered something that contradicts decades of established evidence, it is a big deal. Their evidence would

have to be spectacular, and be robust enough to stand up to scrutiny from the scientific community. This is usually not the case. Our understanding of our bodies improves all the time, but there are very few pivotal moments in which we decide to completely change our recommendations for the way everyone trains, or eats. Usually, our current understanding is just refined, or tweaked, as new evidence comes to light.

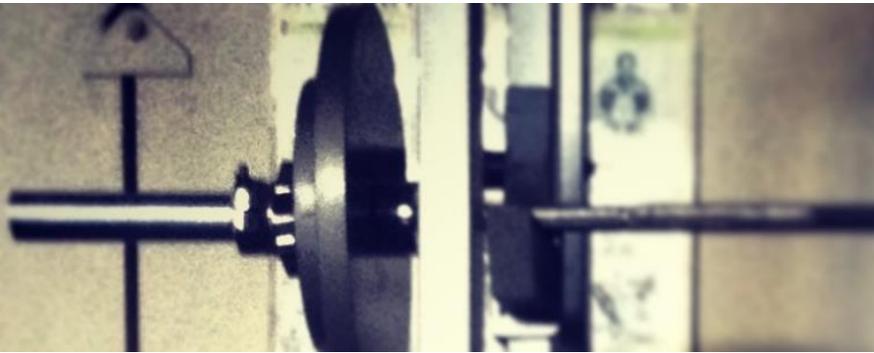
That's it for Part 1

When you're ready proceed to Part 2:
The Placebo Effect



"Thinking at Hell's gate" (CC BY 2.0) by innoxius





Module 6: The Scientific Method

Links to Resources:

- a.** For a good summary of some of the evidence around different warm up techniques for a physiotherapist, have a look at this: <http://www.stadiumsportsphysio.com.au/dynamic-or-static-stretching/>
- b.** If you want the perspective of an accredited exercise physiologist and strength & conditioning coach, see here: <http://www.fitnessnetwork.com.au/resources-library/evidence-based-practice-warm-up-methods-and-protocols>
- c.** Here's a video that explains the scientific method using a different example, if you want to approach it from another angle. <https://www.youtube.com/watch?v=BVfl1wat2y8>



Module 6: The Scientific Method

Part 2: What is the Placebo Effect?

In an earlier module we discussed home remedies for the common cold, and how the illusory correlation bias could lead people to thinking a relationship exists between a remedy and their recovery, even when no relationship exists. But this isn't the whole story. Sometimes people actually **can** feel a reduction in their symptoms as a result of this remedy. In fact, this frequently happens, but this doesn't necessarily means that the remedy has worked... At least, not any better than anything else might.

We'll explain further. Let's say your home remedy is a mug of hot water, lemon juice, and honey. Every time you were sick throughout your childhood, your parents made this drink for you. Every time they gave it to you, they told you it would make you feel better. Over a number of years, you built a very strong association with taking this drink, and feeling better (as we mentioned earlier, you will recovery from your cold **eventually**, no matter what you do), and you continue to use it as an adult.

Just the belief, or expectation, that this remedy will have an effect, will often lead to you feeling better, even if it has no real effect. This is called the **placebo effect**, and it can affect us in a number

of ways. If we expect a cold remedy makes us feel better, then it might, even if there is no other reason for it to work. If we expect a tablet to reduce our pain, then it might, even if it is not a painkiller. We have no control over whether or not we experience the placebo effect. Some of us are more prone to it than others, through no fault of their own.



So when scientists test the effect of a new supplement, they need to make sure any benefit from this new substance is greater than what we see from a placebo. So they will design an experiment where one group gets the new product, and another gets a

placebo. The participants are not told which one they have received (this is called "blinding"). The placebo will look the same as the actual product, and the participants receive the same dose, and same instructions. If the new supplement has an effect, but not greater than the effect of the placebo, then it hasn't worked as hoped.



Module 6: The Scientific Method

This is why we can't rely on the opinion of someone who tried herbal supplements to help them feel better during an illness, or the alternative treatment they used to help treat their muscle injury. This person may be experiencing a placebo effect, and have no other information about the effectiveness of the treatment. They may be surprised by, and even reject, scientific research that shows that it doesn't have the desired effect.

So Why Does This Matter in the Fitness Industry?

Unfortunately, there is a lot of research where people do not apply placebo controls when required, so some research is less robust than others. This is why we need an expert with research experience to interpret some of this information for us – personal trainers just don't have the knowledge to determine whether or not research was designed appropriately, or whether the conclusions drawn were appropriate.



Can you think of any other examples of the placebo effect in the fitness industry? We discussed one in the first module. Remember **Sexy Water**? We identified some of the claims made by the advertising, but at the time, we didn't look at whether or not the water would be able to live up the claims.

If you look at the testimonials provided on the website (of which there is no shortage), you will notice something. Here are a few of the purported benefits in these testimonials from trainers and the public:

- "I felt that my skin & body was clean, energised & full of life"
- "I noticed faster recovery after workouts, increased energy, improved performance"
- "With in [sic] the first two weeks of drinking sexy water I noticed increased energy & overall well being [sic]"
- "I can easily say it is the most cleanest [sic] most refreshing water I have ever tried"
- "The difference in taste is unbelievable and I cant [sic] see myself ever wanting to drink regular water again"

If you have a look at the perceived benefits here, and on their advertising, what do you notice? It is almost all subjective. That is, based on opinion. This is fertile ground for the placebo effect. It is very hard to measure how much someone's energy levels have increased. Taste, likewise, is an entirely personal opinion. Exercise performance in something we could usually measure, but this is affected by our mood, and perceived energy levels too, so is also subject to the placebo effect.





Module 6: The Scientific Method

Also, think back to the previous section when we gave you an outline of the scientific method. One of the criteria we discussed was an appropriate number of participants in your research. How do testimonials compare? Especially when the testimonials all state different benefits? These are the reports of one person. Either Sexy Water could cure just about anything, or the benefits are due to the placebo effect.

Links to Resources:

- a.** For more information about the claims and perceived benefits around Sexy Water, visit their website: <http://sexywater.com.au/>. You will notice they link to quite a lot of research, but without the appropriate qualifications, we cannot draw accurate conclusions from this. But it is useful to note, that almost none of the cited research was conducted on humans, or used Sexy Water specifically. Be wary of those who provide large amounts of irrelevant or poor quality literature as a way of supporting their point. It looks impressive, and most people won't search through it to pick up the useful information.
- b.** For another explanation of the placebo effect, try this video: <https://www.youtube.com/watch?v=z03FQIGgo0>
- c.** Here is an article explaining the use of the placebo effect by doctors: <https://theconversation.com/explainer-what-is-the-placebo-effect-and-are-doctors-allowed-to-prescribe-them-55219>



Module 6: The Scientific Method

Part 3: Research Activity

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

We're now going to have a go at a brief research activity. You will be provided with some background to an exercise product, in the form of a TV infomercial. The product in question is the Ab Circle Pro, which was a popular piece of home fitness equipment a few years ago.

As you watch the video, watch for the claims that are made regarding the effectiveness of this product. If any of them seem a little over-the-top, unrealistic, or at odds with your knowledge and experience as an exercise professional, make a note of the claim, and the time in the video in which it occurs. It's important to be able to refer back to the exact claim, because subtlety in the wording used can dramatically change the claim being made.



Image from <https://www.drillsukala.com.au/exercise/ab-circle-pro-review/>

Pick one claim that you think may be wrong, that you would like to look at in more detail. There are several you could pick from. State the claim in the space provided below, using as close to the exact wording used in the infomercial as you can manage.

Click here to watch the video: <https://www.youtube.com/watch?v=qMrzygFeiew>

Now you need to research the claim made. To do this, you can have a look at any resources you have access to from your personal training qualification or professional development, or any textbooks or articles that may help. You can also open a new window in your browser, and start searching. Take your time here, and read from a number of sources - don't just stop at the first article that has the conclusion you are looking for.

Given this module is about the scientific method, and we have recently examined qualifications, we are looking for high quality evidence to examine this claim.





Module 6: The Scientific Method

Is the claim reasonable? If so, what evidence have you found that supports the claim? Conversely, what evidence have you found that contradicts the claim? It's possible that you were not able to draw a conclusion one way or the other, if evidence is mixed. Provide links to the evidence you use to support your conclusion.

What is the quality of the evidence you used? Discuss the qualifications of the authors of the content you used, and whether they are relying on anecdotes, or they discuss scientific evidence. Keep in mind that if the claim requires us to disregard a large amount of established evidence, then the evidence supporting this claim must be spectacular!

As you may have found over the course of your research into the claim you chose, the Ab Circle Pro has received its' fair share of publicity, and many of the claims made in the infomercial have already been thoroughly examined. Have a look at the following article, which examines the claims made in reasonable detail. The video is a short news article featuring the author of the article. You may have ended up using this information to form your opinion already. If so, that's great. If not, then it should have confirmed what you managed to find out, or maybe added some detail.

Click here for the article: <https://www.drillsukala.com.au/exercise/ab-circle-pro-review/>

Click here if you want to watch the video separately: <https://vimeo.com/161364829>





Module 6: The Scientific Method

Links to Resources:

- a. It turns out the makers of the Ab Circle Pro were taken to court as a result of some of the claims they made in their advertising: <https://www.ftc.gov/news-events/press-releases/2012/08/marketers-ab-circle-pro-device-pay-much-25-million-refunds-settle>
- b. They later settled the case: <http://www.theaustralian.com.au/news/world/refunds-agreed-for-weight-loss-deception/news-story/f6b415d9cca6e1567db5950b9dc10e30>
- c. If you want to see some scientific research into the Ab Circle Pro, have a read of this: https://www.researchgate.net/publication/47815679_A_Comparison_of_Trunk_Muscle_Activation_Ab_Circle_vs_Traditional Modalities.



Module 6: The Scientific Method

Part 4: Burden of Proof

Imagine the following scenario: a new trainer working in your gym has some very strange ideas about strength training. While most other trainers are willing to use a variety of equipment to get the best results for their client, he is convinced that free weights of any description are inherently dangerous, so he will only program with machine weights. Clearly there is

a place for pin loaded machines in many exercise programs, but you are not convinced that his reasoning is sound, so you want to discuss it with him, and maybe even try to change his mind. When you have the discussion though, his response is that he has decided this based on his personal experience with resistance training, and that you cannot prove him wrong.

We've already discussed what value we can place on personal experience or anecdote (even when coming from an expert). But another issue with this is that your colleague has the **burden of proof**. This term simply means that the onus is on the person making the claim to provide the evidence and justification for their claim, rather than the person they are arguing with (go back to Modules 1 & 2 if you want to revise argument). When two people make competing claims, then the burden of proof goes to the claim which contradicts the consensus opinion. In this case, the consensus opinion is clearly that there is a place for free weights in resistance training.



Image copyright Steve Ogden, 2017. All rights reserved.
Used with permission.

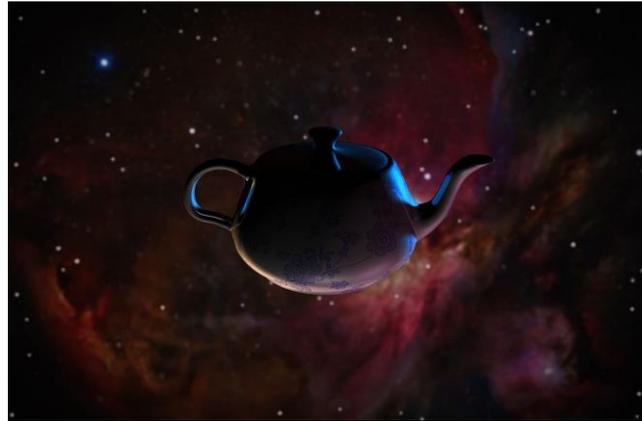
What can we do if the person we are arguing with is not willing to meet the burden of proof? It might be a good sign not to invest too much time and energy in the argument. As we know, arguments are only productive if both sides are flexible in their opinions, and willing to work to reach a consensus. Someone who is not willing to meet the burden of proof may not be willing to accept that the evidence does not support their opinion.



Module 6: The Scientific Method

Sometimes it is impossible to prove a claim is wrong. The late philosopher Bertrand Russell used the analogy of a teapot floating in space to illustrate where the burden of proof lies in this situation:

If I were to suggest that between the Earth and Mars there is a china teapot revolving about the sun in an elliptical orbit, nobody would be able to disprove my assertion provided I were careful to add that the teapot is too small to be revealed even by our most powerful telescopes. But if I were to go on to say that, since my assertion cannot be disproved, it is intolerable presumption on the part of human reason to doubt it, I should rightly be thought to be talking nonsense.



Russell was using the analogy to discuss the existence of God, but the principle applies in any situation where someone is arguing for a claim that cannot be disproved.

In the fitness industry we often encounter claims that cannot be disproved because they are too vague. An example might be the types of exercise, supplements, and products that are claimed to promote "wellness." This is impossible to disprove, for a couple of reasons. The first is that the term "wellness" is sufficiently vague, that it can mean whatever the advertiser wants it to mean. It is also a completely subjective term, so that anyone claiming to feel better cannot really be argued with. If



someone thinks their wellness has improved, then it has! In this case, the burden of proof for the person making the claim would include defining "wellness" in a way that could be accurately tested first. Then we could look at the evidence that supports, or refutes, the claim.

Similarly, there are some people who claim that certain exercises (usually involving an element of balance or coordination) improve the synchronization of the left and right hemispheres of our brain. An example is shown on the left. But for us to examine this claim seriously, we first need to establish that there are actually issues with the way the different hemispheres in our brain interact that need to be addressed. Only then, can we look at whether or not these exercises have any benefit.

Image from <https://braintrainingbyjaynee.com>





Module 6: The Scientific Method

Part 5: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in the previous modules. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 6. Once your responses have been checked, Module 6 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.





Module 7: Sources of Information

Module 7 Learning Outcomes

At the end of this module, you should be able to:

- Discern the trustworthiness of sources of information
- Be aware of the different types of scientific research, and which ones are more relevant to the fitness industry
- Identify which online sources of information can be trusted

Part 1: Hierarchy of Evidence

Last module we looked at the scientific method. We went through the basic steps involved in answering a question, then looked at some of the mistakes people can make if they aren't familiar with this approach. In this module, we are having a look at some of the different sources of information we can rely on when making decisions as a personal trainer.

We don't need to answer every question by reaching out to an expert. Sometimes we can rely on our experience, or our own reasoning skills, when working out whether a certain training approach is appropriate or not. But it helps to know how much our own knowledge and experience can be trusted, and what (if any) better sources of information are out there.

We will go through some of these sources of information now, in order of how trustworthy they are:



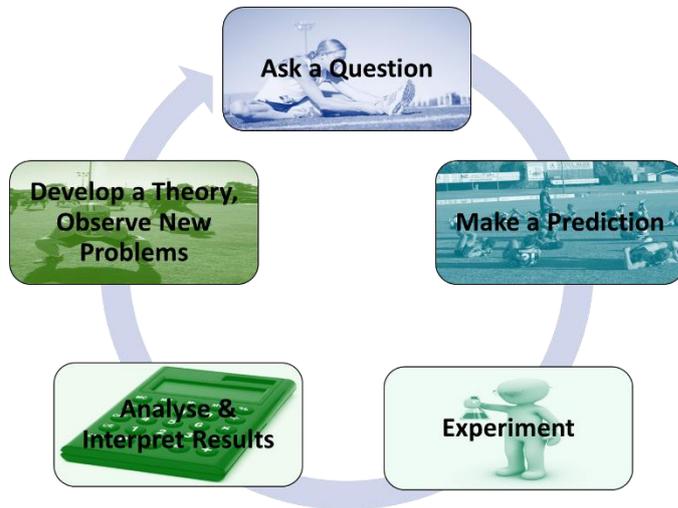
Critical Thinking for Fitness Professionals

Module 7: Sources of Information
Part 1: Hierarchy of Evidence

"Thinking at Hell's gate" (CC BY 2.0) by [innoxius](#)

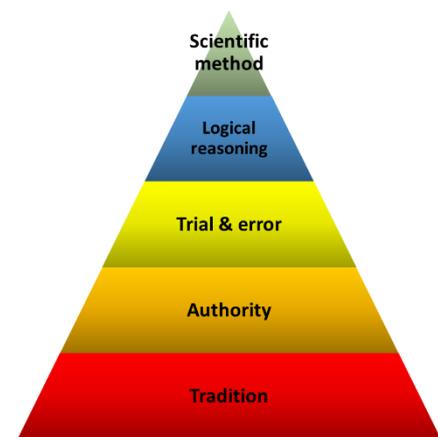


Module 7: Sources of Information



Tradition: this is when we do something, or believe something, only because this is the way it has always been. We do a static stretch before we exercise, because we always have, and we don't question why. We do a certain type of running, or lift weights a certain way, or choose particular exercises, because we always have. Or, the person that taught us always did. Clearly, there is no chance of developing our knowledge here; we are only repeating what has already happened. Our opinions are rigid, and unable to change.

Authority: this is slightly more flexible, in that our opinions and knowledge can progress, but only when this knowledge comes to us from certain sources. For example, we may have a mentor within the fitness industry, or a particular source of information that we trust, and our practice is only informed by that source. When questioned why we hold our opinion, we don't feel the need to doubt our source. They're an expert, and we trust them!



Credit: Bret Contreras



["The old time weight lifter... #halloween" \(CC BY-NC 2.0\) by timlauer](#)

Trial & error: *now* we are getting somewhere! We are willing to adjust our opinions and practice based on what we observe. We may try an exercise with a client, they enjoy it and get stronger, so we use that exercise with other clients. If something doesn't work, we might discard it and try something else.

But, by now hopefully you can see some of the flaws with this approach. We can't necessarily trust our observations - confirmation bias will influence how we interpret information, and we may not be aware of other factors influencing our observations. For example, we see someone lose abdominal body fat when we get them doing an exercise program with lots of crunches in it, so we conclude that our program has worked.



Module 7: Sources of Information

But we can't separate this outcome from other factors - such as other exercise modifications, reduced kilojoule intake, and maybe an increase in incidental activity as our client becomes motivated to change their lifestyle.

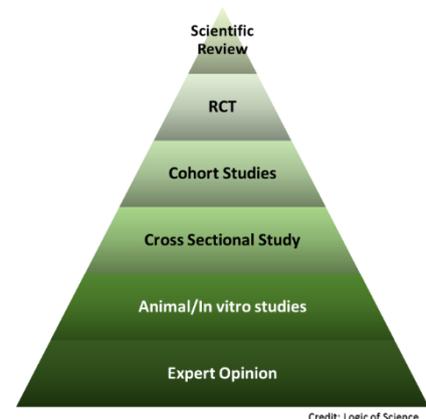


Logical reasoning: this is even better. Rather than just relying on what we see, we can start to work through what should happen, based on our knowledge. If our exercise program *doesn't* have the impact we thought it would, it doesn't mean it's the wrong program - there may be issues with the execution of the program. If someone else proposes a program to you, you don't need to try it for yourself to work out if it will, or won't, have the desired effect.

This is a reasonable standard to achieve as personal trainers, assuming we have learnt our course content well. We can reasonably apply what we have learnt in our course, or in our professional development, and identify an inappropriate option. Sometimes our knowledge is wrong, however, and the conclusions we draw from our reasoning are incorrect as a result. So we need to be able to find, and interpret, new information, so our conclusions can improve. This is when our knowledge of the scientific method can help us.

Scientific research: we discussed the principles behind the scientific method last time, though there are many different types of scientific research we can refer to. Some will be more appropriate than others when assessing information relevant to personal training. Often these are cited inappropriately by people with vested interest in promoting a particular method, or product.

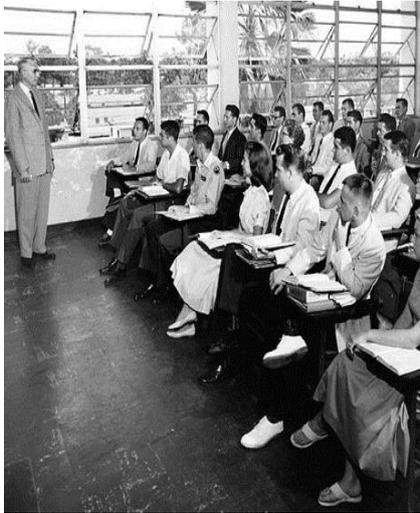
When deciding which type of research is more trusted, or even when deciding what type of research to conduct, a number of factors are considered. The type of question being asked will dictate the type of research (if any) that is conducted. The timeframe, the group we are dealing with, and the cost are other factors to be considered.



Let's take a look at the different types of scientific literature we might come across:



Module 7: Sources of Information



Expert opinion: this may not be any different to the logical reasoning or authority we discussed in our non-scientific sources of information, but the opinion of an expert with research experience will at least be informed by that research. It is still just an opinion, and just as prone to biases and error as we are, but the information they are using to form that opinion is stronger, and they are usually more willing to adjust their opinion as the evidence they use to form it changes (unlike those speaking from tradition or authority, who may be much more rigid in their views).

If you ask an experienced professional for their opinion on the cause of increasing obesity rates in Australia, there is no doubt they will have an opinion. And it may be very well informed. But it is still just an opinion.

Animal/in vitro studies: in the early days of a new supplement, it may be tested in lab conditions, such as in vitro (meaning "in glass", or in practical terms, petri dishes or test tubes), or on animals. It is usually only once a clear, consistent, and safe effect has been shown in these conditions that testing begins on human subjects.

But sometimes this research is taken out of context, and people start to spruik the benefits of this substance before it has been established that it has an effect on humans at all!

Often, when a food or supplement is claimed to have miraculous health properties, it is not because this effect has been demonstrated in humans. It may be, for example, that one chemical contained in that food has an effect on cancer cells in vitro. That's great, but a petri dish is not a person. And the amount of the chemical used in the dish is very different to what is in the food, and may not be safe for human consumption in large doses. This sounds far-fetched, but a lot of alternative medicine or nutrition claims start off this way. This alternative health practitioner, for example, claims that coconut oil is a natural remedy for Alzheimer's disease (<https://draxe.com/coconut-oil-benefits/>). But when you look a little more closely, you find that of the two studies cited, one is in vitro, and the other is a case study (using only a single participant). This is pretty flimsy evidence to base a health claim on.



Often, when a food or supplement is claimed to have miraculous health properties, it is not because this effect has been demonstrated in humans. It may be, for example, that one chemical contained in that food has an effect on cancer cells in vitro. That's great, but a petri dish is not a person. And the amount of the chemical used in the dish is very different to what is in the food, and may not be safe for human consumption in large doses. This sounds far-fetched, but a lot of alternative medicine or nutrition claims start off this way. This alternative health practitioner, for example, claims that coconut oil is a natural remedy for Alzheimer's disease (<https://draxe.com/coconut-oil-benefits/>). But when you look a little more closely, you find that of the two studies cited, one is in vitro, and the other is a case study (using only a single participant). This is pretty flimsy evidence to base a health claim on.

There are many claims that are made for certain chemicals, both causing, and preventing, illness and obesity in humans. But none of them can be taken seriously if this is the standard of evidence that is relied on. At best, it may point us in the right direction for future research.



Module 7: Sources of Information

As personal trainers, we should be taking the health of our clients very seriously, which means only making recommendations within our scope of practice, which are well backed up by evidence. Would your clients be happy knowing that you are providing advice to them on the basis of such weak evidence?

Cross sectional studies: now we are starting to look at more rigorous evidence that involves human subjects, and a decent number of participants. Cross sectional studies are snapshots in time: we take a look at the characteristics of a group of people at that moment. What we might see is a correlation between certain behaviours and health characteristics, such as people weighing less if they live in a certain postcode, have certain exercise habits, eat certain foods, or have certain jobs. We can't conclude that a relationship exists between these characteristics, just that they are more likely to occur together.



For example, does where you live make you more or less overweight? Absolutely not. But where you live is influenced by your income, which may be affected by the job you have and your education levels, which may influence the amount of free time you have to exercise, or your knowledge of the benefits of a healthy lifestyle. And this lifestyle certainly *will* affect your weight.

We usually shouldn't draw conclusions from these types of studies in the fitness industry. We learn something about the group, but not what caused the group to be this way, or how the group is changing.

Cohort studies: one of the weaknesses of cross sectional studies are that they only look at groups at one point in time, though this does make them easier to conduct. If we want to know how the attributes of a group change over time, we need to perform a cohort study. This allows us to look at not just the characteristics of the group we want to know about, but how these change.

But, they are very time consuming. If we want to know about the long term impact of a certain eating pattern or type of exercise, then we need to observe people over this time frame. Very long cohort studies can take decades!



Module 7: Sources of Information

While it is possible to draw some conclusions about how people change, from this kind of study we still can't identify **why** they change. If we are seeing obesity rates changes over decades, as we are told is happening in the National Health Survey, for example, we can't isolate any one reason as the cause. In all probability, there are many causes, with complex interactions, when looking at something like national obesity figures. To identify one factor as the cause is not always possible. We need to be more rigorous again!

Randomized Control Trial: now we can finally identify whether individual factors have an effect. If we use obesity rates as our example again, we can now work out whether it is due to changing diets, increased screen time, etc. How? This is a little more complicated. Let's say we want to see whether the use of a mobile fitness tracking app, which gives feedback on how much energy you've expended during a workout, leads to a better weight loss result in people who use it.



We take a group of people that we want to look at, then assign people randomly into one of two groups - our intervention, and our control. Our intervention group will be exposed to the variable we are trying to assess (use of our app). The other group (our control group) will be similar in terms of weight, exercise levels, education, etc. In fact, we even take a series of measurements beforehand to make sure they are the same. When they exercise, however, they do not use the app. Instead, they need to judge the intensity of their workout for themselves.

To make sure that nothing else changes, participants are instructed to maintain their usual nutrition, sleep, work, and social behaviours. They would come into a lab to exercise for a set timeframe with a researcher, who would assess the intensity of their training session. At the end of an appropriate length of time (in this case, maybe 10-12 weeks), we assess our participants again. If there is a difference in weight loss between the two groups (larger than what would be expected from random chance), then our app has had an effect.

A randomized control trial is very time consuming, and difficult to set up and run well. But it is the first time that we have been able to identify a cause for a change in weight.



Module 7: Sources of Information



If, however, we wanted to look at whether or not a variable led to **increased** weight in a group of people, we probably wouldn't use an RCT. Why? Because it's unethical. This would mean exposing a group of people to something that we think will cause them harm! We may need to rely on weaker forms of evidence for this.

Scientific review: even when we conduct RCTs, however, we are often not definitely sure that we have identified the cause of the weight gain, or weight loss, effect we are looking at. Because another researcher, performing a similar experiment with a different group of people, may come up with different results.

We need to look at the whole body of research to work out our conclusions. Maybe our findings only apply to a small group of people, and other populations find different results. Maybe we made a mistake in our analysis, and someone else did it correctly. Or maybe the effect we are looking at is not consistent. Maybe there's not enough research to make a clear decision one way or another.

For all these reasons, it's important to look at the whole body of research, not just one article. Anyone can find a piece of research that supports a claim, but we need to know the consensus of the scientific community, from research conducted with different people, in different countries, under different conditions. Our topic may be quite controversial, in which case, maybe more research needs to be done. But a good scientific review looks at **all** the research on the topic, and reaches conclusions based on this.

That's it for Part 1

When you're ready proceed to Part 2:
Select the Evidence



"Thinking at Hell's gate" (CC BY 2.0) by [innoksius](#)

Scientific reviews are not perfect - none of the methods we've discussed are. They all have some strengths and weaknesses. But you've seen the way we get more and more rigorous as we climb this pyramid, and the conclusions we draw can become more and more certain. When discussing a topic with an expert in that field, find out what they are basing their opinion on, and listen to how confident (or unconfident) they are with their conclusions. There's a lot we still don't know about the human body, and a real expert will be happy to tell you as much!





Module 7: Sources of Information

Links to Resources:

- a.** Further reading on identifying good and bad scientific research can be found here: <https://theconversation.com/how-to-quickly-spot-dodgy-science-65160>
- b.** This article provides some interesting background on the potential benefits of fitness trackers, and different ways they can be used: <https://research.cc.gatech.edu/sites/edu.ecf/files/p24-miller.pdf>
- c.** This is an example of a randomized control trial looking at the effects of fitness trackers, with or without added incentives, in Singapore: https://www.eurekalert.org/pub_releases/2016-10/tl-tld100316.php



Module 7: Sources of Information

Part 2: Select the Evidence Activity

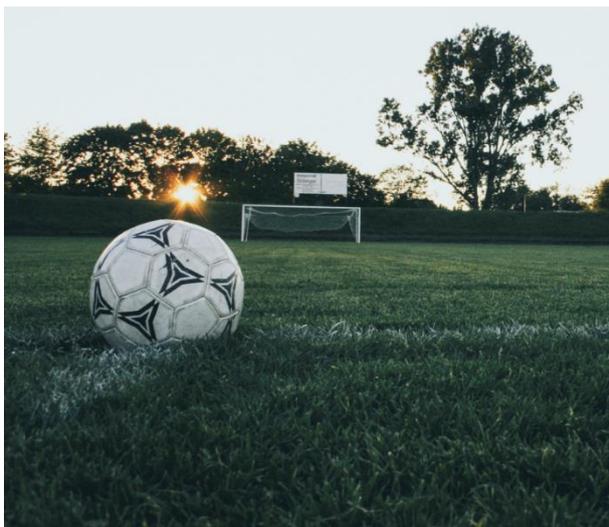
Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

In this activity, you will be provided with a series of scenarios. In each scenario people are sharing their opinions regarding a fitness or nutrition topic, or controversy. They will state their cases, then provide the evidence that they are basing their opinion on. You need to identify the form of evidence used, and tell us whether or not you are (or should be) convinced by the evidence.

The correct answer will be explained after each question. You can have as many goes as you like to get the correct answers, but you need to get all answers correct before you can continue.

Scenario 1: some soccer coaches are discussing the best way to prepare a team for a game. Two coaches agree that a warm up isn't necessary, and that their team could just run straight onto the pitch and play without any increased injury risk. But their reasons are different. Another disagrees, and has his own reasons for wanting to do a warm up with his team. Which one is using the best evidence to support their claim?

The first coach refers back to his playing days: "We didn't warm up when I was playing as a young boy, and we were fine. These kids will be fine too!"



What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all





Module 7: Sources of Information

The second coach uses an analogy from nature: "a gazelle in Africa doesn't warm up before it runs from a predator - it just goes. What makes us any different?"

What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all

The third coach said that he did want to warm his team up. Earlier in the year he went to a coaching course, in which one of the presenters was a strength and conditioning coach, with many years of experience in high level sport. As part of his presentation he discussed the benefits of a dynamic, sport specific warm up, for both injury prevention and improved performance. The presenter based his recommendations on the current state of scientific research, and his own personal experience.

What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all

Scenario 2: two personal trainers are discussing the best way to program resistance training to improve the strength of their clients. They have very different ideas about how to do this. The first one likes to use higher repetitions, train to failure frequently by lifting the heaviest possible weight, and train muscles using largely isolation exercises. The second uses relatively lower repetitions, but heavier weight. He rarely recommends training to failure, and uses mostly compound movements. Which one is using the best evidence to support their claim?



Module 7: Sources of Information



The first trainer bases his opinion on his experience in the gym. He tried a few different methods of training before settling on this one when he was a young man. He consistently does higher repetitions than his colleagues, and trains to failure. He also trains only one or two body parts per day, using lots of isolations exercises in his session. He's also very strong. His reasoning as seeing as this approach has given him significant benefit, then his clients should be able to benefit from this training too.

What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all

The second trainer is nowhere near as strong as his colleague. He is very open to trying lots of different styles of training for his own curiosity, so as a result doesn't settle on any one method for long enough to improve his strength significantly. He feels this experience makes him a better trainer though. But he recently read an article in a professional journal, in which an academic used the results from a number of scientific studies to provide guidelines about the appropriate resistance training variables to get someone stronger. This is what he uses to inform his programming.

What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all



Module 7: Sources of Information

Scenario 3: a client is talking to their trainer about an eating plan to assist them with weight loss. The client has recently read an article that makes claims about the negative health effects of eating sugar. Understandably, the client is concerned, as the article claimed that sugar is toxic, and is responsible for most chronic illnesses. The trainer thinks that the article was misinformed.

The evidence the article cited was a study in which a small number of overweight people either maintained the normal diet, or were fed either a high fat, or high sugar, diet. Each diet consisted of a similar amount of energy. This study found that the high fat diet resulted in better weight loss. However, this was the **only** evidence that the article referred to. It did not refer to any other scientific literature. It then claimed that eliminating simple sugars from the diet, and most grains in general, would result in less obesity, which in turn would result in less of the diseases associated with obesity, such as diabetes and heart disease.



What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all

The trainer is a little more conservative, and thinks that eliminating any nutrient or food group completely from the diet is impractical, and probably not necessary. In response to this article, the trainer refers to the Australian Dietary Guidelines, which identifies an association between added sugar and obesity, then recommends a significant reduction of added sugars in the diet, without the need to eliminate them completely. This document contains numerous references, and draws conclusions based on the consensus of these references.





Module 7: Sources of Information

What evidence is used here?

- Tradition
- Authority
- Trial & error
- Logical reasoning
- Expert opinion
- Cross sectional study
- Cohort study
- Randomised control trial
- Scientific review

Does the evidence convince you?

- Absolutely
- Not sure: I'll need to look into it more
- Not at all

Links to Resources:

- A PDF version of the 2013 Australian Dietary Guidelines is included in the online course for your convenience. A pdf can also be found here: https://www.eatforhealth.gov.au/sites/default/files/files/the_guidelines/n55_australian_dietary_guidelines.pdf
- A Fitness Australia guide to fitness professionals providing dietary advice is also included in the online course. A pdf can also be found here: <http://fitness.org.au/articles/nutrition-advice-within-scope-of-practice-for-ausreps/1356>
- This is an excellent resource for personal trainers and the public alike, with simple resources, advice, and games to educate and inform. It also includes the Australian Dietary Guidelines, as well as information on how this resource is developed: www.eatforhealth.gov.au.



Module 7: Sources of Information

Part 3: How to Look for Evidence

This module has been all about identifying what is reliable information, and what you need to be more sceptical about. This can be a time consuming process. Even if someone presents some rigorous evidence, like a randomized control trial, we may still need to check that it has been used appropriately. Meaning, does the study conclude what the person is claiming it does? Often it takes much longer to work out whether the evidence is reliable or not, and therefore whether the claim is appropriate, than it does to merely make a claim, and provide a link or two in the way of evidence.

Critical Thinking for Fitness Professionals

Module 7: Sources of Information
Part 3: How to Look for Evidence



"Thinking at Hell's gate" (CC BY 2.0) by innoxius

The Internet can be unreliable when it comes to information. There is almost no limit to what you can find, so this means information is of varying quality. It doesn't have to be accurate to make it online. So when clients, other trainers, or friends find an article about health, fitness, or nutrition online which they want to discuss with you, the first question you should ask is "**where is this information from?**" This can save you from spending hours looking at something of poor quality.



Luckily, there are a few shortcuts you can take which will give you a good idea about how seriously you can take the information you are looking at.

Domain names

Firstly, pay attention to the web address you are provided. If you see **.edu**, or **.gov**, at the end of the web address, you can have more confidence.

.edu means that the information is from an educational institution, such as a university. On the other hand, **.gov** means that the information is provided by a government (**.gov.au** means this is the Australian government). While neither of these are guarantees of good information, at the very least the content has been approved by multiple people before being posted online. And there is a better chance an expert has been involved in developing the content.



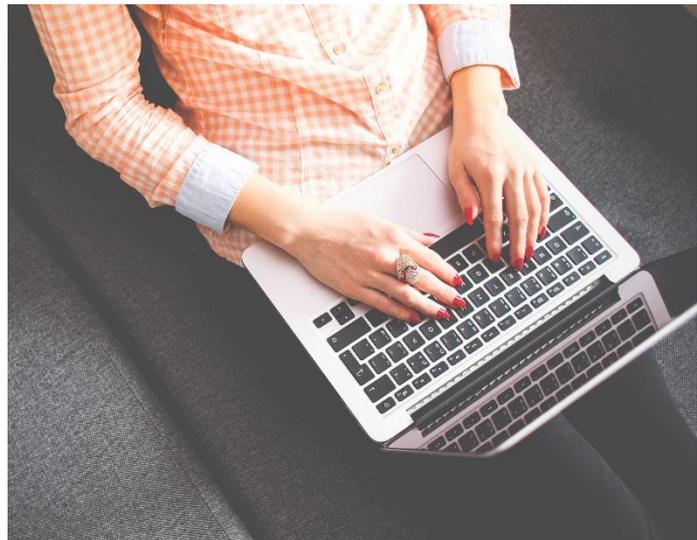
Module 7: Sources of Information

A **.com** domain on the other hand, can be purchased by anyone, and they can post whatever content they like. While it could be fantastic information, the domain doesn't give you any indication of whether it is or not. You may also need to be aware of the country the domain is from, as fitness and dietary recommendations can vary from country to country.

Once you've started reading the article, there are a few more signs of a good source:

Can you identify the author?

A lot of online writing is anonymous, or published using a username. If the author is confident enough in the accuracy of their information to provide their real name, affiliation (such as where they work), and qualifications, then you can more easily determine whether or not this is someone you can trust.



Does the article identify source material?

If the article is based on information from another source, they clearly state this, and provide a link to the original source. This is especially important if the article is a rebuttal of, or disagrees with, the original article. The ability to refer back to the original can tell you whether or not the arguments made by the article you are reading are valid or not. For example, they could misrepresent, or exaggerate, the claims of the original source, which would be committing the straw man fallacy.

Referencing

Furthermore, does the article provide references to back up its arguments? Particularly if the article is refuting the ideas of another, they should provide strong evidence, and a reasonable justification for their arguments (refer back to Modules 1 & 2 for a refresher or arguments). Sometimes the references can be a strong indication of the quality of the article, particularly for sites like Wikipedia, which are crowd sourced.

On the other hand, there are a few signs that you should probably not take the source all that seriously:



Module 7: Sources of Information

Be wary of gurus

As you have probably worked out during your time in the fitness industry, there are often many different ways to reach a goal, within certain guiding principles. Weight loss is a great example. The guiding principle is the need for an energy deficit to achieve weight loss. But there are many different ways we could achieve that, involving changes to a person's diet and exercise. We need to select an approach that is safe, effective, and sustainable for the client. But there is no one way that it *has* to be done.



Conspiracy theories

If the article claims that there is a conspiracy to suppress the truth, you can probably disregard it altogether. This is how some people with unusual beliefs about nutrition ignore the decades of research that have gone into creating the current Australian Dietary Guidelines, and can instead rely on one or two cherry picked pieces of information. This also indicates a poor understanding of science. Researchers try to prove each other wrong by testing each other's theories all the time. A consensus among scientists is reached when a theory withstands this scrutiny, not in order to mask some hidden truth.

Vague claims

The claims made by the source are very vague. Supplement companies may make claims that a product "supports wellness", while exercise products often claim to "tone and firm", without making any specific weight loss claims. This makes a claim impossible to disprove, but also means that any effect is entirely subjective. As discussed in previous modules, if you expect to have improved "wellness", then you might, regardless of the product.

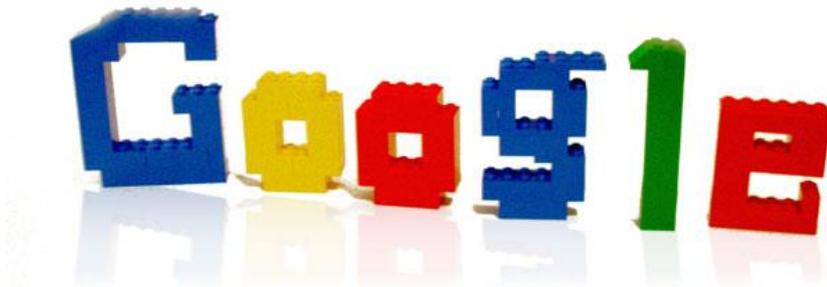
Miracle cures

Anyone who claims to be able to treat dozens of complaints with the same treatment, probably can't treat any of them. Generally, qualified experts are quite careful about what they claim to be able to treat. So it's unlikely that one product, or vitamin, or program, should be able to improve health in a variety of unrelated ways. That's not to say it's impossible, but each health claim would need to be assessed individually, and proven with rigorous evidence.



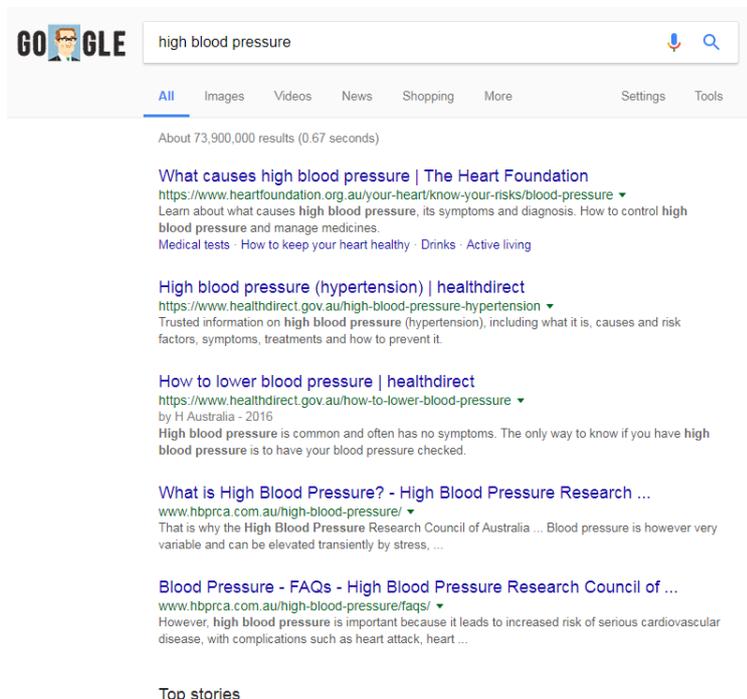
Module 7: Sources of Information

So hopefully you are now developing an idea of what information you can trust, and what you can't. But as we've discussed, it can be challenging to find good information online sometimes. Most of us will go to Google and type something into the search bar, but if you are vague with what you enter in the search bar, then you will get vague, confusing results.



"google" (CC BY-NC-ND 2.0) by [billypalooza](#)

For example, if I have a client with high blood pressure, and I want to know more about the exercise recommendations, I could type "high blood pressure". But I would get almost 74 million results, most of which are not helping me find out about how to program for this client.



Most people won't look past the first page of search results, so you can see here that I might decide it was too hard to find the useful information amongst all the background information about high blood pressure. But if we refine our search terms slightly, by adding "exercise considerations" we get a very different outcome. 4 million results is still too many to read, but look at the difference in the content at the top of the first page.





Module 7: Sources of Information

The screenshot shows a Google search interface with the query "high blood pressure exercise considerations". The search results are as follows:

- Cardiovascular, or aerobic, exercise** can help lower your **blood pressure** and make your heart stronger. Examples include walking, jogging, jumping rope, bicycling (stationary or outdoor), cross-country skiing, skating, rowing, **high-** or low-impact aerobics, swimming, and water aerobics.
[Exercising When You Have High Blood Pressure - WebMD](#)
www.webmd.com/hypertension-high-blood-pressure/safe-exercise-tips
- [PDF] Australian Association for Exercise and Sports Science Position ...**
<https://www.essa.org.au/wp-content/uploads/ESSA-Hypertension-position-statement.pdf>
by JE Sharman - 2009 - Cited by 73 - Related articles
Hypertension (high blood pressure; BP) is a leading contributor to pre- mature death and ... considerations are required and these are discussed in this review.
- Exercising When You Have High Blood Pressure - WebMD**
www.webmd.com/Hypertension/Reference
Cardiovascular, or aerobic, exercise can help lower your blood pressure and make your heart stronger. Examples include walking, jogging, jumping rope, bicycling (stationary or outdoor), cross-country skiing, skating, rowing, high- or low-impact aerobics, swimming, and water aerobics.
- Take Precautions When Exercising With Hypertension - EmpowHER**
[www.empowher.com/Blood Conditions/Essential Hypertension](http://www.empowher.com/Blood%20Conditions/Essential%20Hypertension)
Hypertension (high blood pressure) cases are flooding the doctors offices. Fortunately, this condition can be improved and even reversed with good nutrition and ...
- ACSM - Exercise and Hypertension - IDEA Health & Fitness Association**
[www.ideafit.com/Fitness Articles/IDEA Personal Trainer/May 2004](http://www.ideafit.com/Fitness%20Articles/IDEA%20Personal%20Trainer/May%202004)
May 1, 2004 - A lower-intensity training program should be used for higher-risk patients (such as those with coronary artery disease or chronic heart failure). ACSM also suggests that promoting the blood-pressure-lowering effects of single exercise sessions may be the best way to motivate these clients to exercise.
- Considerations for Personal Training the Hypertensive Client Part 1 ...**
[https://www.ncsf.org/considerationsforpersonaltrainingthehypertensiveclientparti.as...](https://www.ncsf.org/considerationsforpersonaltrainingthehypertensiveclientparti.as)

In the first four hits we see a position statement from Exercise & Sports Science Australia (which regulates exercise physiologists in Australia), and the American College of Sports Medicine, which is also highly reputable. Then below that, we see an article outline considerations for personal trainers specifically. Not only do we get the information we are looking for, in this case we also get high quality information (though we've ignored the WebMD result at the top of the page).

Google Scholar

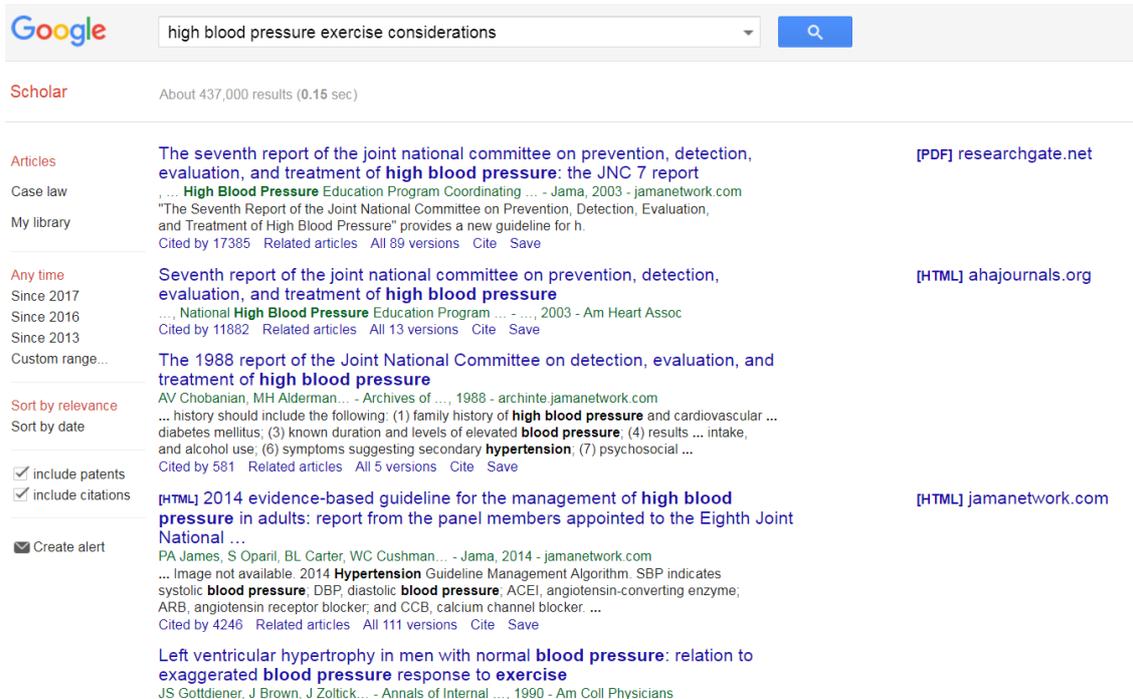
If you want to get even better information (though it might be more detailed than you need), you can try Google Scholar. This is a search engine specifically for

scientific and legal documents. If we try the same search as before we now only get 400 000 results, but these will be from scientific journals. You won't always need the level of detail provided in these sources, but now you know where to find them when you do.

But, even though this information is usually of a higher standard, you still need to read it carefully. Scientific articles can be of varying quality too, so readers need to pay careful attention to how the study was conducted, and what results are reported. You may need to look for review articles which will summarize these findings for you, find an expert with research experience to interpret some of these articles for you, or look for professional organisations like Exercise and Sports Science Australia, or Fitness Australia, whose recommendations are informed by this research.



Module 7: Sources of Information



The screenshot shows a Google Scholar search interface. The search bar contains the text "high blood pressure exercise considerations". Below the search bar, the results are displayed in a list format. The first result is titled "The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report" and is linked to researchgate.net. The second result is titled "Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure" and is linked to ahajournals.org. The third result is titled "The 1988 report of the Joint National Committee on detection, evaluation, and treatment of high blood pressure" and is linked to jamanetwork.com. The fourth result is titled "[HTML] 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National ..." and is linked to jamanetwork.com. The fifth result is titled "Left ventricular hypertrophy in men with normal blood pressure: relation to exaggerated blood pressure response to exercise" and is linked to Am Coll Physicians. The search results are filtered by "Any time" and sorted by "relevance". There are also options to "include patents", "include citations", and "Create alert".

We have spoken about the varying quality of the information you can find online, but we also need to make sure we are assessing information fairly. Don't forget about the biases that we are prone to in our thinking. If a source has challenged what you thought was true, make sure you give it a fair assessment. It isn't necessarily right, but you need to be able to entertain the possibility that it is.





Module 7: Sources of Information

Links to resources

- a) Some more pointers about finding good online information (note the .edu domain!):
<http://www.library.georgetown.edu/tutorials/research-guides/evaluating-internet-content>
- b) And even more: <http://www.ed.ac.uk/information-services/library-museum-gallery/finding-resources/library-databases/databases-overview/evaluating-websites>
- c) Here is an article discussing why someone without scientific training should still look at scientific articles, with advice on how they can read and interpret the information:
<https://blogs.scientificamerican.com/guest-blog/finding-good-information-on-the-internet/>
- d) To find out more about why any given online conspiracy theory is probably not true:
<http://grist.org/science/most-conspiracy-theories-have-one-giant-problem/>

Part 4: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

This exercise is the same as in the previous modules. Please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional.

1. Identify one important concept, theory, or idea that you learned while completing this activity.

2. Why do you believe that this concept, theory, or idea is important?





Module 7: Sources of Information

3. How can you apply what you have learnt from this activity to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?

Congratulations, you've completed Module 7. Once your responses have been checked, Module 8 will be made available for you. This may take up to 2-3 days, depending on the number of participants we have at this time.





Module 8: Putting It All Together

Module 8 Learning Outcomes

At the end of this module, you should be able to:

- Integrate a range of critical thinking skills into a fitness specific research activity
- Make suitable recommendations to clients based on your interpretation of the information you have found

Culmination Activity

Please note: the activities in this section must be completed on the Moodle site before you can progress to the next Module. These notes are provided for your convenience.

By now you've been exposed to a broad range of critical thinking skills and knowledge. You are able to structure an argument appropriately, and choose appropriate evidence from reliable sources to support your arguments. You are also aware of the biases that affect your own thinking, and the limitations of your expertise.

This set of skills and knowledge can set you up well for a future of lifelong learning, and career development. You can identify the things you excel at to take advantage of these skills, while identifying, and correcting, your weaknesses.

Now we have one last activity to check that you have can apply this skills in a more independent manner than we have asked you to do until now. We will provide you with some information on a product that makes some claims about fitness. Once you've looked at this information, you then need to answer a series of questions about the claims made by those selling the product, and then assess these claims. We will ask you to examine evidence both for and against these claims, then draw conclusions about the effectiveness of the product.

It always take longer to assess a claim than it does to make a claim, so don't rush. You will need to spend some time looking at different sources, not all of which will be helpful. If you have any serious issues completing the tasks in this module, please contact the course coordinator.



Module 8: Putting It All Together

The Product



The product in question is the **Power Balance** bracelet. These bracelets are only one product that are sold by Power Balance, but all these products are claimed to have the same effect, and the bracelets are the most well-known product.

In fact, you may have heard quite a bit about these if you were in the fitness industry when they first came onto the market. See below a link to the "about" section of their website.

<http://www.powerbalance.com/rotwview/faq>

To provide some more context about the controversy around these products, here is a newspaper article that was published when they first started to become popular.

<http://www.telegraph.co.uk/sport/8065032/Power-Balance-bracelets-source-of-energy-or-just-a-gimmick.html>

And to help you get started, here is how the company has recommended that you test to see how well Power Balance bracelets work.

<https://www.youtube.com/watch?v=6gIMxjr3n5U>

You may have seen this product before, and know something about its history. Whatever your personal opinions about these products, we ask you to remain impartial. This is one of the challenges of critical thinking: to be able to ignore your own opinions and feelings, and examine an idea on its merits.



Image from <http://www.powerbalance.com/rotwview/>





Module 8: Putting It All Together

Part 2: Assessing the Argument

1. What are the claims made by the company selling these products (Power Balance Technologies, Inc.)? Be as specific as you can, using quotes from the company where possible. Provide references to identify your sources (web links are fine). You can use current claims, or claims the company has made previously.

2. What evidence does the company use to back up these claims? Keep in mind there has been a lot written about these products, so stick to the claims made by the company, rather than others. What is their justification for using this evidence? You can refer to the links we have provided above, and look for more information.

3. Do you find this evidence convincing? Discuss the quality of the evidence provided by the company.

Part 3: Assess the Evidence

Usually a company selling a product has a vested interest in showing you evidence that it works, not evidence that it doesn't. They may not want to fairly examine both sides of an argument. But we do. You've seen a little bit of information from Power Balance demonstrating the effect of their product, as well as an article showing that some people have a different opinion. Now you need to do some research of your own.





Module 8: Putting It All Together

We aren't going to do anything to help you here - by now you have the skills to do this on your own. Using what you know about how and where to search for information, the types of information we can trust, and the types of expertise we can rely on, find out what you can about Power Balance products. You don't have to read or watch everything you find, but look for 3 trustworthy pieces of information. You will then need to answer a few questions about each source.

1. Provide a link to the evidence you have found

2. What is the author's conclusion on the effectiveness of Power Balance products?

3. What evidence are they basing their conclusion on?

4. Explain why you find this source trustworthy.

Part 4: Final Conclusions

Now that you've had a chance to examine a range of evidence, let us know what your final conclusions are.





Module 8: Putting It All Together

1. Does the balance of the available evidence support the use of Power Balance products?

2. If a client asked you about these products, what information would you provide them? What would your recommendation to your client be?

Summary

Well done, you're almost finished. There are just a couple of short activities for you to do before you are finished. Firstly, there's one last review. Then, you need to complete a survey on your knowledge of exercise, nutrition, and weight loss, and your confidence in your knowledge. This should take less than 20 minutes. You are asked not to use any notes, reference material, or online sources when completing the survey.



"Finish" (CC BY 2.0) by JefferyTurner





Module 8: Putting It All Together

Part 5: Review

Please note: the activities in this section must be completed on the Moodle site before you can progress to the survey. These notes are provided for your convenience.

As usual, please take a minute to think about what you've learnt this time, and how it may influence you as a fitness professional. The difference is that this time you have had to use a combination of the skills that you have been taught in this module. So this time you will need to answer these questions considering the whole course to date. Take your time, and go over old notes if you want to.

1. Identify the most important concept, theory, or idea that you learned while completing this course.

2. Why do you believe that this concept, theory, or idea is important?

3. How can you apply what you have learnt from this course to your professional practice?

4. What question(s) has the activity raised for you? What are you still wondering about?





Module 8: Putting It All Together

Part 3: Course Feedback

Now that you've finished the course content, please take a moment to provide some brief feedback to us, so we can make future editions of this course better. These are all quick, yes/no answers, though you can provide some more detailed feedback if you wish.

CONTENT:

- Was the course content appropriate for current fitness professionals? Yes No
Did the course cover the content you were expecting? Yes No
Did the content improve your understanding of the topic? Yes No

PRESENTATION:

- Did your presenter have good knowledge of the content? Yes No
Did you get enough opportunities to practice new skills? Yes No
Was the content clear, and easy to understand? Yes No
Were course resources (handouts, slides, videos, etc.) helpful? Yes No

ORGANISATION:

- Did you receive information about the course quickly enough? Yes No
Was the online environment easy to navigate? Yes No
Were modules opened quickly enough for you? Yes No

Well done, you've made it to the end of the course. You now need to complete a short survey on your knowledge of exercise, nutrition, and weight loss, and your confidence in your knowledge. Once this has been completed, and your responses to this module have been checked, your CEC certificate will be sent to you. This may take up to 2-3 days, depending on the number of participants we have at this time.

Click below to attempt the survey:

https://curtin.au1.qualtrics.com/jfe/form/SV_6RkPS2TkpuHniE5

Thank you for your time and energy completing this course. We hope you enjoyed it. If you have any more feedback about the course, or further questions, please don't hesitate to contact the course coordinator at daniel.j.jolley@postgrad.curtin.edu.au.



Appendix F: Copyright Clearance



YLM SportScience <ylmsportscience@gmail.com>
Sat 16/09/2017 1:03 PM
Dan Jolley



Hi Dan,
Thank you for your mail. Feel free to use it. No problem of course,
Enjoy your weekend
Yann

Envoyé de mon iPhone

Le 16 sept. 2017 à 06:06, Dan Jolley <daniel.j.jolley@postgrad.curtin.edu.au> a écrit :

Hi Yann,

I am doing a Ph.D. looking at the exercise science knowledge and misconceptions of exercise professionals like personal trainers. As part of this, I am writing a critical thinking course to use as an intervention. I would love to be able to use your infographic on the Dunning-Kruger effect, if you would give me permission.

Let me know if you would like more information.

Thanks for your help. I've enjoyed your infographics for years now, and look forward to using one in my work!

Regards,

Dan Jolley
MSc (Ex. Phys.), BSc (Human Movement)
PhD Candidate | School of Psychology and Speech Pathology

Curtin University
Tel | 0402 381 532
Email | daniel.j.jolley@postgrad.curtin.edu.au



Dan Jolley
Fri 11/08/2017 8:58 AM
Steve Ogden <og@steveogden.com> ↵



Thanks for that, my students will appreciate it!

I think the version I've got will be great, thanks for offering.

Cheers,
Dan.

From: Steve Ogden <og@steveogden.com>
Sent: Friday, 11 August 2017 4:43:32 AM
To: Dan Jolley
Subject: Magnificatz cartoon

Perfectly fine, Dan. Thank you for asking!

Is the version you found online good enough, or do you need a higher res version?

Also please make sure it's attributed to me - Copyright Steve Ogden, All rights reserved. www.Magnificatz.com

-Ogden

----- Original Message -----
Subject: New Contact Form Response
From: "Og's Blog" <og@steveogden.com>
Date: Wed, August 09, 2017 9:51 pm
To: og@steveogden.com

[Og's Blog](#)

A new message has been received.

name-field : Dan Jolley
email-field : daniel.j.jolley@postgrad.curtin.edu.au
message : Hi, I'm writing a course on critical thinking as part of my PhD, and would love to use a cartoon you published earlier this year about the burden of proof. I'm getting in touch to see if this is ok, with proper attribution, of course.

Please let me know if you would like any more information.

Regards,
Dan Jolley.