School of Public Health

Using New Technologies to Promote Weight Management

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

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

Human Ethics (For projects involving human participants/tissue, etc): The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Numbers HR90/2014.

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Date:

22 August 2017

ABSTRACT

Background

Almost two billion adults world-wide are currently either overweight or obese. The health consequences of obesity are responsible for 2.8 million preventable deaths per year, and include an increased risk of cardiovascular disease, type 2 diabetes, stroke, metabolic syndrome and some cancers. The World Health Organisation recommends population-wide health promotion strategies to address this issue, and also recognises the importance of social resources in health promotion. Evidence suggests that belonging to a like-minded group can assist individuals with weight management. The now ubiquitous nature of online social networking, combined with its capacity generate and manage groups, has provided health promoters with another vehicle for the delivery of weight management interventions capable of utilising social resources. The current project was designed to assess this strategy by delivering a weight management program via a closed group on the social networking site Facebook, to overweight and obese adults. Changes in weight and other metabolic syndrome risk factors were measured as indicators relating to the effect of the intervention. In addition, this study was also designed to identify possible underlying psychological and/or behavioral mechanisms that could explain any of the physiological changes that occurred.

Aim

The overall aim of this project was to measure weight loss and other outcome measures in overweight and obese individuals when a weight management program was delivered via an online social networking site, compared to the same program presented in written information only, over a period of twenty-four weeks.

Methods

This project was conducted as a three-armed, randomised controlled trial. Participants were recruited from the Perth community, and were randomly assigned to one of the following three groups: the Facebook Group, the Pamphlet Group, or the Control Group. The weight management program used was a condensed version of *The CSIRO Total*

Wellbeing Diet, as it was scientifically developed and tested and proven to achieve weight loss. The Facebook Group was presented the weight management program in a closed group in Facebook, with access to other group members. The Pamphlet Group received the same weight management program in a booklet, and the Control Group was given the Australian Dietary Guidelines and the National Physical Activity Guidelines for Adults, as standard care. All participants attended clinical appointments at Curtin University in the fasted state at baseline, and at weeks 6, 12, 18 and 24, for clinical measurements, which provided data for the between-group differences analysis. Prior to these appointments, participants were required to complete a range of questionnaires, which provided self-reported psychological and behavioural data for the mediation analysis. All statistical analysis was implemented through GLMM, and statistical significance was considered at $p<0.05$.

Results

Metabolic syndrome risk factors: By week 24, the Facebook Group reported a 4.8% reduction in initial weight (p=0.01), and a 4.5 cm reduction in waist (p=0.04), compared to the Control Group. The Facebook Group also registered a 2.6% reduction in fat mass (p=0.01), and a 1.1% increase in lean mass (p=0.03), by week 24, compared to the Control Group. In addition, there were numerically greater improvements in weight (-4.8% vs. -3.6%), waist circumference (-4.5 cm vs. -3.0 cm), fat mass (-2.6% vs. -1.4%), lean mass (+1.1% vs. 0.6%), energy intake (-1465.9 kJ vs. -1071.6 kJ), and step counts (+2153.5 steps/day vs. +933.1 steps/day) compared to the Pamphlet Group.

Psychological outcome measures: Compared to the Control Group, there were significant increases in self-rated quality of life, overall health and social relationships (p=0.002, 0.018 and 0.048 respectively) in the Facebook Group by week 24. However it is the significant changes to outcome measures at week 12 in the Facebook Group that were used for mediation analysis. As these changes were significant between the Facebook Group and Control Group only, the mediation analysis could only be conducted between these two groups. In this case, the Facebook Group recorded a significant increase in self-reported psychological health at week 12 (p=0.022). Mediation analysis with this outcome measure did not confirm this improvement in psychological health as a possible mediator to weight loss in the Facebook Group.

Behavioural outcome measures: While there were no significant changes to behavioural outcomes in the Facebook Group by week 24 compared, there were significant differences to protein intake, cognitive failures, insight and dietary intentions (p=0.006, 0.007, 0.020 and 0.034 respectively) compared to the Control Group at week 12. Therefore, mediation analysis between these two groups suggested that the increase in protein intake during the intervention may be a potential mediator to the weight loss recorded in the Facebook Group by week 24.

Conclusions

The use of online social networking for health promotion is an emerging field of research. Previous evidence had indicated that it may provide valuable resources and peer support for health promotion intervention programs. The significant changes in weight, waist circumference, lean and fat mass by week 24 in the Facebook Group supports this approach. The greater numerical changes in weight, waist circumference, energy intake, step counts, lean and fat mass in the Facebook Group compared to the Pamphlet Group also helps to demonstrate the potential of using this resource, particularly with respect to dietary *and* physical activity modifications, which to date, no other study had done. Results of the mediation analysis conducted with protein intake at week 12, used as a measureable marker of dietary compliance, suggested a potential relationship between change in this outcome measure and weight loss at week 24 in the Facebook Group. While not definitive, this result is important as both the Facebook and the Pamphlet Groups were following the same weight management program, which included a higher protein diet, and may indicate that the Facebook Group had an as yet unidentified advantage over the Pamphlet Group. These results suggest that online social group membership may assist overweight and obese individuals to make the recommended dietary behaviour changes for weight management.

It is expected that social media will provide an invaluable resource for health professionals, as a low cost, low maintenance medium for communicating with patients, in relatively large groups, across geographically diverse locations. Facebook is a free to use and easy to access site with tools to assist the formation and maintenance of social groups, and therefore could be readily translated into health promotion practice. The results of this study justify further research into the use of online social networking in clinical weight management programs. Future investigations should include more detailed assessments of psychological

and behavioural factors with larger, more highly statistically powered studies to identify significant mediators to improved weight loss outcomes within online social networking groups, to enable health professionals to maximise the benefits of this resource.

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The person who says it cannot be done should not interrupt the person doing it.
- Chinese Proverb

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LIST OF PUBLICATIONS

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Jane M, McKay J, Pal S. Effects of daily consumption of psyllium, oat bran and PolyGlycopleX® on obesity-related disease risk factors: A review. 2017. (Submitted to *Advances in Nutrition*)

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ABBREVIATIONS AND ACRONYMS

ANOVA: analysis of variance

ANZCTR: Australian New Zealand Clinical Trial Registry

BIA: bioelectrical impedance

BMI: body mass index

CG: Control Group

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DASS21: Depression Stress Anxiety Scale, 21 question version

FG: Facebook Group

GLMM: generalised linear mixed models

HDL: high density lipoprotein

HREC: Human Research Ethics Committee

ICT: internet communication technologies

LDL: low density lipoprotein

NHMRC: National Health and Medical Research Council

PG: Pamphlet Group

SCT: social cognitive theory

SEM: standard error of the mean

SES: socioeconomic status

TC: total cholesterol

TFEQ: Three Factor Eating Questionnaire

TAG: triacylglycerols

TPB: theory of planned behaviour

WHO: World Health Organisation

CHAPTER ONE

INTRODUCTION AND OVERVIEW

This thesis describes the results of a multidisciplinary project that used a clinical weight management trial to determine the efficacy of utilising social media to promote dietary and lifestyle modifications in overweight and obese adults. The disciplines represented within the project are health promotion, psychology and nutrition.

1.1 Health promotion

The overall objective of health promotion is to induce healthful behaviour changes in groups where health inequalities exist [1]. Health promoters have long relied on the use of the available media and/or technologies such as television, radio, magazine, newspaper, billboard, and leaflet [1-3] to deliver their messages [4, 5]. Health promotion messages can positively influence social networks [1] to change social norms, and this is critical to the success of public health interventions [1, 5, 6]. Influencing social norms is particularly pertinent to weight management, as obesity has been shown to spread extensively throughout social networks [7], possibly by creating new normative influences.

While using traditional broadcast media such as television for public health interventions can positively influence attitudes and knowledge, the overall effect on behaviour change varies [2], and any observed changes are likely to be small [3]. One reason for this may be that providing information only does not always result in meaningful behaviour changes [8], especially where nutrition and food behaviour are concerned [9]. For example, evaluation of the 'Measure-Up' promotion in Australia, linking chronic disease risk to waist measurement via television, found that awareness of abdominal obesity increased, but did not result in increased fruit and vegetable consumption and/or physical activity, despite being the purpose of the promotion [10, 11].

Public health interventions are rarely equipped to address barriers to behaviour changes. For example, individuals of low socioeconomic status (SES) are difficult to influence [12], which may be due to a lack of personal resources or coping skills, their neighbourhood may lack resources or health services [13], or they may have limited access to transport, a lack

of time [14], or poor health literacy [12, 13, 15]. In addition, low SES is widely understood to be a major determinant to poor health outcomes [12, 16]. These and other hindrances suggest more targeted approaches to health promotion are needed, especially in the area of weight management.

1.2 Weight management

The health consequences of overweight and obesity, as well as the increasing prevalence of these conditions, have been a matter of much research in recent years. Briefly, according to the World Health Organisation (WHO) nearly 70% of Australian adults are either overweight or obese [17]. In the United States it is just over 72%, in the United Kingdom it is almost 68%, whereas the figures are slightly lower in most mainland European nations [17].

The physical health consequences of overweight and obesity include an increased risk of diabetes, cardiovascular disease, obstructive sleep apnoea, and some cancers [18, 19]. In addition, excessive weight gain has been associated with an increased risk of metabolic syndrome (MS), which is defined as the presence of central obesity and any two of the following factors: raised triacylglycerols (TAG), reduced high density lipoprotein (HDL), raised blood pressure and raised fasting plasma glucose [20]. Furthermore, having MS significantly increases the risk of cardiovascular disease and type 2 diabetes [18, 19, 21, 22], and exacerbates the risk of cardiovascular disease-related mortality [22, 23].

The causes and consequences of overweight and obesity are not only limited to physical health, but can involve emotional wellbeing as well. The psychosocial consequences include stigmatisation in the workplace, compromised health care and personal relationships [24, 25], and reduced quality of life [19, 25]. Research in the 1990s identified an association between emotional eating and depression, anxiety, and stressful life circumstances [26]. Later studies have shown that mental health issues can be linked to obesity [27-31], possibly in a bilateral manner, such that depressed individuals have a greater chance of developing obesity and vice versa [32, 33].

Weight management is a complicated process, for individuals as well as populations. Explained simply, poor dietary choices and insufficient physical activity create an energy

imbalance which results in excessive weight gain [34]. However the challenge with weight management is that it usually requires a combination of strategies, and may require individuals to learn new behavioural skills [2, 9], especially as the food supply is top-heavy with overly-processed, energy-dense products, high in sugar, salt and/or saturated fats. Other weight management strategies used include increasing physical activity, decreasing energy intake, especially in form of processed foods, increasing fruit and vegetables intake, generally used in combination, and requires time, planning, cooking skills, and health literacy.

Such changes in lifestyle can benefit from the availability of assistance or support, however evidence has shown that most individuals that attempt weight loss do so on their own [35]. Merely following weight loss instructions does not always result in beneficial weight changes. One study provided participants with weight loss manuals without therapist contact and found that, while relatively inexpensive, this approach produced no statistically significant effect on weight loss, and also resulted in a decline in the motivation to lose weight during the treatment period [36]. On the other hand, therapist contact, in addition to the manuals, did result in significant weight loss [36].

To address the issue of support, many weight management studies have provided extra assistance to participants, such as dietetic counseling [37-40], and/or personalised feedback from a health professional [41-43], the provision of the recommended foodstuffs [44], sometimes in meal-sized servings [37], tailored or prescribed macronutrient plans [37, 38], cooking classes [43], and kitchen scales [38, 40, 41]. While these methods are used to determine effective weight management trials, they represent considerable effort, and/or expense which may not be feasible, especially in terms of cost or logistics, and may limit the generalisability of results to real world scenarios. This needs to be taken into account as ongoing weight loss maintenance can be similarly problematic [19].

1.3 Utilising social support

One method of overcoming the aforementioned challenges is to incorporate social or peer support for individuals attempting lifestyle changes [6]. A well-established positive association exists between social support and health outcomes [45], with physical [45-47] and mental [48, 49] health benefits arising from access to social support. One study across

139 countries found a strong association between social support, volunteering and self-rated health [50]. On the other hand, the absence of support can be problematic. Social isolation [13, 47, 51] and specifically loneliness, as a measure of the quality (as opposed to quantity) of social contact [52], can have a negative effect on health outcomes. Socially isolation has been shown to have as much of a detrimental effect on health as such as low income [51, 53, 54] or smoking [55]. One study found that lonely people have higher perceived stress than those who reported stronger connections within their social network [52]. In fact, the perception of support may be an important factor in determining the beneficial effects of social support [56, 57].

The presence of social support may mitigate the need for professional assistance for those engaging in health behaviour change initiatives. Support can be derived from family and friends, or groups created for the purpose [46]. However, obese individuals have reported that family or friends can also disrupt their progress with unhealthy foods and distractions, or that pressure from these people to lose weight can serve as a hindrance [58]. In addition, social networks have also been shown to influence individuals' food choices [9]. For instance, individuals with more overweight friends, or belonging to a network that accepts unhealthy eating habits, tend to have poorer weight loss outcomes [59], so it is not surprising that obesity has been seen to spread in social networks [7]. Therefore co-opting others in a similar situation may be a more helpful approach.

1.4 Group interventions

Group interventions satisfy one of the main health promotion objectives of the World Health Organisation, and that is to strengthen community actions [60]. The many benefits that groups can provide stem from the availability of more than one peer for support. Earlier research involving groups reported that group interactions can provide members with opportunities to observe behaviour, learn and practice new skills, receive feedback and offer help to others, which can improve self-confidence, problem solving skills, and self-esteem [61]. Group membership affords the experience of empathy and positive reinforcement [36], and can be mutually beneficial [46]. One population study found that belonging to groups had a preventive effect against depression, and that joining a group may help relieve existing depressive symptoms [62]. In addition, group interventions are a more targeted approach to health promotion, such that they can influence norms by

providing a reference group to stimulate positive attitudinal shifts and thus prompt behaviour changes [63].

Studies have shown that weight management interventions also benefit from the group approach. A clinical trial compared the effects of a group-based weight management program to individual dietetic counseling, against written information (control), in overweight and obese adults, and while both intervention groups experienced significant improvements in weight and self-efficacy compared to the control, the two intervention groups did not differ in either measure [64]. A retrospective study of bariatric patients found support group membership to be predictive of successful weight loss maintenance following surgery [65]. Furthermore, a systematic review and meta-analysis of group versus individual weight management interventions for obese adults reported a significant improvement in weight loss in group conditions at 12 months [66].

While belonging to a group may provide many benefits and be an asset a weight management program, due to the influence of peer support, creating new groups can be an onerous and sometimes unsuccessful process [4]. On the other hand, recent technological advances have created new channels of communication, which may assist group formation as well as facilitate group interactions.

1.5 The internet in health promotion

The development of internet communication technologies has created additional pathways for health promotion interventions, which have gradually been adopted. Online interventions benefit from being accessible by large numbers, any time, and can be another more targeted approach to health promotion. Initially some health promoters have added website resources to conventional promotions, for example the Find Thirty every day® promotion [67, 68]. This promotion consisted of television commercials, featuring 'ordinary people' engaged in everyday activities, along with a website, targeted to women and those of lower SES [68], and aimed at increasing physical activity in the Western Australian population [67]. Analysis of website activity showed site visits to increase after each new block of commercials aired, peaking at over 6000 hits, and subscriptions to the e-newsletter reached 1285 by the end of the two year promotion period [67]. A separate pre- and post-

test evaluation of participant data (n=2847), reported increases in campaign awareness, intention to exercise, and physical activity level, particularly in women and lower SES groups [68]. While the widespread influence of television is demonstrated by these numbers, the site hits and size of emailing list demonstrate the willingness of individuals to participate in online health promotions.

The WHO endorses measures to address the social determinants of health, and to enhance the social resources of the individual [60]. Both of these factors may be assisted by utilising online social networking communities. Health promoters have already begun putting social media to use in such interventions as smoking cessation [69-71], physical activity [72, 73], sexual health [74, 75], as well as weight management [76, 77]. Likewise, some individuals attempting weight loss have created online support for themselves by documenting their weight loss via blogs where 'followers' can add comment, thus generating virtual communities. Qualitative research investigating weight loss blogs found that bloggers derived a sense of social support from blogging, which also served to keep them accountable to their goals [78]. While neither weight loss nor follower data was analysed in the research [78], the existence of weight loss blogs suggests that there is a place for interactive online communities for individuals wishing to manage their weight. In addition, using online social networking tools may combine the advantages of internet accessibility with the benefits of group interventions and enhance health promotions. A further discussion of this topic is presented in Chapter Two: Review of the literature, as summarised in the Chapter overview section, along with outlines of the remaining chapters, commencing on page 7, below.

1.6 Study overview

This study is a 24-week, three-armed, randomised, controlled, parallel design investigation, conducted with overweight and obese adults from the Perth community. Participants were randomised to one of the three groups as follows: the Control Group (CG), who followed the Australian Government dietary guidelines and the National Physical Activity Guidelines for Adults (as standard care); the Pamphlet Group (PG), who followed a condensed version of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Total Wellbeing Diet, which is an energy-reduced, low fat, lower carbohydrate, higher protein diet, provided in written form; and the Facebook Group (FG), who followed the identical

weight management program as the PG, but posted within a closed and hidden Facebook group. In addition, both the PG and the FG were given a pedometer and instructed to reach 10,000 steps daily (according the Total Wellbeing Diet program recommendations). Participants attended clinical appointments at Curtin University in the fasted state at baseline, and at weeks 6, 12, 18 and 24. Data, including weight and other clinical outcomes, self-reported energy intake and expenditure, as well as self-reported psychological and behavioural measures, were collected at these appointments.

The purpose of this study is to determine whether a weight management program presented within an online social networking group can assist overweight and obese individuals to achieve greater improvements in weight loss and other outcome measures than the same program in written form alone; and to identify the psychological and/or behavioural effects resulting from online group membership that may enable such improvements.

1.7 Chapter overview

1.7.1 Chapter Two

The review of the literature (The review was submitted to the journal *BMC Public Health*, with the title of 'New technologies for health promotion and weight management: a review' for publication) provides more detailed examination of prior research into the use of social media in health promotion and weight management. This chapter provides a brief overview of social support in health, as well as the progress of internet communication technologies and social media into health promotion. The majority of the chapter focuses on how social media has been utilised in weight management interventions (at the time this project was developed), and then draws conclusions based on this evidence, and the highlights gaps in the existing research that form the rationale for the current project.

1.7.2 Chapter Three

This chapter describes the study protocol and provides a thorough description of the clinical trial protocol that forms the basis of this project. In short, this study was as a three-

armed, randomised, controlled, parallel design clinical weight management trial, conducted over a 24-week intervention period. There were two intervention groups and a control group, with five data collection points during the intervention, commencing with baseline measurements with final measurements collected at week 24. This is an extension to the trial protocol originally published in BMC Public Health (with the title of 'Using new technologies to promote weight management: a randomised controlled trial study protocol') [79]. The changes made as a part of the extension to the protocol are explained further in Chapter 3: The study protocol. Clinical measurements, along with self-reported dietary intake (using three-day food diary) and physical activity data (using three-day physical activity record), were collected to examine the effect of the intervention on weight and metabolic syndrome risk factors. (The analysis of these outcome measures are discussed in Chapter 4: The physiological outcome measures.) A range of self-reported quantitative psychometric measures were also collected during this trial, to determine both the psychological and behavioural impact of using social media as an adjunct to a diet and lifestyle program for weight loss. (The analysis of the psychometric data is discussed in Chapter 5: The psychological outcomes and Chapter 6: The behavioural outcomes.)

1.7.3 Chapter Four

The physiological outcome measures (manuscript paper published in *PLoS ONE* with the title of 'Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: a randomised controlled trial) presents the results of the analysis of the between group differences in all of the physiological outcomes data collected. These include metabolic syndrome risk factors such as weight, the primary outcome and analysed as a percentage of initial body weight, as well as the secondary outcome measures of waist and hip circumferences, fasting blood glucose, blood pressure, lean and fat mass, as well as fasting blood lipids and fasting insulin. Self-reported dietary intake and physical activity data were also examined, along with the step counts of the two intervention groups (eg. the Pamphlet and Facebook groups). The results discussed in this chapter provide some measure of the success of the intervention.

1.7.4 Chapter Five

The psychological outcomes (manuscript paper submitted on 3 August 2017 to *Health & Social Care in the Community* with the title of 'Psychological effects of belonging to a Facebook weight management group in overweight and obese adults: Results of a randomised controlled trial' for publication) provides an analysis of possible psychological mediators that may have influenced the physiological outcomes of the intervention. The data collected includes self-reported measures of quality of life, rating of overall health, as well as physical and psychological health, social relationships, depression, anxiety, stress, health anxiety, happiness and emotional eating were examined. In addition, participants in the FG were asked to provide their opinions of the Facebook group. These results may help to explain the potential benefits or pitfalls of having access to online peer support for overweight and obese participants while following dietary and lifestyle modifications for weight management.

1.7.5 Chapter Six

The behavioural outcomes (manuscript paper submitted on 16 August 2017 to *Health Education & Behavior* with the title of 'Behavioural effects of belonging to a Facebook weight management group in overweight and obese adults: Results of a randomised controlled trial' for publication) presents the analysis of potential behavioural mediators that may have helped produce the physiological outcomes of the intervention. The self-reported behavioural data includes self-control, self-efficacy, environment (quality), cognitive failures, competence, ingenuity, insight, initiative, cognitive restraint, uncontrolled eating, emotional eating, as well as intentions towards diet and physical activity. Furthermore, FG participants were asked to provide their perceptions of the activity within the Facebook group. These results may highlight the possible mechanisms involved in having access to online peer support for overweight and obese participants while undertaking dietary and lifestyle modifications for weight management.

1.7.6 Chapter Seven

Review and discussion provides a thorough consolidation of all of the significant results along with the examinations thereof. It recaps the issues highlighted in all of the analyses, the conclusions drawn as well as strengths and limitations of the study. Most importantly, this chapter also presents the final conclusions of the study, and points to future directions in research and professional practice.

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CHAPTER TWO

REVIEW OF THE LITERATURE[1]

Summary

In 2014 an estimated 1.9 billion adults world-wide were either overweight or obese. The health consequences of obesity are responsible for 2.8 million preventable deaths per year. The WHO now considers obesity as a global epidemic and recommends population-wide health promotion strategies to address this issue. Weight gain is caused by increased energy intake and physical inactivity, so treatment should focus on changes to behaviour regarding diet and physical activity. The WHO has also recognised the importance of social resources as a valuable agent for behaviour change in health promotion. Social resources are translated at the community level as support provided by significant others such as family, partners and peers, in the form of information, material aid and encouragement. Social support has been shown to improve health and well-being, whereas social isolation has been shown to have a negative impact on health outcomes. Social support provided by peers has been shown to be a useful strategy to employ in weight management programs. The documented increased use of Internet Communication Technology (ICT) and social media has presented health promoters with a potentially useful medium to increase social support for weight management. While the use of social media for health promotion is an emerging field of investigation, preliminary research suggests that it increases participant engagement, and may provide a cost-effective tool to provide social support for individuals participating in weight management programs. With stringent privacy protocols in place, social media may be a useful, cost-effective accompaniment to multifactorial weight management programs. However more research is needed to identify how to make the best use of social media as health promotion tool.

2.1 Background

According to the WHO world-wide obesity has doubled since 1980, and with 1.9 billion overweight and obese adults worldwide identified in 2014 [1], obesity is now a global epidemic [2]. Should the upward trajectory of obesity continue unabated it may come to be

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considered by individuals as a new social norm. As a measure of public health, overweight is defined as a body mass index (BMI; measured as kg/m²) of 25 or more, and the BMI for obesity it is 30 or more [3]. Overweight and obesity are strongly related to behavioural risk factors, such as low levels of physical activity and intakes of high energy diets. Obesity is associated with increased risk of cardio- and cerebro-vascular diseases, type 2 diabetes and some cancers [1, 3, 4]. The WHO estimates that globally 2.8 million people die every year as a consequence of obesity [5], a preventable condition [1], and as such recommend population-wide interventions as one of several strategies to address this problem [5].

Population-level interventions to prevent and manage obesity focus on changing the behaviours that are associated with increased risk of obesity, i.e. encourage healthy eating and sufficient physical activity. Such interventions rely on a number of strategies or techniques aimed at changing behaviour. Utilising social support has been identified as a key technique that may assist in promoting health behaviour change. According to Gottlieb and Bergen [6] social support can be described as: "the social resources that persons perceive to be available or that are actually provided to them by non-professionals in the context of both formal support groups and informal helping relationships". According to the Ottawa Charter for Health Promotion, in addition to access to health information and services, individuals also need the social resources to support healthful life practices [7]. Health promotion interventions can facilitate health behaviour change by promoting support for individuals and groups from salient agents within their environment [8], such as family members, peers and friends. With the nature of interpersonal interactions evolving in line with advancing digital technology, interactive online platforms such as social media may prove to be an effective method of engaging social resources for health promotion interventions. The aim of this literature review chapter is to examine the efficacy of health promotion interventions delivered via social media, particularly in the area of weight management.

2.2 Social support

Social support encompasses the provision of material resources, useful information, emotional care, and affirmative feedback, which promote health maintenance attitudes and behaviours [9]. Research has indicated that social support confers physical [10-12] and

mental [13, 14] health benefits. Even the perception of support – the belief that help is available if needed - has been shown to have beneficial effects [6, 15]. In addition, a study of self-rated health and happiness conducted in Italy revealed a strong positive association between health and happiness, with the author suggesting that one reason for this is that happy individuals may be more inclined to engage in health-promoting behaviours [16].

Interpersonal communications are highlighted in research into social support and health [13, 15, 17], and are sometimes considered as mediators of behaviour change, although rarely evaluated within health promotion interventions [18, 19]. Interpersonal interactions can facilitate the delivery of potentially useful information or provide encouragement. 'Shared experiences' and like-mindedness can be empowering and promote self-efficacy [17, 20]. According to social learning theories, role modelling of healthy behaviours in social contexts can exert a positive influence on individuals' behaviour [17, 20, 21] and improve health-promoting self-efficacy [20]. As far as weight management specifically is concerned, social influences and normative beliefs have been associated with weight status and intentions to lose weight among young adults that are overweight or obese [22]. Therefore, health promotion interventions that manage to influence social norms may have better and more sustainable outcomes [23].

In terms of weight management, research has shown that individuals who have social support are more likely to have better weight loss outcomes than those who do not [24]. Social groups have been shown to influence food behaviours in individuals [25] so engaging social support for dietary changes may have beneficial effects. The social support may include support from a family member, significant other, weight loss partner, or health professional. However many individuals attempting weight loss do not always receive the required social support for a variety of reasons [26], such as a lack of understanding within their social networks, or the conflicting dietary needs of their families. Weight management studies that employed group-based interventions in either treatment versus standard care [27], or group versus individual treatment [28], have reported clinically meaningful weight loss from participants in all group conditions irrespective of intervention, at least in the short term [29, 30]. This suggests that belonging to a group may be just as useful as the actual treatment program itself. An example of this is a study into social support within weight loss programs compared participants recruited with one or more friends (also wishing to lose weight) to a control group following the same program individually, and

reported greater weight loss and weight loss maintenance for up to ten months in the 'friends' group [31]. In this study those participating with friends also showed better program retention than the control group [31].

2.3 Internet communication technologies

Advances in ICT have created new avenues for the delivery of health promotion interventions, especially as global internet coverage continues to increase. Presently there are well over 3.2 billion internet users world-wide, and counting [32]. In the fifteen years to November 2015, every world region – Africa, Europe, Asia, the Americas, and Oceania (includes Australia) – experienced growth in internet usage [33]. The mobile and (internet-enabled) Smart phone market had reached 96.2% globally, as at the first quarter of 2013, with Africa recording the lowest penetration at 63% [34], however the emerging nations represent a growth area for both mobile and internet services [35]. The implication of the increasing internet and mobile technology sector, as far as health promotion is concerned, is that information can now be accessed at home or away 24-hours a day seven days a week, at the convenience of the individual.

As internet-provided information has the potential to reach large populations, and may also be able to access harder to reach groups [14], health promotion interventions have begun to incorporate this technology [36]. Although initially health promoters were reluctant to use ICT due to the fact that disadvantaged groups had limited access to it [37], the emerging view is that health promotion will benefit from support from online resources [38]. The interactivity and potential cost-effectiveness are additional benefits of the internet as a platform for health promotion. At the moment, internet access is a limiting factor for this approach as coverage is yet to reach 100%.

2.4 Social media

Increased accessibility to ICT and advances in software and hardware for social interaction has given rise to a variety of social networking sites. Initially, social networking sites were solely internet-mediated communication services that allowed individuals to create public profiles with a list others in their online community and to have online interactions with

those individuals [39]. Over time, the capabilities of these services have expanded, enabling users to send messages and share information with the online community. Most social networking sites are free to join, and some sites have gained widespread usage. The growth of Facebook membership is a good example of this. Between the first quarter of 2013 and the first quarter of 2015, steady growth in Facebook usage was recorded in Europe, Asia-Pacific, USA and Canada [40]. Overall, there are currently over 1.5 billion active Facebook users world-wide [41]. As with the internet, social networking sites can also take advantage of mobile technology, and could provide another avenue for health promotion interventions. The term social media will be used in this review as this term encompasses these additional capabilities of online social networking services.

While some health promotion interventions have incorporated an internet element [36], using social media, more specifically, may be better able to target population subgroups (including at risk or minority groups), because it offers direct access to existing online social networks [42]. A recent systematic review of health information presented on social media revealed that social networking sites were accessed by groups that are often hard to reach via traditional health promotion messages, such groups as those of low socioeconomic status (SES), young people and ethnic minorities [43]. Furthermore, research into the motivations for belonging to online support groups found 'information seeking' to be a primary motivation [44].

2.5 Social media and health promotion

Studies have identified social media as a source of social support [45]. For example, a recent study found that individuals who experienced social connectedness through Facebook had lower anxiety and depression, and greater subjective wellbeing [46]. Another study found that Facebook assisted individuals to gain support, which was significantly associated with offline social support and similarly associated with wellbeing [47]. It has also been suggested that online social networks may be able to influence social norms [42, 48], an important element of health promotion interventions [19].

A systematic review identified numerous studies reporting evidence that health promotion messages delivered via social media generated social support for patients and/or peers [43]. The desire to connect with others in similar circumstances was another strong

motivator for belonging to an online support group [44]. One study of 299 Facebook users found that socially anxious individuals were better able to derive social support online than offline [49]. In addition, helping others has been identified as another primary motivation for belonging to online support groups [44]. Helping each other has been found to be mutually beneficial, as the helper also benefits by feeling or becoming more useful or less dependent [20].

Interactive, online health promotion campaigns for specific health issues have been shown to provide social support for behaviour change. A study of health issue-specific social media sites for smoking cessation has shown that active participation – regularly sharing information and experiences, asking/answering questions - exerted a significant positive influence on smoking cessation self-efficacy, improved social capital, perception of similar or shared social norms and of feeling supported socially [50]. However as participation was by self-selection, the positive results may have been achieved by the more active or 'successful' participants within the group. The results of a pre-test, post-test examination that compared an online smoking cessation campaign to a conventional 'Smoker's Helpline' recently conducted in Canada showed that the online intervention had double the smoking cessation rates to that of the helpline; further, the availability of at least one support person was predictive of successful smoking cessation in both groups although this was not significant statistically [51].

Targeted, online health promotion campaigns have also demonstrated the capacity to reach large numbers of participants. The Canadian study mentioned above attracted 37,325 visitors to the site who paid a total of 44,172 visits within the three-month campaign period [51]. It seems that these results are not limited to social networking for smoking cessation. A study that used Facebook to deliver sexual health promotion messages attracted approximately 900 fans (or 'likes') and a total 5309 views of the 31 promotional videos posted during a five-month period [52]. A US intervention to address declining condom use in young adults that used Facebook for recruitment and to deliver health promotion messages to participants, found Facebook to be effective in promoting condom use in the short term (2 months), and suggest that it may be a useful avenue for recruitment (n=1578), however both effect and retention declined over the longer term [53].

In summary, it appears that individuals not only seek health information on the internet, but also have specific health-related motives for wanting to join interactive online support groups. As these studies show, social media is effective at providing a support to network members. They also indicate that health promotion campaigns delivered via social media have the potential to attract large numbers of participants and demonstrate a certain level of engagement with the message.

2.6 Social media and weight management

Prior to the emergence of ICT the self-help approach – following a diet or program without professional help or support - offered the lowest cost weight management strategy [20]. It has been speculated that web-based weight management programs may provide another cost-effective alternative to conventional therapies (e.g. in-person weight management treatments). One study examined the differences in cost per person between two group weight loss programs, one delivered in-person and the other via group internet 'chat' sessions, and while both groups demonstrated clinically meaningful weight loss, the in-person group showed significantly better weight loss than the internet group by the end of the six month intervention period [54]. On the other hand, economic analysis revealed that not only did the internet-delivered weight management program cost less per person it also cost less per kilogram lost [54].

As weight regain after weight loss is very common [4], the cost of continuing care needs to be taken into account after weight loss. A weight loss maintenance trial was conducted following successful weight loss, compared the cost-effectiveness of a 'personal contact' program to an internet-delivered program, and found the internet-delivered program to cost less per person; however only the in-person treatment produced statistically significant weight loss [55], and identifying possible reasons for this result were outside of the scope of the study. Social media may be an even less expensive avenue, particularly if an existing platform (e.g. Facebook) is used for program delivery. The increased interactivity of social media together with user-generated personal profiles may provide a friendlier environment which may enhance such intervention outcomes.

Including an interactive component to an intervention may be especially helpful for intractable public health conditions such as obesity, and may provide cost-effective and accessible weight management interventions [56]. A systematic review and meta-analysis investigated behavioural physical activity and dietary weight management interventions that utilised social networking features and noted that message board services provided as a part of internet-delivered interventions were the most commonly used [57]. The analysis failed to find statistically significant differences in primary outcomes (such as weight, BMI and physical activity levels), and in the few studies that reported improvements, the changes were not maintained [57]. However, these findings may be the result of the heterogeneity of the study protocols, different participant age ranges, or that some studies were not limited to participants with a high BMI [57].

A systematic review and meta-analysis of weight management trials that incorporated elements of online social networking found a small, but statistically significant reduction in BMI in the intervention groups at six months, which tapered off by 12 months, which is similar to findings in conventional weight loss interventions [56], where weight regain after initial weight loss is a common phenomenon [4]. Furthermore, the investigators found no significant differences in any of the other primary measures (such as blood lipid profiles, body fat composition, weight, waist circumference and blood pressure), and participant retention was also found to be problematic [56]. Again, the degree of heterogeneity between study protocols may have influenced these results. Of note, social support was not reported in neither this study nor the study conducted by Williams and colleagues [57], so it is difficult to determine if participants were encouraged to make use of social networking features in this way.

While systematic reviews provide a broad overview of the specific interventions types under investigation, the finer details of the studies reviewed often escape analysis. An assessment of individual studies that have used social media to assist with weight management shows that many interventions have used a combination of ICT as a part of the study protocol, including Twitter, Facebook, text messaging, podcasts, and mobile phone apps. In addition, these studies have sometimes included contact with a trained professional via such media, usually text messages. A weight loss trial using Twitter for social support with program content delivered via podcasts and mobile phone app, found that degree of usage was positively associated with weight loss although it was not clear

whether Twitter use assisted weight loss or participants losing weight 'shared' more, as not all participants engaged with Twitter, and usage declined over time [58]. Interestingly, participants' Twitter posts were examined for elements of social support with the results showing that informational support was predominant, emotional support increased over time, however there was no evidence of material support [58]. Similarly, a study of the Weight Watchers Facebook page to examined members' perceptions of social support reported that the majority of members derived both informational and emotional support through the site [59], however weight loss data was not collected in this study.

On the other hand, some social media weight management trials reported a statistically significant intervention effect i.e. weight loss, but did not report on the degree or type of social support received by participants. One such study used Facebook to provide weight management program content (including podcasts), together with text messaging to program strategy reminders, recorded weight loss in the intervention group [60]. Participants were also required to have a support 'buddy' from outside of the study group, and received personalised feedback, but even so social support was not reported [60]. Another similar trial used text messaging for two-way communication between a trained health coach and participants - to send weight management strategies and receive participants' progress reports – with Facebook for social support, reported weight loss in the intervention group [61]. Despite having a Facebook group and personalised feedback from the health coach social support was not measured in this study [61]. Contrary to the majority of weight management interventions, participant retention was high in both this and the previously-mentioned study, however both trials were of relatively short duration (8 and 14 weeks, respectively) [60, 61].

As the reviewed studies show, weight management interventions that utilise social media tend to measure either changes to weight and other risk factors or level of social support, but rarely the two together. By including a combination of ICT within the same intervention the exact cause/s of the resultant outcomes can be difficult to determine. In order to more fully understand how to make best use of social media as a vehicle for weight management interventions, emerging research has begun to examine changes to weight and other risk factors alongside outcome measures associated with social support, using one social media platform only e.g. Facebook [62].

Due to the complex nature of weight loss and regain [4], social support provided via social media may be a useful tool to include in multifactorial weight management interventions. Research cited in this review demonstrates that social media may be an acceptable supplement or even substitute for offline social support for individuals undergoing health behaviour changes (including weight management), and may be important especially if offline social support is inadequate. Similarly, information sharing can be gained by belonging to social media support groups, and this may provide a useful supplementary service for participants between visits to their health care practitioners, especially where distance can make accessing services difficult. Participant retention seems to be problematic, but this issue is not limited to weight management [20] or social media [63] interventions. Until the root cause/s of high participant attrition are identified, high drop-out rates (of 40 to 70%) [20] will continue to plague weight management interventions, regardless of how they are delivered.

The ability of users to generate and/or share content may create the potential to disseminate incorrect information [43, 56], which could apply to any intervention conducted without professional involvement [20]. Considering the ubiquity and accessibility of ICT, protecting the privacy, data and confidentiality of intervention group members is another concern that has been raised [45]. Some researchers have speculated that engaging with unknown individuals may be a relevant concern [42], while other researchers have suggested that the generation/use of health-specific sites may allay some of these concerns, as participants may feel they can trust those that they can relate to [50]. Others have suggested that participants' online privacy should be treated with same confidentiality as when patients receive professional health care treatments in conventional settings [43]. Some sites such as Facebook have addressed this issue with group privacy settings that can be set to 'secret', so all group content is only visible to group members [64]. Therefore, instead of generating and administering dedicated social networking sites and attempting to attract new members to it, a more practical and financially prudent approach may be to utilise existing social media platforms and user networks, with appropriate caveats and constraints, as the target group may already be within reach [65]. Educating health professionals, patients and the public about social media may help to address issues surrounding privacy concerns as well as those arising from disseminating incorrect information [43].

2.7 Conclusions

The world-wide prevalence of obesity bears testament to the intractability of the issue. That traditional health promotion interventions have failed to have an impact thus far is sufficient evidence for the urgent need for improved weight management interventions. Social support is accepted as important for the maintenance of good health, and appears to be of equal importance when individuals undergo health-related behaviour changes, including weight loss. The use of social media for health promotion interventions in general, and weight management in particular, is still very much in the formative stages. Evidence is beginning to emerge in support of using social media to augment health promotion interventions, by providing social support to those undergoing health behaviour changes. So far, it would seem that social media can provide participants with social support and/or assist with improving health outcomes (including weight loss), however, studies reported in the literature to date have typically examined either health outcomes, or social support, but rarely the two together. In addition, many trials have used a combination of ICT together, making it difficult to determine the cause/s of the resultant outcomes. More research is needed to determine whether incorporating social media into a weight management program will assist overweight and obese individuals to achieve greater improvements in weight loss and other outcome measures than attempting dietary and lifestyle modifications on their own. Research is also needed to elucidate the particular aspects of social media that assist overweight and obese individuals to achieve improvements in weight and other outcome measures, to maximise the potential benefits of this relatively inexpensive tool.

2.8 References

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CHAPTER THREE

THE STUDY PROTOCOL[2]

Summary

Background: Over the last three decades, overweight and obesity and the associated health consequences have become global public health priorities. Many methods that have been tested to rectify this problem have not had the desired impact, suggesting that other approaches need to be considered. One of the lessons learned throughout these attempts is that permanent weight loss requires sustained dietary and lifestyle changes, yet adherence to weight management programs has often been noted as one of the biggest challenges. This trial was designed to address this issue by examining whether social media, as a potential health promotion tool, will improve adherence to a weight management program. To test the effectiveness of this measure, the designated program was delivered via the popular social networking site Facebook, and compared to a standard delivery method that provides exactly the same content but which was communicated through a pamphlet, or a standard care control. The trial was conducted over a period of twenty four weeks. Although weight loss was expected, this study specifically investigated the effectiveness of social media as a program delivery method. The program utilised will be one that has already been proven to achieve weight loss, namely the CSIRO Total Wellbeing Diet.

Methods: This study is a 3-armed, randomised controlled trial. Participants were recruited from the Perth community, and randomly assigned to one of the following three groups: the Facebook Group, the Pamphlet Group, or Control Group. The Facebook Group received the weight management program delivered via a closed group in Facebook, the Pamphlet Group were given the same weight management program presented in a booklet, and the Control Group were given the Australian Dietary Guidelines and the National Physical Activity Guidelines for Adults, as standard care. Change in weight (primary outcome) and other metabolic syndrome risk factors (secondary outcomes) were measured indicators of

[2] An original protocol was published as 'Using new technologies to promote weight management: a randomised controlled trial study protocol', in *BMC Public Health* on 27 May 2015. Since publication the study was expanded and extended, therefore the chapter as it appears here is an edited version of the original publication, and presents an up-to-date version of the protocol to be used in this study. (See Appendix 6: Study protocol paper).

weight management program compliance. Other secondary outcome measures included dietary and physical activity data, as well as psychometric measures such as eating behaviours, psychological wellbeing, quality of life, self-control, self-efficacy, Facebook activity, and dietary and physical activity intentions, to determine possible mechanisms of change promoted by Facebook group membership.

Discussion: It was surmised that this trial will support the use of online social networking groups - a source of peer support and information sharing - as a delivery method for weight management programs, by enhancing the reduction in weight expected from dietary and physical activity changes. Facebook is a popular, easy to access and cost-effective online platform that can be used to assist the formation of social groups, and could be translated into health promotion practice relatively easily. It was anticipated in the context of the predicted findings that social media will provide an invaluable resource for health professionals and patients alike.

3.1 Background

World-wide rates of overweight and obesity continue to rise, despite the growing awareness of the importance of this issue in recent years among health professionals [1-4] as well as the general public [5]. Indeed, there is a widespread lack of acceptance of obesity in the general community, perhaps relating more to the physical appearance of people with obesity rather than the associated health risks [5, 6]. It is also well-established that being socioeconomically disadvantaged increases the risk of overweight and obesity [7]. The health consequences of excessive weight gain include an increased risk of the metabolic syndrome, and such chronic diseases as diabetes, cardiovascular disease, obstructive sleep apnoea and some cancers, all potentially leading to increased mortality [2, 4]. The psychosocial consequences of obesity include stigmatisation in the workplace, compromised health care and personal relationships [5, 8] and reduced quality of life [4, 8].

A review of the relevant literature has revealed that an energy-restricted, low fat, high protein diet assists with weight loss [9, 10] and the reduction of cardiometabolic risk factors [11]. It also increases satiety [12], which is an important factor in dietary compliance [13], and assists with weight loss maintenance [12]. Increasing physical activity has also been

shown to improve cardiometabolic risk factors in both short and long- term trials [14, 15]. According to the National Physical Activity Guidelines for Adults, thirty minutes of moderate physical activity (preferably taken every day) is required to promote health [16].

The Total Wellbeing Diet, developed by the CSIRO [17], is an energy-reduced, low fat, higher protein diet that meets the Australian nutrient reference values for daily intake [18], promotes a minimum thirty minutes of moderate physical activity per day, and has been extensively researched [9, 11, 19, 20]. In Book 2 of the Total Wellbeing Diet, the use of a pedometer is recommended to help individuals meet the suggested physical activity target [17]. Pal et al have shown that setting a goal of 10,000 steps per day results in greater improvements to physical activity levels than the 30-minutes-a-day target [21]. This weight management program, along with the support of a dietitian, has been shown to cause significant improvements in cardiovascular disease risk biomarkers in overweight and obese individuals and weight loss of up to 10 kg after twelve weeks [11, 20]. However, a mean weight loss of 5 kg has been reported by individuals following the Total Wellbeing Diet Book alone [22].

While weight loss can reduce the health risks associated with obesity [12, 23], many dieters have difficulty adhering to weight loss programs [24] or maintaining long-term weight loss [12, 23]. This can contribute to a sense of personal failure [6]. However, the lack of successful long-term weight loss in overweight and obese individuals may be due to the format of the weight management programs, such that dietary and lifestyle recommendations alone may not be enough [8]. In fact, the high attrition rate and/or weight regain after initial weight loss is so common that many researchers have tried to address this key issue by also adding other components to the treatment or intervention [22]. For example cognitive behavioural therapy, group support sessions, frequent medical or clinical appointments with health professionals and dietary supplements are additional strategies that have been included in some weight management programs or trials [4, 7, 25]. Research indicates that a multifactorial approach is likely to be optimal in achieving clinically meaningful weight loss results [22].

Another factor that is frequently overlooked in identifying adequate treatment for overweight and obesity is cost effectiveness [26]. If the socioeconomically disadvantaged are some of the worst affected in the obesity epidemic, then some of the more expensive

commercially available weight loss programs (such as Weight Watchers™) [7] or strategies will probably not be an option for them. However, the evidence suggests that some form of social support yields better weight loss results than 'going it alone' [6]. It has also been clearly established that individuals can expect better health outcomes if they are well supported in a social sense [27, 28]; however as noted in Chapter Two, many individuals attempting weight loss don't always receive the required social support [28].

Advances in ICT in recent years have added another vehicle for the delivery of health promotion material, including weight loss programs. According to a market research conducted by Yellow Pages™, 99% of Australian households have internet access, 69% of Australians use social media and 95% of these social media users have a Facebook account [29]. Almost 99% of the population is covered by a mobile cellular network and there are 102.8 mobile cellular subscriptions for every 100 Australians [30]. This offers health promoters the opportunity to deliver cost-effective weight management programs. Internet-mediated social networking [31] increases this potential, as studies have shown that social media can provide social support to members [32] by motivating and inspiring one another. Social media can also offer a medium for information sharing [33]. Being a part of an online social community undergoing lifestyle modifications may even assist individuals to be more accountable for their progress, and improve motivation further. Moreover, a review of the literature indicates that online health improvement programs often result in positive change [34-36]. A number of internet-based health intervention studies have utilised an interactive or social element, such as discussion boards or chat rooms, with many providing tailored feedback generated via mobile monitoring devices or health professionals [37, 38]. To date there have been few studies that have examined the effectiveness of using the social media platform (such as Facebook) in the area of weight management, and none promoting dietary and physical changes without providing feedback other than the support derived from other study participants [37, 38].

3.2 Aim of this study

The aim of this project was to measure weight loss, and changes in metabolic syndrome risk factor, self-reported psychological and behavioural outcome measures in overweight and obese individuals when a weight management program is delivered via social media, compared to the same program presented in written information and a standard care

control. The trial was undertaken over a period of twenty four week intervention period. This study was designed to: i) determine whether incorporating social media into a weight management program would assist overweight and obese individuals to achieve greater improvements in weight loss and other outcome measures than following the same dietary and lifestyle recommendations in written form alone; and, ii) elucidate the particular aspects of social media that assist overweight and obese individuals to achieve the greater improvements in weight loss and other outcome measures.

3.3 Intervention in brief

Eligible overweight and obese participants were enrolled in the 24-week intervention, and randomly divided into three groups: two intervention groups and a control group. The two intervention groups were instructed to follow the CSIRO Total Wellbeing Diet weight management program and supplied with pedometers with the instruction to attain 10,000 steps per day. The control group were given the Australian Dietary Guidelines as well as National Physical Activity Guidelines for Adults as standard care. One of the intervention groups received the program via a closed group the social networking website Facebook, with access to other the group members for peer support. The other intervention group received the intervention in written form (pamphlet) only. Participants attended clinic appointments for assessment of body weight and other clinical measurements at weeks 0, 6, 12, 18, and 24, and were also required to complete a series of questionnaires regarding dietary and physical activity as well as key psychological variables. The changes to physiological outcome measures were analysed for between group differences to determine the efficacy of the intervention, whereas the psychological outcome measures were analysed to identify possible mechanisms for these changes.

3.4 Hypotheses

In the present study, it was hypothesised that:

- Compared to the Control Group, the Pamphlet Group will experience moderate improvements in metabolic syndrome risk factors, including weight loss of 2% of initial body weight, over the 24 week intervention period.

- Compared to the Control Group, the Facebook Group will experience greater improvements in metabolic syndrome risk factor, including weight loss of 9% of initial body weight, over the 24 week intervention period.
- Participants in the Facebook Group will experience greater improvements in metabolic syndrome risk factors compared to the Pamphlet Group due to the support they receive from using Facebook.

3.5 Methods

3.5.1 Participants

Overweight and obese individuals with a BMI between 25 and 40 kg/m^2 and aged between 21 and 65 years were recruited from the Perth community via flyers posted at community noticeboards, advertisements in local newspapers and advertisements on local community radio stations. Respondents were screened via a telephone screening checklist by the student research coordinator. Eligible participants were required to have access to a computer, laptop, tablet or Smartphone. Exclusion criteria included smoking, lipid lowering medication, use of steroids and other agents that may influence lipid metabolism, use of warfarin, diabetes mellitus, hypo- or hyperthyroidism, cardiovascular events within the last 6 months, major systemic diseases, gastrointestinal problems, proteinuria, liver disease, renal failure, weight fluctuations over the past 6 months, vegetarianism or participation in any other clinical trials within the previous 6 months. All participants were required to provide written informed consent before the trial commences. All identifiable information from participants was coded. This study was conducted according to the ethical guidelines that are specified in the Curtin University Human Research Ethics Committee (HREC) and the National Health and Medical Research Council (NHMRC) guidelines. This trial was approved by the Curtin University HREC (approval number: HR90/2014; see Appendix 1: Ethics approval and amendments), and was registered with Australian New Zealand Clinical Trials Registry (ANZCTR; registration number: ACTRN12614000536662) on 21 May 2014.

3.5.2 Study Design

This study was originally designed to be conducted over a 12 week intervention period, with a follow-up 12 weeks thereafter, but was later extended to a 24 week intervention without a follow-up period. (The original 12-week intervention period was due to conclude during the Christmas/Holiday period, and it was felt that this may skew the weight measurements. In addition, the extended intervention period provided more time for FG participants to get to know one another better, thus allowing for evidence of social support to manifest and to be assessed.) Therefore this study was conducted as a three-armed, randomised, controlled, parallel design intervention study undertaken over a 24 week period. Interested participants were screened according to the inclusion/exclusion criteria and those eligible allocated a three-digit code number, block randomised (according to age and gender) by the student research coordinator to one of the three groups of 40 participants, using research randomisation software [39, 40]. The allocated number was used as the participants' identification number, for all records and questionnaires. The three groups consisted of: the Control Group (CG) who followed the Australian dietary guidelines [41] and National Physical Activity Guidelines for Adults [16], the Pamphlet Group (PG) who were instructed in the weight management program by written information, and the social media group who received exactly the same weight management program via Facebook in the Facebook Group (FG). (See Figure 3.1 Flow of participants, on page 40.) The weight management program presented to the two intervention groups was a condensed version of the CSIRO Total Wellbeing Diet [17], including information of the weight management program, instructions and recipes. Before the commencement of the trial, participants attended information session specific to their group allocation, where participation requirements, including questionnaires and outcome measurements, were explained. (For more details, see Appendix 2: Participant information sessions). During the Facebook Group information session, participants were provided with additional information about the using Facebook in this context. Facebook Group participants were also made aware of the role of the student research coordinator as administrator and facilitator of the Facebook Group. (For further information see Appendix 3: Weight management program in the Facebook Group).

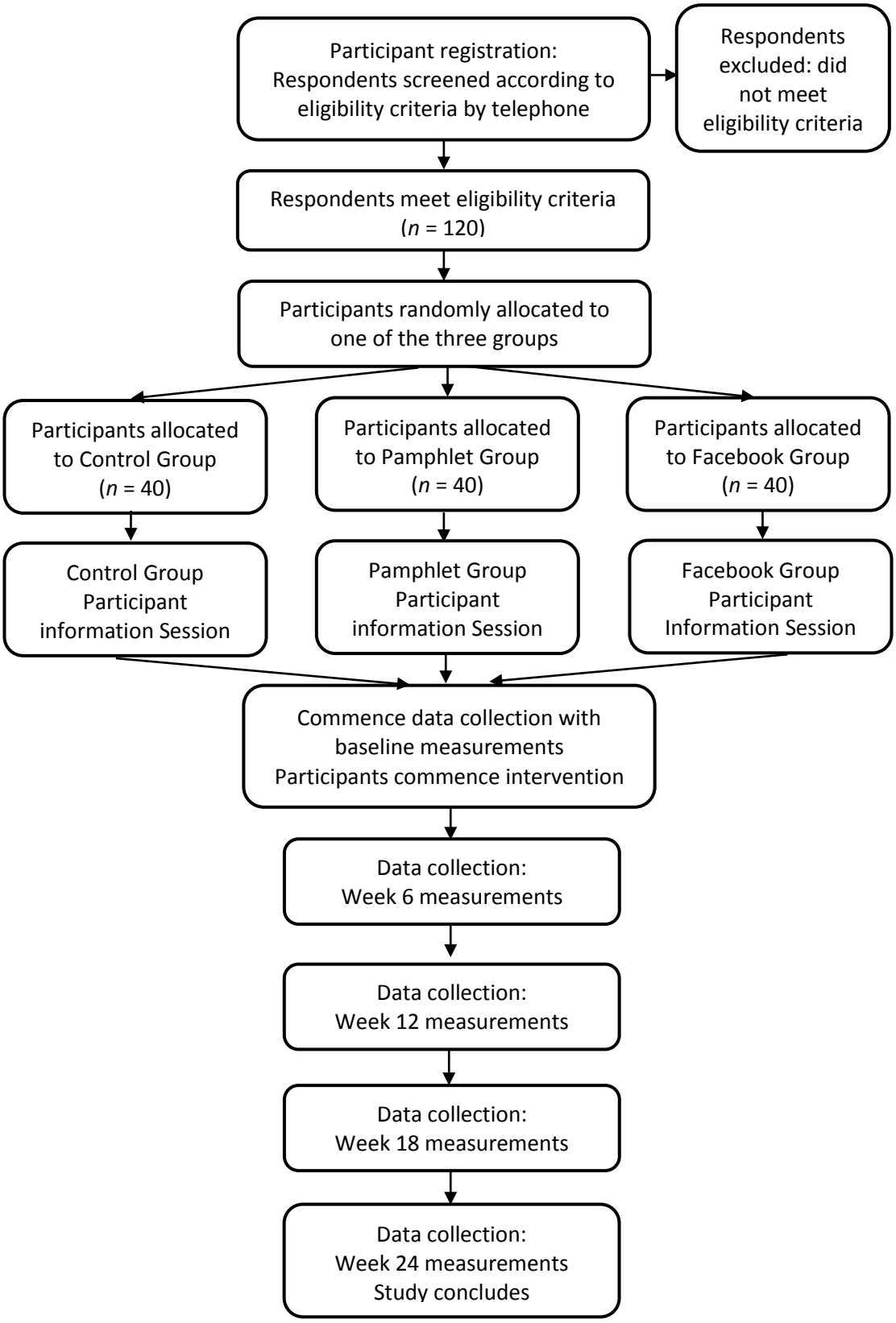

Figure 3.1 Flow of participants

3.5.3 Assessments

All participants were required to attend regular clinical appointments at Curtin University for approximately 15 minutes, as follows: at baseline, at weeks 6, 12, 18 and at week 24 (instead of the original schedule of baseline, weeks 6 and 12). Prior to each appointment, participants were required to complete a Three-Day Food Record and the Bouchard Three-Day Physical Activity Record [43] was used to measure of total physical activity. (The Bouchard 3-Day Physical Activity Record replaced the International Physical Activity Record from the original study protocol as it a more comprehensive data collection instrument, and used alongside the 3-Day Food Record, provides a snapshot of participants' physical activity and dietary intake taken from the same three day period). In addition, all participants will be required selection of questionnaires (previously tested for reliability and validity) prior to the appointments at week 0, 12 and 24, as follows: the Three-Factor Eating Questionnaire (TFEQ) [44] to provide a measure of participants' eating behaviour; the Self-Efficacy Scale [45] to assess changes to participants' self-efficacy; the WHO Quality of Life Questionnaire [46] was used to determine changes in the various quality of life domains; the short version of the Depression Anxiety Stress Scale (DASS21) [47] to measure changes in general psychological wellbeing; and the Self-Control (Brief) Scale [48] to assess participants' impulse control. Participants were required to complete the Diet and Physical Activity Survey, constructed following the Theory of Planned Behaviour (TPB) [49], and to determine participants' intentions with regard to the recommended dietary and physical activity modifications; a selection of psychometric test items (previously tested for reliability and validity), generated using the International Personality Item Tool [50], (added to the original study protocol to provide greater depth to the analysis), combined under the name of Personality and Individual Differences questionnaire for the purposes of this study, and assess to behavioural outcomes; and the Survey of Weight Management Program relating to the ease of use of the dietary and physical activity guidelines provided, with an extra section for FG participants, to indicate the preferred device for accessing the weight management information provided on Facebook.

For Facebook Group participants only, the Social Media Survey was used to assess participants' attitudes to social media; the Facebook Intensity and Network Density Scales contains a combination of questions adapted from previous social media studies [51, 52], and assessed the degree to which participants make use of Facebook, as well as the

strength and frequency of the social interactions within the online group. (The adaptations to the questions were minor changes making them specific to this intervention eg. the question “Facebook is part of my everyday activity” was modified to “The Facebook Group is part of my everyday activity”. Some of the questions were more tailored to the size and purpose of the group eg. “Members will go out of their way to help me” was changed to “At least one Group member has helped me with the weight management program”). In addition, the Facebook group page was printed at the end of each week to monitor participants’ online behaviour. Questionnaires, food and physical activity records were given in hard copy at each clinic appointment, according to group allocation. Aside from their functional attributes, these data collection instruments were chosen based on their brevity or ease of use where possible, to diminish participant burden.

At each clinical appointment, weight was recorded in light clothing without shoes. (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan). Body composition was measured by bioelectrical impedance analysis (BIA) in light clothing without shoes using the digital scales just mentioned. Height was measured without shoes to the nearest 0.1 cm using a wall-mounted stadiometer (26SM 200 cm SECA, Hamburg, Germany), measured once to calculate participants’ BMI. Waist circumference was measured in the standing position at the narrowest area between the lateral lower rib and the iliac crest; hip circumference was measured at the widest area across the buttocks. Briefly, fasting blood glucose was taken using the Accu-Chek® Performa glucometer and lancing device (Roche, Australia). Blood pressure was assessed with an automated, calibrated sphygmomanometer (Dinamap, Compact T, Critikon, Germany). All of these measurements were conducted by the student research coordinator. In addition, at weeks 0, 12 and 24 participants were required to attend a local pathology collection centre (PathWest Laboratory Medicine, Western Australia) for blood tests to measure lipids (triacylglycerols [TAG], total cholesterol [TC], low density lipoprotein [LDL] and high density lipoprotein [HDL]). (See Table 3.1: Schedule of Outcome Measures, on page 43; the Original Schedule of Outcome Measures is shown at Appendix 4 for comparison).

The student research coordinator scored all questionnaires, the food and physical activity records, as well as entered all of the raw data into Excel spreadsheets (MS Office, Microsoft Corporation, Redmond, WA), in preparation for statistical analysis.

Table 3.1 Schedule of outcome measures

Measurement	Week 0			Week 6			Week 12			Week 18			Week 24		
by Group	CG	PG	FG	CG	PG	FG	CG	PG	FG	CG	PG	FG	CG	PG	FG
Three-Day Food Record	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bouchard's Physical Activity Record	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Three Factor Eating Questionnaire	•	•	•				•	•	•				•	•	•
Self-Efficacy Scale	•	•	•				•	•	•				•	•	•
WHO Quality of Life	•	•	•				•	•	•				•	•	•
Depression Anxiety Stress Scale 21	•	•	•				•	•	•				•	•	•
Self-Control Scale	•	•	•				•	•	•				•	•	•
Social Media Survey			•						•						•
Facebook Intensity / Network Density Scales						•			•			•			•
Diet & Physical Activity Survey	•	•	•				•	•	•				•	•	•
Survey of Weight Management Program				•	•	•	•	•	•	•	•	•	•	•	•
Personality & Individual Differences	•	•	•				•	•	•				•	•	•
Height (for BMI)	•	•	•												
Weight	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
BMI	•	•	•				•	•	•				•	•	•
Blood pressure (SBP, DBP, HR)	•	•	•				•	•	•				•	•	•
Blood glucose	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Waist circumference	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Hip circumference	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Body Composition (% - Lean Mass, Fat Mass)	•	•	•				•	•	•				•	•	•
Blood lipids (TC, TAG, LDL, HDL, TC/HDL)	•	•	•				•	•	•				•	•	•
Blood insulin (for HOMA-IR Score)	•	•	•				•	•	•				•	•	•

3.5.4 Outcome Measures

The primary outcome measures for this study was weight loss. Secondary outcome measures include body composition, hip and waist circumference, blood glucose, insulin and lipids, blood pressure, as indicators of changes to metabolic syndrome risk factors. (Arterial stiffness was removed from the original data collection schedule, due to faulty equipment.) Dietary and physical activity compliance, eating behaviour (emotional eating, cognitive restraint, uncontrolled eating), quality of life (physical health, psychological health, social relationships and environment), mental well-being (stress, anxiety, and depression), self-control, weight management program intentions, and Facebook activity were also evaluated as further secondary outcome measures. Additional psychometric outcome measures (self-efficacy, ingenuity, cognitive failures [to indicate level of cognitive control], insight, health anxiety, initiative, competence, happiness) were incorporated with the study protocol extension. These clinical and self-reported measurements were chosen to test the participants' compliance to the weight management program, and to examine the differences between the two different weight loss program delivery methods.

3.6 Theoretical concepts

Provides a description of the theoretical concepts underlying some of the elements of the study protocol, and explains their relevance when used in the current context.

3.6.1 Stages of change theory

Stages of change theory [53] states that individuals can be categorised by their readiness to change their behaviour into one of five stages: 1. the *Precontemplation* stage refers to individuals that do not intend to make any changes in the next six months; 2. the *Contemplation* stage refers to individuals that do intend to makes changes in the next six months; 3. the *Preparation* stage refers to individuals planning to change in the next 30 days and have already made an attempt to do so; 4. the *Action* and 5. *Maintenance* stages refer to individuals that have achieved their desired behaviour change goal, with individuals in the *Action* stage having reached their goal within the last six months.

The stages of change theory can also be applied to individuals making the changes required by health promotion interventions. It is thought that individuals are more inclined to volunteer to participate in trials of this nature (eg. weight management interventions) when they are at the appropriate stage of readiness, that is the *Preparation* stage, and that from there they will proceed through to the *Action* stage while the trial underway. For long-term trials, and if the intervention has been effective, participants may progress to the *Maintenance* stage, whereby the new behaviour has been successfully adopted.

3.6.2 Social cognitive theory (SCT)

This theoretical framework underlies many health promotion interventions. Social cognitive theory [54, 55] is based on the notion that *perceived self-efficacy* is a determinant of behaviour change, and is therefore responsible for the motivation to set goals and learn new skills. This theory also posits that personal self-efficacy is involved in behavioural self-regulation, and the determination to overcome obstacles along the way. A strong sense of personal self-efficacy is not a given however, but according to SCT it can be developed by utilising four key processes: i) social persuasion, or the experience of positive appraisal and other conditions that foster success; ii) mastery experiences, or the experience of success after overcoming obstacles; iii) vicarious experiences, or the social influences demonstrating that sustained effort produces results and can teaches new skills and information; and iv) somatic and emotional states, or by enhancing positive moods or reducing stress so that personal self-efficacy can be correctly estimated. Health promoters using SCT build these concepts into their interventions to increase the likelihood of successful behaviour change.

Social cognitive theory forms the rationale for including a social or group element to a conventional weight management intervention trial. The purpose of adding an *online* social networking group was to determine whether similar psychological benefits to that which can be gained from in-person or offline social groups can also be achieved with virtual interpersonal interactions within a Facebook group. If so, it was speculated that such benefits may augment improvements to weight and other metabolic syndrome risk factors for overweight and obese individuals following a weight management program, and thus provide evidence in support of online social networking as a valuable resource for health professionals and patients alike.

3.6.3 Theory of planned behaviour (TPB)

The TPB [56] is concerns the use of intentions to predict behaviour change. This theory is based on the fundamental assumptions that subjective norms, attitudes, and perceptions of behavioural control, along with behavioural, normative and control beliefs, help to both form as well as explain behavioural intentions. However the TPB also acknowledges that the capacity for intentions to predict behaviour can be moderated somewhat by factors beyond the control of individual, such as actual control over the behaviour.

To ascertain whether subjective norms, attitudes, and perceptions of behavioural control, as well as behavioural, normative and control beliefs can influence behaviour change within online social networking group interventions, as they may do in offline settings, some of the questionnaires used in the present study were constructed using the TPB (eg the Diet and Physical Activity Survey). The data collected from these questionnaires during the trial were analysed to determine whether changes to relevant attitudes or opinions during the trial predicted weight change by the end of the trial, and therefore lend support to the use of online social networking for health promotion interventions.

3.6.4 Identifying mediators

As a statistical process, mediation analysis [57] refers to the concept that an independent variable may cause a mediating variable, which can cause a dependent variable, provided the following conditions are met. There must be a strong relationship between the independent and the mediating variables, and there must be a relationship between the mediating and the dependent variables, in relation to the independent variable. In addition, mediation presumes that the independent variable precedes the mediator as a causal agent, and that the mediator precedes the dependent variable as a causal agent. It is preferable that these causal relationships be implied on the basis of prior research or theoretical concepts, and that repeated measures of the mediating and dependent variables are collected during the intervention. Furthermore, mediation relies on the use of valid and reliable data collection instruments, adequate sample size, and the correct modelling of the distributions of all variables.

The basic concept of statistical mediator analysis was applied to the self-reported psychological and behavioural data collected during the present study, to identify possible 'social' mechanisms to any changes in weight resulting from incorporating an online support group to a weight management intervention.

3.7 Statistical analysis

3.7.1 Weight and metabolic syndrome risk factors

For a three group study with repeated measures and the ability to detect a weight loss difference of 7% of initial body weight (Cohen's d = 0.4) [58] between the FG and the PG, and an alpha of 0.05 (two-sided), a sample size of 96 achieves 80% statistical power. To allow for an attrition rate of 20%, a minimum of 120 participants were needed. Baseline weight (kg) data were assessed for normality, both by study sample and by group, and found to be slightly positively skewed. Therefore this study required a statistical method more robust than the one-way analysis of variance (ANOVA), as planned in the original study protocol [59]; therefore GLMM was used [60]. This method represents a particular class of regression model that is 'generalised' in that it can accommodate violations of normality, and 'mixed' as it includes both random (participant) and fixed (group) effects. A separate GLMM was tested to determine the between group differences in changes to outcome measures relative to baseline at each time point.

3.7.2 Psychological and behavioural outcome measures

The traditional repeated measures ANOVA model requires the following assumptions to be satisfied: Normality, homogeneity of variance, sphericity, and independence of observations. The GLMM 'robust statistics' option accommodates violations of normality and homogeneity of variance. Violations of sphericity are accommodated by changing the covariance matrix from the default of compound symmetry to autoregressive. When data are collected longitudinally, there is the possibility of participant attrition (wave non-response). Wave non-response will normally reduce statistical power. Compared to the traditional statistical procedures for analysing psychometric measures (eg. repeated measures ANOVA), the GLMM maximum likelihood procedure is a full information

estimation procedure that uses all the data present at each assessment point. This reduces sampling bias and the need to replace missing data.

The psychological and behavioural outcome measures was tested to determine whether the intervention groups report changes on the outcome measures relative to baseline measurements and compared to the CG. Each of the GLMMs included one nominal random effects (participant), two nominal fixed effect (group: Facebook, Pamphlet, Control), one ordinal fixed effect (time: 0, 12, 24), and the Group by Time interaction. GLMM is able to use the data present at each assessment point because time (eg. baseline and weeks 12 and 24) is interpreted as a Level 1 variable that is nested within participants at Level 2, which is itself nested within group at Level 3. To optimise the likelihood of convergence, a separate GLMM analysis will be run for each of the psychometric outcome measures. Although analysing each outcome independently of the others can inflate the family-wise error rate, it was decided to evaluate each GLMM at the conventional *p* value of 0.05 [61]. The Facebook Intensity and the Network Density data were not be analysed in the above manner as these were given to the FG only; instead, descriptive statistics were calculated and graphed to indicate within group trends.

3.7.3 Mediation analysis

Mediation effects could not be tested with structural equation modelling due to the relatively small sample size. As the GLMM maximum likelihood procedure was used to analyse the initial changes in psychometric outcome measures, this method was used to test for mediation effects. Therefore, a multi-step regression procedure, implemented through GLMM, was used as follows. Step 1 tested the significance of the between-group comparisons (eg. FG versus CG) and weight at 24 weeks after controlling for weight at baseline. The between-group comparisons of interest were analysed independently of one another in separate mediation models. If this relationship was not significant, then there was no relationship to mediate and the analysis was terminated; otherwise, the analysis will proceed to the next step. Step 2 tested the significance of the relationship between the binary group variable (eg. FG versus CG) and the mediator (eg. significant psychometric outcome measure/s) measured at 12 weeks after controlling for the mediator measured at baseline. Potential mediators were analysed independently of one another in separate mediation models. If this relationship was not significant, then the analysis was terminated;

otherwise, the analysis proceeded to the next step. Step 3 tested the significance of the relationship between the mediator (eg. significant psychometric outcome measure/s) measured at 12 weeks and weight at 24 weeks after controlling for the mediator measured at baseline and weight measured at baseline. If this relationship was not significant, then the analysis was terminated; otherwise, the analysis proceeded to the final step. Step 4 involved testing whether the significant Step 1 group effect was reduced to non-significance after controlling for the mediator. If (and only if) all four steps were passed was it concluded that the between-group difference in weight loss was a mediated effect. (The analysis of the psychological and behaviour outcome measures are discussed in Chapters 5 and 6, respectively.)

3.8 Discussion

The purpose of this study is to evaluate the use of social media as a health promotion tool, specifically to promote dietary and physical activity changes for overweight and obese individuals, without providing any form of tailored feedback. The research coordinator, in the role of Facebook Group facilitator, initiated discussion within the group by posting general, open-ended questions or comments to the Facebook Group's wall (eg. "Does anyone have any ideas or tips to make increasing physical activity easier that they'd like to share with the group?" or "What is the most useful thing you have learnt about weight management so far?"), but did not respond to participants' comments or questions. This type of facilitation was used to 'break the ice' and encourage group members to interact with each other, but not to act as further instruction, in order to minimise the introduction of confounders with the FG. In the best case scenario, it was anticipated that participants would view other group members as a source of peer support, as they all have weight loss as a common goal and quite possibly experienced similar issues with regards to being overweight. The benefits of this type of support (provided by a discreet, interactive online social group) include being able to freely share their views and information, ask and answer questions, and ask for and offer assistance. Providing support to others may be as beneficial to the individual as receiving support [62, 63]. Other possible social-related benefits may come in the form of encouragement (to persevere with the program), the formation of walking groups (to meet the physical activity requirements) and praise for the achievement of any weight loss milestones.

Another important advantage conferred by membership of a group of this nature may be the potential for clarification of the elements of the weight management program. For example, if a group member experienced any difficulty integrating the weight management guidelines into their daily life, they are able to obtain tips from other group members more experienced in food preparation and deciphering amounts (or units) of foods or ingredients, without the need to consult a health professional. This type of support (assistance and understanding, given and received) may augment the weight loss expected when following a proven weight management program. Interestingly, participants in the original trials of the CSIRO Total Wellbeing Diet received intensive dietetic support [11, 20, 64], so it is hoped that the peer support available within the Facebook Group may provide a different, but effective substitute. Further, it was speculated that if FG participants take full advantage of the support built into this intervention, then long term weight maintenance may also be more feasible for them.

3.9 Significance

If online social networking is found to be an effective aid to weight loss, then health promotion professionals, policy-makers and groups interested in changing behaviour may be encouraged to adopt this method as an additional health promotion tool. Using social media for health promotion could have many advantages, such as being able to reach large groups wherever the technological infrastructure is in place, which can then access the information and updates provided in their own time and place. It has the potential to provide health care and health promotion professionals the ability to manage a large and geographically disparate case-load, with a minimal investment of time, and may provide a future role for health professionals. These findings may also have clinical applications, allowing health care professionals to generate support networks for their patients undergoing diet and lifestyle modification, especially for the socially or geographically isolated, or those whose access to health care workers is limited or infrequent. Other advantages include the fact that online social networking sites like Facebook are free to join, so this tool would also be cost-effective and therefore potentially more readily adopted in real world settings than more expensive interventions that have been tested in other studies. Due to the interactive nature of the technology, feedback can also be collected from consenting participants. Moreover, there is the possibility of conducting focus groups with those who would be otherwise out-of-reach. It should not be inferred

however, that social media should be utilised to completely replace in-person consultations with health professionals; rather, its most appropriate use is likely to be in providing on-going support for patients between appointments with relevant health professionals.

So far, studies examining the efficacy of using the social media platform to promote dietary and physical activity changes for weight management have been few. Aside from adapting assessments used in traditional health promotion interventions, methods of evaluating the potential health benefits of social media are still under development. It was therefore anticipated that the results of this study will add significantly to the body of knowledge regarding health promotion methods for weight management programs.

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CHAPTER FOUR

THE PHYSIOLOGICAL OUTCOMES[3]

Summary

Background: The aim of this project was to evaluate the effectiveness of using social media to augment the delivery of, and provide support for, a weight management program delivered to overweight and obese individuals during a twenty four week intervention.

Methods: Participants randomly divided into either one of two intervention groups or a control group. The two intervention groups were instructed to follow identical weight-management program. One group received the program within a Facebook group, along with a support network with the group, and the other intervention group received the same program in a booklet. The control group was given standard care. Participants' weight and other metabolic syndrome risk factors were measured at baseline and at weeks 6, 12, 18 and 24.

Results: The Facebook Group reported a 4.8% reduction in initial weight, significant compared to the CG only (p=0.01), as well as numerically greater improvements in body mass index, waist circumference, fat mass, lean mass, and energy intake compared to the Pamphlet Group and the Control Group.

Conclusions: These results demonstrate the potential of social media to assist overweight and obese individuals with respect to dietary and physical activity modifications for weight management, and justify further research into the inclusion of social media in clinical weight management programs. It is anticipated that social media will provide an invaluable resource for health professionals, as a low maintenance vehicle for communicating with patients, as well as a source of social support and information sharing for individuals undergoing lifestyle modifications.

[3] This chapter was published as 'Effects of a Weight Management Program Delivered by Social Media on Weight and Metabolic Syndrome Risk Factors in Overweight and Obese Adults: A Randomised Controlled Trial', in *PLoS ONE* on 2 June 2017. (See Appendix 7: Physiological outcomes paper.)

4.1 Background

Since 1980 world-wide rates of obesity has doubled [1]. According to the World Health Organisation, obesity is now a global epidemic [2] and is responsible for an estimated 2.8 million deaths per year [3]. This is despite the recognition of the importance of this issue among health professionals [4-7] as well as increasing awareness of obesity within the wider community [8]. Previous public health weight management strategies have not had the desired impact and newer approaches need to be considered. Excessive weight gain is strongly related to socio-environmental changes that promote the consumption of high energy diets and reduced physical activity [1, 7]. This is particularly so for the socioeconomically disadvantaged [9]. Obesity increases the risk of cardiovascular disease, stroke, type 2 diabetes and some cancers [1, 5, 7]. On the other hand, supportive environments and communities can influence dietary and lifestyle choices by making healthy choices available, affordable and accessible [1]; these approaches could therefore be used to treat and prevent obesity.

Weight loss can reduce the cardio-metabolic risk factors associated with obesity [10, 11]. However, many dieters have difficulty with ongoing weight loss maintenance [12]. In an effort to overcome this problem researchers have found that implementing multifactorial weight management programs are more likely to achieve clinically meaningful weight loss results [7], as opposed to following weight loss instructions only. Supplementary strategies include frequent appointments with health professionals, cognitive behavioural therapy, use of supplements and group support sessions [7, 9, 13]. Similarly, individuals have better health outcomes if they are well supported socially [14, 15]; this includes better weight loss outcomes [16, 17]. However, many individuals do not have adequate support while attempting weight loss for a number of reasons [15].

The social aspect may be an important factor that contributes to the effectiveness of group weight management programs. Some studies have found that group weight management programs result in better weight loss outcomes when compared to individual treatment [18, 19]. Group programs are also a more cost-effective option to individual programs [18, 20].

Recent developments in internet and communication technologies may offer health promoters a novel platform for group weight management programs. Internet-based health intervention trials focusing on behaviour change have incorporated a social element using chat rooms or discussion boards, with many of these interventions providing feedback via health professionals or mobile monitoring devices [21, 22]. Internet-mediated social networking sites improve upon these features; already studies have shown that networked members can provide each other with support [23, 24]. This technology also offers new avenues for information sharing [25], so that information and member support are accessible at home or away 24-hours a day seven days a week, at the convenience of members.

Economic analysis shows that internet-delivered weight management programs costs less per person – and per kilogram lost - than an in-person program [26]. Social media may be an even less expensive avenue, particularly if an existing platform is used (e.g. Facebook). This approach has the added convenience of direct access to existing online social networks [27, 28]. In addition, the cost-effectiveness and large scale online connectivity of social media has the potential to assist individuals on low incomes or in geographically remote communities [29] to access support while following a weight management program. Furthermore the increased interactivity of social media (used in conjunction with personal profiles) may provide a friendlier setting that enhances online intervention outcomes.

Few studies have examined the value of using a social media platform like Facebook for weight management, and no studies have been undertaken to date that promote dietary and physical activity modifications with the only feedback being that which can be derived from other study participants, or targeting a particular condition (eg. diabetes), age group or gender [21, 22].

The aim of the current study was to measure changes to weight and other obesity-related disease risk factors in overweight and obese participants when a weight management program was delivered using social media, compared to the same program presented in written information only, over a period of twenty four weeks. It was hypothesised that compared to the Control Group and Pamphlet Group, the Facebook Group would experience greater improvements in weight and other metabolic syndrome risk factors over the 24 week intervention period. In particular, the changes to weight in the were

hypothesised to be 2% of initial body in the Pamphlet Group, and 9% of initial body weight in the Facebook Group, compared to the Control Group.

4.2 Methods

4.2.1 Participants

Overweight and obese individuals with a BMI between 25-40 kg/m^2 and aged between 21 and 65 years were recruited from the Perth community via advertisements in the West Australian Newspaper and Community Newspapers between 2 July and 11 November 2014. Participants were required to have access to a computer, laptop, tablet or Smartphone. Two hundred and eighty four respondents were screened by telephone interview, and 137 individuals were found to be eligible. Exclusion criteria included smoking, lipid lowering medication, use of steroids and other agents that may influence lipid metabolism, use of warfarin, diabetes mellitus, hypo- and hyperthyroidism, cardiovascular events within the last 6 months, major systemic diseases, gastrointestinal problems, proteinuria, liver disease, renal failure, weight fluctuations over the past 6 months, vegetarianism and participation in any other clinical trials within the last 6 months. These measures were in place to ensure harm minimisation and to prevent the introduction of potential confounders. This study was conducted according to the ethical guidelines provided by the NHMRC. The original study protocol was approved by the Curtin University HREC (approval no. HR90/2014) prior to trial commencement, as reported elsewhere [30]. In addition, the amendments to the original study protocol explained in this work also received approval from the Curtin University HREC prior to trial commencement. All identifiable information collected from participants was coded. All participants provided signed, written informed consent. This trial was registered with the ANZCTR (trial registration no.: ACTRN12614000536662).

4.2.2 Study Design

The original protocol consisted of a 12-week intervention period with a 12-week follow-up, as previously reported [30]. The current study was an adaptation of the original intervention and was conducted as a 24-week, three-armed, randomised, controlled,

parallel design (without follow-up) investigation [30]. Recruited participants were enrolled and assigned a three-digit number in chronological order by the student research coordinator. Participants were then randomised to one of the three groups by block randomisation according to age and gender, using online research randomising software [31] (i.e. random number generator). Participants were blinded; randomisation and group allocation was undertaken by the student research coordinator.

4.2.3 Interventions

Prior to trial commencement participants attended information sessions at Curtin University where full details of the study were explained, which included a brief overview of the treatment lasting approximately half an hour, according to group allocation. The Control Group (CG) were instructed to follow the Australian Government dietary guidelines [32] as well as the National Physical Activity Guidelines for Adults [33] as standard care. Both the Pamphlet Group (PG) and the Facebook Group (FG) were instructed to follow the Total Wellbeing Diet developed by the CSIRO, following rigorous scientific testing and proven to result in weight loss [34]. This program is an energy-reduced, low fat, lower carbohydrate, higher protein diet, as explained in greater detail elsewhere [30]. Both the PG and the FG received a condensed version of the diet, which included detailed information and instructions, compiled from excerpts from both the Total Wellbeing Diet Book 2 [35] and Total Wellbeing Diet Recipes on a Budget [36] (with permission from Penguin Publishing). The PG received the information in written form as a booklet, while the FG received identical information contained within the booklet but with pages as snapshots posted within the 'secret' (i.e. closed and hidden from the general Facebook population) Facebook group. In addition to information from the Total Wellbeing Diet, participants in both intervention groups were also issued with a pedometer (G Sensor 2025 Accelerometer, Walk with Attitude Australia) and instructed to achieve a target of 10,000 steps per day (as recommended in the Total Wellbeing Diet program). The FG were given additional information on how to use the Facebook group to access the weight management program, encouraged to interact with one another, and had the rules of polite interaction with other group members were explained to them. Following the completion of the information sessions, FG participants were invited to join the Facebook group by the student research coordinator, who acted as the administrator of the group. Participants in all groups were given the necessary materials at the conclusion of their

baseline clinic appointments and instructed to commence the intervention forthwith. None of the participants were given any further external weight management guidance during the trial by the student research coordinator. The only access the FG had to the program was the information posted on Facebook. In addition, the student research coordinator posted to the Facebook group once per week to the Facebook group over the 24 week intervention.

4.2.4 Assessments

The primary outcome for this trial was weight. The secondary outcome measures were blood pressure waist and hip circumference, fasting blood glucose, lipids and insulin, dietary intake, physical activity and step count (the latter for the PG and the FG only). Participants attended clinical appointments at Curtin University in the fasted state at baseline, and at weeks 6, 12, 18 and 24, (with no follow-up appointment. This appointment schedule is an update of the original study protocol consisting of appointments at baseline, weeks 6 and 12, with a follow-up appointment 12 weeks after the end of the initial 12 week intervention [30]. At these appointments, weight was measured in light clothing without shoes (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan). Differences in weight at each time point were calculated per individual as a percentage of total baseline body weight. Height (baseline only) was measured using a stadiometer (26SM 200 cm SECA, Hamburg, Germany) without shoes. Waist circumference was measured in the standing position at the narrowest area between the lateral lower rib and the iliac crest, and hip circumference was measured at the widest area across the buttocks. Fasting blood glucose measurements were taken using the Accu-Chek® Performa glucometer and lancing device (Roche Diagnostics). (Arterial stiffness was removed from the list of outcome measures reported in the original study protocol [30].

At baseline, weeks 12 and 24 blood pressure was measured with an automated, calibrated sphygmomanometer (Dinamap, Compact T, Critikon, Germany). Lean mass and fat mass was measured in light clothing and without shoes by bioelectrical impedance (using the digital scales already cited), and recorded as a percentage of total body weight per individual. In addition, participants attended their local PathWest Collection Centre to have fasting blood samples taken to measure blood lipids (ie. total cholesterol, triacylglycerols, low density lipoproteins and high density lipoproteins) and blood insulin at baseline, and at

weeks 12 and 24. Blood sample analysis was conducted at PathWest Laboratory Medicine, QEII Medical Centre, Nedlands, Western Australia.

Participants were required to return their completed Three-Day Food Records as well as Three-Day Physical Activity Records [37] with three-day step count (PG and FG participants only) at each time point. Energy and macronutrient intakes from the participants' food records were calculated using Food Works Version 7 (Xyris Software, 2012). Macronutrient intakes were recorded as a percentage of total energy intakes per individual, with the exception of fibre (which was calculated in total grams). Energy expenditure from participants' physical activity records was calculated using the equation devised by Bouchard for the purpose [37].

4.2.5 Statistical analysis

For a three group study with repeated measures and the ability to detect a weight loss difference of 7% of initial body weight (Cohen's d = 0.4) [38] between the FG and the PG, and an alpha of 0.05 (two-sided), a sample size of 96 achieves 80% statistical power. To allow for an attrition rate of 20%, it was planned to recruit a minimum of 120 participants. Baseline weight (kg) data were assessed for normality, both by study sample and by group, and were found to be slightly positively skewed. Therefore a statistical method more robust than the one-way ANOVA, as planned in the original protocol [30]; therefore GLMM were used [39]. A separate GLMM was tested to determine the between group differences in changes to outcome measures relative to baseline at each time point. This method represents a particular class of regression model that is 'generalised' in that it can accommodate violations of normality, and 'mixed' as it includes both random and fixed effects. The covariate structure used in the linear mixed models was variance components. All analysis was implemented through SPSS 22.0 (IBM® SPSS® Statistics, New York, NY). Post hoc power analysis was conducted using G*Power [40]. All data were expressed as mean (±SEM), and statistical tests are evaluated at a *p* value of 0.05.

4.3 Results

4.3.1 Participants

During the recruitment period, 284 respondents were screened and 137 met the eligibility criteria (slightly in excess of the required number indicated in the original study protocol [30]; these individuals were invited participate and gave verbal consent to do so. Recruited participants were randomly allocated to one of the three groups as follows CG: n=45; PG: n=46; FG: n=46. One hundred and one participants attended the baseline appointment (CG: n=34; PG: n=34; FG: n=33) at which time they provided written informed consent; among these individuals, 68 participants provided data post-baseline (CG: n=22; PG: n=23; FG: n=23). Fifty six participants completed the full intervention; however, one participant from the CG was eliminated from the final analysis due to non-compliance (CG: n=17; PG: n=18; FG: n=19). Data from the 67 participants that provided measurements and data after the baseline appointment was used for the statistical analysis. (See Figure 4.1 Flow of clinical trial participants, on page 65.) Baseline characteristics of all participants that contributed data the analysis are shown. (See Table 4.1 Baseline Characteristics of all participants Included in the analysis, on page 66.)

4.3.2 Metabolic Syndrome Risk Factors

The primary outcome measure and a selection of other disease risk factors were collected at four time points following baseline (weeks 6, 12, 18 and 24). The secondary outcome measures were collected at two time points following baseline, at weeks 12 and 24. The paragraphs below summarise the between group differences in changes to baseline measures at each designated time point (see Figure 4.2: Significant between-group differences in outcome measures, (A) weight; (B) BMI; (C) waist; (D) fat mass; (E) lean mass, on pages 68-70).

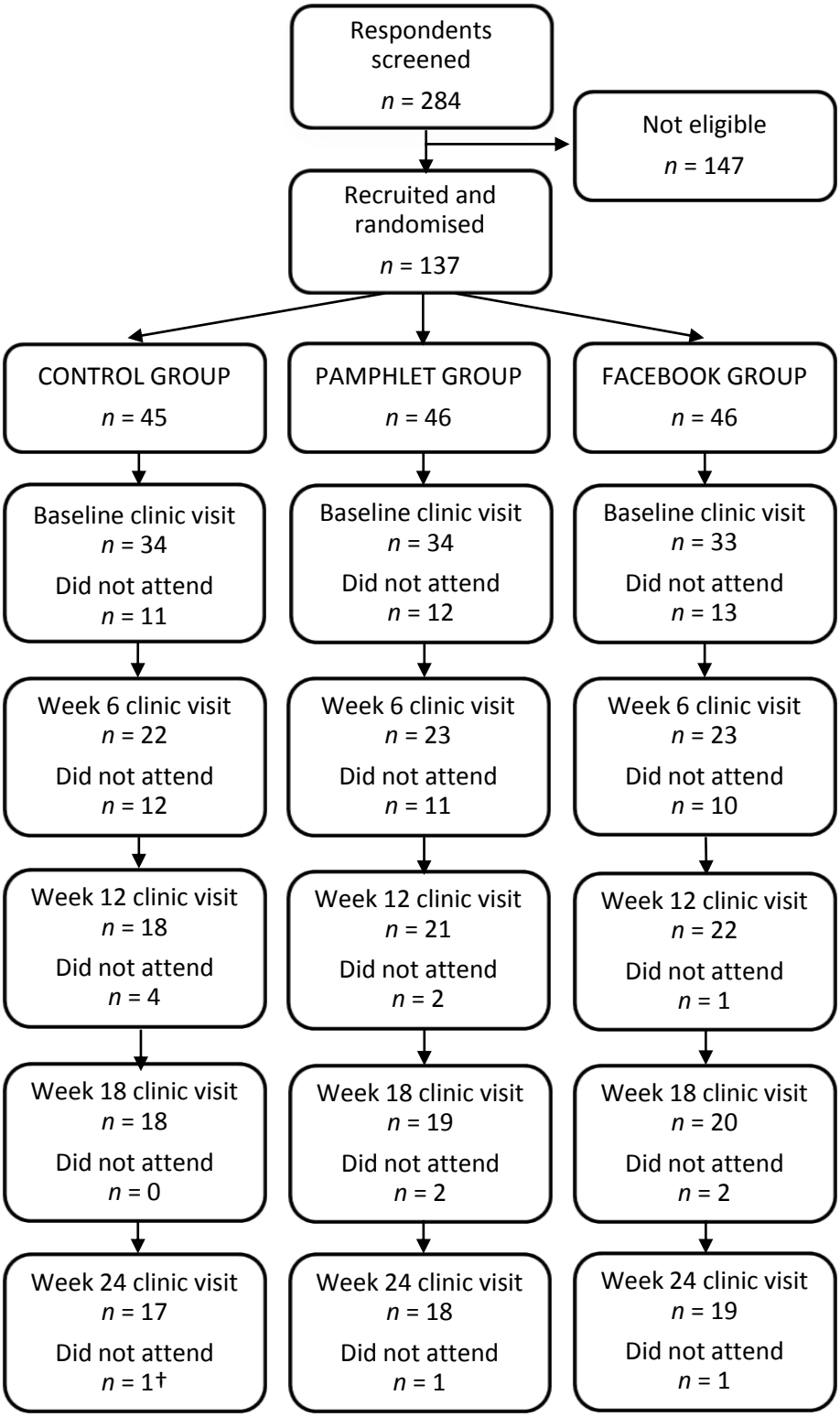


Figure 4.2 Flow of clinical trial participants

Reasons for non-attendance (*n*=82): Did not respond (*n*=44); Time constraints (*n*=26); Did not like assigned program (*n*=5); Unrelated illness (*n*=4); Change in personal circumstances (*n*=3). No adverse events were recorded. †Data eliminated from the final analysis due to non-compliance.

Table 4.1: Baseline characteristics of all participants included in the analysis

	Control (*n*=21)*		Pamphlet (*n*=23)*		Facebook (*n*=23)*	
	Mean	SEM	Mean	SEM	Mean	SEM
Gender (m/f)	4 / 17		2 / 21		4 / 19	
Age (y)	50.2	2.4	54.1	2.3	47.0	2.3
Height (cm)	165.1	1.5	162.2	1.8	165.3	1.9
Weight (kg)	91.5	4.5	86.7	4.2	89.0	3.2
BMI (kg/m^2)	33.3	1.3	32.9	1.3	32.5	1.0
Waist (cm)	98.0	2.8	96.1	2.5	96.3	2.4
Hip (cm)	115.2	2.9	113.8	2.8	113.0	2.1
FBG (mmol/L)	5.8	0.2	6.2	0.3	5.5	0.1
SBP (mmHg)	124.3	3.8	126.5	3.5	128.4	4.0
DBP (mmHg)	69.3	2.2	69.0	1.4	68.6	1.8
Insulin (mU/L)	8.1	0.8	8.8	1.0	9.6	1.2 [20]
Fat Mass (%)°	45.5	1.5	45.1	1.5	44.0	1.6
Lean Mass (%)°	23.6	0.7	23.7	0.7	24.6	0.8
TC (mmol/L)	5.7	0.2	5.8	0.2	5.8	0.2 [20]
TAG (mmol/L)	1.2	0.1	1.1	0.1	1.3	0.1 [20]
LDL (mmol/L)	3.7	0.2	3.7	0.2	3.8	0.2 [20]
HDL (mmol/L)	1.5	0.1	1.5	0.1	1.4	0.1 [20]
EI (kJ/day)	8061.1	435.2 [20]	8266.7	440.1 [21]	8023.6	398.8 [19]
Carbohydrate (%)†	38.7	1.5 [20]	37.8	1.8 [21]	41.1	1.3 [19]
Fat (%)†	35.4	1.3 [20]	35.6	1.3 [21]	35.2	0.1 [19]
Protein (%)†	19.8	0.8 [20]	21.3	1.2 [21]	19.3	1.0 [19]
Alcohol (%)†	3.0	1.2 [20]	2.4	0.7 [21]	1.4	0.4 [19]
Fibre (g)	18.1	1.2 [20]	14.6	1.0 [21]	17.9	1.3 [19]
EE (kJ/day)	17089.1	967.1 [17]	16659.7	1052.7 [20]	15911.1	665.9 [19]
Steps/day	-	-	8735.1	480.8 [19]	7567.8	793.2 [19]

*unless indicated by [n]; °refers to percentage of total body weight; †refers to percentage of total energy intake; BMI: body mass index; FBG: fasting blood glucose; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; TAG: triglycerides; LDL: low density lipoprotein; HDL: high density lipoprotein; EI: energy intake; EE: energy expenditure

The primary outcome measure for this study was change in weight. Both the PG and the FG had significantly greater weight loss than the CG at week 6 (-2.7%, *p*=0.01 and -2.5%, *p*=0.02 respectively), at week 18 (-4.5%, *p*=0.02 and -4.9%, *p*=0.02 respectively) and at week 24 (-3.6%, *p*=0.05 and -4.8%, *p*=0.01 respectively) (Figure 4.2A). While the FG experienced greater weight loss at weeks 12, 18 and 24 compared to the PG group, these differences

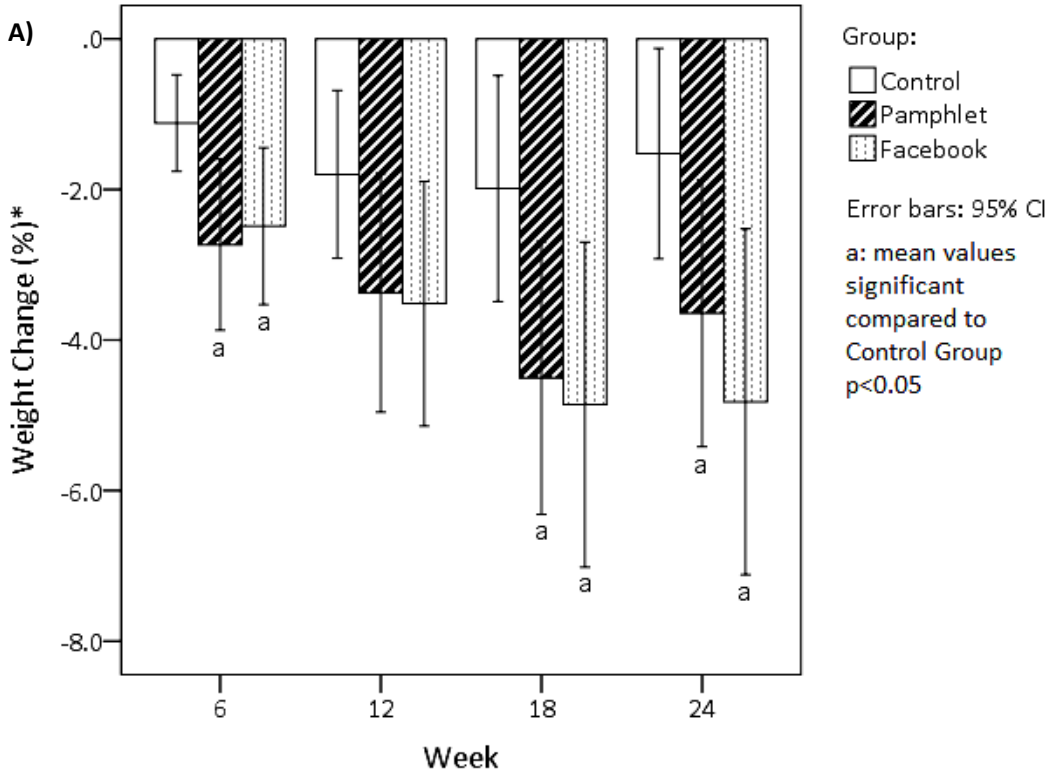
were not statistically significant at any time. Compared to the CG, the PG showed a significant reduction in BMI at week 6 (-1.0 kg/m^2, *p*=0.03), both the PG and the FG showed significant reductions at week 18 (-1.6 kg/m^2, *p*=0.04 and -1.5 kg/m^2, *p*=0.04 respectively), but only the FG maintained this change at week 24 (-1.5 kg/m2, p=0.02) (Figure 4.2B).

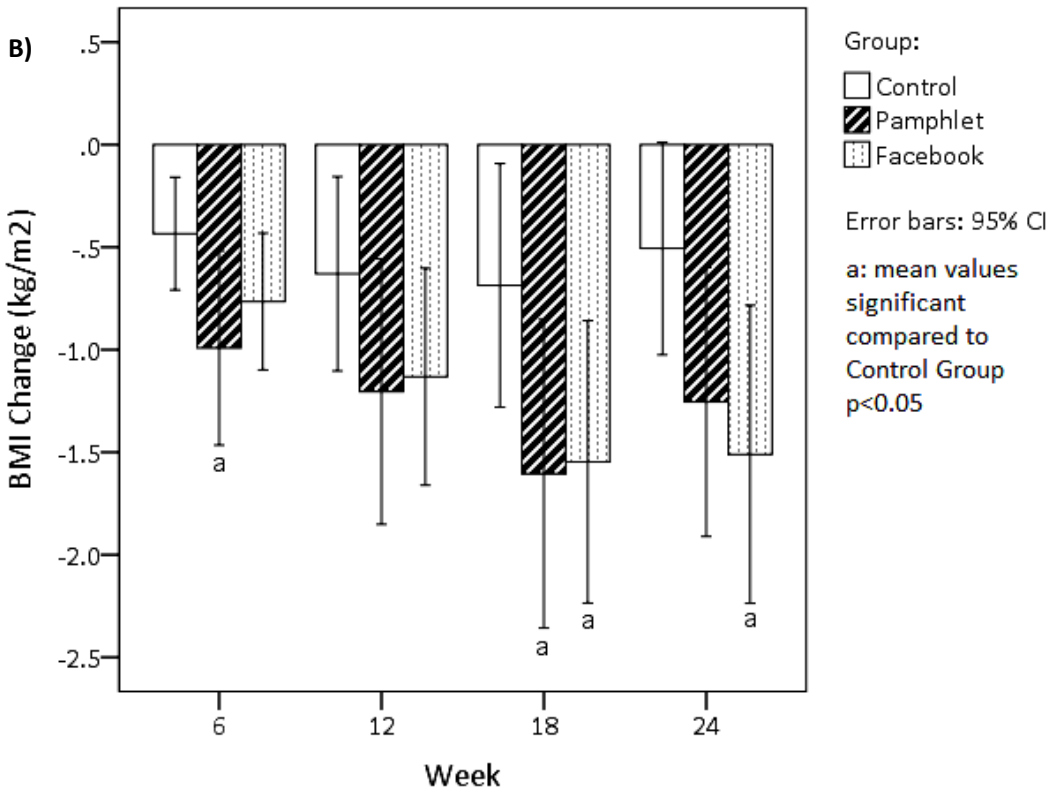
The PG and the FG experienced statistically significant reductions in waist circumference compared to the CG at week 18 (-4.8 cm, *p*=0.01 and -4.6 cm, *p*=0.01 respectively), but only the FG sustained this significant change at week 24 (-4.5 cm, *p*=0.04) (Figure 4.2C). There were no significant differences between group reductions in hip measurements across the intervention.

The PG group had significant reductions in fasting blood glucose compared to the CG and the FG. At week 6 a difference of -0.1 mmol/L was statistically significant against the CG (+0.4 mmol/L, *p*=0.02) and against the FG (+0.4 mmol/L, *p*=0.007), at week 12 a difference of -0.2 mmol/L was significant against the CG (+0.3 mmol/L, *p*=0.04) and the FG (+0.4 mmol/L, *p*=0.001). At week 18 a difference of -0.1 mmol/L was significant against the CG only (+0.6 mmol/L, *p*=0.04), and at week 24 a difference of -0.4 mmol/L was significant against the CG (+0.4 mmol/L, *p*=0.04) and the FG (+0.4 mmol/L, *p*=0.03).

The FG showed numerically greater reductions in fat mass than both the CG and the PG, and was statistically significant reduction compared to CG, at both weeks 12 and 24 (-2.6%, *p*=0.01) (Figure 4.2D). Similarly, the FG showed numerically greater increases in lean mass than both the CG and the PG at both times, but this was statistically significant against the CG only, at week 12 (+1.2%, *p*=0.03) and at week 24 (+1.1%, *p*=0.03) (Fig 4.2E).

There were no significant between group differences in blood pressure measurement during the intervention, with the exception of a reduction in systolic blood pressure in the PG compared to the CG at week 6 (-10.3 mmHg, *p*=0.05) which was not maintained at week 24. (See Table 4.2 Between group differences in outcome measures, on page 71.)


A)
Weight Change (%)*
.0
-2.0
-4.0
-6.0
-8.0
a
a
a
a
a
a
6
12
18
24
Week
Group:
Control
Pamphlet
Facebook
Error bars: 95% CI
a: mean values significant compared to Control Group p<0.05


B)
BMI Change (kg/m2)
.5
.0
-.5
-1.0
-1.5
-2.0
-2.5
a
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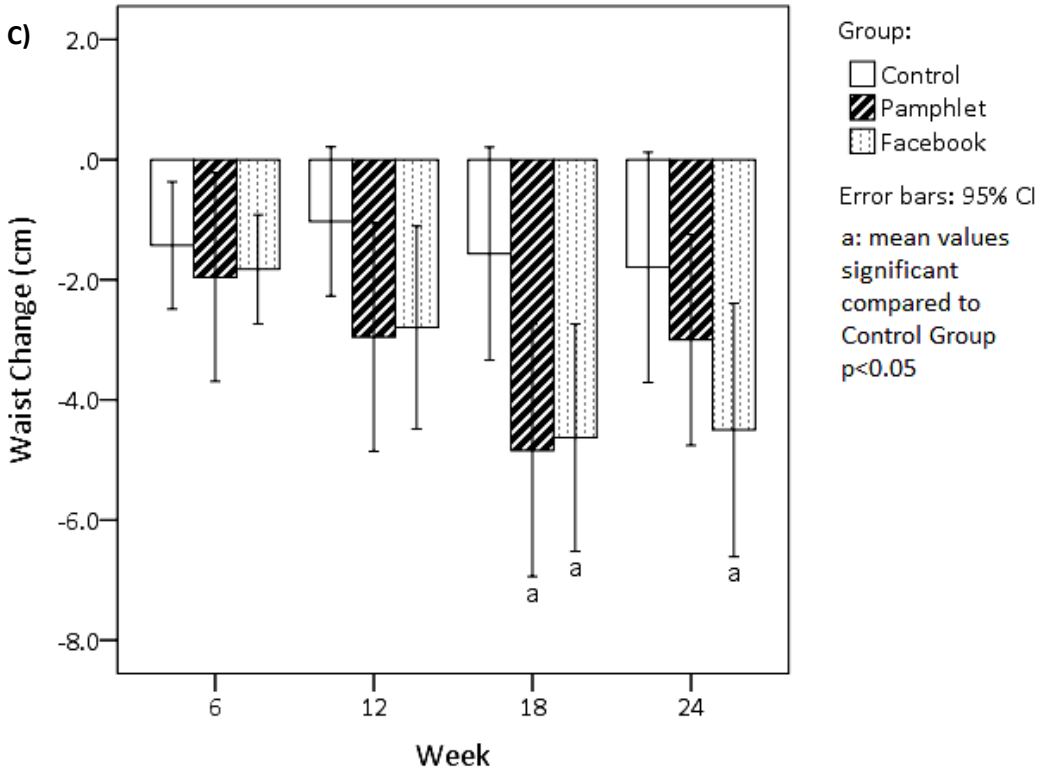
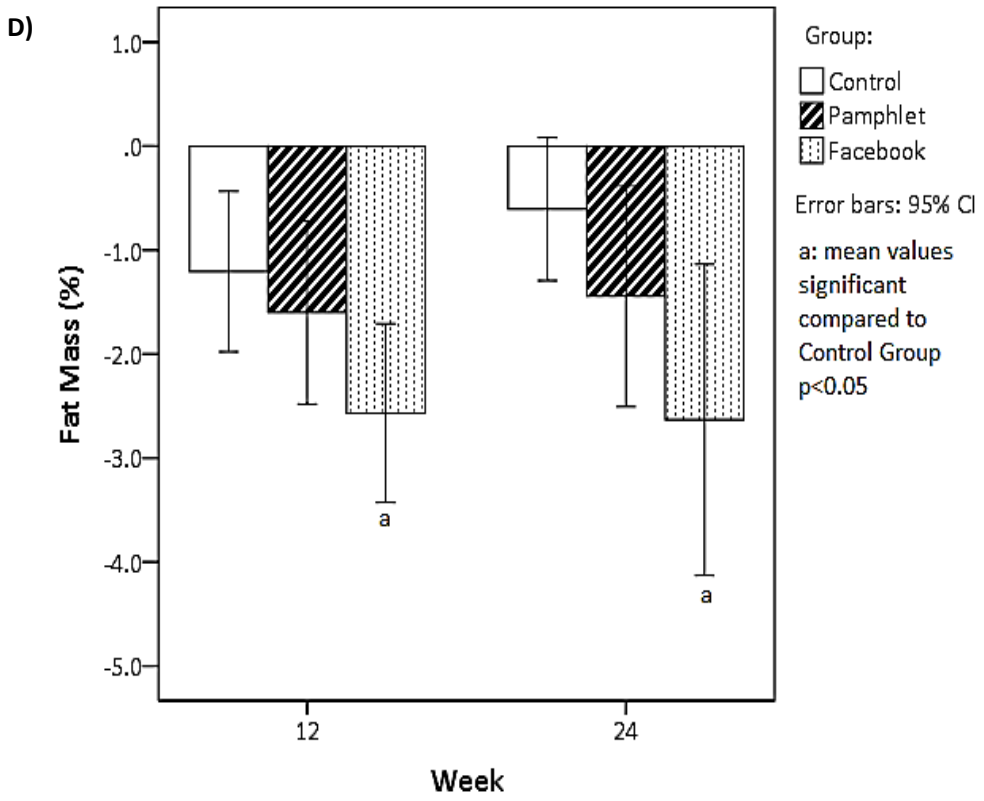
24
Week
Group:
Control
Pamphlet
Facebook
Error bars: 95% CI
a: mean values significant compared to Control Group p<0.05

C)


2.0
.0
-2.0
-4.0
-6.0
-8.0
Waist Change (cm)
a
a
a
6
12
18
24
Week
Group:
Control
Pamphlet
Facebook
Error bars: 95% CI
a: mean values significant compared to Control Group p<0.05

D)


1.0
.0
-1.0
-2.0
-3.0
-4.0
-5.0
Fat Mass (%)
a
a
12
24
Week
Group:
Control
Pamphlet
Facebook
Error bars: 95% CI
a: mean values significant compared to Control Group p<0.05

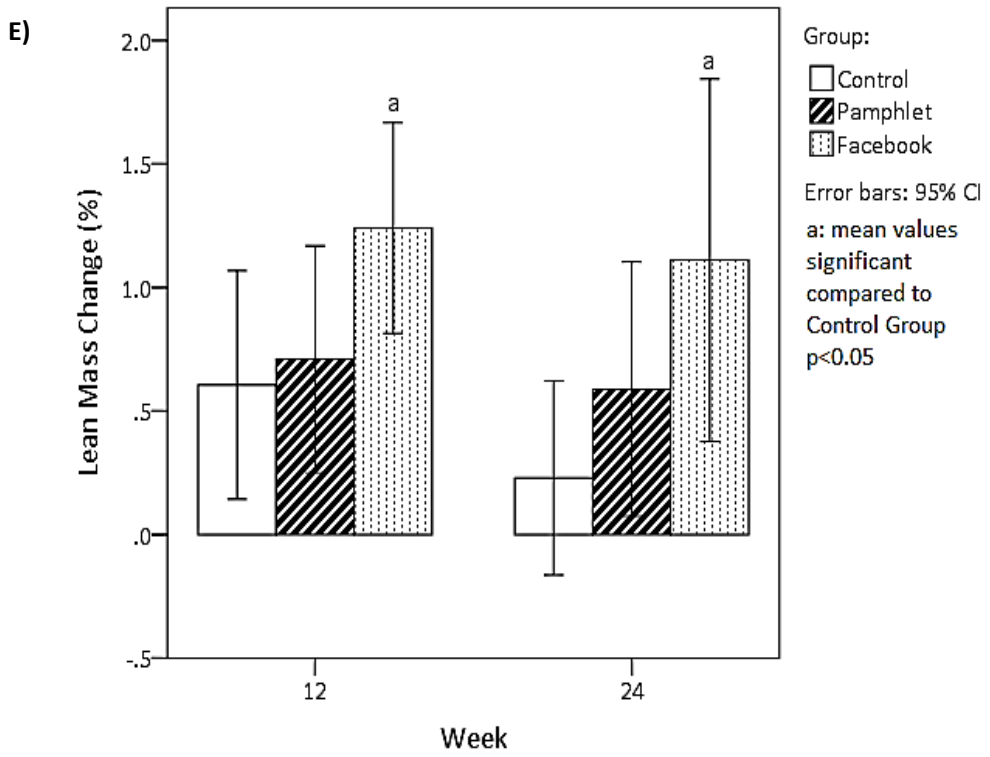


Figure 4.2: Significant between group differences in outcome measures:
(A) weight; (B) BMI; (C) waist; (D) fat mass; (E) lean mass.

4.3.3 Diet and Physical Activity

According to self-reported food intake data, the differences in mean energy intake between the three groups at all four time points compared to baseline were not found to be statistically significant. The greatest numerical reductions in energy intake was observed in the FG at week 24 (to wit CG: -1107.4 kJ/day v PG: -1071.6 kJ/day v FG: -1465.9 kJ/day). Both the PG and the FG showed numerical reductions in carbohydrate intake at each time point; however, the only significant reduction was in the PG at week 6 compared to the CG (-3.8%, p=0.05). There were no significant between group differences in either fat or alcohol intake across the intervention.

Table 4.2: Between group differences in outcome measures

	Week 6			Week 12			Week 18			Week 24		
	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*
Weight (%)*												
◦ Control	-1.1	0.3	22	-1.8	0.5	18	-2.0	0.7	18	-1.5	0.6	17
◦ Pamphlet	-2.7[a]	0.5	23	-3.4	0.7	21	-4.5[a]	0.8	19	-3.6[a]	0.8	18
◦ Facebook	-2.5[a]	0.5	23	-3.5	0.8	22	-4.9[a]	1.0	20	-4.8[a]	1.1	19
BMI (kg/m²)												
◦ Control	-0.4	0.1	22	-0.6	0.2	18	-0.7	0.3	18	-0.5	0.2	17
◦ Pamphlet	-1.0[a]	0.2	23	-1.2	0.3	21	-1.6[a]	0.4	19	-1.3	0.3	18
◦ Facebook	-0.8	0.2	23	-1.1	0.3	22	-1.5[a]	0.3	20	-1.5[a]	0.4	19
Waist (cm)												
◦ Control	-1.4	0.5	22	-1.0	0.6	18	-1.6	0.8	18	-1.8	0.9	17
◦ Pamphlet	-2.0	0.8	23	-2.9	0.9	21	-4.8[a]	1.0	19	-3.0	0.8	18
◦ Facebook	-1.8	0.4	23	-2.8	0.8	22	-4.6[a]	0.9	20	-4.5[a]	1.0	19
Hip (cm)												
◦ Control	-0.3	0.6	22	-1.1	0.6	18	-1.1	0.6	18	-1.5	0.6	17
◦ Pamphlet	-1.3	0.6	23	-2.5	0.7	21	-2.6	0.7	19	-3.2	0.6	18
◦ Facebook	-1.3	0.5	23	-2.4	0.7	22	-2.8	0.8	20	-3.3	0.9	19
FBG (mmol/L)												
◦ Control	0.4	0.1	22	0.3	0.2	18	0.6	0.2	18	0.4	0.3	17
◦ Pamphlet	-0.1[ac]	0.2	23	-0.2[ac]	0.1	21	0.1[a]	0.2	19	-0.4[ac]	0.2	18
◦ Facebook	0.4	0.1	23	0.4	0.1	22	0.5	0.1	20	0.4	0.3	19
Fat Mass (%)**												
◦ Control	-	-	-	-1.2	0.4	17	-	-	-	-0.6	0.3	17
◦ Pamphlet	-	-	-	-1.6	0.4	21	-	-	-	-1.4	0.5	18
◦ Facebook	-	-	-	-2.6[a]	0.4	22	-	-	-	-2.6[a]	0.7	19
Lean Mass (%)**												
◦ Control	-	-	-	0.6	0.2	17	-	-	-	0.2	0.2	17
◦ Pamphlet	-	-	-	0.7	0.2	21	-	-	-	0.6	0.2	18
◦ Facebook	-	-	-	1.2[a]	0.2	22	-	-	-	1.1[a]	0.3	19
SBP (mmHg)												
◦ Control	-	-	-	-2.8	3.0	17	-	-	-	3.5	2.9	17
◦ Pamphlet	-	-	-	-10.3[a]	2.2	21	-	-	-	-0.2	2.7	18
◦ Facebook	-	-	-	-9.6	3.2	22	-	-	-	-3.0	2.0	19
DBP (mmHg)												
◦ Control	-	-	-	-2.1	1.5	17	-	-	-	1.1	1.5	17
◦ Pamphlet	-	-	-	-4.5	1.3	21	-	-	-	-0.1	1.4	18
◦ Facebook	-	-	-	-3.4	1.5	22	-	-	-	-0.5	1.0	19
Insulin (mU/L)												
◦ Control	-	-	-	-1.1	0.9	13	-	-	-	0.1	0.7	17
◦ Pamphlet	-	-	-	-1.3	0.7	19	-	-	-	1.0	0.9	17
◦ Facebook	-	-	-	-0.9	0.5	17	-	-	-	-0.1	0.9	17
TC (mmol/L)												
◦ Control	-	-	-	-0.3	0.2	12	-	-	-	0.1	0.1	16
◦ Pamphlet	-	-	-	-0.4	0.2	21	-	-	-	-0.1	0.2	18
◦ Facebook	-	-	-	-0.3	0.1	17	-	-	-	-0.2	0.1	17
TAG (mmol/L)												
◦ Control	-	-	-	-0.1	0.1	12	-	-	-	0.1	0.2	16
◦ Pamphlet	-	-	-	-0.1	0.0	21	-	-	-	0.4	0.3	18
◦ Facebook	-	-	-	-0.2	0.1	17	-	-	-	-0.2	0.1	17
LDL (mmol/L)												
◦ Control	-	-	-	-0.3	0.2	12	-	-	-	0.0	0.1	16
◦ Pamphlet	-	-	-	-0.3	0.1	21	-	-	-	-0.1	0.1	18
◦ Facebook	-	-	-	-0.3	0.1	17	-	-	-	-0.2	0.1	17
HDL (mmol/L)												
◦ Control	-	-	-	0.0	0.0	12	-	-	-	0.1	0.0	16
◦ Pamphlet	-	-	-	-0.1	0.0	21	-	-	-	0.0	0.0	18
◦ Facebook	-	-	-	0.0	0.0	17	-	-	-	0.0	0.0	17

*percentage of initial body weight; **percentage of total body weight; BMI: body mass index; DBP: diastolic blood pressure; FBG: Fasting blood glucose; HDL: high density lipoprotein; LDL: low density lipoprotein; SBP: systolic blood pressure; TAG: triacylglycerol; TC: total cholesterol; [a]mean values significantly different to Control Group ($p<0.05$); [c]mean values significantly different to Facebook Group ($p<0.05$).

There were increases in protein intake in the three groups at each time point; however, those increases that were significantly different compared to the CG at week 6 were PG (+5.9%, *p*=0.05) and the FG (+5.2%, *p*=0.03), and the FG compared to the CG at week 12 (+4.8%, *p*=0.05). Notable increases in fibre intake occurred in the PG compared to the FG at week 6 (+2.6 g, *p*=0.005) and at week 18 (+2.4 g, *p*=0.03), and in the PG compared to the CG at week 24 (+2.4 g, *p*=0.03).

The only significant increase in self-reported energy expenditure was recorded in the FG at week 6 (+588.8 kJ/day, *p*=0.03) compared to the PG. When measuring physical activity, the step counts were not significantly different, although the FG recorded two-fold numerically greater step count compared to PG at the conclusion of the intervention (PG: +933.1 steps v FG: +2153.5 steps). (See Figure 4.3 Between group differences in step counts, below; and Table 4.3 Changes to diet and physical activity, on page 73).

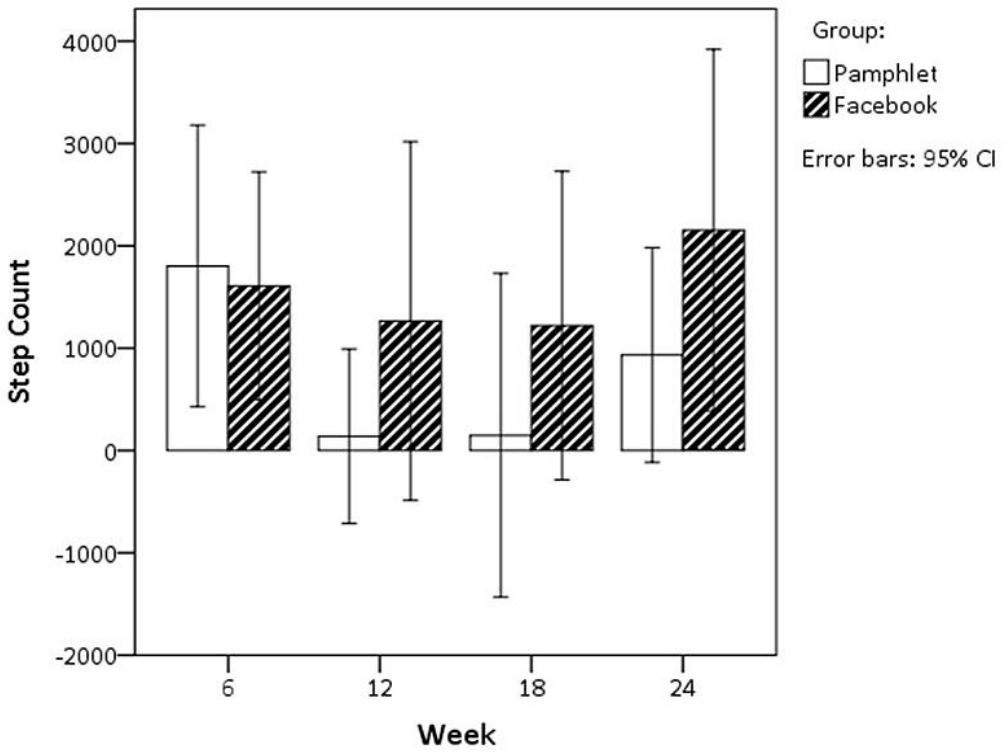


Figure 4.3 Between group differences in step counts

Table 4.3 Changes to diet and physical activity

	Week 6			Week 12			Week 18			Week 24		
	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*
EI (kJ/day)												
◦ Control	-931.0	468.2	16	-990.5	665.4	15	-1839.9	748.2	11	-1107.4	547.4	15
◦ Pamphlet	-1843.6	501.0	20	-1693.1	448.0	20	-2320.9	547.2	17	-1071.6	500.3	17
◦ Facebook	-1498.1	350.1	16	-1539.3	431.5	17	-1570.3	389.7	17	-1465.9	515.3	17
CHO (%)												
◦ Control	0.6	1.5	16	-3.1	2.2	15	-5.0	1.9	11	0.1	2.1	15
◦ Pamphlet	-3.8[a]	1.5	20	-3.2	1.8	20	-2.2	3.0	17	-3.2	1.7	17
◦ Facebook	-3.3	1.2	16	-4.3	1.6	17	-5.2	2.1	17	-3.0	1.7	17
Fat (%)												
◦ Control	-1.8	1.4	16	0.5	2.1	15	2.1	2.3	11	-0.9	1.4	15
◦ Pamphlet	-2.7	1.9	20	-1.8	1.8	20	-2.4	2.8	17	0.0	2.0	17
◦ Facebook	-1.8	1.2	16	-1.4	1.4	17	1.4	1.7	17	-2.0	1.6	17
Protein (%)												
◦ Control	1.3	1.3	16	0.5	1.2	15	4.7	1.6	11	1.3	1.6	15
◦ Pamphlet	5.9[a]	1.8	20	4.0	1.5	20	5.2	2.5	17	3.2	1.8	17
◦ Facebook	5.2[a]	1.1	16	4.8[a]	1.8	17	3.9	1.2	17	4.8	1.9	17
Alcohol (%)												
◦ Control	-0.6	1.2	16	0.6	1.8	15	-2.2	1.9	11	-0.6	0.6	15
◦ Pamphlet	-0.3	0.6	20	-0.5	0.5	20	-1.4	0.9	17	-0.3	0.6	17
◦ Facebook	-0.5	0.2	16	0.5	0.4	17	-0.5	0.3	17	-0.5	0.5	17
Fibre (g)												
◦ Control	0.1	1.5	16	-0.9	1.9	15	-2.0	2.1	11	-1.8	1.5	15
◦ Pamphlet	2.6[c]	1.6	20	1.0	1.2	20	2.4[c]	1.4	17	2.4[a]	1.4	17
◦ Facebook	-3.2	1.1	16	-1.9	1.4	17	-2.8	1.9	17	-1.7	1.7	17
EE (kJ/day)												
◦ Control	311.7	421.4	15	-836.2	365.2	14	600.6	819.1	9	249.9	808.2	12
◦ Pamphlet	-855.8	399.2	19	-1046.1	454.2	19	-1472.3	447.6	17	-1626.0	552.0	16
◦ Facebook	588.8[b]	498.6	17	-142.9	857.1	16	-277.1	452.7	15	-263.8	545.1	16
Steps/day												
◦ Control	-	-	-	-	-	-	-	-	-	-	-	-
◦ Pamphlet	1802.4	637.5	19	139.7	393.1	18	148.2	724.1	17	933.1	476.0	16
◦ Facebook	1608.9	510.0	17	1265.6	789.4	15	1221.6	627.4	14	2153.5	795.3	15

%: percentage of energy intake; CHO: carbohydrate; EI: Energy intake; EE: energy expenditure; [a] mean values significantly different to Control Group ($p<0.05$); [b] mean values significantly different to Pamphlet Group ($p<0.05$); [c] mean values significantly different to Facebook Group ($p<0.05$)

4.4 Discussion

One of the central tenets of health promotion is to create a supportive environment, conducive to health behaviour change [41]. The intervention reported here was designed to provide dietary and physical activity instructions and social support within a dedicated Facebook group, creating a supportive environment for overweight and obese participants to manage their weight. The overall aim of this study was to determine if a weight management program delivered via a dedicated social media group would augment beneficial changes in weight and other metabolic syndrome risk factors compared to written instructions only or a standard care control in overweight and obese individuals.

It was expected that by week 24 the PG would experience a mean weight loss of 2% of initial body weight compared to CG. As the results show, the PG experienced a mean weight loss of 3.6% of initial body weight, 2.1% greater than the CG (p=0.05). The PG also had greater improvements in fasting blood glucose compared to the CG (p=0.04) and the FG (p=0.03) at the conclusion of the intervention.

It was also expected that, compared to the CG, the FG would experience a mean weight loss of 9% initial body weight at the end of the 24 week intervention. While the FG posted the greatest weight loss by week 24 compared to the CG (p=0.01), at 4.8% of initial body weight, the FG didn't achieve that predicted target. However compared to the CG, the FG only demonstrated significant improvements in BMI (p=0.02), waist circumference (p=0.04), lean mass (p=0.03) and fat mass (p=0.01) by week 24. Also, although the FG showed greater numerical improvements in weight, BMI, waist circumference, lean and fat mass compared to the PG, these changes were not statistically significant.

By the end of the 24 week trial period, the FG reported the greatest numerical reduction in energy intake (-1465.9 kJ/day) compared to the PG and the CG, though this result did not achieve statistical significance. The discrepancies between weight loss and changes to dietary intake may be explained by inaccurate dietary intake self-reporting, a common problem in weight management trials (7]. The between group differences in baseline energy expenditure measurements recorded for all groups appears to indicate reductions in physical activity across the course of the study, with few exceptions; this is inconsistent

with the trial recommendations. The between group comparisons show an increase in energy expenditure measurements at week 6 in the CG (+311.7 kJ/day, p=0.05) and the FG (+588.8 kJ/day, p=0.03) compared to the PG, and an increase was noted at week 18 in the CG (+600.6 kJ/day, p=0.03) compared to reductions in the PG and the FG. These results are also inconsistent with the increase in baseline step counts reported in the PG and FG. While the differences were not statistically significant at any of the time points, both groups reported increases in step counts with the PG recording more steps at week 6, but the FG recording greater increases in number of steps for the remaining three time points (including a difference of +1220.4 steps at week 24 compared to the PG).

Overall the changes to weight, BMI, waist, lean and fat mass measures observed in the present study in the FG are very encouraging, particularly in light of the smaller than expected sample size of this study. While these changes were not significant in the present study for the FG compared to the PG, they represent successful, practical outcomes. For example, a 5% reduction in total body weight can provide clinically significant changes to metabolic syndrome risk factors such as lipid profiles [42, 43] and fat mass [42] in overweight/obese individuals. The 4.8% reduction in total body weight and the reductions in BMI, waist circumference, fat mass and energy intake that were noted together with the increases in lean mass and step count posted by the FG are thus very encouraging. The fact that these improvements were maintained to week 24 suggest that the Facebook group may have assisted participants in this group persevere with the weight management program over the holiday season (around week 12) and beyond.

With respect to relevant considerations in interpreting the current findings, it should be noted that the original 12-week intervention (with a 12-week follow-up) was extended to a 24-week intervention only as the week 12 collection point was due to occur during the Christmas and New Year period, and data collected at this time may not have reflected the dietary and physical activity changes made during the twelve weeks prior [30]. It was not advisable to delay the start of the trial by another 12 weeks to avoid the festive season, as many of those individuals recruited at the start of the recruitment period were likely to lose interest in the study if it had been delayed further. According to 'Stages of change' theory, if an individual was at the 'Preparation stage' at recruitment it would be optimal for them to commence the intervention within 30 days; if they were at the 'Action Stage', they would need to have already started the intervention [44, 45]. In addition, it was not feasible to

adopt a 'rolling recruitment' approach, as it was important for all Facebook Group participants to be given access to the group page at the same time, to avoid any social disadvantage within the group. Therefore all participants were required to be randomised into groups before the trial commenced. In addition, due to necessity limited resources were spent on recruitment, which may have extended the length of the recruitment phase.

Even so, the effect of this intervention on weight measures and metabolic syndrome risk factors may have been blunted by the occurrence of Christmas in the middle of the intervention period. Excessive food consumption during Christmas is a well-known and common phenomenon [46-49]. The between group differences in outcome measures data (Table 2) shows very few statistically significant results were recorded at this time (week 12). It is speculated that this period may have especially been detrimental to the FG as they may have spent less time online receiving support, information and help, due to the commitments of the season. Alternatively, the results of a clinical weight management trial conducted across such a time period could be viewed as more representative of real world scenarios, as opposed to contriving ideal study conditions that rarely occur in day to day life.

In this trial the weight management guidelines were briefly explained to participants at an initial information session, but beyond that participants were given no further guidance or counselling, as would be the case with most free living individuals making such modifications. One of the reasons for this is that it is common for participants in weight management trials to have the benefit of regular dietetic counselling [50-53] and/or personalised feedback of some kind [54, 55]. In addition, participants in some previous trials had access to food items consistent with the recommended diet [56], which is sometimes provided in dietary meal-sized portions [50], or of specific macronutrient composition [50, 51] and/or provided with kitchen scales [51, 53, 54]. This type of high level of support would require considerable financial expenditure were participants expected to pay, and does not reflect real world scenarios (especially among low socioeconomic groups). Indeed, the results of weight management trials conducted in this way may not represent realistic outcomes for individuals or population groups. However, it is quite possible that social media groups such as the one in the present study may benefit from active leadership from within the group [57] to encourage greater program engagement. This strategy would also maintain cost-effectiveness of the intervention by keeping health

professional involvement down to a minimum. Additional facilitator involvement in the FG may be another strategy that could be used to boost participant engagement. It may also be the case that the use of social media for weight management may appeal differentially to certain individual or personality types [58].

Other factors may have influenced the outcomes of this intervention. Ambivalence towards health food choices and/or weight loss has been shown to result in poorer weight loss outcomes, such that an individual with a negative attitude towards the task or their ability to undertake it can undermine the execution of positive intentions [59-61]. Anecdotally provided information in this study indicated that several FG participants accessed a hard copy of the Total Wellbeing Diet, which may have meant that they had a reduced need to access the Facebook group page. In addition, one study has shown participants to view social connectedness on Facebook to be distinct from social connectedness with offline connections, i.e. in the 'real world' [24]. Perhaps participants in the present study did not rely on each other in the same way that they would typically rely on their offline social connections, particularly as participants were unknown to each other before trial commencement. Furthermore, participants did not choose to join the Facebook Group, but were placed there via study randomisation. Any reluctant social media users within this group may have been less inclined to engage with the other group members online, which could potentially blunt the overall changes to group outcomes.

For many individuals, particularly those in the obese category (BMI ≥30 kg/m^2), weight loss requires continued effort, not only to maintain a relatively small amount of weight loss, but to persevere until a healthy weight is achieved [62]. Due to the cost-effectiveness of social media, particularly when using existing social media platforms, an ongoing intervention or program delivered within an online social media group may help participants to make sustained progress towards their personal goals. Being a longer-term member of an online group than was possible in the present study may also help to build stronger relationships between members, as stronger online relationships have been shown to improve trust between members [63], and may therefore result in better outcomes over time. The fact that the FG maintained their improvement at the conclusion of the intervention, while the results in both the PG and the CG had declined, lends support to this notion.

4.4.1 Strengths and limitations

The results of this study demonstrate the potential benefits of using social media tools to assist overweight and obese individuals with dietary and physical activity modifications for weight management. As mentioned above, a mean weight loss of 5% of total body weight can result in positive metabolic changes in overweight and obese individuals. In the current study, a mean weight loss of 4.8% of initial body weight was noted in the FG in conjunction with positive changes in waist circumference and in both lean and fat mass. Research in this area is still in its relative infancy, and the results of this trial add significantly to the current knowledge base while suggesting potential benefits that can be applied in the context of both public health and clinical practice.

The results suggest that social media has some potential to assist with weight management, and identifies areas where improvements can be made to optimise this potential. However, the small sample size may have limited the capacity of this study to produce any further statistically significant results. Based on the total sample available at week 24 (n=54) and the observed effect size (Cohen's d=0.37)[38], post hoc analysis found that this study achieved a statistical power of 0.65 (or 65%). The statistical methods employed in this study were chosen with generalisability in mind; to wit, in real world settings some individuals may not persevere with a specific weight management program for any length of time e.g. twenty four weeks. Participant burden may have influenced attrition [64] in the present study, as a large amount of data was collected, including psychometric measures and Facebook group activity, which will be analysed and presented in future reports. While the high volume of data collected may have contributed to participant burden, examination of this data may provide further clues to the outcomes reported here.

4.4.2 Implications for future research and practice

Social networking platforms may provide several benefits to group members, such as bridging geographical boundaries, connecting with likeminded individuals (which may be particularly helpful if offline support is lacking), and providing support at low cost and 24-hour accessibility. The ability of group members to assist each other via social media may also remove some of the burden from health care services, for instance between

appointments. The potential advantages to health professionals of social networking platforms also include the ability to deliver relatively low cost health interventions, the capacity to manage large caseloads in a time-effective manner and the possibility of reaching minority or hard to access groups. This potential is enhanced if a ready-made platform such as Facebook is used, as this further minimises costs and provide health professionals with access to existing social networks.

Future intervention trials involving social media may benefit from allocating participants to either a 'treatment program' or a 'treatment program with a social media' group according to their personal preference, as this may reflect more realistically how this resource would be utilised in clinical settings. Participants that are identified as very active social media users could be given leadership roles within these groups to assist with overall participant engagement. Allowing participants to get to know each other a little beforehand (through social media or other channels), or to enrol with one or more friends, may also improve trial outcomes. In addition, future weight management trials may need to accommodate food-related events like Christmas and other relevant time periods (e.g. Passover, Ramadan) in order to inform improved strategies for weight management practices. Information gained from such approaches is likely to help clarify how to make the best use of social media in both the research and the clinical environments.

4.5 Conclusions

In spite of the issues discussed, the FG reported numerically greater improvements in weight, BMI, waist circumference, fat mass, lean mass, and energy intake compared to the CG and the PG, and a greater step count than the PG, by the end of the 24 week intervention. These results demonstrate the potential of social media to assist overweight and obese individuals with respect to dietary and physical activity modifications for weight management. Further research is needed to clarify these results, and to identify the particular features of social media that may be most beneficial for weight management programs, as well as the types of individuals most likely to benefit from this approach.

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CHAPTER FIVE

THE PSYCHOLOGICAL OUTCOMES[4]

Summary

Background: While global obesity rates continue to threaten the health and well-being of an alarming number of individuals, there is evidence to indicate that peer support can assist those following weight management programs. Belonging to a group can improve psychological well-being, and with the advent of social media there are now more avenues available for group membership.

Aim: This study was conducted to test whether weight outcomes in an online social networking group were associated with changes to psychological outcome measures in overweight and obese individuals in overweight and obese individuals following a weight management program delivered via Facebook.

Methods: The data analysed in the current study was collected during a three-armed, randomised, controlled clinical weight management trial conducted with overweight and obese adults over 24 weeks. Two intervention groups were given the same weight management program: one within a Facebook group, along with peer support from other group members; the other group received the program in a pamphlet. A control group was given standard care. The primary outcome was weight; secondary outcomes included self-reported energy intake and expenditure; psychological health, social relationships, physical health, quality of life, depression, anxiety, stress, health anxiety, happiness, as well as Facebook Group participants' opinion of this group.

Results: Participants in the Facebook Group experienced a significant change in weight by week 24 (p=0.016), compared to those in the Pamphlet and Control Groups. Quality of life domain psychological health showed a significant increase in the Facebook Group at week 12 relative to baseline (p=0.022). Mediation analysis indicated a statistical trend but not

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statistical significance for psychological health to mediate weight loss in the Facebook Group.

Conclusions: While both intervention groups showed significant changes in psychological outcome measures, the Facebook Group was the only group to experience statistically significant weight loss by the end of the 24 week intervention; however this result was not significantly mediated by the noted improvement in psychological health. An examination of psychological health and other behavioural outcome measures undertaken in larger, more highly statistically powered studies may help to identify significant mediators of Facebook group membership and improved weight loss outcomes.

5.1 Background

Much is already known about the prevalence of obesity, including the common physical causes as well as the associated health risks. Studies have shown that mental health issues can also be linked to obesity [1-5]. In 2010, a systematic review and meta-analysis identified a reciprocal relationship between obesity and depression, such that depressed individuals had a 58% chance of developing obesity and obese individuals had a 55% chance of becoming depressed [6]. This relationship strengthened according to the degree of overweight [6]. Findings from a large scale two-year study elucidated the relationship between depression/anxiety and changes in weight to the extent that: i) individuals with comorbid depression and anxiety were 70% more likely to gain weight; ii) severity of depression predicted greater weight gain; iii) participants depressed at baseline had a 66% chance of gaining ≥6 kg; iv) participants with depression, but without comorbid anxiety, had a 53% chance of losing ≥4 kg; and v) individuals with depression in remission were 53% more likely to lose ≥4 kg [7].

Possible causal pathways between mood and weight gain have been investigated. A 1995 study noted an association between emotional eating and anxiety, depression, and stressful life circumstances [8]. Further research found a greater inclination to eat associated with unfavourable emotions to be related to higher depressive symptoms, particularly in obese individuals [9]. Stressful life events have also been shown to promote weight regain as some individuals tend to eat in response to stress [10]. Specifically, periods of high stress

can influence eating behaviours and such periods are positively associated with consumption of energy-dense foods and increasing BMI [11], waist circumference [12] and weight gain [13]. Potential mechanisms underlying these effects include the involvement of relevant biochemical pathways [13], psychological coping mechanisms [12], learned responses from early childhood [14] or a complex interplay of these factors [15]. Furthermore, high kilojoule 'comfort foods' appear to mitigate the biochemical response to stress [16], while fatty acid infusions have been found to moderate experimentally induced sadness in healthy weight individuals [17]. Interestingly, one study found those identified as 'emotional eaters' to report overeating when stressed [18], whereas another found individuals in this category to report healthier eating habits when happy [11].

The condition of obesity places individuals in a peculiar position by also creating some of its own stressors. For example, obese individuals have reported experiencing social isolation and disruptions to relationships with some in their families and communities, and often feel stigmatised [1]. In some cases, past stigmatisation has prevented obese individuals engaging in health-related activities in public places [19]. On the other hand, support from peers has been reported as an important motivator to persist with weight loss programs [20]. In addition, social support can moderate the effect of stress, and has been shown to act as a buffer between stressful life events and depression [21]. Further evidence suggests that joining a social group can have a remedial effect on depression [22].

Weight management represents a significant challenge for many people [23]. Individuals attempting weight loss have reported a preference for ongoing dietary and psychological support, but find that professional help is not always affordable [1]. Internet technologies offer relatively cost-effective avenues for individuals to connect with other like-minded people, via increasingly available smartphones, social networking platforms and issue-specific peer-support groups. Background research conducted by the student researcher into the use of social media for facilitating weight management outcomes has been discussed in a paper yet to be published [24]. It would appear that a greater understanding of the underlying mechanisms involved in using online social networking for health promotion and weight management is required, particularly in terms of psychological well-being. Mediation analysis can help identify such possible causal pathways [25].

The initial study was a clinical weight management trial conducted to investigate the potential of a Facebook group to assist overweight and obese participants in following a weight management program; this study measured changes to weight and metabolic syndrome risk factors, with results reported in a previous publication [26]. During this weight management trial, a range of self-reported psychometric measures were collected to assess changes to subjective wellbeing and to identify the associations between these measures and weight changes, via mediation analysis. The aim of the current study was to determine whether weight outcomes from an online social networking group were associated with changes to psychological outcome measures in overweight and obese individuals following a weight management program delivered via Facebook over a period of 24 weeks, compared to the same program in written form and a standard care control.

5.2 Methods

5.2.1 Participants

Overweight and obese individuals with a BMI between 25-40 kg/m^2 and aged between 21 and 65 years were recruited from the Perth community via advertisements in local newspapers, flyers and community radio between July and November 2014. Further details of the inclusion/exclusion criteria have been outlined elsewhere [27]. This study was conducted according to the ethical guidelines provided by the NHMRC; all procedures involving human participants were approved by the Curtin University HREC (approval no. HR90/2014). All identifiable information collected from participants was coded. All participants provided signed, written informed consent. This trial was registered with the ANZCTR (trial registration no.: ACTRN12614000536662).

5.2.2 Study Design

This study was as a three-armed, randomised, controlled, parallel design intervention which was conducted over a 24-week trial period. Participants were randomised to one of the three groups by block randomisation according to age (ten year blocks commencing at age 21) and gender. The Control Group (CG) were instructed to follow the Australian Government dietary guidelines [28] as well as the National Physical Activity Guidelines for

Adults [29] as standard care. Both the Pamphlet Group (PG) and the Facebook Group (FG) were instructed to follow the Total Wellbeing Diet developed by the CSIRO [30] as outlined in greater detail elsewhere [27]. Prior to trial commencement participants attended information sessions at Curtin University where full details of the study procedures were explained, according to group allocation. All participants were instructed to commence the allocated intervention following the completion of baseline data collection.

5.2.3 Assessments

Participants attended clinical appointments at Curtin University in the fasted state at baseline, and at weeks 6, 12, 18 and 24. Prior to these appointments, participants were required to record their food and drink consumption in a Three-Day Food Diary, and their physical activity in a Three-Day Physical Activity Record. At these appointments, weight was measured in light clothing without shoes (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan).

Just prior to the appointments at baseline and at weeks 12 and 24, participants completed the following range of questionnaires: the WHO Quality of Life Questionnaire [31]; the 21-question Depression Anxiety Stress Scale [32]; and a seven item measure of personality traits [33] two of which are of interest in the present analysis.

The FG participants were required to complete a Facebook Intensity Questionnaire at weeks 6, 12, 18 and 24, adapted from work by Ellison et al [34]. Baseline measures were not collected as the questions concerned participants' perceptions of the FG, which they had no experience of at the start of the trial. This also allowed participants time to familiarise themselves with the group. Examples of questions include 'I feel I am part of the Facebook Group community' and 'The Facebook Group helps me to continue with the weight management program'. Responses to the questions Facebook Intensity Questionnaire were rated using a five-point Likert scale.

5.2.4 Outcome Measures

The primary outcome measure for the overall study was weight loss. The secondary outcome measures of interest were energy intake in kilojoules, energy expenditure in kilojoules and weight-adjusted physical activity. Secondary psychological outcome measures include self-rated quality of life, overall health, physical health, psychological health, social relationships (which includes social support), environment, reported symptoms of stress, anxiety and depression, health anxiety and happiness. The FG participants were also asked to rate their opinion of the Facebook group during the intervention.

5.2.5 Statistical analysis

The sample size calculation for the overall study has been discussed in greater detail previously [27]. Briefly, the recruitment of 120 participants allows for an attrition rate of 20%, resulting in a sample of 96 participants that achieves 80% statistical power, based on estimated weight loss. The initial study experienced higher than expected participant attrition and baseline weight (kg) data were found to be slightly positively skewed. Therefore a GLMM was tested to determine changes to each outcome measure in the intervention groups relative to the CG, as it can accommodate violations to the assumption necessary in general linear models [35].

In this case, assumption violations in the current study were accommodated using the GLMM maximum likelihood procedure. This procedure is a full information estimation process that uses all data present at each assessment point because time (eg. weeks 0, 12 and 24) is interpreted as a Level 1 variable that is nested within participants at Level 2 (which is itself nested within group at Level 3). To optimise the likelihood of convergence, a separate GLMM analysis was run for each of the outcome measures. While analysing each outcome measure separately can inflate the family-wise error rate, it was decided to evaluate each GLMM at the conventional p value of >0.05, as only one primary outcome measure was used [36]. All data is expressed as mean (±SEM). The Facebook Intensity data were not analysed in the above manner as descriptive statistics only were required to identify a possible trend in group members' opinions of the Facebook group.

5.2.6 Mediation analysis

Mediation effects could not be tested with structural equation modelling due to the relatively small sample size, therefore a multi-step regression procedure was used and implemented through GLMM. A separate GLMM was used to assess the relationship between weight change at week 24 and each behavioural outcome measure significant at week 12, while controlling for baseline covariates. If the initial significant group effect was reduced to non-significance by the conclusion of this procedure, it can be concluded that the between-group difference in weight loss was a mediated effect. Data is presented using *p* values (and includes the unstandardised regression coefficient in the diagrams). All analysis was implemented through SPSS 22.0 (IBM® SPSS® Statistics, New York, NY).

5.3 Results

5.3.1 Participants

Of the 284 respondents, 137 were eligible take part in the trial and all gave verbal consent to do so. They were then randomly allocated to one of the three groups. One hundred and one participants provided data at baseline along with written informed consent; of these, 68 participants provided data after baseline, and 56 participants completed the trial. Data from one participant was excluded due to non-compliance; however all other available data were used in the current analysis. The composition of the groups at baseline was presented with the initial report [26]. Additional baseline measurements, as well as the mean values for all outcome measures at each time point, are displayed in Table 5.1 Mean primary and secondary psychological outcome measures over time, on page 93.

5.3.2 Weight Management

The between group differences in weight loss have been reported in a previous publication [26]. The current analysis reports the group by time effect to be consistent with the analysis of the psychological outcome measures, and as it is necessary for the mediation analysis that follows. While weight decreased in both the FG and the PG, this was significant only in the FG at week 24 (p=0.016), compared to the CG.

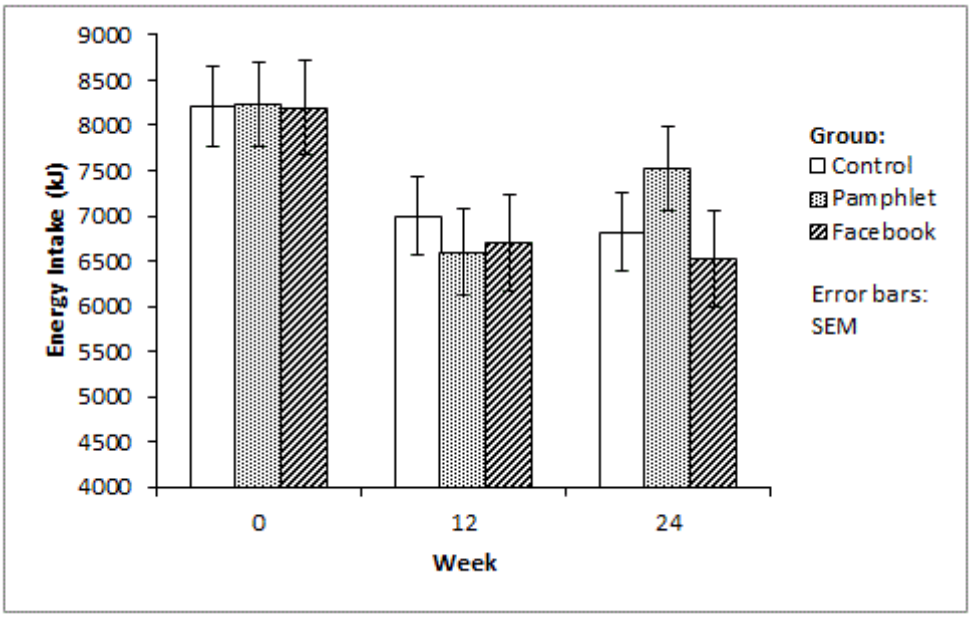
Both the FG and CG showed reductions in self-reported energy intake, while self-reported energy expenditure showed little change between groups throughout the trial period; these changes were not statistically significant. Based on these results, energy expenditure was found to be improbably elevated, making these values were more than double the energy intake values (see Figure 5.1 Energy intake and expenditure by group, A) Total energy intake; B) Energy expenditure; C) Weight-adjusted physical activity, on pages 94-95). This was likely due to body weight factoring in the original calculation, consequently the energy expenditure values were recalculated to generate a weight-adjusted physical activity score. This equilibration of scores further reduced the within and between group differences in physical activity outcomes. (Both sets of values are included in Table 5.1, which demonstrates the discrepancy in values.)

Table 5.1 Mean primary and secondary psychological outcome measures over time

	Baseline			Week 12			Week 24		
	Control Group	Pamphlet Group	Facebook Group	Control Group	Pamphlet Group	Facebook Group	Control Group	Pamphlet Group	Facebook Group
Weight (kg)	94.1 ± 3.6 [33]	92.7 ± 4.1 [34]	88.2 ± 2.5 [33]	92.6 ± 5.0 [17]	84.0 ± 4.0 [21]	86.2 ± 3.7 [22]	94.3 ± 5.1 [17]	84.8 ± 4.9 [18]	83.6 ± 4.1 [19]*
Energy Intake (kJ/day)	8206 ± 362 [26]	8227 ± 355 [28]	8197 ± 309 [30]	6996 ± 433 [16]	6598 ± 335 [21]	6702 ± 348 [19]	6821 ± 465 [15]	7516 ± 450 [18]	6518 ± 408 [19]
Energy Expenditure (kJ/day)	17125 ± 825 [23]	16274 ± 899 [25]	15794 ± 521 [28]	16952 ± 954 [14]	15748 ± 945 [20]	15492 ± 842 [18]	17574 ± 1431 [13]	15592 ± 855 [18]	15315 ± 861 [19]
Adjusted daily PA Scores†	184.6 ± 4.5 [23]	187.3 ± 5.3 [21]	179.1 ± 3.3 [28]	180.7 ± 5.0 [13]	186.3 ± 4.0 [20]	184.2 ± 7.4 [18]	185.8 ± 9.5 [13]	185.3 ± 5.8 [18]	183.2 ± 4.5 [19]
Quality of Life	4.4 ± 0.1 [31]	3.9 ± 0.2 [32]	4.1 ± 0.2 [32]	4.5 ± 0.2 [16]	4.5 ± 0.1 [21]*	4.2 ± 0.2 [20]	4.2 ± 0.1 [15]	4.6 ± 0.1 [18]*	4.2 ± 0.2 [19]*
Overall Health	3.3 ± 0.2 [31]	3.0 ± 0.2 [32]	3.2 ± 0.2 [31]	3.5 ± 0.2 [16]	3.8 ± 0.2 [21]	3.5 ± 0.2 [20]	3.5 ± 0.3 [15]	4.1 ± 0.2 [18]*	4.0 ± 0.2 [19]*
Physical Health	28.3 ± 0.6 [31]	25.9 ± 1.0 [31]	28.2 ± 1.0 [31]	28.9 ± 0.8 [16]	29.8 ± 0.7 [21]*	29.2 ± 1.0 [20]	29.4 ± 0.9 [15]	29.3 ± 0.9 [18]	30.1 ± 0.8 [19]
Psychological Health	21.4 ± 0.7 [31]	20.1 ± 0.8 [31]	21.0 ± 0.7 [30]	22.2 ± 0.8 [16]	22.6 ± 0.8 [21]*	22.8 ± 1.0 [20]*	22.4 ± 1.0 [15]	23.1 ± 0.8 [18]*	22.6 ± 0.9 [19]
Social Relationships	10.7 ± 0.5 [31]	9.7 ± 0.6 [31]	10.4 ± 0.5 [30]	10.9 ± 0.5 [16]	11.1 ± 0.4 [21]	11.3 ± 0.4 [20]	10.2 ± 0.5 [15]	11.4 ± 0.6 [18]*	11.0 ± 0.6 [19]*
Environment	32.8 ± 0.7 [31]	29.9 ± 1.0 [32]	31.5 ± 0.8 [30]	34.3 ± 1.0 [16]	32.7 ± 0.8 [21]	33.2 ± 0.8 [20]	33.7 ± 1.0 [15]	33.1 ± 0.8 [18]	32.7 ± 1.0 [19]
Depression	6.6 ± 1.4 [31]	8.3 ± 2.0 [32]	7.6 ± 1.6 [31]	5.5 ± 1.6 [15]	5.6 ± 1.6 [21]	5.4 ± 1.5 [19]	4.3 ± 1.1 [15]	5.7 ± 1.7 [18]	6.1 ± 1.6 [19]
Anxiety	4.1 ± 1.0 [31]	7.0 ± 1.5 [32]	4.3 ± 1.0 [31]	2.5 ± 0.8 [15]	4.9 ± 1.4 [21]	3.0 ± 0.8 [19]	1.7 ± 0.7 [15]	4.2 ± 1.4 [18]	3.1 ± 1.0 [19]
Stress	9.0 ± 1.4 [31]	11.4 ± 1.7 [32]	9.5 ± 1.4 [31]	7.4 ± 1.1 [15]	9.1 ± 1.8 [21]	8.7 ± 1.6 [19]	8.4 ± 2.2 [15]	10.2 ± 1.9 [18]	6.3 ± 1.5 [19]
Happiness	35.3 ± 1.5 [26]	35.7 ± 1.3 [24]	37.9 ± 1.8 [23]	37.8 ± 1.9 [16]	37.8 ± 1.9 [21]	36.9 ± 2.0 [18]	39.6 ± 1.8 [16]	38.6 ± 1.7 [17]	37.3 ± 2.0 [18]
Health Anxiety	14.0 ± 1.1 [26]	13.1 ± 1.0 [24]	13.0 ± 1.0 [23]	12.7 ± 1.7 [16]	11.3 ± 1.0 [21]	11.6 ± 0.8 [18]	11.9 ± 1.6 [16]	9.6 ± 0.7 [17]*	10.6 ± 0.9 [18]
Emotional Eating	8.1 ± 0.6 [30]	7.9 ± 0.6 [31]	8.1 ± 0.4 [32]	6.8 ± 0.7 [16]	7.0 ± 0.6 [21]	6.6 ± 0.7 [21]	6.4 ± 0.5 [15]	6.3 ± 0.7 [18]	7.5 ± 0.5 [19]

Values are mean ± SEM; [n] refers to sample size; *mean statistically significant compared to week 0 and the Control Group as the reference value, $p<0.05$; PA refers to physical activity; †scores adjusted for weight

A)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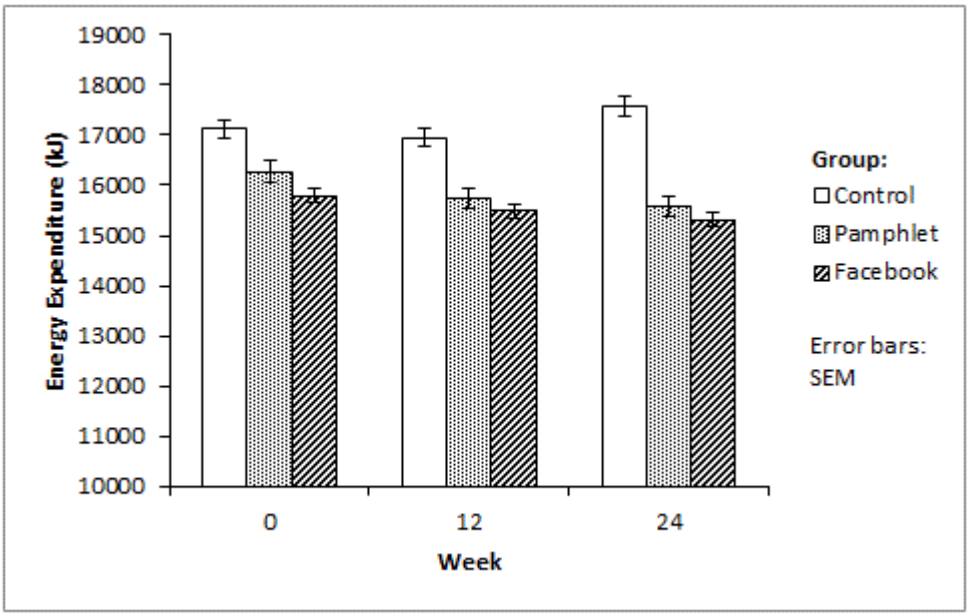
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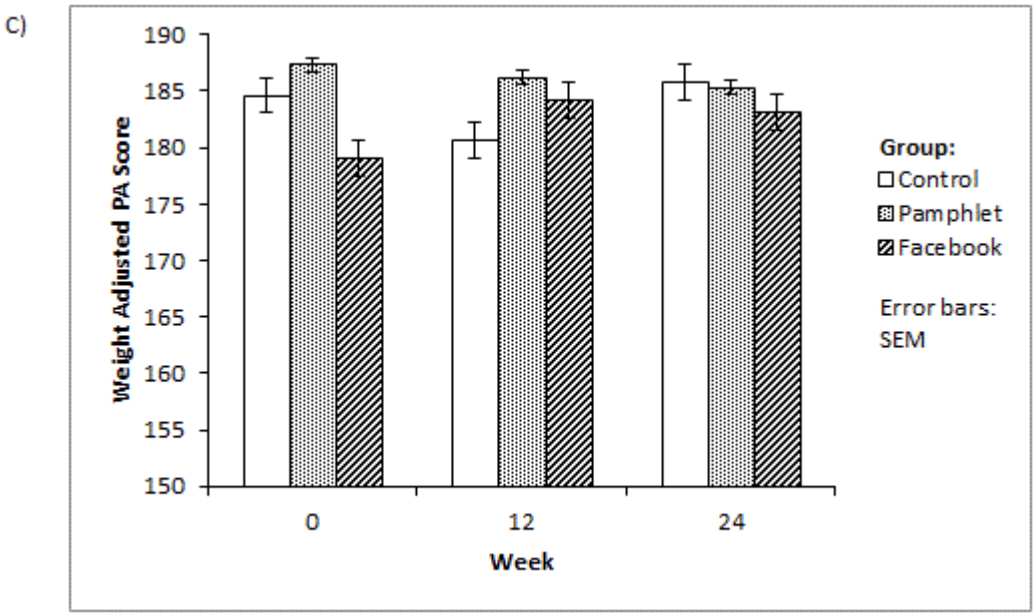

Figure 5.1 Energy intake and expenditure by group
A) Total energy intake; B) Energy expenditure; C) Weight-adjusted physical activity

5.3.3 Psychological Measures

Participants in both intervention groups (PG and FG) reported increases in overall quality of life. The FG reported a gradual increase in quality of life over time, significant at week 24 (p=0.002), whereas the PG recorded significant increases at week 12 (p=0.017) and week 24 (p=0.000). Participants' perceptions of their overall health in the FG and the PG showed increases at both time points, which was statistically significant at week 24 (p=0.018, and 0.045, respectively). As far as self-rated physical health is concerned, the PG showed a significant improvement at week 12 only (p=0.001) whereas for psychological health: the FG reported a significant increase at week 12 (p=0.022) which declined slightly at week 24, the PG reported significant increases at both week 12 (p=0.008) and week 24 (p=0.004), and compared to the CG. In social relationships domain, the FG and the PG recorded steady improvements at both time points which were statistically significant at week 24 (p=0.048 and 0.027, respectively). Self-reported health anxiety scores in the FG showed a steady decline at weeks 12 and 24; however, the PG recorded the only statistically significant decrease at week 24 (p=0.019) whereas CG reported moderate reductions at both time points after baseline. None of the changes in self-rated environment, depression, anxiety, stress and happiness values were found to be statistically significant. While self-reported

baseline measures of Facebook Intensity were not recorded, mean values at weeks 12, 18 and 24 indicate a slight decline in FG participants' opinion of the overall group by the end of the intervention. (See Figure 5.2 Facebook Intensity graph with data, showing a trend line with mean values ± SEM, below).

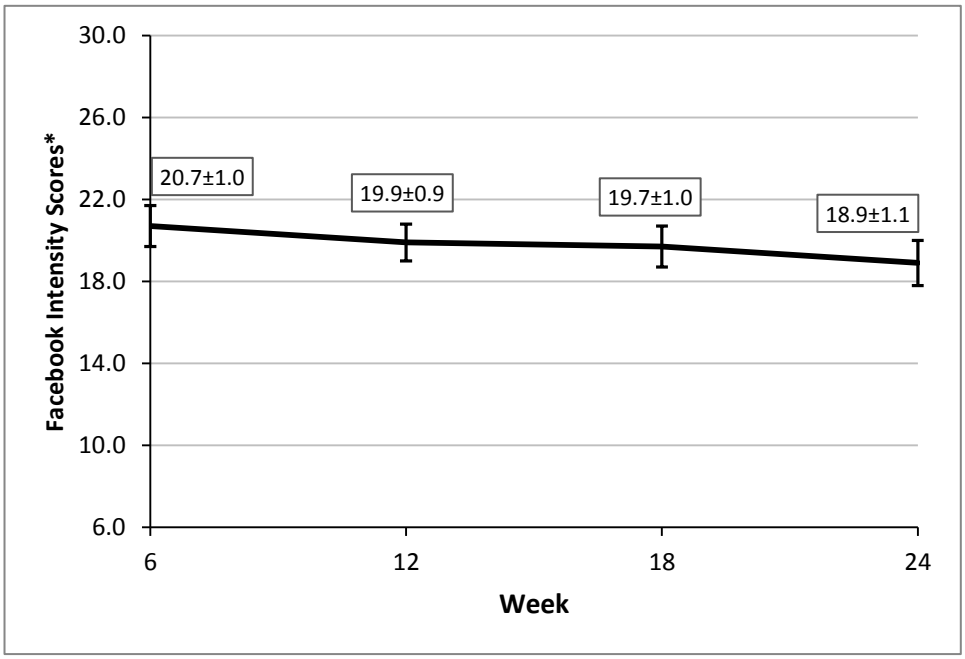

Figure 5.2 Facebook Intensity graph with data
*y-axis shows score range; data labels are mean ± SEM

5.3.4 Potential Mediators

As noted above, the reduction in weight (the primary outcome) at week 24 was significant in the FG only, compared to the CG; self-rated psychological health was the only secondary outcome measure significant in the FG at week 12 compared to the CG. Therefore these two factors formed the basis of the modelling for potential mediators outlined in the Methods section, as demonstrated in the model shown in Figure 5.3 Potential psychological mediator, on page 97.

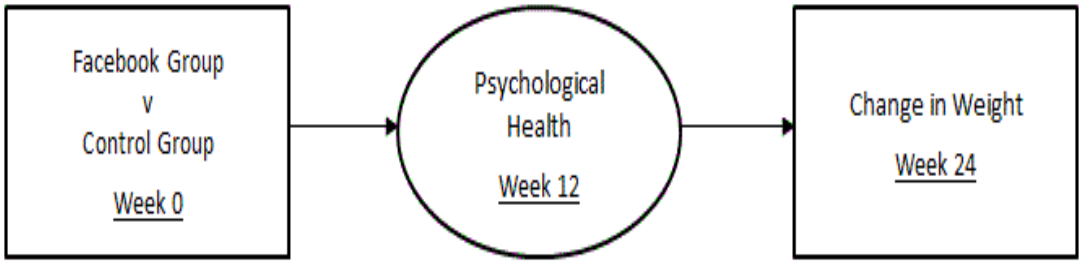

Figure 5.3 Potential psychological mediator

First, the relationship between the FG versus the CG and weight at week 24 was tested, after controlling for weight at baseline, and found to be significant (p=0.022). Second, the relationship between the FG versus the CG and psychological health at week 12 was tested, after controlling for the psychological health at baseline, and also found to be significant (p=0.010). Then, the relationship between psychological health at week 12 and weight at week 24 was tested, after controlling for both psychological health and weight at baseline, and found to be not statistically significant (p=0.063). While this result may indicate a 'statistical trend', it precluded further testing. Therefore the change in psychological health during the trial could not be considered a mediator to the change in weight for the FG by week 24.

5.4 Discussion

The results discussed here were based on the outcomes of a clinical trial examining the effects of a weight management program delivered within a Facebook group to overweight and obese individuals, and measured changes in weight and other metabolic, dietary and physical activity risk factors. Self-reported psychological data were collected as secondary outcome measures during the trial to identify possible mediators to any effects found. Therefore the purpose of the current analysis was to determine whether weight change in the FG was influenced by any changes to FG participants' psychological wellbeing.

The weight results analysed in this report showed the Facebook Group to experience greater weight reduction by week 24 (p=0.016) compared to the Control Group, while the Pamphlet Group showed not such change. This result is important, because both the PG

and the FG were following the exact same dietary and physical activity guidelines. Analysis of self-reported dietary intake shows that while all groups recorded a downward trend in energy intake, the PG finished the trial with the highest intake and the FG finished with the lowest; these results were not statistically significant. In addition, the self-reported physical activity values were similar between all groups. Therefore, it is not possible to draw any firm conclusions regarding the effect that energy intake and expenditure exerted on the weight reduction identified in the FG at week 24 using these self-report instruments.

An overview of the self-reported psychological outcomes results showed that participants in both the FG and the PG appeared to experience some beneficial changes during the intervention period. The FG participants' perceptions of their overall quality of life (p=0.002), health (p=0.018) and social relationships (p=0.048) showed significant improvements by week 24, and significant improvements also occurred in these measures in the PG (p=0.000, 0.045 and 0.027 respectively), along with significant improvements in psychological health (p=0.004). Although the FG showed a significant improvement in psychological health at week 12 (p=0.022), the PG also showed a significant improvement in this measure (p=0.008) as well as in physical health (p=0.001) and quality of life (p=0.017) at this time point. Furthermore, the PG experienced a greater reduction in health anxiety by week 24 (p=0.019) compared to CG. In other words, although the PG showed greater improvements in psychological outcomes, this did not appear to translate to a significant reduction in weight in this group.

To better understand the possible psychological benefits a Facebook group may provide for participants following a weight management program, potential psychological mediators were identified. This was done using the psychological outcome measures that significantly improved in the FG at week 12, namely psychological health. Mediation analysis on this outcome measure revealed a statistical trend but not statistical significance; therefore, the change in weight shown in the FG may not have resulted from changes in self-reported psychological health *per se* but via other, possibly complementary mechanisms.

Related to the reported findings with respect to psychological health, it may be that FG participants did not consider other Facebook Group members as a resource to assist with weight management. A cross-sectional study found that patients in online support groups preferred social interaction within these groups if they felt that support from their offline

network was inadequate [37]. As the social relationships results were not significant in the FG during the trial (e.g. at week 12), it may be that the majority FG participants in this particular study may have been satisfied with the existing level of support they received offline. Another possibility is that 24 weeks may not be enough time for ties between FG members to strengthen to the extent that interpersonal support would be routinely given and received, thus positively influence psychological well-being. Recent research has shown that well-being is improved when the online support is provided via stronger ties rather than via weaker ties [38]. In addition, the moderately declining Facebook Intensity scores over time noted in the present study suggest that while the participants in FG were not averse to group membership they did not rate the group as highly as they might have done.

While the FG registered fewer significant results in terms of secondary outcome measures, the significant change in weight by week 24 suggests that some part of the intervention did exert a beneficial effect. Conversely, while the PG had a greater number of significant changes in psychological outcome measures at week 12, the weight reduction in this group was not significant; this may indicate that the weight management program alone was not responsible for the improvements in psychological outcome measures. A recent randomised controlled trial found a reduction in depressive symptoms with improved diet quality, independent of weight loss; however, in that trial participants were give personalised dietary advice and support from a clinical dietician (e.g. goal setting, motivational interviewing and mindful eating) [39] which may have influenced this result. Nevertheless, the differing changes evident between the two intervention groups in the current study raise interesting questions for further research. Future investigations may lead to a better understanding of the relevant psychological processes when overweight and obese individuals undertake weight management programs, with or without the assistance of social media. Furthermore, Facebook group membership may have provided other benefits to participants, such as improved behavioural outcomes, such as self-efficacy or self-control, as discussed in a forthcoming report [40].

5.4.1 Strengths and limitations

The main strength of this current study was the collection and analysis of psychometric measures in combination with outcome measures reflecting risk factors for weight increase and the metabolic syndrome. To the best of our knowledge at the time of project

development, no other social media weight/management trial had taken this approach. The use of GLMM and the ability of this method of statistical analysis to utilise all available data represents another strong point in the current study. This type of analysis applies an intention-to-treat approach, recommended by CONSORT [41], allowing these results to be generalisable to the target population. The limitations to this study include the higher than expected participant attrition resulting in a relatively small sample size and, therefore, reduced statistical power. Incidentally, post hoc analysis shows a small to moderate effect size (F=0.18) could be expected from a sample of 54 participants. A possible confounder concerning the study design may have been the occurrence of the Christmas/Holiday Season at week 12 of the intervention period. It seems plausible that this period may have been particularly unfavourable to the FG as they may have spent less time during the holiday season online receiving peer support (and the associated potential benefits) due to their other engagements. In addition, aside from the weight and metabolic outcomes all other data analysed in this study were derived from self-report instruments, which may have introduced inter-individual and/or intra-individual bias into these results.

5.5 Conclusions

While the FG was the only group to experience statistically significant weight loss by the end of the 24 week intervention, this result does not appear to have been mediated by improvements in self-reported psychological health (although a statistical trend in this direction was noted). The results do not elucidate definitively the possible psychological benefits of belonging to a Facebook group while attempting weight loss; however, the fact the FG recorded significantly greater weight loss than the other two groups demonstrates the potential for overweight and obese adults to profit from online social networking when used in conjunction with a sensible weight management plan. In addition, the findings obtained may help direct further research into the use of internet-mediated social within a weight management program. An examination of psychological wellbeing and other behavioural outcome measures undertaken in larger, more highly statistically powered studies may help to identify significant mediators of Facebook group membership and improved weight loss outcomes.

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CHAPTER SIX

THE BEHAVIOURAL OUTCOMES[5]

Summary

Background: Rising global obesity rates continue to place affected individuals at an increased risk of cardiometabolic diseases and some cancers. There is evidence to suggest that group membership can assist individuals in making dietary behaviour changes. The emergence of online social networking has provided an important new forum for group-based support for weight management interventions.

Aim: The aim of this study was to examine the behavioural outcome measures in overweight and obese participants following a weight management program presented within a Facebook platform.

Method: Overweight and obese adults were recruited to a three-armed, 24-week, randomised, controlled clinical weight management intervention. Two intervention groups were given the same weight management program: one group received the program within a Facebook group, along with peer support from other group members; the other group received the program in a written pamphlet. A control group was provided with standard care. The primary outcome was weight; the secondary outcomes were self-reported measures of behavioural change, eg. protein, fat and carbohydrate as percentages of total energy intake) and step counts (the latter in the PG and the FG only), as tangible indicators of program compliance and possible behaviour change; along with cognitive restraint, uncontrolled eating, emotional eating, self-control, self-efficacy, ingenuity, insight, initiative, competence, and cognitive failures as well as participants' dietary and physical activity intentions.

Results: The Facebook Group was the only group to experience statistically significant weight loss by the end of the 24 week intervention (p=0.016), compared to the Control Group. Secondary outcome measures significant at week 12 in this group were increases in protein intake (p=0.006), insight (p=0.020), and dietary intentions (p=0.034). Mediation

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analysis identified increased protein intake as a potential mediator to weight change in this group.

Conclusion: The increase in protein intake, as mediator to weight loss and an indicator of dietary compliance, suggests that Facebook group membership may assist overweight and obese adults to make dietary behaviour changes for weight management.

6.1 Background

Rising global obesity rates continue to place affected individuals at an increased risk of cardiovascular disease, type 2 diabetes, stroke, metabolic syndrome and some cancers [1, 2]. While short-term weight loss can be achieved with diet, with or without increased physical activity, weight regain in the longer term is common [3]. Behavioural strategies appear to be effective as they address cognitive factors responsible for eating behaviours, notably dietary restraint [4]. Weight management programs incorporating these strategies target both mood and thought patterns [4]. While adding cognitive targets to treatments can improve weight loss outcomes, cognitive-only treatments tend to produce unsatisfactory results [4].

A Cochrane Review has shown that diet and exercise programs combined with behavioural strategies can augment weight loss outcomes [4]. Aside from explicit diet and exercise instructions, which can be found in many self-help manuals [5], examples of behavioural strategies include regular self-weighing, goal setting, nutrition education [4, 6], stimulus control [4], and/or some form of dietary/behavioural counselling [7-9]. The strategies are aimed at improving self-control and self-efficacy to participate in weight management behaviours. Greater self-efficacy often results in better weight loss outcomes, and self-efficacy can improve during treatment particularly with experiences of success [10]. In addition, individuals with high self-control are less likely to engage in binge eating [11], are better able to comply with diet and physical activity guidelines [12], and are more likely to successfully lose weight [12, 13]. These strategies are commonly based on social cognitive theory (SCT) [14], which "…specifies factors governing the acquisition of competencies can profoundly affect…the self-regulation of health habits" [15].

According to SCT, role-modelling may also be used to enhance self-control and self-efficacy [15], and has been shown to improve weight loss self-efficacy in the absence of behavioural weight loss strategies [16]. In addition, SCT posits that a shared belief within the group can create a sense of collective self-efficacy, which can be as effective as self-efficacy for effective behaviour change [17]. Individuals with more people among their social networks attempting weight loss at the same time tend to have better weight loss intentions, an effect mediated by weight control social norms [18]. Social networks are a source of additional information (eg. dietary or physical activity etc), which not only helps to generate these normative influences, but access to resources help to improve health outcomes [19]. Incidentally, those with low self-reported social support have been found to improve their cognitive task performance under the influence of experimentally provided support [20]. In addition, the theory of planned behaviour (TPB) postulates that the intention to change a particular behaviour stems from an individuals' attitude towards that behaviour, subjective norms, as well as their perceived behavioural control; therefore intentions can be a determinant of behaviour change [21]. The social aspect is considered a cogent factor in behaviour change outcomes, acting via a number of possible mechanisms.

Internet communication technologies have provided additional tools to support behaviour change. For example, computer [22-24] and mobile phone apps [25], some providing real time digital feedback, including energy and/or macronutrient intake and/or energy expenditure, or contact with a health professional. In addition, health promoters can now leverage the reach and influence of internet-mediated social networks to encourage healthful behaviour changes. Social media has already started being used to influence behaviour change, and have been shown to be especially effective if messages presented via this medium are considered salient [26]. For example, one study using an online social networking website (Facebook) reported better smoking cessation rates compared to a conventional telephone 'helpline' [27]; another reported improved condom usage rates in those at risk [28]. Interestingly, Facebook pages dedicated to promoting healthy dietary and/or physical activity modifications have been shown to facilitate information sharing, as well as provide access to offline exercise 'buddies' [29].

The use of social media in this way is a growing area of investigation. Tools available within most social networking sites can assist with the formation and maintenance of online social groups, which extends the functionality of this platform, and could be particularly useful in

health-promoting behaviour change interventions. Therefore it is incumbent on public health researchers to determine whether online social groups can perform similar functions to offline groups, in terms of the effect on intentions, self-efficacy, self-control, and other cognitive factors. It would be particularly useful to explore the influence these factors have on weight loss in the absence of behavioural weight management strategies (eg. personalised counselling feedback, face-to-face group setting environment etc.) in online weight management groups, via mediation analysis. This type of statistical analysis helps determine the causal processes by which psychosocial factors shape health outcomes [30].

The original study was a clinical weight management trial conducted to examine the potential of a Facebook group to assist overweight and obese participants in following a weight management program; this trial measured weight loss and changes to metabolic syndrome risk factors, with results reported in a previous publication [31]. During this weight management trial, a range of self-reported psychometric measures were collected to evaluate changes to behavioural factors and to determine the associations between these measures and weight changes, using mediation analysis. The aim of the current study was to test whether weight outcomes in an online social networking group were associated with changes to behavioural outcome measures in overweight and obese participants following a weight management program presented within a Facebook group over a 24-week period.

6.2 Methods

6.2.1 Participants

Overweight and obese individuals with a BMI between 25-40 kg/m^2 and aged between 21 and 65 years, with a computer, laptop, tablet or Smartphone, were recruited from the Perth community via advertisements in the local newspapers, flyers and community radio, between July and November 2014. Further details of the inclusion/exclusion criteria have been outlined elsewhere [32]. This study was conducted according to the ethical guidelines set out by the NHMRC, and all procedures involving human participants were approved by the Curtin University HREC (approval no. HR90/2014). All identifiable participant

information was coded, and all participants signed written informed consent. This clinical trial was registered with the ANZCTR (trial registration no.: ACTRN12614000536662).

6.2.2 Study Design

The study adopted a three-group, randomised, controlled, parallel-design design, conducted over a 24-week period. Recruited participants were randomly assigned to one of the three groups by block randomisation according to age and gender, using an online random number generator [33]. The Control Group (CG) followed the Australian Government dietary guidelines [34] and the National Physical Activity Guidelines for Adults [35] as standard care. The Pamphlet Group (PG) and the Facebook Group (FG) followed a low fat, lower carbohydrate, higher protein diet program [36], and provided with a pedometer (G Sensor 2025 Accelerometer, Walk with Attitude Australia) with the instruction to achieve 10,000 steps per day. Details of the intervention program are outlined elsewhere [32]. All participants attended an introductory information session at Curtin University where full details of the study were explained according to group allocation, prior to trial commencement. All participants allocated to the FG were added to the group following the collection of baseline data.

6.2.3 Assessments

Participants attended fasting clinic appointments at Curtin University at baseline, and at weeks 6, 12, 18 and 24. Prior to attendance, participants were required to record all food and drink consumed in a three-day food diary, and all physical activity in a three-day physical activity record, with step counts for the PG and FG on corresponding days. At these appointments, participants' weight was measured in light clothing without shoes (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan).

Before attending appointments at baseline and at weeks 12 and 24, participants completed the following selection of questionnaires: the three factor eating questionnaire [37]; the self-efficacy scale [38], the self-control scale [11], a diet and physical activity survey based on the TPB [21], and a seven-item measure of personality traits [39], five of which are relevant to this report.

The FG participants were also required to complete a Network Density Questionnaire adapted from work by Zhao et al [40]. Baseline measures were not collected as the questions related to participants' opinions of activity within the Facebook group, which they had no experience of prior to the commencement of the trial. This also allowed participants time to familiarise themselves with the operation of the group. Examples of questions include 'group members encourage each other' and 'at least one group member has helped me with the weight management program'. Responses to network density questionnaire were rated using a five-point Likert scale.

6.2.4 Outcome Measures

The primary outcome measure for this study was weight loss. The secondary outcome measures are macronutrient intake (e.g., protein, fat and carbohydrate as percentages of total energy intake) and step counts (the latter in the PG and the FG only), as tangible indicators of program compliance and tangible evidence of possible behaviour change. Secondary behavioural outcome measures include cognitive restraint, uncontrolled eating, emotional eating, self-control, self-efficacy, ingenuity, insight, initiative, competence, and cognitive failures (or cognitive control) as well as participants' intentions towards dietary and physical activity recommendations. In addition, FG participants rated their opinion of the activity within the group.

6.2.5 Statistical analysis

The sample size calculation for the overall study has been discussed in greater detail previously [32]. Briefly, the recruitment of 120 participants allows for an attrition rate of 20%, resulting in a sample of 96 participants that achieves 80% statistical power, based on estimated weight loss. The initial study experienced higher than expected participant attrition and baseline weight (kg) data were found to be slightly positively skewed. Therefore separate a GLMM [41] was tested to determine changes to each outcome measure in the intervention groups relative to the CG, with the covariance matrix set to autoregressive.

The GLMM maximum likelihood procedure is a full information estimation procedure, which accommodates non-normal distributions, uses all data present at each assessment point because time (eg. weeks 0, 12 and 24) is interpreted as a Level 1 variable that is nested within participants at Level 2 (which is itself nested within group at Level 3). Although analysing each outcome measure separately can inflate the family-wise error rate, it was decided to evaluate each GLMM at the usual *p* value of >0.05, as only one primary outcome measure was used [42]. All data is expressed as mean (±SEM). The Network Density data were not analysed in the above manner as the descriptive statistics only were required to identify a possible activity trend within the Facebook group.

6.2.6 Mediation analysis

Mediation effects could not be tested with structural equation modelling due to the relatively small sample size. As the GLMM maximum likelihood procedure was used to analyse the initial changes in psychometric outcome measures, this method was used to test for mediation effects. Therefore a multi-step regression procedure, implemented through GLMM, was used. A separate GLMM was used to assess the relationship between weight change at week 24 and each behavioural outcome measure significant at week 12, while controlling for baseline covariates. If the significant group effect was reduced to non-significance following this analysis it will be concluded that the between-group difference in weight loss was a mediated effect. Data is presented using *p* values (and includes the unstandardised regression coefficient in the diagrams). All analysis was implemented through SPSS 22.0 (IBM® SPSS® Statistics, New York, NY).

6.3 Results

6.3.1 Participants

From 284 respondents, 137 met the eligibility criteria, were invited take part in the trial and gave verbal consent to do so. Recruited participants were then randomly allocated to one of the three groups. One hundred and one participants provided data at baseline along with written informed consent, 68 participants provided data after baseline, and 56 participants completed the trial. Data from one participant was excluded due to non-compliance,

however all other available data was used in the current analysis. The composition of the groups at baseline was presented with the initial report [31]. All other baseline measurements, along with the mean values for all outcome measures at every time point, are shown in Table 6.1. Mean primary and secondary behavioural outcome measures over time, on page 112.

6.3.2 Weight Management

Between group differences in weight loss has been reported previously [31]. The current analysis reports the group by time effect to be consistent with the analysis of the psychometric measures and preparatory to the mediation analysis that follows. The results shows that while weight reduction occurred in both the FG and the PG, it was significant in the FG at week 24 only (p=0.016), relative to the CG. In terms of physical activity, there were no significant differences in step counts between the PG and the FG, however the FG had the largest increase in step count compared to the PG, and completed the trial with the highest count at 9607 steps per day. (See Figure 6.1 Step counts over time, on page 113). As far as macronutrient intake is concerned, the FG showed a significant increase in percentage of protein intake at week 12 (p=0.006), maintained to week 24 but not significant, and was the only significant between group difference in among the dietary and physical activity measures.

Table 6.1 Mean primary and secondary behavioural outcome measures over time

	Baseline			Week 12			Week 24		
	Control Group	Pamphlet Group	Facebook Group	Control Group	Pamphlet Group	Facebook Group	Control Group	Pamphlet Group	Facebook Group
Weight (kg)	94.1 ± 3.6 [33]	92.7 ± 4.1 [34]	88.2 ± 2.5 [33]	92.6 ± 5.0 [17]	84.0 ± 4.0 [21]	86.2 ± 3.7 [22]	94.3 ± 5.1 [17]	84.8 ± 4.9 [18]	83.6 ± 4.1 [19]*
Daily Step Count	-	8553 ± 469 [23]	7970 ± 629 [28]	-	8595 ± 685 [21]	9268 ± 833 [17]	-	9187 ± 684 [18]	9608 ± 821 [18]
Fat Intake (%)	35.8 ± 1.0 [26]	36.2 ± 1.1 [28]	35.2 ± 0.8 [30]	35.6 ± 1.6 [16]	33.8 ± 1.4 [21]	33.5 ± 1.1 [19]	34.3 ± 1.9 [15]	35.1 ± 1.4 [18]	33.4 ± 1.6 [19]
Carbohydrate Intake (%)	39.0 ± 1.4 [26]	37.3 ± 1.5 [28]	41.7 ± 1.0 [30]	35.8 ± 1.8 [16]	34.2 ± 1.5 [21]	36.5 ± 1.3 [19]	38.9 ± 2.4 [15]	35.0 ± 1.3 [18]	38.3 ± 1.5 [19]
Protein Intake (%)	19.5 ± 0.8 [26]	21.6 ± 1.0 [28]	18.7 ± 0.7 [30]	20.3 ± 0.9 [16]	25.5 ± 1.2 [21]	24.5 ± 1.3 [19]*	21.2 ± 1.4 [15]	24.5 ± 1.1 [18]	23.8 ± 1.3 [19]
Self-Control	39.3 ± 1.4 [31]	37.8 ± 15 [32]	40.8 ± 1.1 [32]	40.6 ± 1.5 [16]	41.3 ± 1.9 [19]	41.0 ± 1.8 [20]	42.1 ± 1.8 [15]	41.0 ± 2.0 [18]	43.6 ± 15 [19]
Self-Efficacy	32.1 ± 0.7 [31]	30.4 ± 1.0 [31]	31.5 ± 0.9 [32]	32.2 ± 0.9 [16]	32.0 ± 1.1 [21]	32.5 ± 1.2 [19]	33.3 ± 0.9 [15]	32.6 ± 0.9 [18]	32.1 ± 1.3 [19]
Cognitive Failures	24.8 ± 1.6 [26]	24.1 ± 1.6 [24]	21.5 ± 1.5 [23]	21.3 ± 2.0 [16]	21.4 ± 1.9 [21]	23.0 ± 1.4 [18]*	21.6 ± 1.6 [16]	22.5 ± 2.7 [17]	21.2 ± 1.6 [18]
Competence	31.3 ± 0.8 [26]	31.6 ± 1.1 [24]	32.0 ± 0.9 [23]	32..9 ± 1.2 [16]	31.7 ± 1.4 [21]	28.6 ± 1.9 [19]	32.1 ± 1.2 [16]	32.5 ± 1.4 [17]	31.9 ± 1.1 [18]
Ingenuity	37.0 ± 1.3 [26]	38.0 ± 1.3 [24]	41.4 ± 1.4 [23]	37.4 ± 1.8 [16]	37.5 ± 1.5 [21]	36.9 ± 2.0 [18]	39.1 ± 1.6 [16]	38.0 ± 1.8 [17]	38.3 ± 1.9 [18]
Insight	37.3 ± 1.3 [26]	36.7 ± 1.3 [24]	41.0 ± 1.4 [23]	38.6 ± 1.3 [16]	36.7 ± 1.6 [21]	37.3 ± 1.9 18]*	39.5 ± 1.6 [16]	38.5 ± 1.6 [17]	38.8 ± 1.8 [17]
Initiative	33.2 ± 1.4 [26]	35.5 ± 1.6 [24]	35.3 ± 1.9 [23]	34.9 ± 1.9 [16]	36.2 ± 1.9 [21]	34.2 ± 1.7 [18]	33.8 ± 1.9 [16]	35.5 ± 1.8 [17]	34.7 ± 2.3 [18]
Cognitive Restraint	15.0 ± 0.7 [31]	14.4 ± 0.7 [32]	16.0 ± 0.7 [32]	16.2 ± 1.0 [16]	18.7 ± 0.9 [21]	18.3 ± 0.8 [19]	17.6 ± 0.8 [15]	17.3 ± 1.1 [18]	19.3 ± 0.8 [19]
Uncontrolled Eating	20.8 ± 1.2 [30]	21.3 ± 1.1 [31]	20.1 ± 1.0 [32]	17.9 ± 1.3 [16]	19.1 ± 1.3 [21]	17.7 ± 1.4 [20]	16.6 ± 1.2 [15]	18.3 ± 1.3 [18]	17.4 ± 1.1 [19]
Emotional Eating	8.1 ± 0.6 [30]	7.9 ± 0.6 [31]	8.1 ± 0.4 [32]	6.8 ± 0.7 [16]	7.0 ± 0.6 [21]	6.6 ± 0.7 [21]	6.4 ± 0.5 [15]	6.3 ± 0.7 [18]	7.5 ± 0.5 [19]
Dietary Intentions	33.8 ± 0.6 [30]	34.3 ± 0.6 [32]	33.7 ± 0.5 [32]	31.8 ± 0.7 [16]	35.2 ± 0.5 [21]*	33.4 ± 0.7 [20]*	31.1 ± 0.8 [15]	34.4 ± 0.8 [18]*	32.8 ± 0.9 [19]
Physical Activity Intentions	34.8 ± 0.6 [30]	34.4 ± 0.7 [32]	35.1 ± 0.6 [32]	33.4 ± 1.1 [16]	35.0 ± 0.8 [21]	33.8 ± 0.8 [20]	31.9 ± 0.7 [15]	33.9 ± 0.9 [18]	34.0 ± 0.9 [19]

Values are mean ± SEM; [n] refers to sample size; *mean statistically significant compared to baseline and the Control Group as the reference value, $p<0.05$

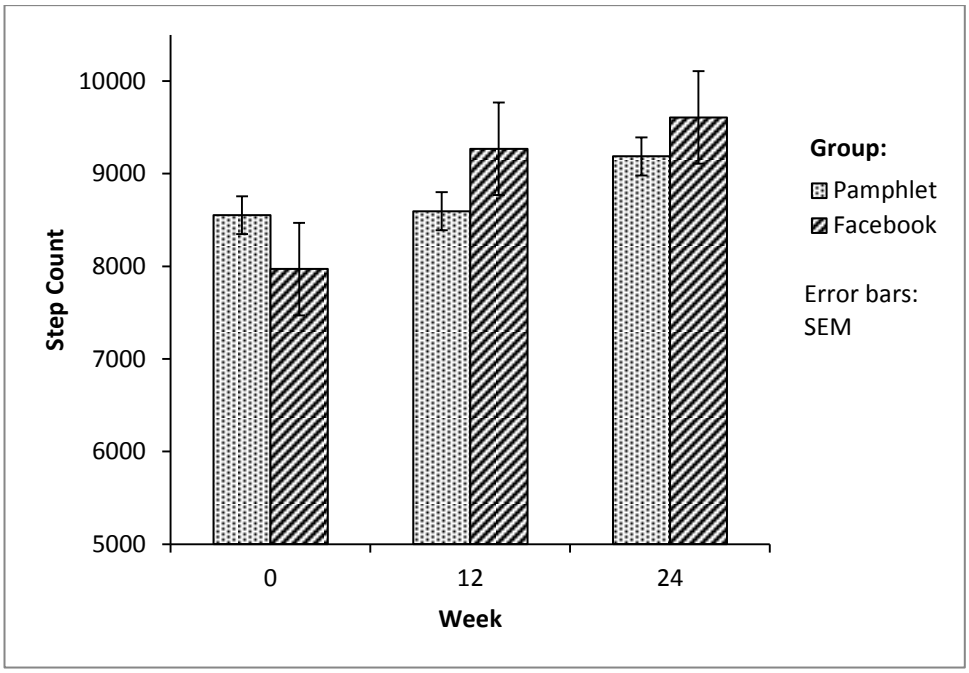

Figure 6.1 Step counts over time

6.3.3 Psychometric Measures

There were some significant changes in the self-reported psychometric outcome measures to be noted. First, the FG showed a significant increase in cognitive failures at week 12 (p=0.007), and an overall reduction in insight, significant at week 12 (p=0.020), which were not carried through to week 24. There were significant increases in dietary intentions in both the PG and FG at week 12 (p=0.001 and 0.034, respectively), and in the PG only at week 24 (p=0.016). Results for self-control, self-efficacy, initiative, competence, ingenuity, uncontrolled eating, emotional eating, cognitive restraint, and physical activity intentions were not significant. (Refer to Table 6.1.) Mean Network Density values show very little change in participants' perception of the activity between group members within the FG throughout the intervention. See Figure 6.2 Network Density graph with data. Group mean values (± SEM) are presented within the graph, on page 114.

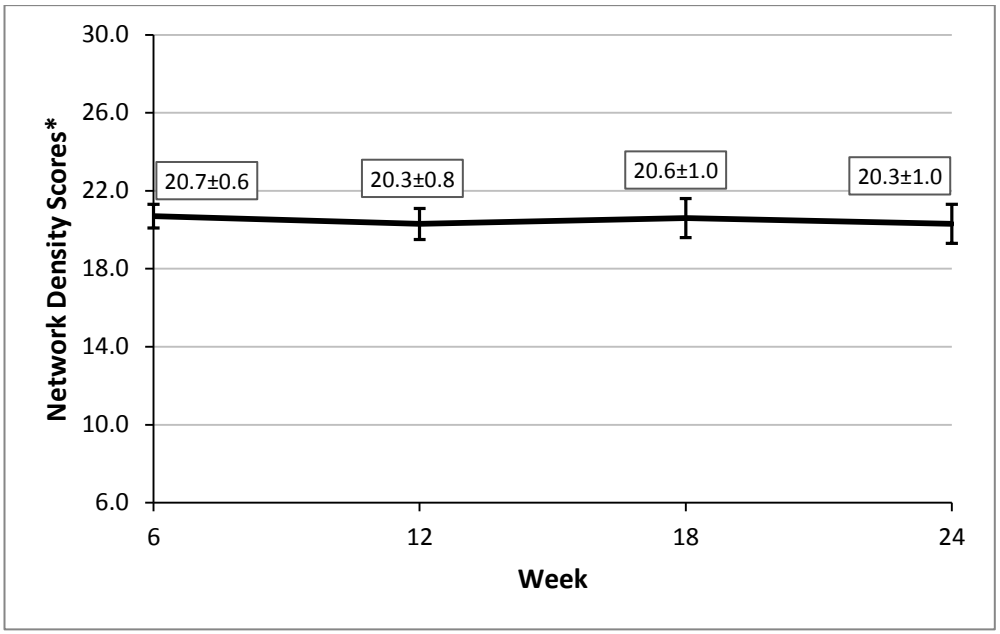

Figure 6.2 Network Density graph with data
*y-axis shows score range; data labels are mean ± SEM

6.3.4 Potential Mediators

Four potential mediators have been identified for further analysis. These are protein intake, cognitive failures, insight, and dietary intentions. (See the model in Figure 6.3 Potential behavioural mediators, on page 115). First, the relationship between the intervention and weight at week 24 was tested, after controlling for weight at baseline, and found to be significant (p=0.022). Second, the relationship between the intervention and protein intake at week 12 was tested, after controlling for the protein intake at baseline, and found to be significant (p=0.016). Then, the relationship between protein intake at week 12 and weight at week 24 was tested, after controlling for both protein intake and weight at baseline, and also found to be significant (p<0.001). Finally, to determine the potential of the change in protein intake during the trial (e.g., week 12) to mediate the relationship between the intervention and weight at week 24, the effect of the intervention on weight was tested after protein intake was included as a mediator, and found to be non-significant (p=0.149). This result is depicted the model in Figure 6.4 Protein intake as mediator, on page 115. Cognitive failures, insight and dietary intentions were all eliminated early in the analysis at step 2 (p=0.099, 0.073, 0.205 respectively).

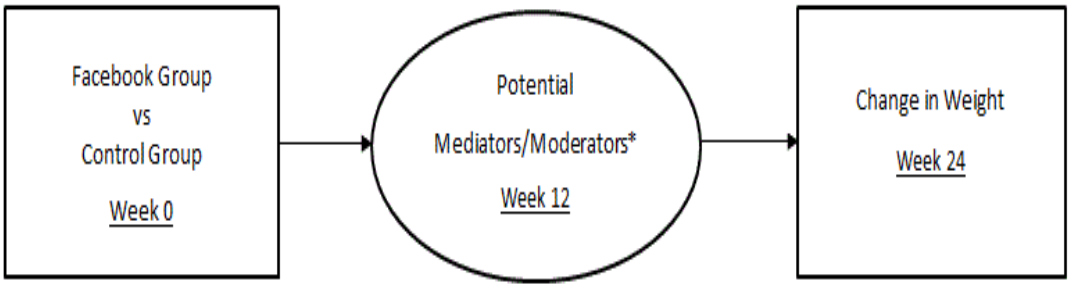

Figure 6.3 Potential behavioural mediators
*Secondary outcome measures, significant in the Facebook Group at week 12, analysed separately: protein intake; cognitive failures; insight; and dietary intentions

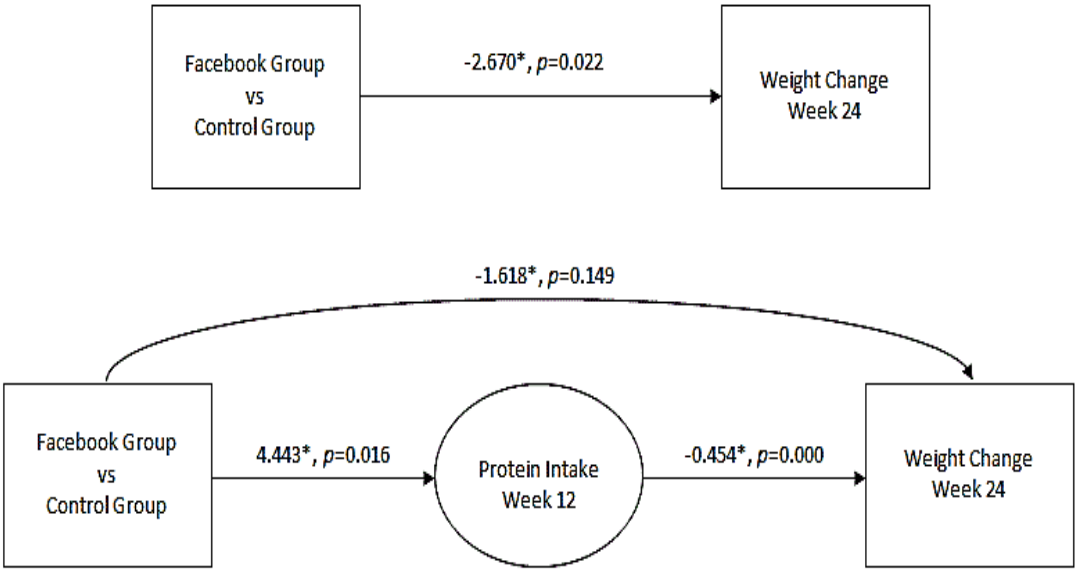

Figure 6.4 Protein intake as mediator
*Unstandardised regression coefficient

6.4 Discussion

This report outlines the results of the behavioural outcome measures collected during a clinical trial investigating the effects of a weight management program delivered to overweight and obese participants via a Facebook group, and measured changes in weight and other metabolic, dietary and physical activity risk factors. Self-reported behavioural data were collected as secondary outcome measures during the trial to identify possible mediators to the weight loss reported in the original study. Therefore the purpose of the

current analysis was to determine whether weight change in the FG was influenced by any changes to behavioural factors with the FG.

The weight results analysed in this report show that the Facebook Group experienced greater weight reduction by week 24 (p=0.016) compared to the Control Group, whereas there were no significant weight change in the Pamphlet Group. In addition, while the percentage of fat or carbohydrate intake fluctuated in all groups throughout the trial, the increase in protein intake in the FG by week 12 was the only significant macronutrient change (p=0.006) in this group. While the current study makes no firm predictions, these are meaningful results as access to the Facebook group was the only intervention component that differed between the PG and the FG. The latter finding is also important as the weight management program used in the intervention for both the PG and the FG is comparatively high in protein, and may indicate program compliance and/or dietary behaviour change, however further testing would be required to consolidate this finding.

While increasing protein intake can assist with weight loss [43, 44], this factor alone may not entirely account for the significant reduction in weight, as both the PG and the FG were following the same dietary instructions. Analysis of protein intake as a potential mediator for weight change in the FG indicated that increased protein intake may have assisted the FG with this change in weight. As the program was delivered via Facebook only for this group, this result implies a useful level of group engagement. This result may also suggests that access to the Facebook group may have promoted behaviour change or dietary compliance in some way not identified in this study (eg. as an effect of perceived support, or the notion of having to be accountable to the other group members), and provides grounds for further research in this area. It is worth noting that the dietary intake data was collected from self-reported information, therefore the use of more sophisticated dietary intake data collection, using some of the newer ICT tools (such as mobile phone apps), may clarify the issue of program compliance to a greater extent.

As can be seen, cognitive failures and insight, both significant at week 12, were eliminated at an early stage of the analysis as possible mediators to weight change in the FG. It was surprising to note that these factors - rudimentary markers of cognitive performance - were significant in the FG, as weight loss has been shown to improve cognitive functioning in obese adults [45, 46]. Another noteworthy result was that dietary intentions were

significantly reduced in the FG at week 12, however further analysis did not suggest a mediating effect on weight change with this variable. Conversely, the PG recorded significant increases in dietary intentions at weeks 12 and 24, possibly due to their relatively small non-significant weight loss outcomes. It may be that intentions do not always precede behaviour change in the manner described by the TPB [47]. Interestingly, research conducted with newly formed offline groups found that 'social intentions', as opposed to personal intentions, can be influenced by social identity and group norms [48]. Nonetheless, the significance of these three variables in the initial analysis provides matter for further investigation, particularly with a larger sample size, which may produce more telling information.

6.4.1 Strengths and limitations

This study has several strengths. Collecting behavioural data from clinical trial participants following a diet and physical activity weight management program on social media provided a comprehensive range of data for analysis. This is particularly important as participants were not given any additional behavioural strategies or instructions to guide their behaviour. In addition, there was minimal involvement from the student research coordinator, all of which was to try to isolate any possible behavioural changes resulting from Facebook group membership, and to minimise potential confounding influences. The use of GLMM analysis is another strong point in this study. Specifically, the ability of this method of statistical analysis to employ all available data, which complies with the intention-to-treat approach, preferred by CONSORT [49], and ensures the generalisability these results to the target population. At the same time, this study was not without limitations. The relatively small sample size prevented the data from being analysed using Structural Equation Modelling, which may have provided more definitive results regarding the influence of potential mediators or moderators on the overall outcomes. The use of general self-efficacy and self-control questionnaires, as opposed to 'dietary/physical activity self-efficacy' and/or 'dietary/physical activity self-control' instruments, may not have captured the specific changes taking place during the intervention.

6.5 Conclusions

The initial intention of the clinic trial was to determine if a weight management program, involving dietary and physical activity modifications, delivered within a Facebook group would result in better weight outcomes compared to the same program presented in a pamphlet or to a standard care control, in overweight and obese adults over 24 weeks. The FG recorded significant weight change by the end of the intervention, whereas the PG did not, therefore the purpose of the current study was to identify any possible mechanisms for this effect. Among the variables examined in this instance, self-reported protein intake emerged as a potential mediator to weight change, and may be a tangible indicator of program compliance and/or dietary behaviour change. However this does not imply causation, therefore further research is needed to provide a more definitive understanding of the potential mechanisms involved when using social media in weight management.

6.6 References

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CHAPTER SEVEN

REVIEW AND DISCUSSION

This discussion section draws together the significant results from the twenty four week randomised clinical trial. The first phase of the analysis was to determine the efficacy of delivering a weight management program via a Facebook group, as measured by changes in weight parameters - the primary outcome measure - and other metabolic syndrome risk factors. The second phase was to identify the potential psychological and behavioural mediators which may be responsible for the observed weight change in the Facebook Group. The strengths and limitations encountered during the course of the intervention, as well as future directions for clinical research and practice, are also discussed in this chapter.

7.1 Brief recap

The global rise of obesity, along with the search for effective weight management treatments, has been the focus of ongoing research in recent decades. Many overweight or obese individuals have difficulty with weight management [1], as enduring solutions are yet to be found. One of the health promotion strategies endorsed by the World Health Organisation is the concept of creating a supportive environment with which to enable healthful behaviour changes [2]. The results of a qualitative study found that individuals attempting weight loss have a preference for ongoing support, however finding professional help is not always affordable [3].

Contemporary health promoters are now able to take advantage of the reach and influence of internet technologies, particularly social media, to support weight management initiatives. These technologies can provide relatively cost-effective avenues for individuals to share relevant information and to give and receive peer support. As far as obesity is concerned, these examples suggest an obligation to assess the efficacy of using online social networking in the promotion of dietary and physical activity modifications for weight management in overweight and obese individuals. There is an additional need to identify the possible mechanisms operating when social media is used health promotion in general, and weight management in particular, in terms of the psychological and/or behavioural factors involved. At the time this project was conceived, there was a dearth of studies investigating the use of social media to deliver a weight management program that

included both dietary and physical activity modifications. In addition, there were no such studies examining the potential psychological and/or behavioural changes occurring as a result of incorporating an online peer support group into a clinical weight management intervention. Therefore the current intervention was structured to provide a dietary and physical activity modification program, with access to peer support via a dedicated Facebook group, and thus create a supportive environment for overweight and obese individuals attempting weight loss. The study was designed to determine the effectiveness of this intervention, conducted over a 24 week period, by evaluating changes to weight and other metabolic syndrome risk factors as well as key self-reported psychological and behavioural outcome measures.

7.1.1 Intervention

Participants were recruited from the Perth community, and randomly divided into three groups: two intervention groups, who followed a condensed version of the CSIRO Total Wellbeing Diet weight management program, and a control group. One of the intervention groups was given the program as written information in a booklet (Pamphlet Group; PG). The other intervention group received the identical program posted to a dedicated online social networking group (eg a Facebook), along with access to the other group members as peer support (Facebook Group; FG). The control group followed the Australian Dietary Guidelines and the National Physical Activity Guidelines for Adults as standard care (Control Group; CG). Data were collected from participants at clinic appointments held at weeks 0, 6, 12, 18 and 24.

7.1.2 Hypotheses

In the present study, it is hypothesised that, compared to the Control Group, the Pamphlet Group will experience moderate improvements in metabolic syndrome risk factors, including weight loss of 2% of initial body weight, over the 24 week intervention period. It was also hypothesised that, compared to the Control Group, the Facebook Group will experience greater improvements in metabolic syndrome risk factor, including weight loss of 9% of initial body weight, over the 24 week intervention period. It was further hypothesised that participants in the Facebook Group will experience greater

improvements in metabolic syndrome risk factors compared to the Pamphlet Group due to the support they receive from using Facebook.

7.2 Changes to weight and metabolic syndrome risk factors

It was hypothesised that compared to the Pamphlet Group (PG) and the Control Group (CG), the Facebook Group (FG) would record greater improvements in weight and other metabolic syndrome risk factors by the conclusion of the 24 week intervention. Specifically, the changes to weight were hypothesised to be 2% of initial body in the PG, and 9% of initial body weight in the FG, compared to the CG. The results show that the PG recorded a mean weight loss of 3.6% of initial body weight by week 24, 2.1% greater than the CG (p=0.05). The PG also had greater improvements in fasting blood glucose compared to the CG (p=0.04) and the FG (p=0.03) by the end of the intervention. Meanwhile, by week 24 the FG recorded the highest weight loss compared to the CG (p=0.01), which at 4.8% of initial body weight, did not reach the hypothesised amount. Nonetheless, by week 24, only the FG showed significant improvements in BMI (p=0.02), waist circumference (p=0.04), lean mass (p=0.03) and fat mass (p=0.01) compared to the CG.

In terms of self-reported energy intake and expenditure, the FG reported the greatest reduction in energy intake by week 24 (-1465.9 kJ/day) compared to the PG and the CG, although this reduction was not statistically significant. The between group differences in energy expenditure for all groups physical activity levels declined across the study, with few exceptions. The discrepancies between significant weight loss and no significant changes to dietary intake and energy expenditure may be due to the faulty self-reporting in diaries commonly found in weight management trials [7]. In addition, the energy expenditure results using the physical activity self-report logs are inconsistent with the increases in step counts, using a pedometer, reported in the PG and FG. Between the two intervention groups - the only groups issued with pedometers - the FG showed a higher pedometer step count compared to the PG by week 24 (+1220.4 steps), however this difference was also not statistically significant. While the FG showed greater numerical improvements in weight, BMI, waist circumference, lean and fat mass, energy intake and step counts in this study, they were not statistically significant compared to the PG as hypothesised, but was significant compared to CG.

The changes observed in the FG are noteworthy, particularly considering the relatively small sample size. Taken together, the 4.8% weight loss and decreases in BMI, waist circumference, fat mass and energy intake as well as increases in lean mass and step count recorded by the FG would be considered favourable outcomes for the individual nonetheless. In a clinical sense, 5% weight loss has been shown to provide positive changes to metabolic syndrome risk factors such as blood lipids [4, 5] and fat mass [4] in overweight or obese individuals.

Consideration should also be given to the fact that the intervention was conducted across a Christmas/New Year or holiday season, and that dietary intake and physical activity may have been impacted by social commitments and the overindulgence common during such a time. In addition, this period may have been a particularly unfavourable to the FG, as they may have spent less time online seeking information and support, due to increased offline social engagements. The outcome measures data collected at week 12 - the corresponding time period of Christmas/New Year - shows very few statistically significant results overall and seems to support one or more of these suppositions above. However the outcomes of a weight management trial conducted over a socially busy time may better reflect real world circumstances than study which used fabricated conditions to avoid such occasions. Furthermore, participants were randomly allocated to the Facebook Group, so any indifferent social media users in the FG may have been less active within the group, and therefore may not have benefited as much as the more proactive group members.

7.3 Psychological wellbeing

The between groups differences in weight loss found in the initial analysis were supported when the analysis was conducted to determine a Group by Time effect and relative to baseline. Specifically, the FG reported a greater weight change by week 24 (p=0.016), while the change in the PG was not significant, compared to the CG. This is an important finding for two reasons. First, participants in the PG were following an identical dietary and physical activity modification program. Second, this result dictated the nature of the mediation analysis, conducted with the psychological outcome measures (significant in the FG at week 12), and used to identify possible causal pathways that may be responsible for the change in the weight registered in the FG. The secondary outcome measures examined in this analysis were self-reported such as energy intake and energy expenditure, as well as

the questionnaire domains quality of life, overall health, physical health, psychological health, social relationships, environment, depression, anxiety, stress, happiness, health anxiety and emotional eating, as indicators of psychological wellbeing.

The first stage of this analysis shows that, compared to the CG, participants in both the FG and the PG recorded beneficial changes to self-reported psychological wellbeing during the intervention. While the FG showed a significant improvement in psychological health at week 12 (p=0.022), the PG also showed significant improvements in this measure (p=0.008), along with significant changes to physical health (p=0.001) and quality of life (p=0.017) at this time. By week 24, participants in the FG reported improvements to their overall quality of life (p=0.002), health (p=0.018), and social relationships (p=0.048), however participants in the PG also posted significant improvements in these measures (p=0.000, 0.045 and 0.027 respectively), and in psychological health (p=0.004) as well as in health anxiety (p=0.019).

As psychological health was the only outcome measure that showed a significant improvement during the trial for the FG (eg. at week 12) compared to the CG, mediation analysis was conducted with this outcome measure. This analysis was to determine whether the improvement in self-reported psychological health may have assisted with the significant change in weight found in the FG at week 24. However this variable was eliminated at an early stage of the multi-step process, therefore no potential mediators were identified among the psychological variables. There are several possible explanations for this result. The FG participants in this particular study may have been satisfied with the weight management support they received from members of their social offline networks. One study reported that patients in online support groups preferred to interact with other group members if support from their offline social network was inadequate [6]. It may be that 24 weeks is not long enough for ties between group members to strengthen to the extent that support received from them would improve psychological well-being. There is evidence to suggest that well-being is enhanced when the online support is provided by stronger ties instead of weaker ties [7].

While the PG appeared to experience greater improvements in psychological outcomes during the intervention, the weight reduction in this group was not significant, which suggests that the weight management program alone may not have been responsible the

significant reduction in the FG. Though the reduction in weight in the FG may not have been assisted by improved psychological health, the result suggests that one or more elements of the intervention provided an advantage lacking for the PG.

7.4 Behavioural factors

The significant difference in weight found in the FG compared to the CG (discussed in the above section) similarly determined the analytical methods used for the self-reported behavioural outcome measures, also assessed in this study. In other words, the between group differences in behavioural outcomes were initially analysed relative to baseline and compared to the CG. Significant results at week 12 in the FG were then examined using mediation analysis to identify any possible associations among the behavioural outcome measures. In addition to weight, the variables examined in this analysis included step counts (PG vs. FG only), fat, carbohydrate and protein intake, as well as the questionnaire items self-control, self-efficacy, cognitive failures, competence, ingenuity, insight, initiative, cognitive restraint, uncontrolled eating, emotional eating, dietary and physical activity intentions, as indicators of behaviour change.

Among the changes to macronutrient intake, increased protein intake in the FG at week 12 was the only significant result (p=0.006). However, the FG showed a significant increase in cognitive failures at week 12 (p=0.007), and a reduction in insight significant at week 12 (p=0.020), while the PG and CG recorded increases in these measures. Significant increases in dietary intentions were also found in both the PG and FG at week 12 (p=0.001 and 0.034, respectively), and at week 24 in the PG only (p=0.016).

The significant difference in results between the FG and the CG at week 12 (eg. during the intervention) were used in the analysis to determine potential mediators to the difference in weight posted in the FG at week 24. Therefore this analysis examined protein intake, cognitive failures, insight and dietary intentions. Cognitive failures, insight and dietary intentions were eliminated from the analysis at an early stage in the analysis. However change in protein intake was found to be a potential mediator to weight reduction in the FG, suggests that increased protein intake may have augmented the weight loss recorded in the FG at week 24. While it is worth noting that higher protein intake can improve weight

loss outcomes [8, 9], this factor may not be solely responsible for the significant reduction in weight, as both the PG and the FG were following the same weight management program.

This finding is also noteworthy as the weight management program used in the intervention in the PG and the FG is comparatively high in protein, and suggests that Facebook group access - the only intervention component to differ between the PG and the FG - may have had a positive influence on dietary behaviour change and/or dietary compliance in some way yet to be identified. Furthermore, as these data were collected via self-report, further research using more sophisticated data collection instruments is required to confirm these findings.

7.5 The Facebook Group - within group differences

A separate chapter devoted to the within group analysis of the activity within the Facebook Group was intended, based on metrics from within the Facebook Group. However the Facebook data extraction software currently available, which would have provided the metrics, is only able to access data from the site that is publicly available. The Facebook group has very strict privacy settings keeping the group members and their activities within the group hidden from the public domain. Participants consented to enroll in this trial on that basis, which in addition, satisfies the confidentiality requirements stated by the Curtin University HREC. Therefore this data cannot be accessed. The remaining data from this group consists of a self-reported Social Media Survey. The data from this survey was not intended to be examined on its own, but in relation to the Facebook activity data referred to above, as well as the within group differences in weight.

The Social Media Survey contains two sections. The first section relates to the frequency of social media usage, whereby participants were required to select from a list of responses ranging from 'more than once daily' to 'not at all'. A high score in this section indicates a greater amount of general online social networking activity. The second section requests participants to rate their opinions of social media with statements such as 'Social media is a good way to share information' and 'Social media fills a gap in my offline social network', using a five-point Likert scale. A high score in this section indicates a

higher opinion of social media overall. These measurements were collected at baseline and at weeks 12 and 24.

Analysis of the within group differences in weight (using GLMM) shows significant within group reductions at both weeks 12 and 24, compared to the baseline measurement ($p<0.001$, at both times). Frequency of social media usage shows an increase at both time points, significant only at week 12 ($p=0.014$), however Facebook Group participants' opinion of social media did not differ significantly. (See Table 7.1 Within group differences in weight and self-reported social media usage and opinion data, below.) As the Social Media Survey refers to participants' usage and opinions of all online social networking sites in general, it is not appropriate to conduct mediation analysis with the significant week 12 usage result, with the intention of establishing a relationship between actual Facebook group usage and change in weight at week 24. Therefore, based on this data it is not possible to draw any firm conclusions regarding the effect of Facebook as a delivery method for a weight management program. Unfortunately, whether analysis of the actual Facebook group usage data (metrics) would result in significant within group improvements will remain unclear in the present study.

Table 7.1 Within group differences in weight with social media usage and opinion data

	Baseline			Week 12				Week 24			
	Mean	**SEM**	**n**	**Mean**	**SEM**	***p* value**	**n**	**Mean**	**SEM**	***p* value**	**n**
Weight	88.2	2.5	33	86.2	3.7	<0.001	22	83.6	4.1	<0.001	19
Usage	3.9	0.3	27	4.9	0.1	0.014	16	4.3	0.4	0.056	17
Opinion	46.1	1.2	30	47.6	1.1	0.347	19	45.3	1.5	0.489	19

SEM refers to standard error of the mean; *n* refers to participant number

7.6 Further comments

The timing of the current intervention requires further comment. Anecdotal information (eg. verbal communications) revealed that some participants found it difficult to maintain their commitment the weight management program during the festive season. This is not uncommon for individuals to attend a greater number of social engagements at this time, with the central focus the consumption of food and alcoholic beverages [10-12]. In

addition, the data collected in this study show that FG participants' engagement within the group was not overly strong to begin with, and declined somewhat by the end of the 24-week period (see Chapters 5 and 6). It is possible that this group may not have considered their virtual (Facebook) 'friends' as actual friends.

Another factor to be considered is the cost-effectiveness of the current online intervention. In-depth economic analysis of online interventions has previously demonstrated the cost-effectiveness of using this method for weight management [13, 14]. The current intervention was created and presented to participants without any financial assistance, aside from the essential facilities provided by the university, so costs needed to be kept to a minimum. Fortunately the financial outlay for this intervention was modest. The images and information used in the weight management program were sourced from the two Total Wellbeing Diet eBooks (referred to in Chapter 2), and currently retail for AU$19.99 each [15]; in practice this cost would likely be borne by the health professional or organisation. The pedometers used - G-Sensor 2025 Acceleromotor - currently retail at AU$22.95 each [16]; in practice this cost may be borne by the patient. The food recommended within the weight management program was regular grocery items and the cost borne by the participant, as is likely the case for patients in health practice. With respect to the time commitment involved, the initial set-up (eg. sourcing materials, transferring the program to the online format, and instructing participants) was the greatest, and amounted to the equivalent of approximately one week of full-time employment. The ongoing maintenance of the Facebook group, with minimal interaction from the student research coordinator, amounted to approximately 2 to 3 hours per week. In practice, this latter time commitment may vary, depending on the preferred level of health professional engagement. Overall, the online intervention used in the current study required a small investment of time and capital to reach overweight/obese participants.

7.7 Strengths

This study has a number of strengths. At the time the study protocol was developed, no other study in the area of weight management had conducted a clinical trial to examine the effects of providing dietary and physical activity guidelines within a dedicated online social networking group to overweight and obese individuals. In addition, the current study collected weight and other metabolic syndrome risk factor outcome measures along with

psychometric outcome measures - to assess changes to psychological wellbeing and behavioural factors - adding further originality to the design. The inclusion of psychometric outcome measures added depth and substance to the conventional clinical weight management trial design, and was to identify any possible psychological and/or behavioural influences resulting from Facebook group membership, especially important in the absence of any counselling or additional behaviour change instructions. Furthermore, the use of the GLMM method of statistical analysis and its capacity to utilise all available data - rather than replace or eliminate missing data - allows these results of to be generalisable to the target population.

7.8 Limitations

While these results suggest that online social networking has the capacity to assist overweight and obese individuals with weight management, this study has several limitations. The smaller than expected sample size may have limited the ability of this study to produce any further statistically significant results. The volume of data collected, together with the necessity of making dietary and physical activity modifications, may have increased participant burden, possibly causing the higher than expected participant attrition [17]. The inability to access the Facebook Group metrics somewhat reduced the depth of the data obtained from this group. These factors not only limited to the analysis for between group differences, but it also prevented further analysis using Structural Equation Modelling, which is the preferred method for the identification of mediators. This in particular made it difficult to draw definite conclusions regarding the effect of Facebook as a delivery method for weight management.

As participants in this trial were randomly allocated to one of the three groups, it is possible that some participants in the FG may not have been proficient social media users, and either less inclined to interact with other members online, or require more training or encouragement. In order not to introduce any bias or other confounders by way of advantage to the FG members, the student research coordinator had minimal interactions within the FG. While both of these strategies are necessary in terms of randomised controlled trials, either one of these points (or both together) may have moderated participant engagement and/or blunted the results to some degree. Engagement of participants may have increased if the study co-ordinator had a more active role but this

can be investigated in future studies. Furthermore, anecdotal information indicates that between weeks 12 and 24, as many six FG participants had sourced hard copies of the Total Wellbeing Diet book, which may have reduced the need for these participants to refer to the Facebook group for recipes and so on, and thus reduced their engagement with the group.

The Christmas and New Year or holiday season occurred during the clinical trial period, representing barriers to dietary and/or physical activity behaviour change faced in real world scenarios, as discussed. Nonetheless, it may have been an inopportune time to collect data regarding the use of Facebook, as FG participants may have spent less time online, due to holiday season social engagements with their families and friends, and therefore some of the results in this group may have been blunted. In addition, some of the data collection instruments used in this study warrant further thought. The use of general self-efficacy and self-control questionnaires, instead of dedicated 'dietary/physical activity self-efficacy' and 'dietary/physical activity self-control' questionnaires, may not have adequately recorded any changes in these outcomes specific to weight management interventions. Furthermore, as self-reported questionnaires are not as rigorous as using objective data collection measures, it is likely that some degree of bias may have had an influence on these particular results.

7.9 Significance

In summary, the results of this study will add to the burgeoning body of knowledge regarding interactive online health promotion methods. As the FG posted the greatest numerical weight loss compared to the other two groups, these findings demonstrate the potential of using social media for weight management to assist overweight and obese individuals. This is particularly noteworthy as online social networking has several clinical applications: it has the capacity reach large and/or geographically disparate groups, wherever the infrastructure is in place; patients can then access the information and peer support in their own time and place, with any internet-enabled device; it could give health professionals the ability to manage large case-loads, in a relatively small amount of time; it could allow health care professionals to generate peer support networks for patients following weight management programs, especially for the socially or geographically isolated or whose access to health care workers is limited; compared to other labour-

intensive behavioural weight management strategies, it would be a low maintenance resource to use in weight management; and finally most social networking platforms are free to use, so it would be cost-effective, and therefore more accessible in real world settings than other resources or services. While the results are encouraging, this study highlights a compelling need for a greater understanding of the barriers faced by overweight and obese individuals undergoing weight management during socially difficult times or occasions, and how to overcome them. Therefore the main significance of these findings lies in their implications for future research.

7.10 Implications for future research

Using online social networking for health promotion and particularly weight management is an emerging area of scientific investigation. According to the literature, no other study has examined using social media for weight management in this way, ie. including dietary and physical activity modifications, and collecting clinical measurements (weight and metabolic syndrome risk factors), as well as psychometric outcome measures, to identify possible psychological and/or behavioural mechanisms to the changes recorded. This trial shows that more research is needed to gain a better understanding of the apparent complexities involved in applying this resource to weight management, such as catering for the needs of - and the difficulties faced by - overweight and obese individuals. Future research will benefit greatly from the lessons learned during this study.

With respect to participant retention, future trials involving social media in this way may benefit from: allocating participants to either the 'treatment only group' or the 'treatment program with an online social group' according to their preference, as this may reflect how this resource would be applied in a clinical setting; participants identified as socially active or social media savvy could be given leadership roles within the group to encourage group activity or engagement; allowing participants the time to get to know each other better beforehand or enrol with one or more friends or be recruited from established clubs or community groups; or set tasks for them to do as a group to help strengthen ties. Furthermore, future trials may benefit from varying group size, or targeting participants in certain age groups. For example, smaller groups may facilitate greater familiarity between group members within the given timeframe, whereas larger groups may provide greater

diversity among members, and supply different skills and knowledge; those of similar age may be able to relate to each better.

From a research design perspective the evidence gathered may benefit from: the use of more sophisticated data collection methods, particularly for dietary intake and energy expenditure, and in place of self-reported psychometric measures; using more objective data collection methods may also reduce the need for a large amount of secondary outcome measures to identify underlying mechanisms (and help diminish participant burden); accommodating food-related social events within the intervention program (e.g. Christmas, Passover, Ramadan, birthdays, New Year); and depending on the recruitment of a relatively large sample size (or how well participant retention is managed), the use of Structural Equation Modelling to clearly identify the mediators or mechanisms facilitating changes evinced in such interventions.

7.11 Conclusions

In the current study, a mean weight loss of 4.8% of initial body weight was found in the FG along with improvements in waist circumference, lean mass and fat mass, statistically significant compared to the Control Group by the end of the 24 week intervention. As already noted, a mean weight loss of 5% of total body weight can result in clinically meaningful changes in overweight and obese individuals. The Facebook Group also posted numerically greater improvements by in these measures as well as step counts compared to the PG, by the conclusion of the trial. Further analysis identified increased protein intake in the Facebook Group, significant compared to the Control Group at week 12, as a potential mediator to weight loss in the Facebook Group. This result may be an indicator of behaviour change and/or intervention adherence in this group.

Research using social media to promote weight management is relatively new; however these results illustrate the potential advantages of using online social networking groups to support overweight and obese individuals with a dietary and physical activity weight management program, and justify continued investigation in this area. Further research is needed to clarify the psychological and behavioural aspects of using online social networking, to enable health professionals to maximise the benefits of using it as a

resource for overweight and obese individuals making dietary and physical activity modifications for weight management.

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APPENDIX 1: ETHICS APPROVAL AND AMENDMENTS

Curtin University

Memorandum

To	A/Professor Sebely Pal, Public Health
From	Professor Peter O'Leary, Chair Human Research Ethics Committee
Subject	Protocol Approval **HR 90/2014**
Date	27 May 2014
Copy	Ms Monica Jane Public Health Professor Martin Hagger, Psychology Public Health

Office of Research and Development
Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for providing the additional information for the project titled "*Using New Technologies to Promote Weight Management*". The information you have provided has satisfactorily addressed the queries raised by the Committee. Your application is now **approved**.

- You have ethics clearance to undertake the research as stated in your proposal.
- The approval number for your project is **HR 90/2014.** *Please quote this number in any future correspondence*.
- Approval of this project is for a period of four years **27-05-2014** to **27-05-2018**.
- Your approval has the following conditions:
  i) Annual progress reports on the project must be submitted to the Ethics Office.
- **It is your responsibility, as the researcher, to meet the conditions outlined above and to retain the necessary records demonstrating that these have been completed.**

Applicants should note the following:

It is the policy of the HREC to conduct random audits on a percentage of approved projects. These audits may be conducted at any time after the project starts. In cases where the HREC considers that there may be a risk of adverse events, or where participants may be especially vulnerable, the HREC may request the chief investigator to provide an outcomes report, including information on follow-up of participants.

The attached **Progress Report** should be completed and returned to the Secretary, HREC, C/- Office of Research & Development annually.

Our website https://research.curtin.edu.au/guides/ethics/non_low_risk_hrec_forms.cfm contains all other relevant forms including:

- Completion Report (to be completed when a project has ceased)
- Amendment Request (to be completed at any time changes/amendments occur)
- Adverse Event Notification Form (If a serious or unexpected adverse event occurs)

Yours sincerely

Professor Peter O'Leary
Chair Human Research Ethics Committee

Curtin University

Memorandum

To	A/Professor Sebely Pal, Public Health
From	Professor Peter O'Leary, Chair Human Research Ethics Committee
Subject	Protocol Amendment Approval **HR 90/2014**
Date	1 October 2014
Copy	Ms Monica Jane, Public Health Professor Martin Hagger, Psychology

Office of Research and Development
Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your progress report, indicating modifications / changes, for the project *"Using New Technologies to Promote Weight Management"*. Your application has been ***approved***.

The Committee notes the following amendments have been approved:

1. Instead of using the International Physical Activity Questionnaire to measure changes in the physical activity levels of studt participants, I would like to use Bouchard's Physical Activity Record for this.

Approval for this project remains until **27-05-2018.**

Your approval number remains **HR 90/2014,** please quote this number in any further correspondence regarding this project.

Yours sincerely

Professor Peter O'Leary
Chair Human Research Ethics Committee

Curtin University

Memorandum

To	A/Professor Sebely Pal, Public Health
From	A/Prof Clare Rees, Deputy Chair Human Research Ethics Committee
Subject	Protocol Amendment Approval **HR 90/2014**
Date	26 November 2014
Copy	Ms Monica Jane, Public Health Professor Martin Hagger, Psychology, Public Health

Office of Research and Development
Human Research Ethics Committee

TELEPHONE 9266 2784
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EMAIL hrec@curtin.edu.au

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your progress report, indicating modifications / changes, for the project *"Using New Technologies to Promote Weight Management"*. Your application has been ***approved***.

The Committee notes the following amendments have been approved:

1. Remove the three-day salivary cortisol self-collection measure from the study protocol completely.
2. Add the Personality and Individual Differences Questionnaire.
3. To extend the intervention period from a 12 weeks intervention with a 12-week follow-up period (as originally approved) to a 24 week intervention.
4. To include one extra data collection time point within the 24 week intervention period, which will increase the number of participant clinic appointments from 4 to 5 for the duration of the trial (eg every 6 weeks). The proposed data collection schedule will be as follows: weeks 0, 6, 12, 18 and 24 (instead of weeks 0, 6, 12 and 24 as previously approved).

Approval for this project remains until **27-05-2018.**

Your approval number remains **HR 90/2014,** please quote this number in any further correspondence regarding this project.

Yours sincerely

A/Prof Clare Rees
Deputy Chair Human Research Ethics Committee

APPENDIX 2: PARTICIPANT INFORMATION SESSIONS

Participant information sessions were held after recruitment, and consist of three separate information sessions for the different groups, as follows:

The Control Group

Participants in the Control Group were instructed to follow the Australian Dietary Guidelines together with the National Physical Activity Guidelines for Adults. Also included in this session were the schedule of clinic and pathology appointments, including the outcome measurements collected, the instructions for a completing the Three-Day Food Record, the Three-Day Physical Activity Record, as well as the questionnaires. The dietary and physical activity guidelines were given to participants at the end of their first appointment. This was to ensure that participants did not begin the intervention before baseline measurements are collected.

The Pamphlet Group

Participants in the Pamphlet Group were instructed to follow the CSIRO Total Wellbeing Diet, which they received in booklet form along with a weekly checklist. Also explained at this session were the schedule of clinic and pathology appointments, including the outcome measurements collected, the instructions for a completing the Three-Day Food Record, the Three-Day Physical Activity Record, as well as the questionnaires. Participants were supplied pedometers at this session; however participants were given the booklet at the end of their first appointment. This was to ensure that participants did not begin the intervention before baseline measurements are collected.

The Facebook Group

The Facebook Group were instructed to follow The CSIRO Total Wellbeing Diet, which was posted to a dedicated group on Facebook, with the privacy settings set to 'secret', and consisted of snapshots of all of the information from the booklet given to the Pamphlet Group, so that both the Facebook Group and the Pamphlet Group received identical information, as well as given the weekly checklists. Also explained at this session will be the schedule of clinic and pathology appointments, including the outcome measurements

collected, the instructions for a completing the Three-Day Food Record, the Three-Day Physical Activity Record as well as the questionnaires. Participants were supplied pedometers at this session; however participants were added to the group on Facebook after of their first appointment. This was to ensure that participants dis not begin the intervention before baseline measurements are collected.

In addition, Facebook Group participants were shown how to use the Facebook Group, as well as how to interact with other group members (for example sharing recipes, how they are integrating the program in the daily lives, forming walking groups, inspiring and motivating other, posting before and after pic of themselves, congratulating others for their successes, problem solving etc), and were then invited to join the closed Facebook Group.

All groups

At the conclusion of each participant information session, participants were invited to ask questions, or raise any concerns that they may have.

APPENDIX 3: WEIGHT MANAGEMENT PROGRAM IN THE FACEBOOK GROUP

The student research coordinator was the administrator and facilitator of the Facebook Group. The group facilitator spent two hours per week monitoring the Facebook site. Participants were advised that the facilitator was have a presence within the site, and monitored posts to make sure that they fall within the guidelines specified at the Participant Information Session and stated in hard copy on the Participant Information Sheet.

After all of the participants had joined the Facebook Group, snapshots of the entire weight management program used in the booklet were posted to the Facebook Group as photos in a series of photo albums. This was to save participants the trouble of scrolling through the more recent posts and comments, added over time, to review the program when needed. Being able to easily access the program provided participants in this group the same advantage as the Pamphlet Group, who were able to read and review the program in hard copy at their leisure.

To stimulate discussion between Facebook Group members a list of general questions was created. Twice a week, the facilitator posted one of the questions from the list to the group's wall. Examples of the types of questions to be posted include: 'Does anyone have a favourite recipe based on the program that they would like to share with the group?' And, 'what is a good way to incorporate thirty minutes of moderate physical activity into the day?' Without directly telling the participant what to do on the Facebook site, it is hoped that this minimal facilitation helped spontaneous discussions begin to take place during the course of the 24-week intervention period as well.

Participants using Facebook were instructed to be polite in their interactions with other members, and never to say anything that may embarrass other members, or clutter up the newsfeed with trivial information like 'Sitting down for my morning coffee'. They were instructed to post their thoughts on the weight management program and how they were integrating it into their lives, any achievements brought about by using the program, or ask for assistance from group members if they encountered a problem. Participants in this group were instructed to offer praise and encouragement for the achievements of others, offer useful tips, form walking groups, post recipes or motivational quotes. It was made

extremely clear to the participants using Facebook that this group was in place to provide a friendly and supportive environment for all members.

The Facebook Group facilitator also monitored the comments posted by the group daily, in order to act swiftly on any negative comments or erroneous statements posted on the group's wall with an appropriate response or correction. In the event of an offensive comment, the facilitator was to remove the post immediately, and contact the offending participant privately. If the issue could not be resolved or there was a repetition of the offence, the offending participant was to be removed from the group, and take no further part in the project.

Privacy

The Facebook Group was set as a 'Secret Group', whereby only group members could see the group, who was in it and what members posted. In addition, the group's administrator (student research coordinator) was the only member to grant approval to new members. (These settings are features provided by Facebook.) These precautions were taken to provide a discreet online environment for the participants in the Facebook Group, and also to ensure that no-one else can see or join this group.

APPENDIX 4: ORIGINAL SCHEDULE OF OUTCOME MEASURES

Measurement	Week 0			Week 6			Week 12			Week 24		
by Group	CG	PG	FG	CG	PG	FG	CG	PG	FG	CG	PG	FG
3-Day Food Record	•	•	•	•	•	•	•	•	•	•	•	•
International Physical Activity Questionnaire	•	•	•	•	•	•	•	•	•	•	•	•
Three Factor Eating Questionnaire	•	•	•	•	•	•	•	•	•	•	•	•
Self-Efficacy Scale	•	•	•	•	•	•	•	•	•	•	•	•
WHO Quality of Life	•	•	•	•	•	•	•	•	•	•	•	•
Depression Anxiety Stress Scale	•	•	•	•	•	•	•	•	•	•	•	•
Self-Control (Brief) Scale	•	•	•	•	•	•	•	•	•	•	•	•
Diet & Physical Activity Survey	•	•	•	•	•	•	•	•	•	•	•	•
Survey of Weight Management Program				•	•	•	•	•	•			
Social Media Survey			•			•			•			•
Facebook intensity & Network Density Scales						•			•			•
Height	•	•	•									
Weight	•	•	•	•	•	•	•	•	•	•	•	•
Blood pressure	•	•	•	•	•	•	•	•	•	•	•	•
Arterial stiffness	•	•	•	•	•	•	•	•	•	•	•	•
Blood glucose	•	•	•	•	•	•	•	•	•	•	•	•
Waist circumference	•	•	•	•	•	•	•	•	•	•	•	•
Hip circumference	•	•	•	•	•	•	•	•	•	•	•	•
Body Composition	•	•	•	•	•	•	•	•	•	•	•	•
Blood lipids	•	•	•				•	•	•			
Blood insulin	•	•	•				•	•	•			

APPENDIX 5: COPYRIGHT PERMISSIONS

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Jane M, Foster J, Hagger M, Pal S. Using new technologies to promote weight management: a randomised controlled trial study protocol. BMC Public Health. 2015;15:509.

Jane M, Foster J, Hagger M, Kane R, Ho S, Pal S. Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: A randomised controlled trial. 2017.

APPENDIX 6: CO-AUTHOR STATEMENTS

14 August 2017

To Whom It May Concern

Please note the following six signed Co-Author Statements, relating to papers published as well as papers submitted for publication.

1)

I, *Monica Jane*, contributed 80% to the paper/publication entitled:

Jane M, Hagger M, Foster J, Ho, S, Pal S. New technologies for health promotion and weight management: a review. 2017. Unpublished. Submitted to *BMC Public Health.*

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Associate Professor Sebely Pal

John Curtin Distinguished Professor Martin Hagger

Professor Jonathan Foster

Dr Suleen Ho

2)

I, *Monica Jane*, contributed 80% to the publication entitled:

Jane M, Foster J, Hagger M, Pal S. Using new technologies to promote weight management: A randomised controlled trial study protocol. *BMC Public Health*. 2015;15:509.

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Associate Professor Sebely Pal

John Curtin Distinguished Professor Martin Hagger

Professor Jonathan Foster

3)

I, *Monica Jane*, contributed 75% to the publication entitled:

Jane M, Hagger M, Foster J, Kane R, Ho S, Pal S. Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: a randomised controlled trial. 2017 Published in *PLoS ONE*.

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Associate Professor Sebely Pal

John Curtin Distinguished Professor Martin Hagger

Professor Jonathan Foster

Dr Robert Kane

Dr Suleen Ho

4)

I, *Monica Jane*, contributed 75% to the paper/publication entitled

Jane M, Foster J, Hagger M, Kane R, Ho S, Pal S. Psychological effects of belonging to a Facebook weight management group in overweight and obese adults: Results of a randomised controlled trial. 2017. Unpublished. Submitted to *Health and Social Care in the Community*.

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Associate Professor Sebely Pal

John Curtin Distinguished Professor Martin Hagger

Professor Jonathan Foster

Dr Robert Kane

Dr Suleen Ho

5)

I, *Monica Jane*, contributed 75% to the paper/publication entitled

Jane M, Hagger M, Foster J, Kane R, Ho S, Pal S. Behavioural effects of belonging to a Facebook weight management group in overweight and obese adults: Results of a randomised controlled trial. 2017. Unpublished. Submitted to *Health Education and Behavior*.

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Associate Professor Sebely Pal

John Curtin Distinguished Professor Martin Hagger

Professor Jonathan Foster

Dr Robert Kane

Dr Suleen Ho

6)

I, *Monica Jane*, contributed 70% to the paper/publication entitled

Jane M, J McKay, Pal S. Effects of Daily Consumption of Psyllium, Oat Bran and PolyGlycopleX® on Obesity-Related Disease Risk Factors: A Review. 2017. Unpublished. Submitted to *Advances in Nutrition*.

Monica Jane

I, as a Co-Author, endorse that this level of contribution by the candidate indicated above is appropriate.

Assoc. Prof Sebely Pal

Ms Jenny McKay

Please note that while this paper is in a related field, it is not included as a part of this thesis.

APPENDIX 7: STUDY PROTOCOL PAPER

Jane M, Foster J, Hagger M, Pal S: Using new technologies to promote weight management: a randomised controlled trial study protocol. *BMC Public Health*. 2015, 15:509.

Jane et al. BMC Public Health (2015) 15:509
DOI 10.1186/s12889-015-1849-4

BMC Public Health

STUDY PROTOCOL Open Access

Using new technologies to promote weight management: a randomised controlled trial study protocol

Monica Jane[1], Jonathan Foster[2], Martin Hagger[2] and Sebely Pal[1*]

Abstract

Background: Over the last three decades, overweight and obesity and the associated health consequences have become global public health priorities. Methods that have been tried to address this problem have not had the desired impact, suggesting that other approaches need to be considered. One of the lessons learned throughout these attempts is that permanent weight loss requires sustained dietary and lifestyle changes, yet adherence to weight management programs has often been noted as one of the biggest challenges. This trial aims to address this issue by examining whether social media, as a potential health promotion tool, will improve adherence to a weight management program. To test the effectiveness of this measure, the designated program will be delivered via the popular social networking site Facebook, and compared to a standard delivery method that provides exactly the same content but which is communicated through a pamphlet. The trial will be conducted over a period of twelve weeks, with a twelve week follow-up. Although weight loss is expected, this study will specifically investigate the effectiveness of social media as a program delivery method. The program utilised will be one that has already been proven to achieve weight loss, namely *The CSIRO Total Wellbeing Diet*.

Methods/design: This project will be conducted as a 3-arm randomised controlled trial. One hundred and twenty participants will be recruited from the Perth community, and will be randomly assigned to one of the following three groups: the Facebook group, the pamphlet group, or a control group. The Facebook Group will receive the weight management program delivered via a closed group in Facebook, the Pamphlet Group will be given the same weight management program presented in a booklet, and the Control Group will follow the Australian Dietary Guidelines and the National Physical Activity Guidelines for Adults as usual care. Change in weight, body composition and waist circumference will be initial indicators of adherence to the program. Secondary outcome measures will be blood glucose, insulin, blood pressure, arterial stiffness, physical activity, eating behaviour, mental well-being (stress, anxiety, and depression), social support, self-control, self-efficacy, Facebook activity, and program evaluation.

Discussion: It is expected that this trial will support the use of social media - a source of social support and information sharing - as a delivery method for weight management programs, enhancing the reduction in weight expected from dietary and physical activity changes. Facebook is a popular, easy to access and cost-effective online platform that can be used to assist the formation of social groups, and could be translated into health promotion practice relatively easily. It is anticipated in the context of the predicted findings that social media will provide an invaluable resource for health professionals and patients alike.

(Continued on next page)

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(Continued from previous page)

Trial registration: Australian New Zealand Clinical Trials Register (ANZCTR): ACTRN12614000536662. Date registered: 21 May 2014.

Keywords: Overweight, Obesity, Weight management, Social media, Facebook, Health promotion, Dietary intake, Physical activity, Social support, Total Wellbeing Diet

Background

World-wide rates of overweight and obesity continue to rise, despite the growing awareness of the importance of this issue in recent years among health professionals [1–4] as well as the general public [5]. Indeed, there is a widespread lack of acceptance of obesity in the general community, perhaps relating more to the physical appearance of people with obesity rather than the associated health risks [5, 6]. It is also well-established that being socioeconomically disadvantaged increases the risk of overweight and obesity [7]. The health consequences of excessive weight gain include an increased risk of the metabolic syndrome, and such chronic diseases as diabetes, cardiovascular disease, obstructive sleep apnoea and some cancers, all potentially leading to increased mortality [2, 4]. The psychosocial consequences of obesity include stigmatisation in the workplace, compromised health care and personal relationships [5, 8] and reduced quality of life [4, 8].

A review of the relevant literature has revealed that an energy-restricted, low fat, high protein diet assists with weight loss [9, 10] and the reduction of cardiometabolic risk factors [11]. It also increases satiety [12], which is an important factor in dietary compliance [13], and assists with weight loss maintenance [12]. Increasing physical activity has also been shown to improve cardiometabolic risk factors in both short and long- term trials [14, 15]. According to the National Physical Activity Guidelines for Adults, thirty minutes of moderate physical activity (preferably taken every day) is required to promote health [16].

The CSIRO Total Wellbeing Diet (TWD), developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [17], is an energy-reduced, low fat, higher protein diet that meets the Australian nutrient reference values for daily intake [18], promotes a minimum thirty minutes of moderate physical activity per day, and has been extensively researched [9, 11, 19, 20]. In Book 2 of the TWD, the use of a pedometer is recommended to help individuals meet the suggested physical activity target [17]. Pal et al. have shown that setting a goal of 10,000 steps per day results in greater improvements to physical activity levels than the 30-min-a-day target [21]. This weight management program, along with the support of a dietitian, has been shown to cause significant improvements in cardiovascular disease risk biomarkers in overweight and obese individuals and weight loss of up to 10 kg after twelve weeks [11, 20]. However a mean weight loss of 5 kg has been reported by individuals following the TWD Book alone [22].

While weight loss can reduce the health risks associated with obesity [12, 23], many dieters have difficulty adhering to weight loss programs [24] or maintaining long-term weight loss [12, 23]. This can contribute to a sense of personal failure [6]. However, the lack of successful long-term weight loss in overweight and obese individuals may be due to the format of the weight management programs, such that dietary and lifestyle recommendations alone may not be enough [8]. In fact, the high attrition rate and/or weight regain after initial weight loss is so common that many researchers have tried to address this key issue by also adding other components to the treatment or intervention [22]. For example cognitive behavioural therapy, group support sessions, frequent medical or clinical appointments with health professionals and dietary supplements are additional strategies that have been included in some weight management programs or trials [4, 7, 25]. Research indicates that a multifactorial approach is likely to be optimal in achieving clinically meaningful weight loss results [22].

Another factor that is frequently overlooked in identifying adequate treatment for overweight and obesity is cost effectiveness [26]. If the socioeconomically disadvantaged are some of the worst affected in the obesity epidemic, then some of the more expensive commercially available weight loss programs (such as Weight Watchers™) [7] or strategies will probably not be an option for them. However, the evidence suggests that some form of social support yields better weight loss results than 'going it alone' [6]. It has also been clearly established that individuals can expect better health outcomes if they are well supported in a social sense [27, 28]. However, many individuals attempting weight loss don't always receive the required social support for a variety of reasons [28].

Advances in internet communication technology in recent years have added another vehicle for the delivery of health promotion material, including weight loss programs. According to recent survey data, 99 % of Australian households have internet access, 69 % of Australians use social media and 95 % of these social media users have a Facebook account [29]. Almost 99 % of the population is covered by a mobile cellular network and there are 102.8 mobile cellular subscriptions for every 100 Australians [30]. This offers health promoters the opportunity to deliver

cost-effective weight management programs. Internet-mediated social networking [31] increases this potential, as studies have shown that social media can provide social support to members [32] by motivating and inspiring one another. Social media can also offer a medium for information sharing [33]. Being a part of an online social community undergoing lifestyle modifications may even assist individuals to be more accountable for their progress, and improve motivation further. Moreover, a review of the literature indicates that online health improvement programs often result in positive change [34–36]. A number of internet-based health intervention studies have utilised an interactive or social element, such as discussion boards or chat rooms, with many providing tailored feedback generated via mobile monitoring devices or health professionals [37, 38]. To date there have been few studies that have examined the effectiveness of using the social media platform (such Facebook) in the area of weight management, and none promoting dietary *and* physical changes *without* providing feedback other than the support derived from other study participants [37, 38].

Aim of this study

The aim of this project is to measure weight loss and other outcome measures in overweight and obese individuals when a weight management program is delivered via social media, compared to the same program presented in written information only. The study will be undertaken over a period of twelve weeks, with a twelve-week follow-up thereafter. This trial will: i) determine whether incorporating social media into a weight management program will assist overweight and obese individuals to achieve greater, more sustainable improvements in weight loss and other outcome measures than following the same dietary and lifestyle recommendations in written form alone; ii) elucidate the particular aspects of social media that assist overweight and obese individuals to achieve the greater improvements in weight loss and other outcome measures.

Summary of intervention

One hundred and twenty overweight and obese participants from the Perth community will be enrolled into the study, and randomly divided into three groups: two intervention groups and a control group. The two intervention groups will be instructed to follow the CSIRO TWD [17] weight management program for the twelve-week intervention period. One of the intervention groups will receive the diet via the social networking website Facebook and will be enrolled into a support network which is hosted via the Facebook site. The other group will receive the intervention in written form (pamphlet) alone. Both of the intervention groups will be supplied with pedometers (G Sensor 2025 Accelerometer, Walk with Attitude Australia) and set a target of 10,000 steps per day. The control group will follow the Australian Dietary Guidelines [39] as well as National Physical Activity Guidelines for Adults [16] as usual care. Participants will complete a series of questionnaires which will evaluate key psychological variables (see below) and attend Curtin University for assessment of body weight and other clinical outcome variables (outlined in the Design/Methods section) at weeks 0, 6, and 12 and at further 12-week follow-up (week24). The primary outcome measures in this trial include weight, body composition and waist circumference. Blood glucose, insulin, blood pressure, arterial stiffness [40], physical activity, eating behaviour, mental well-being (stress, anxiety, and depression), social support, self-control, self-efficacy, Facebook activity, and program evaluation are secondary outcome measures. Changes in psychological and clinical outcomes are expected to be greatest in the intervention group delivered and supported by social media relative to the pamphlet intervention and control groups. It is anticipated that social media will provide an invaluable resource for health professionals, serving as a low maintenance vehicle for communicating with patients and a source of social support and information sharing for individuals undergoing lifestyle modifications.

Hypotheses

In the present study, it is hypothesised that, compared to the Control Group, the Pamphlet Group will experience moderate improvements in outcome measures (including weight loss of approximately 2 kg) as a result of the twelve-week pamphlet-delivered intervention. It is also hypothesised that, compared to the Control Group, the Facebook Group will experience greater improvements in outcome measures (including weight loss of approximately 8 kg) as a result of the twelve-week social media-delivered intervention. It is further hypothesised that participants in the Facebook Group will experience greater improvements in outcome measures compared to the Pamphlet Group due to the support they receive from using Facebook. Finally, it is hypothesised that at the expiration of the twelve-week intervention period the Facebook Group will be self-sustaining with respect to their ongoing stable weight.

Methods/design

Participants

A cohort of 120 overweight and obese individuals with a body mass index (BMI) between 25–40 kg/m^2 and aged between 21 and 65 years will be recruited from the Perth community via flyers posted at community noticeboards, advertisements in local newspapers and advertisements on local community radio stations. Eligible participants will also be required to have access to a computer, laptop, tablet or Smartphone. Exclusion criteria will include

smoking, lipid lowering medication, use of steroids and other agents that may influence lipid metabolism, use of warfarin, diabetes mellitus, hypo- or hyperthyroidism, cardiovascular events within the last 6 months, major systemic diseases, gastrointestinal problems, proteinuria, liver disease, renal failure, weight fluctuations over the past 6 months, vegetarianism or participation in any other clinical trials within the last 6 months. All participants will be required to provide written informed consent before the trial commences. All identifiable information from participants will be coded. This study will be conducted according to the ethical guidelines that are specified in the Curtin University Human Research Ethics Committee (HREC) and the National Health and Medical Research Council (NHMRC) guidelines. This trial has been approved by the Curtin University HREC (approval number: HR90/2014) and has been registered with ANZCTR (registration number: ACTRN12614000536662), on 21 May 2014.

Study design

This will be a three-armed, randomised, controlled, parallel design intervention study undertaken over a 12 week period, with a subsequent 12 week follow-up. Interested participants will be screened according to the inclusion/exclusion criteria and those eligible will be allocated a number, stratified according to age and gender, and then randomly allocated to one of the three groups of 40 participants, using dedicated computer randomisation software [41, 42] The allocated number will also be used as the participants' identification number, to be used on all records and questionnaires. The three groups will consist of: the Control Group who will follow the Australian dietary guidelines [39] and National Physical Activity Guidelines for Adults [16], the Pamphlet Group who will be instructed in the weight management program by written information, and the social media group who will receive exactly the same weight management program via Facebook in the Facebook Group. [Please see Fig. 1: Flow of participants.] The initial twelve-week weight management program will be presented to the two intervention groups as a condensed version of the CSIRO TWD [17], which includes information of the weight management program, along with weekly checklists available from the CSIRO TWD [43]. Before the commencement of the trial, participants will attend an information session specific to their group allocation, where the participation requirements, including questionnaires and outcome measurements, will be explained. An additional file explains this in greater detail [please see Additional file 1]. During the Facebook Group information session, participants will be provided with additional information about using Facebook in this context. Facebook Group participants will also be made aware of the role of the primary investigator as administrator and facilitator of the Facebook Group. In addition, participants in this group will be informed that at the completion of the twelve-week intervention period, all facilitation will cease, however the group will still be monitored by the facilitator to ensure that they continue to conduct themselves according the instructions provided. This change in strategy for the twelve-week follow-up period will be used to determine whether the Facebook Group has become self-sustaining. An additional file explains the added information provided for Facebook Group participants in greater detail [please see Additional file 2].

Outcome measures

The primary outcome measures for this study is weight loss, body composition and waist circumference. Secondary outcome measures include blood glucose, insulin and lipids, blood pressure, arterial stiffness and hip circumference, as indicators of changes to cardiometabolic disease risk factors. Dietary and physical activity compliance, eating behaviour, quality of life, mental well-being (stress, anxiety, and depression), self-control, self-efficacy, Facebook activity, and program evaluation will also be evaluated as further secondary outcome measures. These clinical and self-reported measurements have been chosen to test the participants' adherence to the weight management program, and to compare the outcomes of the two different weight loss program delivery methods.

Assessments

All participants will be required to attend regular clinical appointments for a duration of approximately 15 min, as follows: at baseline, at weeks 6 and 12, and then again for a follow-up appointment at week 24. Prior to each appointment, participants will complete a Three-Day Food Record and selection of questionnaires to monitor compliance and address some of the secondary outcome measures. The Bouchard Three-Day Physical Activity Record [44] will be used to measure of total physical activity. The Three-Factor Eating Questionnaire (TFEQ) [45] will provide a measure of dietary restraint, disinhibition and hunger, and will also be used here to assess changes in satiety. The Self-Efficacy Scale [46] will be used to assess changes to participants' self-efficacy. The WHO Quality of Life Questionnaire [47] will be used to determine changes in participants' quality of life. The short version of the Depression Anxiety Stress Scale (DASS 21) [48] will be used to measure changes in general psychological wellbeing. The Self-Control (Brief) Scale [49] will be used to provide an understanding of participants' impulse control as it relates to eating behaviour. The Diet and Physical Activity Survey, constructed using the Theory of Planned Behaviour [50], will be used to determine participants' intentions with regard to the dietary and physical activity

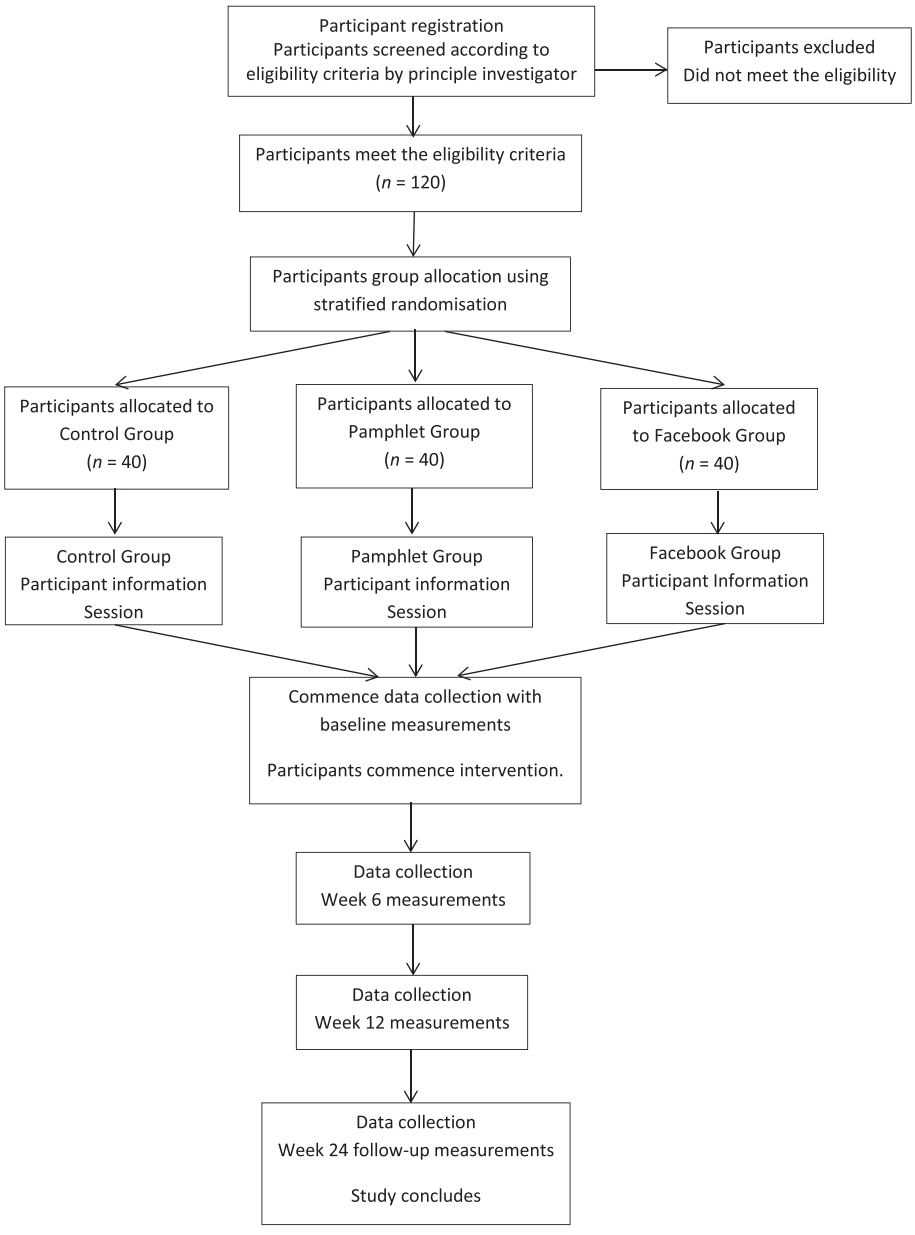

Fig. 1 Flow of participants

guidelines being used in the trial. The Survey of Weight Management Program has some general questions regarding the ease of use of the dietary and physical activity guidelines being utilized; there will be an extra section for Facebook Group participants to assess the preferred device for accessing the weight management information provided on Facebook. For Facebook Group participants only, the Social Media Survey will be used to assess participants' attitudes to social media. The final questionnaire will also be administered to Facebook Group participants only; the Facebook Intensity and Network Density Scales contains a combination of questions used in previous social media research [51, 52]. It will be adapted for this study to assess the degree to which participants make use of Facebook, as well as the strength and frequency of the social interactions within the Facebook Group. In addition, the Facebook Group page will be printed at the end of each week to corroborate self-reported Facebook usage data and monitor participants' online behaviour. Participants will be given questionnaires (including the Food Record and Physical Activity Record) at each clinic appointment, according to their group allocation. [For further information regarding the assessments please see Table 1: Schedule of

Table 1 Schedule of assessments

Measurement by Group	Week 0			Week 6			Week 12			Week 24		
	CG	PG	FG	CG	PG	FG	CG	PG	FG	CG	PG	FG
3-Day Food Record	•	•	•	•	•	•	•	•	•	•	•	•
Physical Activity Record	•	•	•	•	•	•	•	•	•	•	•	•
Three Factor Eating Questionnaire	•	•	•	•	•	•	•	•	•	•	•	•
Self-Efficacy Scale	•	•	•	•	•	•	•	•	•	•	•	•
WHO Quality of Life	•	•	•	•	•	•	•	•	•	•	•	•
Depression Anxiety Stress Scale	•	•	•	•	•	•	•	•	•	•	•	•
Self-Control (Brief) Scale	•	•	•	•	•	•	•	•	•	•	•	•
Diet & Physical Activity Survey	•	•	•	•	•	•	•	•	•	•	•	•
Survey of Weight Management Program*				•	•	•	•	•	•			
Social Media Survey			•			•			•			•
Facebook intensity & Network Density Scales						•			•			•
Height	•	•	•									
Weight	•	•	•	•	•	•	•	•	•	•	•	•
Blood pressure	•	•	•	•	•	•	•	•	•	•	•	•
Arterial stiffness	•	•	•	•	•	•	•	•	•	•	•	•
Blood glucose	•	•	•	•	•	•	•	•	•	•	•	•
Waist circumference	•	•	•	•	•	•	•	•	•	•	•	•
Hip circumference	•	•	•	•	•	•	•	•	•	•	•	•
Body Composition	•	•	•	•	•	•	•	•	•	•	•	•
Blood lipids	•	•	•				•	•	•			
Blood insulin	•	•	•				•	•	•			

Key: CG = Control Group; PG = Pamphlet Group; FG = Facebook Group
* There will be two versions of the Survey of Weight Management Program. Version 2 will include an additional section specific to Facebook Group participants only

Assessments.] Participants will be instructed to use their participant identification number only when completing all documents relating to this trial [42].

At each clinical appointment, weight will be recorded in light clothing without shoes. (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan). Body composition will be measured by bioelectrical impedance analysis (BIA) in light clothing without shoes using the digital scales just mentioned. Height will be measured without shoes to the nearest 0.1 cm using a wall-mounted stadiometer (26SM 200 cm SECA, Hamburg, Germany). Height and weight measurements will be used to calculate participants' BMI. Waist circumference will be measured in the standing position at the narrowest area between the lateral lower rib and the iliac crest; hip circumference will be measured at the widest area across the buttocks. Briefly, fasting blood glucose will be taken using the Accu-Chek® Performa glucometer and lancing device (Roche, Australia). Blood pressure will be assessed with an automated, calibrated sphygmomanometer (Dinamap, Compact T, Critikon, Germany). Pulse contour analysis (PCA) will be used to assess arterial stiffness using the Pulse Trace PCA 2 (CareFusion, NSW, Australia). In addition, at weeks 0 and 12 participants will be required to attend a local pathology collection centre (PathWest Laboratory Medicine, Western Australia) for blood tests to measure lipids (triglycerides (TG), total cholesterol (TC), low density lipoprotein (LDL) and high density lipoprotein (HDL)) and insulin. [For further information regarding the assessments please see Table 1: Schedule of Assessments.]

Statistical analysis

Based on a three group study with repeated measures, a sample size of 96 achieves 80 % statistical power to detect a medium to large effect size (Cohen's $d = 0.4$); that is, a difference of 6 kg between the two intervention groups, with alpha set at 0.05. To allow for an attrition rate of 20 %, a total of 120 participants will be recruited; i.e. 40 participants per group. Stratified randomisation will be used to ensure that each group is matched in age and gender. The results will be analysed using a mixed repeated measures analysis of variance (ANOVA) design. Data will be expressed as mean (±SEM) and assessed for normality to ensure that the assumptions of the analysis are met. If significant between groups effects are present, post hoc analysis will be conducted using the Least

Significant Difference (LSD) method. Statistical significance will be considered at $p < 0.05$. All statistical analyses will be performed using SPSS 21.0 for Windows (SPSS Inc., Chicago, IL), and conducted using the participant identification number only [42].

Discussion

The purpose of this study is to evaluate the use of social media as a health promotion tool, specifically to promote dietary and physical activity changes for overweight and obese individuals, without providing any form of tailored feedback. The principle investigator, in the role of Facebook Group facilitator, will initiate discussion within the group by posting general questions or comments to the Facebook Group's wall, but will not respond to participants' comments or questions. This type of facilitation will be used to 'break the ice' and encourage group members to interact with each other. In the best case scenario, it is anticipated that participants will then view other group members as a source of social support, as they all have weight loss as a common goal and quite possibly may have experienced similar issues with regards to being overweight. The benefits of this type of support (provided by a discreet, interactive online social group) include being able to freely share their views and information, ask and answer questions and ask for and offer assistance. *Providing support to others* may be as beneficial to the individual as receiving support [53, 54]. Other possible social-related benefits may come in the form of encouragement (to persevere with the program), the formation of walking groups (to meet the physical activity requirements) and praise for the achievement of any weight loss milestones. Another important advantage conferred by membership of a group of this nature is the potential for clarification of the elements of the weight management program. For example, if a group member experiences any difficulty integrating the weight management guidelines into their daily life, they may find help can be obtained from other group members more experienced in food preparation and deciphering amounts (or units) of foods or ingredients, *without the need to consult a health professional*. This type of support (assistance and understanding, given and received) may augment the weight loss expected when following a proven weight management program, as help will potentially be available from other group members. Indeed, participants in the original trials of the CSIRO TWD received intensive dietetic support [11, 20, 55], so it is hoped that the social support available within the Facebook Group will provide a different, but effective substitute. Further, it is speculated that if Facebook Group participants take full advantage of the social support built into this intervention, then long term weight maintenance will also be more feasible for them.

If using social media to assist weight loss is found to be effective then health promotion professionals, policymakers and groups interested in changing behaviour may be encouraged to adopt social media as an additional health promotion tool. Using social media for health promotion could have many advantages, such as being able to reach large groups wherever the technological infrastructure is in place. These individuals can then access the information and updates provided in their own time and place. It has the potential to provide health care and health promotion professionals the ability to manage a large and geographically disparate case-load, with a minimal investment of time, and may provide a future role for health professionals. These findings may also have clinical applications, allowing health care professionals to generate support networks for their patients undergoing diet and lifestyle modification, especially for the socially or geographically isolated, or those whose access to health care workers is limited or infrequent. Other advantages include the fact that social media is essentially free to use, so this tool would also be cost-effective and therefore potentially more readily adopted in real world settings than more expensive interventions that have been tested in other studies. Due to the interactive nature of the technology, feedback can also be collected from participating individuals. Moreover, there is the possibility of conducting focus groups with those who would be otherwise out-of-reach. It should not be inferred however, that social media should be utilised to completely replace in-person consultations with health professionals; rather, its most appropriate use is likely to be in providing on-going support for patients between appointments with relevant health professionals.

So far, studies examining the efficacy of using the social media platform to promote dietary and physical activity changes for weight management have been few. Aside from adapting assessments used in traditional health promotion interventions, methods of evaluating the potential health benefits of social media are still under development. It is therefore anticipated that the results of this study will add significantly to the body of knowledge regarding health promotion methods for weight management programs.

Additional files

Additional file 1: Participant information sessions.

Additional file 2: Weight management program within the Facebook Group.

Abbreviations

ANOVA: Analysis of variance; ANZCTR: Australian New Zealand clinical trial registry; BIA: Bioelectrical impedance analysis; BMI: Body mass index; CSIRO: Commonwealth scientific and industrial research organisation; DASS 21: Depression, anxiety, and stress scale, short version; HDL: High density lipoprotein; HREC: Human research ethics committee; IPAQ: International

physical activity Questionnaire; LDL: Low density lipoprotein; NHMRC: National health and medical research council; PCA: Pulse contour analysis; TC: Total cholesterol; TFEQ: Three-factor eating questionnaire; TG: triglycerides; TWD: Total wellbeing diet; WHO: World health organisation.

Competing interests
The authors declare that they have no competing interests. No external funding has been received for the conduct of the study.

Authors' contributions
Principal responsibility for study design was assumed by SP. The principal responsibility for the study conduct was assumed by MJ. MJ, JF and MH contributed to the development of the intervention and study design. MJ drafted the manuscript. All authors read and commented on drafts and approved the final manuscript.

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APPENDIX 8: PHYSIOLOGICAL OUTCOMES PAPER

Jane M, Hagger M, Foster J, Ho S, Kane R, Pal S. Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: A randomised controlled trial. *PLoS ONE*. 2017;12(6):e0178326

PLOS ONE

RESEARCH ARTICLE

Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: A randomised controlled trial

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Abbreviations: BMI, Body mass index; CG, Control group; FG, Facebook group; PG, Pamphlet group.

Abstract

Introduction

The aim of this project was to evaluate the effectiveness of using social media to augment the delivery of, and provide support for, a weight management program delivered to overweight and obese individuals during a twenty four week intervention.

Methods

Participants randomly divided into either one of two intervention groups or a control group. The two intervention groups were instructed to follow identical weight-management program. One group received the program within a Facebook group, along with a support network with the group, and the other intervention group received the same program in a booklet. The control group was given standard care. Participants' weight and other metabolic syndrome risk factors were measured at baseline and at weeks 6, 12, 18 and 24.

Results

The Facebook Group reported a 4.8% reduction in initial weight, significant compared to the CG only ($p = 0.01$), as well as numerically greater improvements in body mass index, waist circumference, fat mass, lean mass, and energy intake compared to the Pamphlet Group and the Control Group.

Conclusions

These results demonstrate the potential of social media to assist overweight and obese individuals with respect to dietary and physical activity modifications for weight management, and justify further research into the inclusion of social media in clinical weight management programs. It is anticipated that social media will provide an invaluable resource for health professionals, as a low maintenance vehicle for communicating with patients, as well as a source of social support and information sharing for individuals undergoing lifestyle modifications.

Introduction

Since 1980 world-wide rates of obesity has doubled [1]. According to the World Health Organisation, obesity is now a global epidemic [2] and is responsible for an estimated 2.8 million deaths per year [3]. This is despite the recognition of the importance of this issue among health professionals [4–7] as well as increasing awareness of obesity within the wider community [8]. Previous public health weight management strategies have not had the desired impact and newer approaches need to be considered. Excessive weight gain is strongly related to socio-environmental changes that promote the consumption of high energy diets and reduced physical activity [1, 7]. This is particularly so for the socioeconomically disadvantaged [9]. Obesity increases the risk of cardiovascular disease, stroke, type 2 diabetes and some cancers [1, 5, 7]. On the other hand, supportive environments and communities can influence dietary and lifestyle choices by making healthy choices available, affordable and accessible [1]; these approaches could therefore be used to treat and prevent obesity.

Weight loss can reduce the cardio-metabolic risk factors associated with obesity [10, 11]. However, many dieters have difficulty with ongoing weight loss maintenance [12]. In an effort to overcome this problem researchers have found that implementing multifactorial weight management programs are more likely to achieve clinically meaningful weight loss results [7], as opposed to following weight loss instructions only. Supplementary strategies include frequent appointments with health professionals, cognitive behavioural therapy, use of supplements and group support sessions [7, 9, 13]. Similarly, individuals have better health outcomes if they are well supported socially [14, 15]; this includes better weight loss outcomes [16, 17]. However, many individuals do not have adequate support while attempting weight loss for a number of reasons [15].

The social aspect may be an important factor that contributes to the effectiveness of group weight management programs. Some studies have found that group weight management programs result in better weight loss outcomes when compared to individual treatment [18, 19]. Group programs are also a more cost-effective option to individual programs [18, 20].

Recent developments in internet and communication technologies may offer health promoters a novel platform for group weight management programs. Internet-based health intervention trials focusing on behaviour change have incorporated a social element using chat rooms or discussion boards, with many of these interventions providing feedback via health professionals or mobile monitoring devices [21, 22]. Internet-mediated social networking sites improve upon these features; already studies have shown that networked members can provide each other with support [23, 24]. This technology also offers new avenues for information sharing [25], so that information and member support are accessible at home or away 24-hours a day seven days a week, at the convenience of members.

Economic analysis shows that internet-delivered weight management programs costs less per person–*and* per kilogram lost—than an in-person program [26]. Social media may be an even less expensive avenue, particularly if an existing platform is used (e.g. Facebook). This approach has the added convenience of direct access to existing online social networks [27, 28]. In addition, the cost-effectiveness and large scale online connectivity of social media has the potential to assist individuals on low incomes or in geographically remote communities [29] to access support while following a weight management program. Furthermore the increased interactivity of social media (used in conjunction with personal profiles) may provide a friendlier setting that enhances online intervention outcomes.

Few studies have examined the value of using a social media platform like Facebook for weight management, and no studies have been undertaken to date that promote dietary *and* physical activity modifications with the only feedback being that which can be derived from other study participants, or targeting a particular condition (eg diabetes), age group or gender [21, 22].

The aim of the current study was to measure changes to weight and other obesity-related disease risk factors in overweight and obese participants when a weight management program was delivered using social media, compared to the same program presented in written information only, over a period of twenty four weeks. It was hypothesised that compared to the Control Group and Pamphlet Group, the Facebook Group would experience greater improvements in weight and other metabolic syndrome risk factors over the 24 week intervention period. In particular, the changes to weight in the were hypothesised to be 2% of initial body in the Pamphlet Group, and 9% of initial body weight in the Facebook Group, compared to the Control Group.

Methods

Participants

Overweight and obese individuals with a body mass index (BMI) between 25–40 kg/m^2 and aged between 21 and 65 years were recruited from the Perth community via advertisements in the West Australian Newspaper and Community Newspapers between 2 July and 11 November 2014. Participants were required to have access to a computer, laptop, tablet or Smartphone. Two hundred and eighty four respondents were screened by telephone interview, and one hundred and thirty seven individuals were found to be eligible. Exclusion criteria included smoking, lipid lowering medication, use of steroids and other agents that may influence lipid metabolism, use of warfarin, diabetes mellitus, hypo- and hyperthyroidism, cardiovascular events within the last 6 months, major systemic diseases, gastrointestinal problems, proteinuria, liver disease, renal failure, weight fluctuations over the past 6 months, vegetarianism and participation in any other clinical trials within the last 6 months. These measures were in place to ensure harm minimisation and to prevent the introduction of potential confounders. This study was conducted according to the ethical guidelines provided by the National Health and Medical Research Council. The original study protocol was approved by the Curtin University Human Research Ethics Committee (approval no. HR90/2014) prior to trial commencement, as reported elsewhere [30]. In addition, the amendments to the original study protocol explained in this work also received approval from the Curtin University Human Research Ethics Committee prior to trial commencement. All identifiable information collected from participants was coded. All participants provided signed, written informed consent. This trial was registered with the Australian New Zealand Clinical Trials Register (trial registration no.: ACTRN12614000536662).

Study design

The original protocol consisted of a 12-week intervention period with a 12-week follow-up, as previously reported [30]. The current study was an adaptation of the original intervention and was conducted as a 24-week, three-armed, randomised, controlled, parallel design (without follow-up) investigation [30]. Recruited participants were enrolled and assigned a three-digit number in chronological order by the study co-ordinator. Participants were then randomised to one of the three groups by block randomisation according to age and gender, using online research randomising software [31] (i.e. random number generator). Participants were blinded; randomisation and group allocation was undertaken by the study co-ordinator.

Interventions

Prior to trial commencement participants attended information sessions at Curtin University where full details of the study were explained, which included a brief overview of the treatment lasting approximately half an hour, according to group allocation. The Control Group (CG) were instructed to follow the Australian Government dietary guidelines [32] as well as the *National Physical Activity Guidelines for Adults* [33] as standard care. Both the Pamphlet Group (PG) and the Facebook Group (FG) were instructed to follow the *Total Wellbeing Diet* developed by the Commonwealth Scientific and Industrial Research Organisation, following rigorous scientific testing and proven to result in weight loss [34]. This program is an energy-reduced, low fat, lower carbohydrate, higher protein diet, as explained in greater detail elsewhere [30]. Both the PG and the FG received a condensed version of the diet, which included detailed information and instructions, compiled from excerpts from both the *Total Wellbeing Diet Book 2* [35] and *Total Wellbeing Diet Recipes on a Budget* [36] (with permission from Penguin Publishing). The PG received the information in written form as a booklet, while the FG received identical information contained within the booklet but with pages as snapshots posted within the 'secret' (i.e. closed and hidden from the general Facebook population) Facebook group. (See; S2 File. Trial Protocol Part 1. Intervention Program.) In addition to information from the *Total Wellbeing Diet*, participants in both intervention groups were also issued with a pedometer (G Sensor 2025 Accelerometer, Walk with Attitude Australia) and instructed to achieve a target of 10,000 steps per day (as recommended in the *Total Wellbeing Diet* program). The FG were given additional information on how to use the Facebook group to access the weight management program, encouraged to interact with one another, and had the rules of polite interaction with other group members were explained to them. Following the completion of the information sessions, FG participants were invited to join the Facebook group by the study co-ordinator, who acted as the administrator of the group. Participants in all groups were given the necessary materials at the conclusion of their baseline clinic appointments and instructed to commence the intervention forthwith. None of the participants were given any further external weight management guidance during the trial by the study coordinator. The only access the FG had to the program was the information posted on Facebook. In addition, the study co-ordinator posted to the Facebook group once per week to the Facebook group over the 24 week intervention. (More detailed information can be found the additional file with the title of S3 File. Trial Protocol Part 2. Project Outline.)

Assessments

The primary outcome for this trial was weight. The secondary outcome measures were blood pressure waist and hip circumference, fasting blood glucose, lipids and insulin, dietary intake, physical activity and step count (the latter for the PG and the FG only). Participants attended clinical appointments at Curtin University in the fasted state at baseline, and at weeks 6, 12, 18

and 24, (with no follow-up appointment. This appointment schedule is an update of the original study protocol consisting of appointments at baseline, weeks 6 and 12, with a follow-up appointment 12 weeks after the end of the initial 12 week intervention [30]. See S1 Fig for the up-to-date schedule of outcome measures). At these appointments, weight was measured in light clothing without shoes (UM-018 Digital Scales; Tanita Corporation, Tokyo, Japan). Differences in weight at each time point were calculated per individual as a percentage of total baseline body weight. Height (baseline only) was measured using a stadiometer (26SM 200 cm SECA, Hamburg, Germany) without shoes. Waist circumference was measured in the standing position at the narrowest area between the lateral lower rib and the iliac crest, and hip circumference was measured at the widest area across the buttocks. Fasting blood glucose measurements were taken using the Accu-Chek® Performa glucometer and lancing device (Roche Diagnostics). (Arterial stiffness was removed from the list of outcome measures reported in the original study protocol [30]. See S1 Fig for the up-to-date schedule of outcome measures).

At baseline, weeks 12 and 24 blood pressure was measured with an automated, calibrated sphygmomanometer (Dinamap, Compact T, Critikon, Germany). Lean mass and fat mass was measured in light clothing and without shoes by bioelectrical impedance (using the digital scales already cited), and recorded as a percentage of total body weight per individual. In addition, participants attended their local PathWest Collection Centre to have fasting blood samples taken to measure blood lipids (ie. total cholesterol, triacylglycerols, low density lipoproteins and high density lipoproteins) and blood insulin at baseline, and at weeks 12 and 24. Blood sample analysis was conducted at PathWest Laboratory Medicine, QEII Medical Centre, Nedlands, Western Australia.

Participants were required to return their completed Three-Day Food Records as well as Three-Day Physical Activity Records [37] with three-day step count (PG and FG participants only) at each time point. Energy and macronutrient intakes from the participants' food records were calculated using Food Works Version 7 (Xyris Software, 2012). Macronutrient intakes were recorded as a percentage of total energy intakes per individual, with the exception of fibre (which was calculated in total grams). Energy expenditure from participants' physical activity records was calculated using an equation devised for the purpose [37]. (Psychological and behavioural outcome measures were also collected, as indicated in the original study protocol [30], and will be assessed and reported in a future publications in due course. See S4 File. Trial Protocol Part 3. Questionnaires.)

Statistical analysis

For a three group study with repeated measures and the ability to detect a weight loss difference of 7% of initial body weight (Cohen's d = 0.4) [38] between the FG and the PG, and an alpha of 0.05 (two-sided), a sample size of 96 achieves 80% statistical power. To allow for an attrition rate of 20%, it was planned to recruit a minimum of 120 participants. Baseline weight (kg) data were assessed for normality, both by study sample and by group, and were found to be slightly positively skewed. Changes in outcome measures relative to baseline were analysed for between group differences at each time point. Generalised Linear Mixed Models was the method of statistical analysis used as it represents a particular class of regression model that is 'generalised' in that it can accommodate violations of normality, and 'mixed' as it includes both random and fixed effects [39]. In addition, Generalised Linear Mixed Models is less sensitive to participant attrition because it does not rely on participants providing data at every assessment point but uses all the data present at each assessment point, thus reducing sampling bias and the need to replace missing data [39]. (The above explanation forms the rationale for

using this method of analysis in favour of the General Linear Methods eg. repeated measures analysis of variance, outlined in the original study protocol [30]). The covariate structure used in the linear mixed models was variance components [39]. This analysis was implemented through SPSS 22.0 (IBM® SPSS® Statistics, New York, NY). Post hoc power analysis was conducted using G*Power [40]. All data were expressed as mean (±SEM), and statistical tests are evaluated at a p-value of .05.

Results

Participants

During the recruitment period, 284 respondents were screened and 137 were found to meet the eligibility criteria (slightly in excess of the required number indicated in the original study protocol [30]; these individuals were invited participate and gave verbal consent to do so. Recruited participants were randomly allocated to one of the three groups as follows CG: $n = 45$; PG: $n = 46$; FG: $n = 46$. One hundred and one participants attended the baseline appointment (CG: $n = 34$; PG: $n = 34$; FG: $n = 33$) at which time they provided written informed consent; among these individuals, 68 participants provided data post-baseline (CG: $n = 22$; PG: $n = 23$; FG: $n = 23$). Fifty six participants completed the full intervention; however, one participant from the CG was eliminated from the final analysis due to non-compliance (CG: $n = 17$; PG: $n = 18$; FG: $n = 19$) (Fig 1).

Data from 67 participants were therefore used for the statistical analysis. Baseline characteristics of all participants that contributed data the analysis are shown (Table 1).

Metabolic syndrome risk factors

The primary outcome measure and a selection of other disease risk factors were collected at four time points following baseline (weeks 6, 12, 18 and 24). The secondary outcome measures were collected at two time points following baseline (weeks 12 and 24), as referred to above (and in Table 1: Schedule of outcome measures.) The paragraphs below summarise the between group differences in changes to baseline measures at each designated time point.

The primary outcome measure for this study was change in weight. Both the PG and the FG had significantly greater weight loss than the CG at week 6 (-2.7%, $p = 0.01$ and -2.5%, $p = 0.02$ respectively), at week 18 (-4.5%, $p = 0.02$ and -4.9%, $p = 0.02$ respectively) and at week 24 (-3.6%, $p = 0.05$ and -4.8%, $p = 0.01$ respectively) (Fig 2A). While the FG experienced greater weight loss at weeks 12, 18 and 24 compared to the PG group, these differences were not statistically significant at any time. Compared to the CG, the PG showed a significant reduction in BMI at week 6 (-1.0 kg/m^2, $p = 0.03$), both the PG and the FG showed significant reductions at week 18 (-1.6 kg/m^2, $p = 0.04$ and -1.5 kg/m^2, $p = 0.04$ respectively), but only the FG maintained this change at week 24 (-1.5 kg/m^2, $p = 0.02$) (Fig 2B).

The PG and the FG experienced statistically significant reductions in waist circumference compared to the CG at week 18 (-4.8 cm, $p = 0.01$ and -4.6 cm, $p = 0.01$ respectively), but only the FG sustained this significant change at week 24 (-4.5 cm, $p = 0.04$) (Fig 2C). There were no significant differences between group reductions in hip measurements across the intervention.

The PG group had significant reductions in fasting blood glucose compared to the CG and the FG. At week 6 a difference of -0.1 mmol/L was statistically significant against the CG (+0.4 mmol/L, $p = 0.02$) and against the FG (+0.4 mmol/L, $p = 0.007$), at week 12 a difference of -0.2 mmol/L was significant against the CG (+0.3 mmol/L, $p = 0.04$) and the FG (+0.4 mmol/L, $p = 0.001$). At week 18 a difference of -0.1 mmol/L was significant against the CG only (+0.6 mmol/L, $p = 0.04$), and at week 24 a difference of -0.4 mmol/L was significant against the CG (+0.4 mmol/L, $p = 0.04$) and the FG (+0.4 mmol/L, $p = 0.03$).

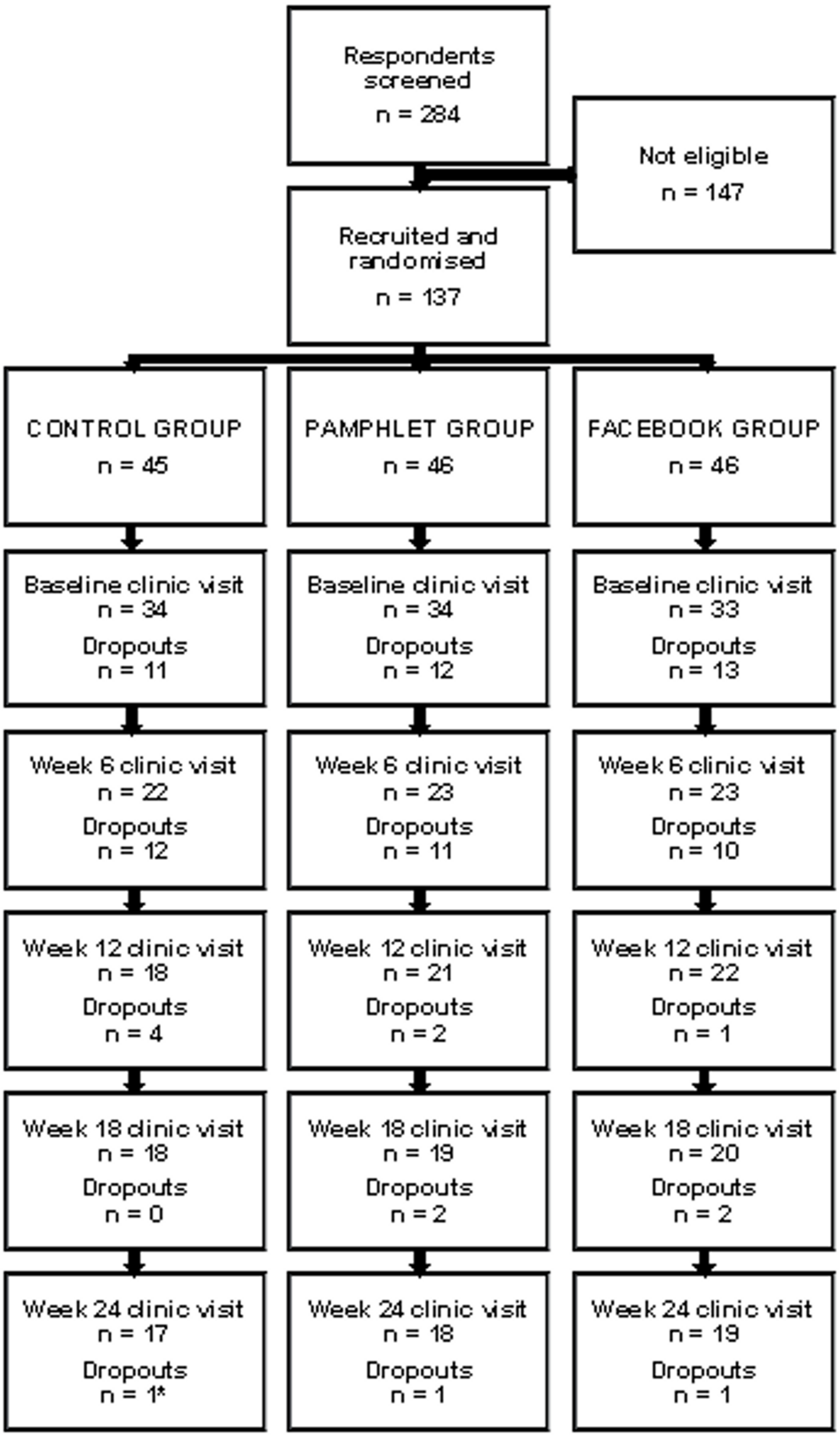

Fig 1. Flow of participants. Reasons for dropouts (n = 82): Did not respond (n = 44); Time constraints (n = 26); Did not like assigned program (n = 5); Unrelated illness (n = 4); Change in personal circumstances (n = 3). No adverse events were recorded. *Data eliminated from the final analysis due to non-compliance.

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Table 1. Baseline characteristics of all participants included in the analysis.

	Control (n = 21)*		Pamphlet (n = 23)*		Facebook (n = 23)*	
	Mean	SEM	Mean	SEM	Mean	SEM
Gender (m/f)	4 / 17		2 / 21		4 / 19	
Age (y)	50.2	2.4	54.1	2.3	47.0	2.3
Height (cm)	165.1	1.5	162.2	1.8	165.3	1.9
Weight (kg)	91.5	4.5	86.7	4.2	89.0	3.2
BMI (kg/m^2)	33.3	1.3	32.9	1.3	32.5	1.0
Waist (cm)	98.0	2.8	96.1	2.5	96.3	2.4
Hip (cm)	115.2	2.9	113.8	2.8	113.0	2.1
FBG (mmol/L)	5.8	0.2	6.2	0.3	5.5	0.1
SBP (mmHg)	124.3	3.8	126.5	3.5	128.4	4.0
DBP (mmHg)	69.3	2.2	69.0	1.4	68.6	1.8
Insulin (mU/L)	8.1	0.8	8.8	1.0	9.6	1.2 [20]
Fat Mass (%)˚	45.5	1.5	45.1	1.5	44.0	1.6
Lean Mass (%)˚	23.6	0.7	23.7	0.7	24.6	0.8
TC (mmol/L)	5.7	0.2	5.8	0.2	5.8	0.2 [20]
TAG (mmol/L)	1.2	0.1	1.1	0.1	1.3	0.1 [20]
LDL (mmol/L)	3.7	0.2	3.7	0.2	3.8	0.2 [20]
HDL (mmol/L)	1.5	0.1	1.5	0.1	1.4	0.1 [20]
EI (kJ/day)	8061.1	435.2 [20]	8266.7	440.1 [21]	8023.6	398.8 [19]
Carbohydrate (%)†	38.7	1.5 [20]	37.8	1.8 [21]	41.1	1.3 [19]
Fat (%)†	35.4	1.3 [20]	35.6	1.3 [21]	35.2	0.1 [19]
Protein (%)†	19.8	0.8 [20]	21.3	1.2 [21]	19.3	1.0 [19]
Alcohol (%)†	3.0	1.2 [20]	2.4	0.7 [21]	1.4	0.4 [19]
Fibre (g)	18.1	1.2 [20]	14.6	1.0 [21]	17.9	1.3 [19]
EE (kJ/day)	17089.1	967.1 [17]	16659.7	1052.7 [20]	15911.1	665.9 [19]
Steps/day	-	-	8735.1	480.8 [19]	7567.8	793.2 [19]

*Unless indicated by [n]

˚refers to percentage of total body weight

†refers to percentage of total energy intake; SEM: Standard Error of the Mean; BMI: body mass index; FBG: fasting blood glucose; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; TAG: triacylglycerides; LDL: low density lipoprotein; HDL: high density lipoprotein; EI: energy intake; EE: energy expenditure.

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The FG showed numerically greater reductions in fat mass than both the CG and the PG, and was statistically significant reduction compared to CG, at both weeks 12 and 24 (-2.6%, $p = 0.01$) (Fig 2D). Similarly, the FG showed numerically greater increases in lean mass than both the CG and the PG at both times, but this was statistically significant against the CG only, at week 12 (+1.2%, $p = 0.03$) and at week 24 (+1.1%, $p = 0.03$) (Fig 2E).

There were no significant between group differences in blood pressure measurement during the intervention, with the exception of a reduction in systolic blood pressure in the PG compared to the CG at week 6 (-10.3 mmHg, $p = 0.05$) which was not maintained at week 24 (Table 2).

Diet and physical activity

According to self-reported food intake data, the differences in mean energy intake between the three groups at all four time points compared to baseline were not found to be statistically significant. The greatest numerical reductions in energy intake was observed in the FG at week

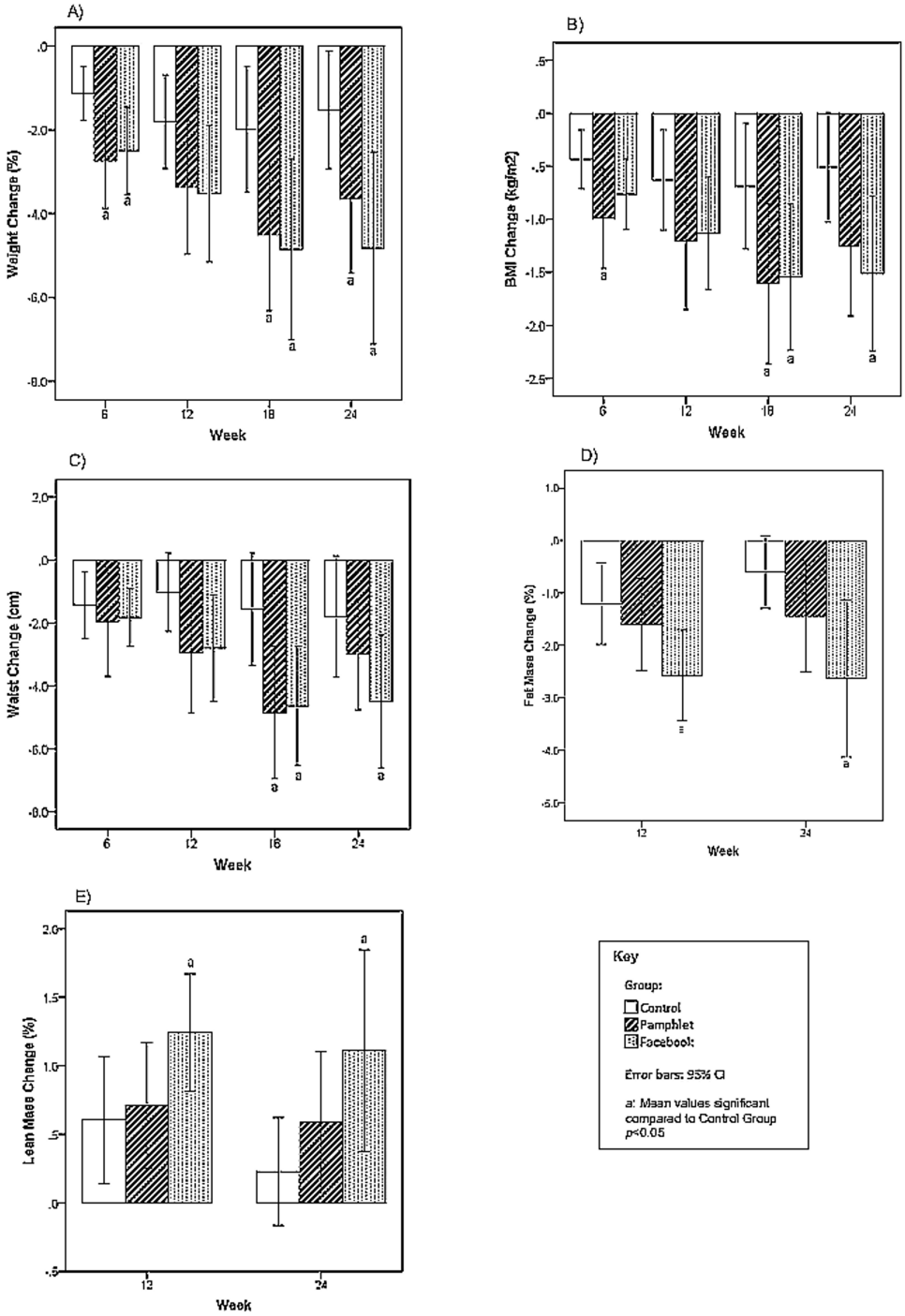

Fig 2. Significant between group differences in outcome measures. (A) weight; (B) BMI; (C) waist; (D) fat mass; (E) lean mass.

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24 (to wit CG: -1107.4 kJ/day v PG: -1071.6 kJ/day v FG: -1465.9 kJ/day). Both the PG and the FG showed numerical reductions in carbohydrate intake at each time point; however, the only significant reduction was in the PG at week 6 compared to the CG (-3.8%, $p = 0.05$).

Table 2. Between group differences in outcome measures.

	Week 6			Week 12			Week 18			Week 24		
	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*
Weight (%)*												
○ **Control**	-1.1	0.3	22	-1.8	0.5	18	-2.0	0.7	18	-1.5	0.6	17
○ **Pamphlet**	-2.7[a]	0.5	23	-3.4	0.7	21	-4.5[a]	0.8	19	-3.6[a]	0.8	18
○ **Facebook**	-2.5[a]	0.5	23	-3.5	0.8	22	-4.9[a]	1.0	20	-4.8[a]	1.1	19
BMI (kg/m^2)												
○ **Control**	-0.4	0.1	22	-0.6	0.2	18	-0.7	0.3	18	-0.5	0.2	17
○ **Pamphlet**	-1.0[a]	0.2	23	-1.2	0.3	21	-1.6[a]	0.4	19	-1.3	0.3	18
○ **Facebook**	-0.8	0.2	23	-1.1	0.3	22	-1.5[a]	0.3	20	-1.5[a]	0.4	19
Waist (cm)												
○ **Control**	-1.4	0.5	22	-1.0	0.6	18	-1.6	0.8	18	-1.8	0.9	17
○ **Pamphlet**	-2.0	0.8	23	-2.9	0.9	21	-4.8[a]	1.0	19	-3.0	0.8	18
○ **Facebook**	-1.8	0.4	23	-2.8	0.8	22	-4.6[a]	0.9	20	-4.5[a]	1.0	19
Hip (cm)												
○ **Control**	-0.3	0.6	22	-1.1	0.6	18	-1.1	0.6	18	-1.5	0.6	17
○ **Pamphlet**	-1.3	0.6	23	-2.5	0.7	21	-2.6	0.7	19	-3.2	0.6	18
○ **Facebook**	-1.3	0.5	23	-2.4	0.7	22	-2.8	0.8	20	-3.3	0.9	19
FBG (mmol/L)												
○ **Control**	0.4	0.1	22	0.3	0.2	18	0.6	0.2	18	0.4	0.3	17
○ **Pamphlet**	-0.1[ab]	0.2	23	-0.2[ab]	0.1	21	0.1[a]	0.2	19	-0.4[ab]	0.2	18
○ **Facebook**	0.4	0.1	23	0.4	0.1	22	0.5	0.1	20	0.4	0.3	19
Fat Mass (%)**												
○ **Control**	-	-	-	-1.2	0.4	17	-	-	-	-0.6	0.3	17
○ **Pamphlet**	-	-	-	-1.6	0.4	21	-	-	-	-1.4	0.5	18
○ **Facebook**	-	-	-	-2.6[a]	0.4	22	-	-	-	-2.6[a]	0.7	19
Lean Mass (%)**												
○ **Control**	-	-	-	0.6	0.2	17	-	-	-	0.2	0.2	17
○ **Pamphlet**	-	-	-	0.7	0.2	21	-	-	-	0.6	0.2	18
○ **Facebook**	-	-	-	1.2[a]	0.2	22	-	-	-	1.1[a]	0.3	19
SBP (mmHg)												
○ **Control**	-	-	-	-2.8	3.0	17	-	-	-	3.5	2.9	17
○ **Pamphlet**	-	-	-	-10.3[a]	2.2	21	-	-	-	-0.2	2.7	18
○ **Facebook**	-	-	-	-9.6	3.2	22	-	-	-	-3.0	2.0	19
DBP (mmHg)												
○ **Control**	-	-	-	-2.1	1.5	17	-	-	-	1.1	1.5	17
○ **Pamphlet**	-	-	-	-4.5	1.3	21	-	-	-	-0.1	1.4	18
○ **Facebook**	-	-	-	-3.4	1.5	22	-	-	-	-0.5	1.0	19
Insulin (mU/L)												
○ **Control**	-	-	-	-1.1	0.9	13	-	-	-	0.1	0.7	17
○ **Pamphlet**	-	-	-	-1.3	0.7	19	-	-	-	1.0	0.9	17
○ **Facebook**	-	-	-	-0.9	0.5	17	-	-	-	-0.1	0.9	17
TC (mmol/L)												
○ **Control**	-	-	-	-0.3	0.2	12	-	-	-	0.1	0.1	16
○ **Pamphlet**	-	-	-	-0.4	0.2	21	-	-	-	-0.1	0.2	18
○ **Facebook**	-	-	-	-0.3	0.1	17	-	-	-	-0.2	0.1	17
TAG (mmol/L)												
○ **Control**	-	-	-	-0.1	0.1	12	-	-	-	0.1	0.2	16

(*Continued*)

Table 2. (*Continued*)

	Week 6			Week 12			Week 18			Week 24		
	mean	**SEM**	***n***	**mean**	**SEM**	***n***	**mean**	**SEM**	***n***	**mean**	**SEM**	***n***
○ **Pamphlet**	-	-	-	-0.1	0.0	21	-	-	-	0.4	0.3	18
○ **Facebook**	-	-	-	-0.2	0.1	17	-	-	-	-0.2	0.1	17
LDL (mmol/L)												
○ **Control**	-	-	-	-0.3	0.2	12	-	-	-	0.0	0.1	16
○ **Pamphlet**	-	-	-	-0.3	0.1	21	-	-	-	-0.1	0.1	18
○ **Facebook**	-	-	-	-0.3	0.1	17	-	-	-	-0.2	0.1	17
HDL (mmol/L)												
○ **Control**	-	-	-	0.0	0.0	12	-	-	-	0.1	0.0	16
○ **Pamphlet**	-	-	-	-0.1	0.0	21	-	-	-	0.0	0.0	18
○ **Facebook**	-	-	-	0.0	0.0	17	-	-	-	0.0	0.0	17

*percentage of initial body weight

**percentage of total body weight

SEM: Standard Error of the Mean; BMI: body mass index; DBP: diastolic blood pressure; FBG: Fasting blood glucose; HDL: high density lipoprotein; LDL: low density lipoprotein; SBP: systolic blood pressure; TAG: triacylglycerol; TC: total cholesterol

[a]mean values significantly different to Control Group ($p<0.05$)

[b]mean values significantly different to Facebook Group ($p<0.05$).

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There were no significant between group differences in either fat or alcohol intake across the intervention.

There were increases in protein intake in the three groups at each time point; however, those increases that were significantly different compared to the CG at week 6 were PG (+5.9%, $p = 0.05$) and the FG (+5.2%, $p = 0.03$), and the FG compared to the CG at week 12

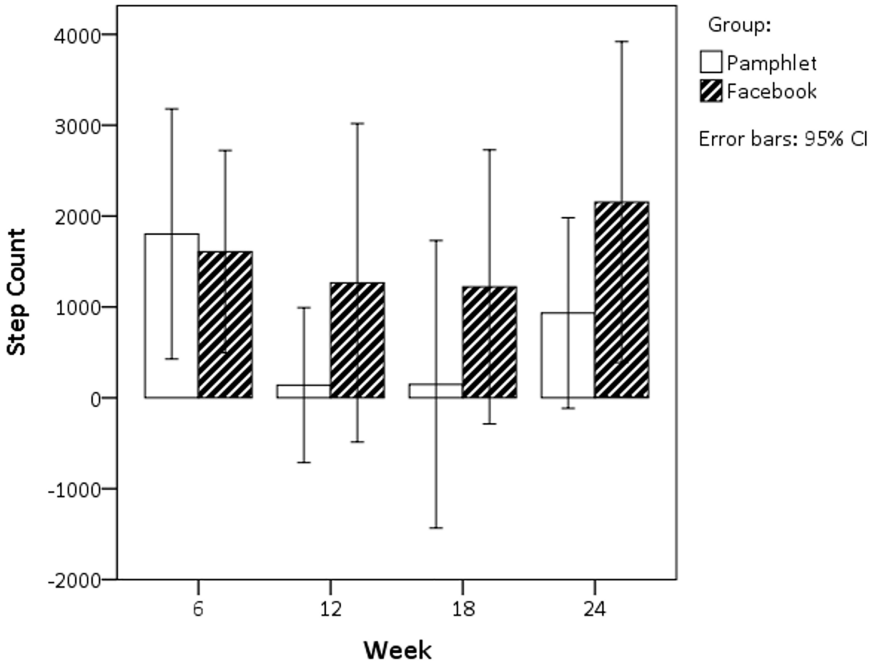

Fig 3. Between group differences in step counts.

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Table 3. Changes to Diet and physical activity.

	Week 6			Week 12			Week 18			Week 24		
	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*	mean	SEM	*n*
EI (kJ/day)												
○ **Control**	-931.0	468.2	16	-990.5	665.4	15	-1839.9	748.2	11	-1107.4	547.4	15
○ **Pamphlet**	-1843.6	501.0	20	-1693.1	448.0	20	-2320.9	547.2	17	-1071.6	500.3	17
○ **Facebook**	-1498.1	350.1	16	-1539.3	431.5	17	-1570.3	389.7	17	-1465.9	515.3	17
CHO (%)												
○ **Control**	0.6	1.5	16	-3.1	2.2	15	-5.0	1.9	11	0.1	2.1	15
○ **Pamphlet**	-3.8[a]	1.5	20	-3.2	1.8	20	-2.2	3.0	17	-3.2	1.7	17
○ **Facebook**	-3.3	1.2	16	-4.3	1.6	17	-5.2	2.1	17	-3.0	1.7	17
Fat (%)												
○ **Control**	-1.8	1.4	16	0.5	2.1	15	2.1	2.3	11	-0.9	1.4	15
○ **Pamphlet**	-2.7	1.9	20	-1.8	1.8	20	-2.4	2.8	17	0.0	2.0	17
○ **Facebook**	-1.8	1.2	16	-1.4	1.4	17	1.4	1.7	17	-2.0	1.6	17
Protein (%)												
○ **Control**	1.3	1.3	16	0.5	1.2	15	4.7	1.6	11	1.3	1.6	15
○ **Pamphlet**	5.9[a]	1.8	20	4.0	1.5	20	5.2	2.5	17	3.2	1.8	17
○ **Facebook**	5.2[a]	1.1	16	4.8[a]	1.8	17	3.9	1.2	17	4.8	1.9	17
Alcohol (%)												
○ **Control**	-0.6	1.2	16	0.6	1.8	15	-2.2	1.9	11	-0.6	0.6	15
○ **Pamphlet**	-0.3	0.6	20	-0.5	0.5	20	-1.4	0.9	17	-0.3	0.6	17
○ **Facebook**	-0.5	0.2	16	0.5	0.4	17	-0.5	0.3	17	-0.5	0.5	17
Fibre (g)												
○ **Control**	0.1	1.5	16	-0.9	1.9	15	-2.0	2.1	11	-1.8	1.5	15
○ **Pamphlet**	2.6[c]	1.6	20	1.0	1.2	20	2.4[c]	1.4	17	2.4[a]	1.4	17
○ **Facebook**	-3.2	1.1	16	-1.9	1.4	17	-2.8	1.9	17	-1.7	1.7	17
EE (kJ/day)												
○ **Control**	311.7	421.4	15	-836.2	365.2	14	600.6	819.1	9	249.9	808.2	12
○ **Pamphlet**	-855.8	399.2	19	-1046.1	454.2	19	-1472.3	447.6	17	-1626.0	552.0	16
○ **Facebook**	588.8[b]	498.6	17	-142.9	857.1	16	-277.1	452.7	15	-263.8	545.1	16
Steps/day												
○ **Control**	-	-	-	-	-	-	-	-	-	-	-	-
○ **Pamphlet**	1802.4	637.5	19	139.7	393.1	18	148.2	724.1	17	933.1	476.0	16
○ **Facebook**	1608.9	510.0	17	1265.6	789.4	15	1221.6	627.4	14	2153.5	795.3	15

%: percentage of energy intake; CHO: carbohydrate; EI: Energy intake; EE: energy expenditure

[a]mean values significantly different to Control Group ($p<0.05$); SEM: Standard Error of the Mean

[b]mean values significantly different to Pamphlet Group ($p<0.05$)

[c]mean values significantly different to Facebook Group ($p<0.05$)

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(+4.8%, $p = 0.05$). Notable increases in fibre intake occurred in the PG compared to the FG at week 6 (+2.6 g, $p = 0.005$) and at week 18 (+2.4 g, $p = 0.03$), and in the PG compared to the CG at week 24 (+2.4 g, $p = 0.03$).

The only significant increase in self-reported energy expenditure was recorded in the FG at week 6 (+588.8 kJ/day, $p = 0.03$) compared to the PG. When measuring physical activity, the step counts were not significantly different, although the FG recorded two-fold greater step numerical count compared to PG at the conclusion of the intervention (PG: +933.1 steps v FG: +2153.5 steps) (Fig 3, Table 3).

Discussion

One of the central tenets of health promotion is to create a supportive environment, conducive to health behaviour change [41]. The intervention reported here was designed to provide dietary and physical activity instructions and social support within a dedicated Facebook group, creating a supportive environment for overweight and obese participants to manage their weight.

The overall aim of this study was to determine if a weight management program delivered via a dedicated social media group would augment beneficial changes in weight and other metabolic syndrome risk factors compared to written instructions only in overweight and obese individuals.

It was expected that by week 24 the PG would experience a mean weight loss of 2% of initial body weight compared to CG. As the results show, the PG experienced a mean weight loss of 3.6% of initial body weight, 2.1% greater than the CG ($p = 0.05$). The PG also had greater improvements in fasting blood glucose compared to the CG ($p = 0.04$) and the FG ($p = 0.03$) at the conclusion of the intervention.

It was also expected that, compared to the CG, the FG would experience a mean weight loss of 9% initial body weight at the end of the 24 week intervention. While the FG posted the greatest weight loss by week 24 compared to the CG ($p = 0.01$), at 4.8% of initial body weight, the FG didn't achieve that predicted target. However compared to the CG, the FG only demonstrated significant improvements in BMI ($p = 0.02$), waist circumference ($p = 0.04$), lean mass ($p = 0.03$) and fat mass ($p = 0.01$) by week 24. Also, although the FG showed greater numerical improvements in weight, BMI, waist circumference, lean and fat mass compared to the PG, these changes were not statistically significant.

By the end of the 24 week trial period, the FG reported the greatest numerical reduction in energy intake (-1465.9 kJ/day) compared to the PG and the CG, though this result did not achieve statistical significance. The discrepancies between weight loss and changes to dietary intake may be explained by inaccurate dietary intake self-reporting, a common problem in weight management trials [7]. The between group differences in baseline energy expenditure measurements recorded for all groups appears to indicate *reductions* in physical activity across the course of the study, with few exceptions; this is inconsistent with the trial recommendations. The between group comparisons show an increase in energy expenditure measurements at week 6 in the CG (+311.7 kJ/day, $p = 0.05$) and the FG (+588.8 kJ/day, $p = 0.03$) compared to the PG, and an increase was noted at week 18 in the CG (+600.6 kJ/day, $p = 0.03$) compared to reductions in the PG and the FG. These results are also inconsistent with the increase in baseline step counts reported in the PG and FG. While the differences were not statistically significant at any of the time points, both groups reported increases in step counts with the PG recording more steps at week 6, but the FG recording greater increases in number of steps for the remaining three time points (including a difference of +1220.4 steps at week 24 compared to the PG).

Overall the changes to weight, BMI, waist, lean and fat mass measures observed in the present study in the FG are very encouraging, particularly in light of the smaller than expected sample size of this study. While these changes were not significant in the present study for the FG compared to the PG, they represent successful, practical outcomes. For example, a 5% reduction in total body weight can provide clinically significant changes to metabolic syndrome risk factors such as lipid profiles [42, 43] and fat mass [42] in overweight/obese individuals. The 4.8% reduction in total body weight and the reductions in BMI, waist circumference, fat mass and energy intake that were noted together with the increases in lean mass and step count posted by the FG are thus very encouraging.

With respect to relevant considerations in interpreting the current findings, it should be noted that the original 12-week intervention (with a 12-week follow-up) was extended to a 24-week intervention only as the week 12 collection point was due to occur during the Christmas and New Year period, and data collected at this time may not have reflected the dietary and physical activity changes made during the twelve weeks prior [30]. It was not advisable to delay the start of the trial by another 12 weeks to avoid the festive season, as many of those individuals recruited at the start of the recruitment period were likely to lose interest in the study if it had been delayed further. According to 'Stages of Change' theory, if an individual was at the 'Preparation Stage' at recruitment it would be optimal for them to commence the intervention within 30 days; if they were at the 'Action Stage', they would need to start the intervention immediately [44, 45]. In addition, it was not feasible to adopt a 'rolling recruitment' approach, as it was important for all Facebook Group participants to be given access to the group page at the *same* time, to avoid any social disadvantage within the group. Therefore *all* participants were required to be randomised into groups before the trial commenced. In addition, due to necessity limited resources were spent on recruitment, which may have extended the length of the recruitment phase.

Even so, the effect of this intervention on weight measures and metabolic syndrome risk factors may have been blunted by the occurrence of Christmas in the middle of the intervention period. Excessive food consumption during Christmas is a well-known and common phenomenon [46–49]. The between group differences in outcome measures data (Table 2) shows very few statistically significant results were recorded at this time (week 12). It is speculated that this period may have especially been detrimental to the FG as they may have spent less time online receiving support, information and help, due to the commitments of the season. Alternatively, the results of a clinical weight management trial conducted across such a time period could be viewed as more representative of real world scenarios, as opposed to contriving ideal study conditions that rarely occur in day to day life.

In this trial the weight management guidelines were briefly explained to participants at an initial information session, but beyond that participants were given no further guidance or counselling, as would be the case with most free living individuals making such modifications. One of the reasons for this is that it is common for participants in weight management trials to have the benefit of regular dietetic counseling [50–53] and/or personalised feedback of some kind [54, 55]. In addition, participants in some previous trials had access to food items consistent with the recommended diet [56], which is sometimes provided in dietary meal-sized portions [50], or of specific macronutrient composition [50, 51] and/or provided with kitchen scales [51, 53, 54]. This type of high level of support would require considerable financial expenditure were participants expected to pay, and does not reflect real world scenarios (especially among low socioeconomic groups). Indeed, the results of weight management trials conducted in this way may not represent realistic outcomes for individuals or population groups. However, it is quite possible that social media groups such as the one in the present study may benefit from active leadership from within the group [57] to encourage greater program engagement. This strategy would also maintain cost-effectiveness of the intervention by keeping health professional involvement down to a minimum. Additional facilitator involvement in the FG may be another strategy that could be used to boost participant engagement. It may also be the case that the use of social media for weight management may appeal differentially to certain individual or personality types [58].

Other factors may have influenced the outcomes of this intervention. Ambivalence towards health food choices and/or weight loss has been shown to result in poorer weight loss outcomes, such that an individual with a negative attitude towards the task or their ability to undertake it can undermine the execution of positive intentions [59–61]. Anecdotally provided

information in this study indicated that several FG participants accessed a hard copy of the *Total Wellbeing Diet*, which may have meant that they had a reduced need to access the Facebook group page. In addition, one study has shown participants to view social connectedness on Facebook to be distinct from social connectedness with offline connections, i.e. in the 'real world' [24]. Perhaps participants in the present study did not rely on each other in the same way that they would typically rely on their offline social connections, particularly as participants were unknown to each other before trial commencement. Furthermore, participants did not choose to join the Facebook Group, but were placed there via study randomisation. Any reluctant social media users within this group may have been less inclined to engage with the other group members online, which could potentially blunt the overall changes to group outcomes.

For many individuals, particularly those in the obese category (BMI $\geq$30 kg/m^2), weight loss requires continued effort, not only to maintain a relatively small amount of weight loss, but to persevere until a healthy weight is achieved [62]. Due to the cost-effectiveness of social media, particularly when using existing social media platforms, an ongoing intervention or program delivered within an online social media group may help participants to make sustained progress towards their personal goals. Being a longer-term member of an online group than was possible in the present study may also help to build stronger relationships between members, as stronger online relationships have been shown to improve trust between members [63], and may therefore result in better outcomes over time.

In spite of the issues discussed, the FG reported numerically greater improvements in weight, BMI, waist circumference, fat mass, lean mass, and energy intake compared to the CG and the PG, and a greater step count than the PG, by the end of the 24 week intervention. These results demonstrate the potential of social media to assist overweight and obese individuals with respect to dietary and physical activity modifications for weight management. Further research is needed to clarify these results, and to identify the particular features of social media that may be most beneficial for weight management programs, as well as the types of individuals most likely to benefit from this approach.

Strengths

The results of this study demonstrate the potential benefits of using social media tools to assist overweight and obese individuals with dietary and physical activity modifications for weight management. As mentioned above, a mean weight loss of 5% of total body weight can result in positive metabolic changes in overweight and obese individuals. In the current study, a mean weight loss of 4.8% of initial body weight was noted in the FG in conjunction with positive changes in waist circumference and in both lean and fat mass. Research in this area is still in its relative infancy, and the results of this trial add significantly to the current knowledge base while suggesting potential benefits that can be applied in the context of both public health and clinical practice.

Limitations

The results suggest that social media has some potential to assist with weight management, and identifies areas where improvements can be made to optimise this potential. However, the small sample size may have limited the capacity of this study to produce any further statistically significant results. Based on the total sample available at week 24 (n = 54) and the observed effect size (Cohen's d = 0.37)[38], *post hoc* analysis found that this study achieved a statistical power of 0.65 (or 65%). The statistical methods employed in this study were chosen with generalisability in mind; to wit, in real world settings some individuals may not persevere with a specific weight management program for any length of time e.g. twenty four weeks. Participant

burden may have influenced attrition [64] in the present study, as a large amount of data was collected, including psychometric measures and Facebook group activity, which will be analysed and presented in future reports. While the high volume of data collected may have contributed to participant burden, examination of this data may provide further clues to the outcomes reported here.

Implications for research and practice

Social networking platforms may provide several benefits to group members, such as bridging geographical boundaries, connecting with likeminded individuals (which may be particularly helpful if offline support is lacking), and providing support at low cost and 24-hour accessibility. The ability of group members to assist each other via social media may also remove some of the burden from health care services, for instance between appointments. The potential advantages to health professionals of social networking platforms also include the ability to deliver relatively low cost health interventions, the capacity to manage large caseloads in a time-effective manner and the possibility of reaching minority or hard to access groups. This potential is enhanced if a ready-made platform such as Facebook is used, as this further minimises costs and provide health professionals with access to existing social networks.

Future intervention trials involving social media may benefit from allocating participants to either a 'treatment program' or a 'treatment program with a social media' group according to their personal preference, as this may reflect more realistically how this resource would be utilised in clinical settings. Participants that are identified as very active social media users could be given leadership roles within these groups to assist with overall participant engagement. Allowing participants to get to know each other a little beforehand (through social media or other channels), or to enroll with one or more friends, may also improve trial outcomes. In addition, future weight management trials may need to accommodate food-related events like Christmas and other relevant time periods (e.g. Passover, Ramadan) in order to inform improved strategies for weight management practices. Information gained from such approaches is likely to help clarify how to make the best use of social media in both the research and the clinical environments.

Supporting information

S1 File. PLOS CONSORT 2010 checklist.
(DOC)

S2 File. Trial Protocol Part 1. Intervention program.
(PDF)

S3 File. Trial Protocol Part 2. Project Outline.
(DOCX)

S4 File. Trial Protocol Part 3. Questionnaires.
(DOCX)

S1 Fig. Showing up-to-date schedule of outcome measures.
(TIF)

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Trial registration

Australian New Zealand Clinical Trials Register (ANZCTR): ACTRN12614000536662. Date registered: 21 May 2014. Study protocol can be accessed at: http://www.anzctr.org.au/Default.aspx

Author Contributions

Conceptualization: SP.

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Supervision: SP.

Validation: SP SH.

Visualization: MJ.

Writing – original draft: MJ.

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