Predicting Physical Activity-Related Outcomes in Overweight and Obese Adults: A Health Action Process Approach

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Abstract

The present study examined the efficacy of constructs from the Health Action Process Approach (HAPA) with respect to physical activity participation in predicting changes in biomedical and psychological outcomes in overweight and obese adults undergoing a 12-week weight-loss intervention. Measures of the HAPA constructs (action and maintenance self-efficacy, outcome expectancies, planning, risk perceptions, and intentions), psychological outcomes (quality of life, and depression, anxiety, and stress symptoms), and biomedical outcomes (body fat mass, heart pulse, waist circumference, total cholesterol, and low density lipoprotein) were administered to overweight and obese participants (N = 74). Measures were taken at baseline and 6 and 12 weeks after a behavioural weight-loss intervention. A variance-based structural equation model revealed significant direct effects of action self-efficacy and outcome expectancies on physical activity intentions, and significant direct effects of maintenance self-efficacy and intentions on planning. Action self-efficacy was indirectly related to planning mediated by intention and maintenance self-efficacy. Planning had a direct relationship with each biomedical and psychological outcome. There were also significant indirect effects of intentions on the biomedical and psychological outcomes mediated by planning. Data support the hypothesised direct and indirect effects of the HAPA and demonstrate its efficacy in explaining variance in key physical activity outcomes.

Keywords: Action self-efficacy, Behaviour change, Exercise, Health action process approach, HEALTHI Program, Intention, Maintenance self-efficacy, Obesity, Overweight, Outcome expectancies, Physical Activity, Planning, Risk perception, Weight-loss.

Practitioner Points:

- The current study examined the efficacy of the Health Action Process Approach in providing an evidence base for behavioural interventions that will be optimally effective in changing physical activity behaviour and weight-loss outcomes.
- The model indicates that interventions that promote action and maintenance self-efficacy (e.g., providing experiences of success, positive feedback, appropriate role models) as well as planning (e.g., stating when and where the behaviour should be performed) should lead to improvements in physical activity intentions and related outcomes.
- The current model indicates how changing the variables (e.g., action and maintenance self-efficacy, outcome expectancies, planning, risk perceptions, and intentions) in the model will evoke change in behavioural and outcomes related to weight loss, effects that are not routinely tested in models of behaviour change.

Predicting Physical Activity-Related Outcomes in Overweight and Obese Adults: A Health Action Process Approach

Obesity and overweight are linked to multiple chronic health conditions and illnesses including cardiovascular disease and diabetes (World Health Organization; WHO, 2012). The main cause of overweight and obesity is an imbalance between the amount of energy consumed and expended, highlighting sufficient physical activity as an important means to maintain a healthy weight and to achieve weight loss (WHO). Physical activity may also help in reducing incidence of metabolic risk factors linked to chronic conditions and illnesses in overweight and obese individuals (WHO). Even in the absence of weight loss it has been found that physical activity leads to improvements in risk factors associated with chronic diseases like cardiovascular disease such as cholesterol and blood pressure (Ho, Dhaliwal, Hills, & Pal, 2012a, 2012b; Ho, Dhaliwal, Hills, & Pal, 2013; Shaw, Gennat, O'Rourke, & Mar, 2006). Physical activity guidelines in America and Australia suggest that to receive health benefits adults should engage in a minimum of 30 minutes of moderate activity on most or all days of the week (Norton, Norton, & Sadgrove, 2010; Pal, Cheng, & Ho, 2011). Similarly, Australia's Physical Activity and Sedentary Behaviour Guidelines for Adults (Department of Health, 2014) recommend that adults are active on most, preferably all, days of the week. Regular physical activity has also been found to lead to better psychological and affective outcomes (Nieman, 2002). For example, physical activity has been found to relate to better management of symptoms of stress, anxiety, and depression. In addition, research has found that being overweight impacts on an individual's quality of life with weight having a negative correlation with the quality of life level within both clinical and community populations (Fontaine & Barofsky, 2001; Kolotkin, Crosby, Williams, Hartley, & Nicol, 2001; Kushner & Foster, 2000; Wright et al., 2013). Studies have found that improvement in quality of life is apparent following various types of weight loss interventions (Kolotkin et

al., 2001; Mamplekou, Komesidou, Bissias, Papakonstantinou, & Melissas, 2005; Wright et al., 2013).

According to the 2011-2012 National Nutritional and Physical Activity Survey, 36% of Australian adults were classed as insufficiently active and did not meet guideline physical activity levels of at least 150 minutes of activity over five or more sessions per week (Australian Bureau of Statistics, 2013). Researchers in behavioural medicine have aimed to identify the theory-based modifiable psychological factors that should be targeted in behavioural interventions to evoke a change in health behaviour such as physical activity. This information can be used to guide the adoption of appropriate techniques that will be effective in affecting a change in the psychological factors most strongly related to physical activity (Hagger & Hardcastle, 2014; Michie & Johnston, 2012). Adopting a theoretical basis provides an explanatory system to identify the psychological constructs that could be targeted by specific behaviour-change techniques and mediate the effect of the techniques on key health-related outcome variables (Hagger & Luszczynska, 2014; Knäuper et al., 2011). Such an approach allows researchers to propose specific hypotheses as to how a particular technique may evoke behaviour change and how the technique operates. The hypotheses can then be confirmed or rejected against observation.

The current study adopts the Health Action Process Approach (HAPA; Schwarzer, 2008), a widely used social psychological model that has been used to identify components related to changes in weight loss behaviours and how the various components inform the intervention content to highlight the change process. The aim of the current study is to examine the effectiveness of the HAPA variables in predicting changes in biomedical and psychological outcomes in overweight and obese adults within the context of behaviour-change in a physical activity intervention.

Health Action Process Approach

The HAPA is a social-cognitive model that aids understanding of health behaviour as it provides a solution to the problem that forming strong intentions does not always lead to behaviour change, often referred to as the intention-behaviour 'gap.' According to the main tenets of the HAPA, the health behaviour change process consists of two phases: a *motivational* phase, which describes the process by which individuals form intentions to change behaviour, and a *volitional* phase, which describes the process by which individuals implement their intentions to perform the actual behaviour (Schwarzer, 2008). The model suggests that *intentions* (e.g., how much participants intend to participate in the recommended physical activity) are related to *planning* (e.g. whether participants made a detailed plan about when, where and how they would engage in physical activity), which then influences *action*. Specifically, planning is depicted as the key mediating factor by which intentions are enacted.

The initial motivational phase describes the process by which individuals form intentions to perform health behaviours (Schwarzer & Luszczynska, 2008). The HAPA identifies three social-cognitive belief-based constructs that give rise to intentions: *risk perception* (e.g., perceived risk of developing obesity related risk factors), *outcome expectancy* (e.g., participants expectation of the effect of physical activity), and *action self-efficacy* (e.g., participants' confidence and ability to engage in the recommended physical activity guidelines). These three variables are proposed to directly relate to intentions. Individuals, therefore, form their intentions based on these sets of beliefs. Once an individual has formed the intention to perform the action, the volitional phase is critical to behavioural enactment. Within this phase self-efficacy and planning are key variables. There are various types of perceived self-efficacy: *action self-efficacy* describes the motivation an individual has to perform action; *maintenance self-efficacy* describes the individual's beliefs regarding

their ability to deal with barriers that may arise; *recovery self-efficacy* describes the individual's experience of setbacks and the trust they have in their ability to recover (Schwarzer & Luszczynska, 2008). Action self-efficacy is believed to have a direct relationship to maintenance self-efficacy, which is directly related to *planning. Planning* the steps for the action formation is necessary to convert good intentions to actual behaviour change.

Evidence Supporting the HAPA

The HAPA is well supported by empirical research in multiple health behaviours and contexts. Studies have illustrated that the HAPA framework is effective in predicting physical activity (Barg et al., 2012; Lippke, Ziegelmann, & Schwarzer, 2004; Scholz, Sniehotta, & Schwarzer, 2005; Sniehotta, Scholz, & Schwarzer, 2005; Ziegelmann, Lippke, & Schwarzer, 2006). For example, Barg and colleagues (2012) examined predictors of physical activity using a sample of inactive middle-aged women and illustrated that the main hypotheses relating to the HAPA predictions are supported. This includes, action self-efficacy and outcome expectancies significantly predicted intentions, and outcome expectancies affect planning indirectly through intentions. Intentions and maintenance self-efficacy significantly predicted planning, and action self-efficacy affected planning indirectly through intentions. Risk perception was not found to predict intention which is in contrast to model hypotheses. Support for the HAPA has also been found in studies examining dietary health behaviour (Chiu, Lynch, Chan, & Rose, 2012; Kreausukon, Gellert, Lippke, & Schwarzer, 2012). For example, Kreausukon and colleagues (2012) examined an intervention program based on the HAPA with an emphasis on dietary self-efficacy and planning skills; with the participants within the intervention condition consuming increased fruit and vegetable consumption compared to the control condition. Results indicated that self-efficacy and planning were statistically significant predictors of change in dietary behaviours. Overall, research has

generally provided support for the model in predicting health behaviours in a number of domains.

To date, the majority of the research studies have been correlational and prospective in design and focused on behavioural prediction rather than behaviour change. While prediction of variance in health behaviour and its antecedents has value, such approaches have been criticised as focusing exclusively on explanation and not explaining change (Sniehotta, Presseau, & Araújo-Soares, 2015). This is particularly important when one regards the typically strong effects of past behaviour and habit on prospectively-measured behavioural outcomes over time, and the strong auto-regressive effects of psychological factors on themselves over time (Lindwall, Larsman, & Hagger, 2011). This means that many studies do not adequately account for change, particularly the stability of the behavioural relationship over time, which reduces the value of the model in accounting for behaviour over time (i.e. mediating the past behaviour-future behaviour, of habit-behaviour relationship over time). Better approaches that account for changes in these factors over time are likely to have greater value when it comes to understanding how behaviour changes over time. To date, there have been a number of studies, many of them adopting cross-lagged panel design with autoregressive techniques to predict change and control for the stability of psychological constructs over time, in the context of social cognitive models of health behaviour (Davis, 1985; Hagger, Chatzisarantis, & Biddle, 2002a; Hagger, Chatzisarantis, & Biddle, 2002b; Jacobs, Hagger, Streukens, De Bourdeaudhuij, & Claes, 2011; Liska, Felson, Chamlin, & Baccaglini, 1984). However, there are no studies to date that have examined effect of dynamic changes in HAPA variables on multiple behavioural outcomes. The aim of the current research was to address this gap in the literature.

The present study and hypotheses

The purpose of the present study was to examine the efficacy of the HAPA constructs for physical activity in predicting change in key health-related biomedical and psychological outcomes in overweight and obese individuals from baseline to week 6 and 12 undergoing a weight loss intervention. The research focused on predicting change while controlling for intervention effects. The hypothesised relations among the HAPA variables in the present study are displayed in Figure 1 and summarised in Table 1. We have detailed each hypothesised relationship in the next sections using Figure 1 and Table 1 as a guide. It is important to note that in the Figure and Table, the constructs reflect a *change* in the construct across study time points.

Direct effects. Based on the HAPA (Schwarzer, 2008), we predicted that changes in action self-efficacy would predict changes in intention (H_1), and changes in intention would predict planning (H_2). We also predicted that changes in action self-efficacy would be related to changes in maintenance self-efficacy (H_3), and changes in maintenance self-efficacy would be predict changes in planning (H_4), consistent with predictions of the HAPA. In addition, it was predicted that changes in outcome expectancies (H_5), and risk perception (H_6) would predict changes in intention. We also hypothesised that changes in planning would predict changes in each of the biomedical and psychological outcome variables ($H_{7a\text{-}f}$).

Indirect effects. We also hypothesised a series of indirect effects in the model based on HAPA predictions. We hypothesised indirect effects of changes in action self-efficacy on changes in planning mediated by changes in intention (H_8), and changes in action self-efficacy on changes in planning mediated by changes in maintenance self-efficacy (H_9). Also, changes in outcome-expectancies (H_{10}) and risk perception (H_{11}) was predicted to have indirect effects on changes in planning mediated by changes in intention.

In addition, changes in intention were expected to predict changes in each of the biomedical and psychological outcome variables mediated by changes in planning (H_{12a-f}). We also hypothesised that changes in maintenance self-efficacy would predict changes in the outcome variables mediated by changes in planning (H_{13a-f}). Changes in action self-efficacy was also predicted to have indirect effects on changes in the outcome variables mediated by changes in both maintenance self-efficacy and planning in three-segment mediation effects (H_{14a-f}). Similarly, changes in action self-efficacy (H_{15a-f}), outcome expectancies (H_{16a-f}), and risk perceptions (H_{17a-f}) was also hypothesised to have indirect effects on changes in the outcome variables mediated by changes in intention and planning in three-segment mediation effects. In addition, we hypothesised an overall indirect effect of changes in action self-efficacy on changes in planning mediated by changes in maintenance self-efficacy and intention (H_{18}). In addition, we hypothesised an overall indirect effect of changes in action self-efficacy on changes in each outcome variable mediated by changes in maintenance self-efficacy and intention, and changes in intention and planning (H_{19a-f}). Together these indirect effects are proposed to chart the motivational processes that lead to action based on the HAPA.

Method

Design

The current study adopted an intervention-controlled three-wave prospective design with HAPA constructs (action self-efficacy, maintenance self-efficacy, outcome expectancies, risk perception, intention, planning) and biomedical (body fat mass, heart pulse, waist circumference, total cholesterol and low density lipoprotein) and psychological (quality of life, and depression, anxiety, and stress symptoms) outcomes measured at an initial data collection occasion (baseline) and at 6- and 12-week (excluding body fat mass which was

only measured at baseline and week 12). Data were collected as part of an intervention study in which overweight and obese participants were randomly-allocated to one of three conditions to complete a 12-week Healthy Eating and Active LifesTyle Health Intervention (HEALTHI). The full protocol for the intervention is provided in a separate article outlining the specific details of the study design and method (Hattar, Hagger, & Pal, 2015). While participants in the three conditions differed in the behaviour-change techniques used, no intervention effects were found within the data used for the current study. For completion, we controlled for intervention effects in all study variables in order to completely negate any potential intervention effects. Ethical approval for the trial was obtained from the [University omitted for masked review] University Human Research Ethics Committee.

Participants

Participants provided informed consent to participate in the research study and for the data results to be published. Overweight or obese participants (N = 74*; M* age = 41.10 years, SD = 12.10, Body Mass Index = 31.13, SD = 3.55) from [Location omitted for masked review] completed various measures at baseline after randomisation, and at follow up data collection occasions 6 and 12 weeks later. Participants within the three original conditions did not differ on any of the demographic information. Of the 74 participants 63.5% were born in Australia, and 36.5% were born outside of Australia. Participant nationalities included White/Caucasian (75.7 %), Asian (6.8%), Black/African American (1.4%), other (14.9%) and the remainder did not provide their ethnicity (1.4%). The majority of the participants reported a high level for education, reporting completing education at university or tertiary level (75.7%), technical/trade certificate (6.8%), completed high school (13.5%) and the remainder left high school before completion (4.1%). The majority of participants were engaged in full time employment (60.8%), with a further in part time employment (28.4%), part time volunteers (2.7%), engaged in home duties (2.7%), working as a part time volunteer and in

part time employment (2.7%), and the remainder did not provide their employment status (2.7%). Participants reported engaged in jobs that involved predominately sitting (67.6%), standing and some walking (16.2%), predominately physical (12.2%), other (2.7%), and the remainder reported none (1.4%).

Measures

Health Action Process Approach. Self-report measures of the HAPA variables were administered at baseline and at week 6- and 12-weeks during the intervention, as adapted from Barg and colleagues' (2012) measures. The items are outlined in Appendix A. *Risk perception* was assessed using four items (e.g., "I think it is likely that I will develop health problems related to obesity at some point in my life") with responses provided on a six-point scales ranging from 1 (strongly disagree) to 5 (strongly agree). *Outcome expectancy* was assessed using three items (e.g., "I think that engaging in daily physical activity with a minimum of 30 minutes of planned exercise will help me to lose weight") with responses provided on five-point scales ranging from 1 (strongly disagree) to 5 (strongly agree). *Intention* was assessed with two items (e.g., "I intend to participate in daily physical activity with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks") with responses ranging from 1 (strongly disagree) to 5 (strongly agree). *Action self-efficacy* was measured using five items (e.g., "if it were entirely up to you, how confident are you that you would be able to participate in daily physical activity with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks?") with item responses ranging from 1 (not confident) to 5 (completely confident). Participants were informed of the guidelines as part of the intervention. *Maintenance self-efficacy* was measured using nine items (e.g., "how confident are you that you will do daily physical activity with a minimum of 30 minutes of planned exercise during your leisure time on each individual occasion over the next 6 weeks even if…" followed by a list of barriers, such as,

but not limited to bad weather and feeling tired) with responses ranging from 1 (not confident) to 5 (completely confident). *Planning* was assessed using one item (e.g., "I have made a detailed plan about when, where, and how I will do daily physical activity with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks") with responses ranging from 1 (strongly disagree) to 5 (strongly agree).

Biomedical outcome variables. Biomedical outcome variables related to risk from chronic illness that have also shown to be sensitive to changes in physical activity level were measured at baseline, week 6 and 12 unless specified otherwise. *Total body fat* measured in grams was measured using the whole body dual-energy X-ray absorptiometry (DEXA; Lunar Prodigy, Lunar, Madison, WI, USA) at baseline and 12 weeks. The DEXA apparatus was calibrated and a phantom scan undertaken daily. *Heart pulses* per minute was measured three times with the average reading reported using an automated, blood pressure monitor (A & D Medical, model UA-851) with participants in a supine position with the tested arm at the level of their heart for at least a minimum of 10 minutes before and during measurements (Naissides, Pal, Mamo, James, & Dhaliwal, 2006; Pal & Radavelli-Bagatini, 2013). *Waist circumference* in centimetres was calculated by measuring waist circumference in standing position at the narrowest area between the iliac crest and lateral lower rib to the nearest 0.1cm using a circumference measuring tape (Seca 203). Waist circumference was measured twice with the average of the two readings used (Pal, Khossousi, Binns, Dhaliwal, & Ellis, 2011). *Total cholesterol* (TC) and *low-density lipoprotein* (LDL) were measured at an approved pathology laboratory using a venous blood sample within an approximately three-day period prior to the clinic appointment.

Psychological outcome variables. Psychological variables were measured at baseline, week 6 and 12 using the two listed questionnaires. *Quality of life* was measured

using the 31-item Impact of Weight on Quality of Life Questionnaire (Kolotkin & Crosby, 2002) self-reported measure that assesses the effect of obesity on quality of life in five domains: physical function, self-esteem, sexual life, public distress, and work. Scores on each domain are summed to provide an overall index of quality of life. Responses were made on five-point scales ranging from 1 (never true) to 5 (always true). The Depression Anxiety Stress Scales-21 (Lovibond & Lovibond, 1995) was used to measure symptoms of *depression*, *anxiety*, and *stress*. Participants rated their symptoms over the past week by answering 21 items with responses made on four-point scales anchored by 0 (did not apply to me at all) and 3 (applied to me very much, or most of the time), (Lovibond & Lovibond, 1995).

Statistical analysis

Participant Attrition

Seventy-five participants commenced the HEALTHI Program. Participant retention rates were high throughout the intervention. Four participants withdrew from the study for personal reasons prior to the week 6 appointment, and a further three withdrew or did not attend the week 12 appointment. In addition, one participant's data was excluded from the analysis due to a low baseline body mass index of 24 which did not match the study inclusion criteria, leaving 74 participants for analysis. We conducted a full intention-to-treat analysis with last measured data points carried forward in order to provide a conservative estimate of hypothesised effects.

Analyses

Data used in this study were collected at baseline and after the intervention had been administered with intervention effects found to be small and not statistically significant. We

tested the hypothesised relationships among construct from the HAPA illustrated in Figure 1. If the major hypotheses of the model are non-significant this indicates that the model should be rejected. Data were analysed using variance-based structural equation modelling (VB-SEM), also known as Partial Least Squares analysis. As our analysis focused on examining change in psychological and outcome variables across study time points, we computed residualised change scores for each variable in the proposed model. Residualised change scores were calculated prior to the VB-SEM analysis by regressing the follow-up measures onto the baseline measures, while subtracting the predicted value from the follow-up value. Unstandardised residualised change scores were computed for all the variables within the model including the HAPA constructs and biomedical and psychological change outcome variables. These residualised change scores were also controlled for participants' intervention condition, age, and gender by including each of these control variables in the regression equation to compute the change scores. The residualised change scores also controlled for the baseline and week 6 scores for the variable of interest.

The VB-SEM was conducted using the Warp PLS v.5.0 statistical software (Kock, 2015), which uses ranked data which reduces outlier value distances without compromising on sample size. Effects were estimated using bootstrapped resampling method with 100 resamples as recommended by Kock (2015). VB-SEM analysis is similar to covariance based SEM analyses with both explicitly modelling measurement error through the use of latent variables. However, the partial least-squares algorithm is based on ranked data which means it is distribution free unlike covariance-based methods. This means the estimation is less affected by the model complexity, data non-normality, and small sample size. However, partial least squares structural equation modelling (PLS-SEM) approaches are often criticised for being used due to small sample sizes without support through additional power analyses (Ringle, Sarstedt, & Straub, 2012). Ringle and colleagues suggest that for PLS-SEM

researchers can use power tables from regression (Cohen, 1992) to determine the minimum sample size needed for appropriate statistical power (Chin, 2010). In the current study sample size was determined by a power analysis for multiple regression with six predictor variables (the 3-predictor system being the most complex regression system in the proposed model), with statistical power set at .80 and alpha set at .05 (Soper, 2015) and a medium effect size consistent with previous predictive studies using the HAPA (e.g., Barg et al., 2010). Our analysis revealed an estimated sample size of 73 participants is adequate.

Results

Model goodness of fit

The VB-SEM exhibited adequate model fit with the data according to multiple recommended indices with overall large effect sizes (Kock, 2015). The Tenenhaus Goodness-of-Fit (GoF) value indicates the model has large explanatory power with a value greater than the expected cut-off of 0.360, (GoF = 0.504). Both the average path coefficient (APC) and average R^2 (ARS) indicate adequate model fit with both indices statistically significant, (APC = 0.398, $p < .001$; ARS = 0.272, $p = .003$). The average full collinearity VIF (AFVIF) indicates that the model has adequate overall predictive and explanatory quality with the value below the proposed cut-off value 3.3, (AFVIF = 1.804), (Kock, 2015). Correlations among the latent variables included in the VB-SEM are provided in Table 2.

Model effects

Figure 2 displays the standardised path coefficients for the hypothesised direct effects in our model based on the HAPA. Parameter estimates for paths not depicted in Figure 2 for clarity are provided in Appendix B as online supplemental materials**.** Next, we provide details of our tests of hypotheses from the HAPA.

Direct effects. As predicted there was a statistically significant direct effect of changes in action self-efficacy on changes in intention (H_1, $\beta = .527$, $p < .001$), and changes in intention on changes in planning (H_2, $\beta = .423$, $p < .001$). There was a statistically significant direct effect of changes in action self-efficacy on changes in maintenance self-efficacy (H_3, $\beta = .755$, $p = < .001$), as well as changes in maintenance self-efficacy on changes in planning (H_4, $\beta = .339$, $p < .001$) consistent with hypotheses. We also found statistically significant direct effects of changes in outcome expectancies on changes in intention (H_5, $\beta = -.233$, $p = .017$). There was no statistically significant direct effect of changes in risk perception on changes in intentions. Statistically significant effects for changes in planning on changes in each of the outcome variables were found for body fat mass (H_{7a}, $\beta = -.332$, $p = .001$), heart pulse (H_{7b}, $\beta = -.351$, $p < .001$), waist circumference (H_{7c}, $\beta = -.312$, $p = .002$), total cholesterol and low density lipoprotein (H_{7d}, $\beta = -.472$, $p < .001$), quality of life (H_{7e}, $\beta = -.38$, $p < .001$), and depression, anxiety, and stress (H_{7f}, $\beta = .515$, $p < .001$).

Indirect effects. We found a statistically significant indirect effect of changes in action self-efficacy on changes in planning mediated by intention (H_8, $\beta = .319$, $p < .001$), and a statistically significant indirect effect of changes in action self-efficacy on changes in planning mediated by changes in maintenance self-efficacy (H_9, $\beta = .428$, $p < .001$). Contrary to hypothesised predictions there was no significant indirect effect of changes in outcome expectancies on changes in planning mediated by changes in intention (H_{10}). As we found no statistically significant direct effect of changes in risk perception on changes in intentions (H_6), we found no statistically significant indirect effect was found of changes in risk perception on changes in planning mediated by changes in intention, so we rejected hypothesis H_{11}.

The results indicated that there was a statistically significant indirect effect of changes in intention on changes in each of the outcome variables of body fat mass (H_{12a}, $\beta = -.140$, p

= .039), heart pulse (H_{12b}, β = -.148, p = .031), waist circumference (H_{12c}, β = -.132, p = .049), total cholesterol and low density lipoprotein (H_{12d}, β = -.200, p = .006), quality of life ($H_{12e,}$ β = -.161, p = .022), and depression, anxiety, and stress (H_{12f}, β = .217, p = .003) mediated by changes in planning. In addition, there were statistically significant indirect effects of changes in maintenance self-efficacy on changes in only the outcome variables of total cholesterol and low density lipoprotein (H_{13d}, β = -.160, p = .022) and depression, anxiety, and stress ($H_{13f:}$ β = .174, p = .014) mediated by changes in planning. Statistically non-significant indirect effects were found for changes in maintenance self-efficacy on body fat mass, heart pulse, waist circumference, and quality of life mediated by changes in planning, so our hypotheses relating to these variables were rejected ($H_{13a\text{-}c,}$ H_{13e}).

We also found statistically significant indirect effects of changes in action self-efficacy on changes in all the outcome variables of body fat mass (H_{14a}, β = .142 p = .015), heart pulse (H_{14b}, β = -.150, p = .011), waist circumference (H_{14c}, β = -.133 p = .021, total cholesterol and low density lipoprotein (H_{14d}, β = -.202, p < .001), quality of life ($H_{14e,}$ β = -.163, p = .006), depression, anxiety, and stress (H_{14f}, β = .220, p < .001) mediated by changes in maintenance self-efficacy and planning in three-segment mediation pathways. There was a statistically significant indirect effect of changes in action self-efficacy on changes in heart pulse (H_{15b}, β = -.112, p = .044), total cholesterol and low density lipoprotein (H_{15d}, β = -.151, p = .011), quality of life ($H_{15e,}$ β = -.121, p = .032), and depression, anxiety, and stress (H_{15f}, β = .164, p = .006) mediated by changes in intentions and planning in three segment mediation effects. There were no statistically significant indirect effects of changes in action self-efficacy on changes in body fat mass (H_{15a}), and waist circumference (H_{15c}) mediated by changes in intentions and planning in three segment mediation effects. Results indicated no statistically significant indirect effects of changes in outcome expectancies and changes in

risk perceptions on changes in the outcome variables mediated by changes in intention and planning in three-segment mediation effects ($H_{16a\text{-}f}$, and $H_{17a\text{-}f}$, respectively).

The overall indirect effect of changes in action self-efficacy on changes in planning mediated by changes in maintenance self-efficacy and intention in two-segment mediation effects was statistically significant ($H_{18,}$ $\beta = .479$, $p < .001$). The total indirect effects of changes in action self-efficacy on changes in the outcome variables through multiple paths revealed statistically significant effects on body fat mass ($H_{19a,}$ $\beta = -.159$, $p = .041$), heart pulse (H_{19b} $\beta = -.168$, $p = .033$), total cholesterol and low density lipoprotein (H_{19d} $\beta = -.226$, $p = .006$), quality of life (H_{19e} $\beta = -.182$, $p = .023$), and depression, anxiety, and stress ($H_{19f,}$ $\beta = .246$, $p = .003$). The total effect of action self-efficacy on waist circumference was not statistically significant ($H_{19c).}$

Discussion

The present study examined the efficacy of changes in HAPA constructs associated with physical activity participation in predicting changes in biomedical (body fat mass, heart pulse, waist circumference, total cholesterol and low density lipoprotein) and psychological (quality of life, and depression, anxiety, and stress symptoms) outcomes in overweight and obese adults undergoing a weight-loss intervention. Results supported key hypothesised relationships consistent with previous research conducted adopting the HAPA (Barg et al., 2012; Kreausukon et al., 2012). As predicted, changes in action self-efficacy and outcome expectancies were statistically significant predictors of changes in participants' intentions, with changes in action-self efficacy as the major predictor; similar findings have been found in other studies (Barg et al., 2012). These results suggest that changes in participants' confidence and beliefs in their own ability to engage in physical activity prior to action commencement is related to changes in participants' intention to engage in the behaviour or

action. The study results indicated that changes in action self-efficacy was directly related to changes in intentions, and indirectly related to changes in planning mediated through changes in maintenance self-efficacy, which suggests that action-self efficacy may have a role in both the motivational and volitional phases of the HAPA process model. This finding is consistent with research conducted by Barg and colleagues (2012). Consistent with the HAPA, changes in intentions and maintenance self-efficacy were significant predictors of changes in planning. Intention to engage in physical activity was found to predict planning of the behaviour. Changes in action self-efficacy predicted changes in planning indirectly through intention changes, consistent with previous research (Barg et al., 2012; Sniehotta et al., 2005). Changes in planning had a direct relationship with changes within each of the biomedical (body fat mass in grams, heart pulses per minute, waist circumference, total cholesterol and low density lipoprotein), and psychological (impact of weight on quality of life, and symptoms of depression, anxiety, and stress) outcome variables. The results indicate that changes in planning are antecedent of changes in the biomedical and psychological outcome variables. An important contribution of the present study is that these effects are supported in terms of change scores, to enable better links between the model constructs. Contrary to our hypotheses, changes in risk perception was not a good predictor of changes in intentions; other studies have also found that this relationship was not statistically significant (Barg et al., 2012; Luszczynska & Schwarzer, 2003; Schwarzer & Renner, 2000). Schwarzer (2008) also noted that risk perception is a distal predictor of intentions and Luszczynska and Schwarzer (2003) state that risk perception may have an influence in the initial consideration of behaviour but may not be as pertinent following the formation of intentions.

Contribution, Strengths and Limitations

The current research makes two important contributions to knowledge. First, it corroborates prior research that supports the HAPA model and extends these to multiple

objectively-measured health-related outcomes as indicators of participation in physical activity. Second, the current research also examines these in light of changes in these variables over the course of a long-term behavioural follow-up, which is rare in research adopting the HAPA and other social cognitive models. This has important implications for supporting the long-term predictive and nomological validity of the HAPA.

The present research has a number of notable strengths. We had high retention rates with low participant drop-out the study data collection occasions. A further strength is that the study is one of the first to adopt a well-defined theoretical approach, the HAPA, to identify theory-based predictors and mediators of study outcomes. Adopting this approach permitted the posing of hypotheses and research questions based on the model and to confirm or reject those hypotheses alongside observation. A major innovation of the present study is the examination of change in the psychological and outcome variables of time, an approach which is in contrast to the typically 'static' perspective adopted in many studies testing social cognitive theories and models in health contexts. For example, many previous tests of such models have focused solely on prediction. Using residualised change scores that control for participants responses to the variable at baseline, week 6, the condition allocation, gender, and age is an important strength as not doing so could misrepresent the effects of the HAPA constructs on outcomes.

It is also important to acknowledge some of the limitations of the current study. The current study is not a comprehensive test of the HAPA, we omitted the coping planning and recovery self-efficacy variables for reasons of parsimony. In addition, physical activity behavioural variable data collected could not be included due to a mistake in the operationalisation of the construct within the questionnaire. Our research was therefore confined to examining relations among the HAPA variables and the biomedical and psychological outcomes, which serve as indirect indicators of behavioural effects. In other

words, our test only indirectly reflects the influence of behaviour as a mediator between HAPA variables and health related outcomes. Although there is considerable research that has found health behaviour as a mediator between HAPA variables and behaviour, it would have been advantageous to confirm, rather than infer, this in the current data set. Another limitation was that all measures were self-reported thus subject to social desirability bias. Our adoption of psychometrically-verified, valid measures of the HAPA constructs with explicit instructions for participants to answer candidly and without prejudice were means to allay this bias. In addition, generalisability of the findings to the broader population may be limited. This is because our sample was neither ethnically nor socioeconomically diverse with 75.7% participants classified as white/Caucasian and 75.7% indicating that their highest level of education was at university or tertiary education level. Caution must, therefore, be exercised in generalising results beyond a highly education predominantly white/Caucasian population. In addition, as this investigation was part of a larger intervention, participants completed a number of questionnaires which may have placed undue burden on participants. We managed participant burden by encouraging participants to take regular breaks when completing the intervention materials and measures.

Overall, results of the current study provide support for the HAPA model in regards to examining changes in the construct variables. Practical recommendations based on findings of the current study are that health behaviour interventions should aim to increase action self-efficacy and planning to lead to changes in both biomedical and psychological outcomes. This would mean health care professionals that promote self-efficacy (e.g., promoting experiences of success, providing feedback, using modelling and imagery) and planning (e.g., assisting in identifying salient cues, encouraging if-then plans) in clients may foster better engagement in physical activity levels.

References

Barg, C. J. (2010). *Does the plan fit? The effectiveness of combining implementation intentions and regulatory fit for increasing physical activity and decreasing sedentary behaviour.* Master of Science Queen‟s University Kingston, Ontario, Canada

Barg, C. J., Latimer, A. E., Pomery, E. A., Rivers, S. E., Rench, T. A., Prapavessis, H., & Salovey, P. (2012). Examining predictors of physical activity among inactive middle-aged women: An application of the health action process approach. *Psychology & Health, 27*(7), 829-845. http://dx.doi.org/:10.1080/08870446.2011.609595

Chin, W. W. (2010). How to Write Up and Report PLS Analyses. In V. E. Vinzi, W. W. Chin, J. Henseler & H. Wang (Eds.), *Handbook of Partial Least Squares: Concepts, Methods and Applications in Marketing and Related Fields* (pp. 655-690). Berlin: Springer.

Chiu, C., Lynch, R. T., Chan, F., & Rose, L. (2012). The Health Action Process Approach as a Motivational Model of Dietary Self-Management for People With Multiple Sclerosis: A Path Analysis. *Rehabilitation Counseling Bulletin, 56*(1), 48-61. Retrieved from http://rcb.sagepub.com/content/56/1/48.abstract

Cohen, J. (1992). A Power Primer. *Psychological Bulletin, 112*(1), 155-159.

Davis, R. A. (1985). Social Structure, Belief, Attitude, Intention, and Behavior: A Partial Test of Liska's Revisions. *Social Psychology Quarterly 48*(1), 89-93.

Fontaine, K. R., & Barofsky, I. (2001). Obesity and quality of life. *Obesity Reviews, 2*, 173-182.

Hagger, M., & Hardcastle, S. (2014). Interpersonal style should be included in taxonomies of behaviour change techniques. *Frontiers in Psychology, 5*, 254.

Hagger, M., & Luszczynska, A. (2014). Implementation intention and action planning Interventions in health contexts: State of the research and proposals for the way forward. *Applied Psychology: Health and Wellbeing, 6*, 1-47.

Hagger, M. S., Chatzisarantis, N. L. D., & Biddle, S. J. H. (2002a). The influence of autonomous and controlling motives on physical activity intentions within the Theory of Planned Behaviour. *British Journal of Health Psychology, 7*, 299-316. http://dx.doi.org/:10.1348/135910702760213689

Hagger, M. S., Chatzisarantis, N. L. D., & Biddle, S. J. H. (2002b). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of Sport and Exercise Psychology, 24*, 3-32.

Hattar, A., Hagger, M. S., & Pal, S. (2015). Weight-loss intervention using implementation intentions and mental imagery: a randomised control trial study protocol. *BMC Public Health, 15: 196*

Ho, S., Dhaliwal, S., Hills, A., & Pal, S. (2012a). The effect of 12 weeks of Aerobic, Resistance or Combination Exercise Training on blood pressure and vascular function in overweight and obese individuals. *Journal of Clinical Hypertension, 14*(12), 848-854. http://dx.doi.org/:10.1111/j.1751-7176.2012.00700

Ho, S., Dhaliwal, S., Hills, A., & Pal, S. (2012b). The effect of 12 weeks of aerobic, resistance or combination exercise training on cardiovascular risk factors in the overweight and obese in a randomized trial. *BMC Public Health, 12*(1), 704. Retrieved from http://www.biomedcentral.com/1471-2458/12/704

Ho, S., Dhaliwal, S., Hills, A. P., & Pal, S. (2013). Effects of Chronic Exercise Training on Inflammatory Markers in Australian Overweight and Obese Individuals in a Randomized Controlled Trial. *Inflammation, 36*(3), 625-632.

Jacobs, N., Hagger, M. S., Streukens, S., De Bourdeaudhuij, I., & Claes, N. (2011). Testing an integrated model of the theory of planned behaviour and self-determination theory for different energy balance-related behaviours and intervention intensities. *Br J Health Psychol, 16*(Pt 1), 113-134. http://dx.doi.org/:10.1348/135910710x519305

Knäuper, B., McCollam, A., Rosen-Brown, A., Lacaille, J., Kelso, E., & Roseman, M. (2011). Fruitful plans: Adding targeted mental imagery to implementation intentions increases fruit consumption. *Psychology & Health, 26*(5), 601-617. http://dx.doi.org/:10.1080/08870441003703218

Kock, N. (2015). *WarpPLS 5.0 user manual.* Laredo, Texas: ScriptWarp Systems.

Kolotkin, R. L., & Crosby, R. D. (2002). Psychometric evaluation of the impact of weight on quality of life-lite questionnaire (IWQOL-Lite) in a community sample. *Quality of Life Research, 11*, 157-171.

Kolotkin, R. L., Crosby, R. D., Williams, G. R., Hartley, G. G., & Nicol, S. (2001). The relationship between health-related quality of life and weight loss. *Obesity Research, 9*(9), 564-571.

Kreausukon, P., Gellert, P., Lippke, S., & Schwarzer, R. (2012). Planning and self-efficacy can increase fruit and vegetable consumption: a randomized controlled trial. *J Behav Med, 35*, 443-451. http://dx.doi.org/:10.1007/s10865-011-9373-1

Kushner, R. F., & Foster, G. D. (2000). Obesity and quality of life. . *Nutrition Research Reviews, 16*(10), 947-952.

Lindwall, M., Larsman, P., & Hagger, M. S. (2011). The reciprocal relationship between physical activity and depression in older European adults: a prospective cross-lagged panel design using SHARE data. *Health Psychol, 30*(4), 453-462. http://dx.doi.org/:10.1037/a0023268

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004). Behavioral intentions and action plans promote physical exercise: A longitudinal study with orthopedic rehabilitation patients. *Journal of Sport & Exercise Psychology, , 26*, 470-483.

Liska, A. E., Felson, R. B., Chamlin, M., & Baccaglini, W. (1984). Estimating Attitude-Behavior Reciprocal Effects Within a Theoretical Specification. *Social Psychology Quarterly, 47*(1), 15-23. http://dx.doi.org/:10.2307/3033884

Lovibond, P., & Lovibond, S. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy, 33*, 335-343. http://dx.doi.org/:10.1016/0005-7967(94)00075-U

Luszczynska, A., & Schwarzer, R. (2003). Planning and Self-Efficacy in the Adoption and Maintenance of Breast Self-Examination: A Longitudinal Study on Self-Regulatory Cognitions. *Psychology & Health, 18*(1), 93-108. http://dx.doi.org/:10.1080/0887044021000019358

Mamplekou, E., Komesidou, V., Bissias, C., Papakonstantinou, A., & Melissas, J. (2005). Psychological condition and quality of life in patients with morbid obesity before and after surgical weight loss. *Obesity Surgery, 15*(8), 1177-1184. http://dx.doi.org/:10.1381/0960892055002356

Michie, S., & Johnston, M. (2012). Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychology Review, 6*(1), 1-6. http://dx.doi.org/:10.1080/17437199.2012.654964

Naissides, M., Pal, S., Mamo, J. C., James, A. P., & Dhaliwal, S. S. (2006). The effect of chronic consumption of red wine polyphenols on vascular function in postmenopausal women. *European Journal of Clinical Nutrition, 60*, 740-745.

Nieman, P. (2002). Psychosocial aspects of physical activity. *Paediatrics & Child Health, 7*(5), 309-312. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2795619/

Norton, K., Norton, L., & Sadgrove, D. (2010). Position statement on physical activity and exercise intensity terminology*. *Journal of Science and Medicine in Sport, 13*(5), 496-502. Retrieved from http://search.proquest.com/docview/751431911?accountid=10382

Pal, S., Cheng, C., & Ho, S. S. (2011). The effect of two different health messages on physical activity levels and health in sedentary overweight, middle-aged women. *BMC Public Health, 11(1): 204* http://dx.doi.org/:10.1186/1471-2458-11-204

Pal, S., & Radavelli-Bagatini, S. (2013). Association of Arterial Stiffness With Obesity in Australian Women: A Pilot Study. *The Journal of Clinical Hypertension, 15*(2), 118-123. http://dx.doi.org/:10.1111/jch.12038

Ringle, C. M., Sarstedt, M., & Straub, D. W. (2012). A Critical Look at the Use of PLS-SEM in MIS Quarterly. *MIS Quarterly*, *36*(1), 3-14. Retrieved from http://misq.org/

Scholz, U., Sniehotta, F. F., & Schwarzer, R. (2005). Predicting physical exercise in cardiac rehabilitation: The role of phase-specific self-efficacy beliefs. . *Journal of Sport and Exercise Psychology, Health and Medicine, 27*, 135-151.

Schwarzer, R., & Luszczynska, A. (2008). How to overcome health-compromising behaviors: The health action process approach. *European Psychologist, 13*(2), 141-151.

Schwarzer, R., & Renner, B. (2000). Social-cognitive predictors of health behavior: Action self-efficacy and coping self-efficacy. *Health Psychology, 19*, 487-495.

Shaw, K. A., Gennat, H., O'Rourke, P., & Mar, C. D. (2006). Exercise for overweight or obesity. *Cochrane Database of Systematic Reviews*,(4) http://dx.doi.org/:10.1002/14651858.CD003817.pub3

Sniehotta, F. F., Presseau, J., & Araújo-Soares, V. (2015). On the development, evaluation and evolution of health behaviour theory. *Health Psychology Review. Advance online publication, 9*(2), 176-189. http://dx.doi.org/:10.1080/17437199.2015.1022902

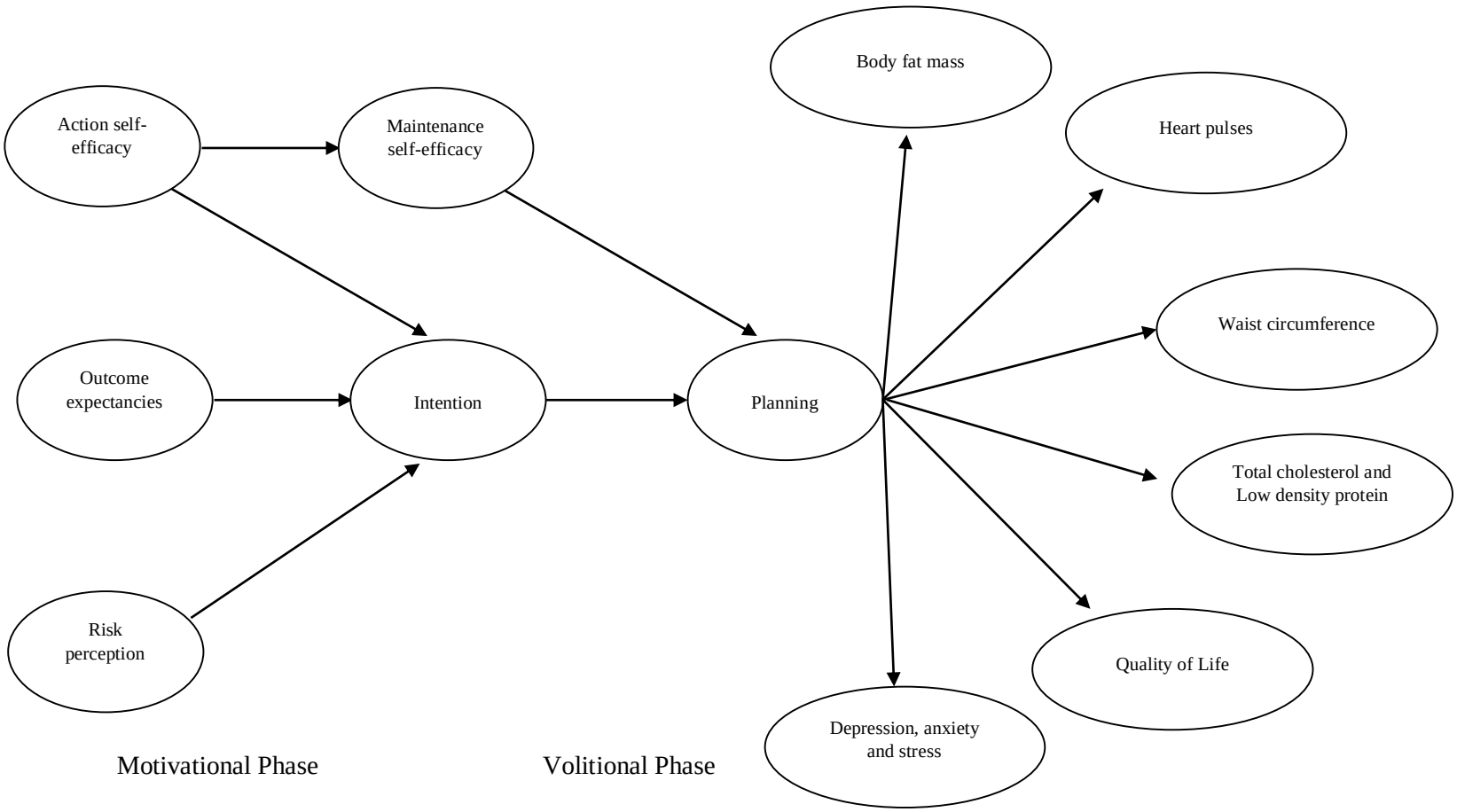
Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention-behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology and Health, 20*, 143-160.

Soper, D. S. (2015). Soper, D. S. (2015). A-priori Sample Size Calculator for Multiple Regression (Software). Retrieved from http://www.danielsoper.com/statcalc

Wright, F., Boyle, S., Baxter, K., Gilchrist, L., Nellaney, J., Greenlaw, N., & Forde, L. (2013). Understanding the relationship between weight loss, emotional well-being and health-related quality of life in patients attending a specialist obesity weight management service. *J Health Psychol, 18*(4), 574-586. http://dx.doi.org/:10.1177/1359105312451865

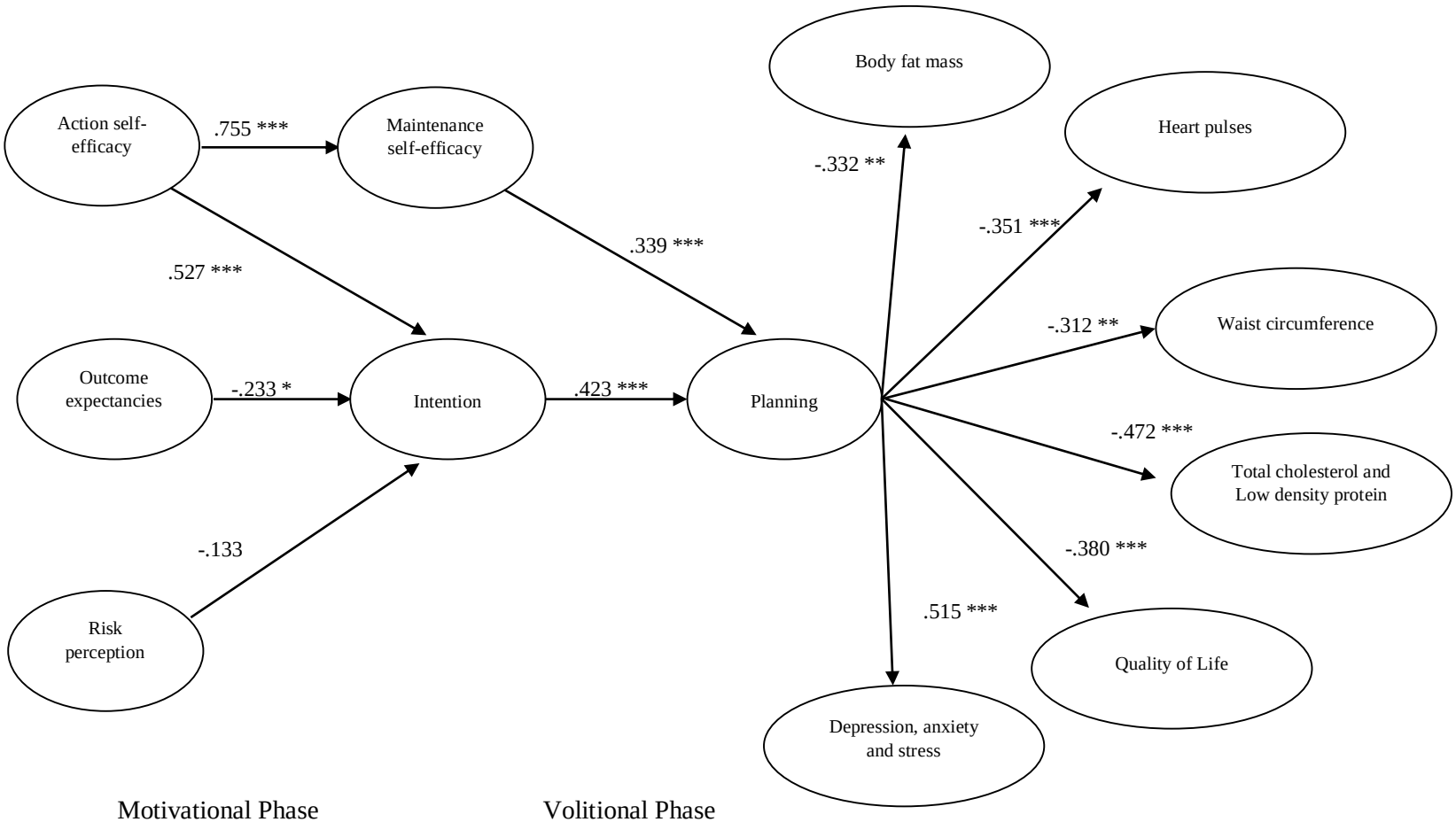
Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2006). Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. *Psychology & Health, 21*, 145-163.

Figure 1. Health Action Process Approach theoretical model and outcome variables



Note. Variable change was measured at Week 12 from baseline, controlling for Week 6, gender, age, and group condition. Body fat mass change was measured at Week 12 from baseline, controlling for gender, age, and group condition.

Figure 2. Standardised Path Coefficients from a Variance-Based Structural Equation Model of Hypothesised Relations among HAPA Constructs.



Note: *P* *<.05. **<.01. ***<.001.

Table 1

Summary of Hypothesised Direct and Indirect Effects from the HAPA

Hypothesis	Independent variable	Dependent variable	Mediator/mediators
H_1	Action self-efficacy	Intention	–
H_2	Intention	Planning	–
H_3	Action self-efficacy	Maintenance self-efficacy	–
H_4	Maintenance self-efficacy	Planning	–
H_5	Outcome expectancies	Intention	–
H_6	Risk perception	Intention	–
H_{7a}	Planning	Body fat mass	–
H_{7b}	Planning	Heart pulse	–
H_{7c}	Planning	Waist circumference	–
H_{7d}	Planning	Cholesterol and low density lipoprotein	–
H_{7e}	Planning	Quality of life	–
H_{7f}	Planning	Depression, anxiety, and stress	–
H_8	Action self-efficacy	Planning	Intention
H_9	Action self-efficacy	Planning	Maintenance self-efficacy
H_{10}	Outcome expectancies	Planning	Intention
H_{11}	Risk perception	Planning	Intention

H_{12a}	Intention	Body fat mass	Planning
H_{12b}	Intention	Heart pulse	Planning
H_{12c}	Intention	Waist circumference	Planning
H_{12d}	Intention	Cholesterol and low density lipoprotein	Planning
H_{12e}	Intention	Quality of life	Planning
H_{12f}	Intention	Depression, anxiety, and stress	Planning
H_{13a}	Maintenance self-efficacy	Body fat mass	Planning
H_{13b}	Maintenance self-efficacy	Heart pulse	Planning
H_{13c}	Maintenance self-efficacy	Waist circumference	Planning
H_{13d}	Maintenance self-efficacy	Cholesterol and low density lipoprotein	Planning
H_{13e}	Maintenance self-efficacy	Quality of life	Planning
H_{13f}	Maintenance self-efficacy	Depression, anxiety, and stress	Planning
H_{14a}	Action self-efficacy	Body fat mass	Maintenance self-efficacy & Planning
H_{14b}	Action self-efficacy	Heart pulse	Maintenance self-efficacy & Planning
H_{14c}	Action self-efficacy	Waist circumference	Maintenance self-efficacy & Planning
H_{14d}	Action self-efficacy	Cholesterol and low density lipoprotein	Maintenance self-efficacy & Planning

H_{14e}	Action self-efficacy	Quality of life	Maintenance self-efficacy & Planning
H_{14f}	Action self-efficacy	Depression, anxiety, and stress	Maintenance self-efficacy & Planning
H_{15a}	Action self-efficacy	Body fat mass	Intention & Planning
H_{15b}	Action self-efficacy	Heart pulse	Intention & Planning
H_{15c}	Action self-efficacy	Waist circumference	Intention & Planning
H_{15d}	Action self-efficacy	Cholesterol and low density lipoprotein	Intention & Planning
H_{15e}	Action self-efficacy	Quality of life	Intention & Planning
H_{15f}	Action self-efficacy	Depression, anxiety, and stress	Intention & Planning
H_{16a}	Outcome expectancies	Body fat mass	Intention & Planning
H_{16b}	Outcome expectancies	Heart pulse	Intention & Planning

H_{16c}	Outcome expectancies	Waist circumference	Intention & Planning
H_{16d}	Outcome expectancies	Cholesterol and low density lipoprotein	Intention & Planning
H_{16e}	Outcome expectancies	Quality of life	Intention & Planning
H_{16f}	Outcome expectancies	Depression, anxiety, and stress	Intention & Planning
H_{17a}	Risk perception	Body fat mass	Intention & Planning
H_{17b}	Risk perception	Heart pulse	Intention & Planning
H_{17c}	Risk perception	Waist circumference	Intention & Planning
H_{17d}	Risk perception	Cholesterol and low density lipoprotein	Intention & Planning
H_{17e}	Risk perception	Quality of life	Intention & Planning
H_{17f}	Risk perception	Depression, anxiety, and stress	Intention & Planning

H_{18}	Action self-efficacy	Planning	Maintenance self-efficacy & Intention
H_{19a}	Action self-efficacy	Body fat mass	[a]Maintenance self-efficacy & Planning. Intention & Planning
H_{19b}	Action self-efficacy	Heart pulse	[a]Maintenance self-efficacy & Planning. Intention & Planning
H_{19c}	Action self-efficacy	Waist circumference	[a]Maintenance self-efficacy & Planning. Intention & Planning
H_{19d}	Action self-efficacy	Cholesterol and low density lipoprotein	[a]Maintenance self-efficacy & Planning. Intention & Planning
H_{19e}	Action self-efficacy	Quality of life	[a]Maintenance self-efficacy & Planning. Intention & Planning
H_{19f}	Action self-efficacy	Depression, anxiety, and stress	[a]Maintenance self-efficacy & Planning. Intention & Planning

[a]H_{19a-f} effects are comprised of indirect effects through the two three segment pathways involving maintenance self-efficacy and planning, and the three segment pathway involving intention and planning.

Table 2

Factor correlations, and R^2 statistics for latent variables in Variance-Based Structural Equation Model

Variable	R^2	1	2	3	4	5	6	7	8	9	10	11	12
1. Action self-efficacy	–	–											
2. Outcome expectancies	–	.016	–										
3. Risk perception	–	-.144	.083	–									
4. Maintenance self-efficacy	.571	.749***	-.040	-.086	–								
5. Intention	.470	.625***	-.123	-.103	.565***	–							
6. Planning	.447	.434***	.041	.034	.521***	.591***	–						
7. Body fat mass	.110	-.227	.024	.228	-.261*	-.259*	-.323**	–					
8. Heart pulses	.123	-.146	.019	.023	-.240*	-.218	-.345**	.321**	–				
9. Waist circumference	.097	-.310**	.056	.143	-.291*	-.165	-.175	.528***	.154	–			
10. Cholesterol and LDL	.223	-.088	-.081	-.042	-.084	-.136	-.385***	.303**	.246*	.112	–		
11. Quality of life	.145	-.203	.027	.239*	-.131	-.207	-.224	.364**	.089	.347**	.066	–	
12. Depression, anxiety and stress	.265	.145	-.169	-.099	.032	.097	.182	.086	.092	.179	.163	-.047	–

Note. LDL = Low density lipoproteins; R^2 = Variance accounted for in dependent variable in VB-SEM model; ρ = Composite reliability estimate for each variable

*<.05. **<.01. ***<.001.

Appendix A. Details of Measures Used to Tap Health Action Process Approach Components

Scale	*Items*	*Scale anchors*
Risk Perception	I *think it is likely* that I will develop health problems related to obesity at *some point in my life*	1 = Strongly disagree, 5 = Strongly agree
	Personally, I *feel vulnerable* to developing health problems related to obesity at *some point in my life*	
	Compared to the average person, I feel that my chance of developing health problems related to obesity is:	1 = Much lower, 5 = Much higher.
	How likely do you think it is that you will get health problems related to obesity at *some point in the future*?	1 = Not likely, 5 = Extremely likely
Outcome expectancy	I think that engaging in daily *physical activity* with a minimum of 30 minutes of planned exercise is a very important way to help me to lose weight.	1 = Strongly disagree, 5 = Strongly agree.
	I believe that engaging in daily *physical activity* with a minimum of 30 minutes of planned exercise will help me to lose weight.	
	How effective do you feel that engaging in daily *physical activity* with a minimum of 30 minutes of planned exercise would be to help you to lose weight?	1= Not at all effective, 5 = Extremely effective
Action self-	If it were entirely up to you, how confident are you that	1 = Not

efficacy	you would be able to participate in daily *physical activity* with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks?	confident, 5 = Completely confident.
	How confident are you that you can complete daily *physical activity* with a minimum of 30 minutes of planned exercise no matter what, on each individual occasion over the next 6 weeks?	
	How confident are you that you can arrange your schedule to include daily *physical activity* with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks?	
	To what extent do you see yourself as being capable of participating in daily *physical activity* with a minimum of 30 minutes of planned exercise, on each individual occasion over the next 6 weeks?	1 = Not likely, 5 = Extremely likely.
	I believe I have the ability to participate in daily *physical activity* with a minimum of 30 minutes of planned exercise, on each individual occasion over the next 6 weeks?	1 = Strongly disagree, 5 = Strongly agree.
Maintenance self-efficacy	Stem: How *confident* are you that you will do daily *physical activity* with a minimum of 30 minutes of planned exercise during your leisure time on each individual occasion over the next 6 weeks even if…	1 = Not confident, 5 = Completely confident
	…you get busy and have limited time?	

	…the weather is very bad? …you are feeling tired? …you are feeling stressed? …there are competing interests like …your favourite TV show? …you have no one to do physical activity with? …you are not enjoying your physical activity? …you do not receive support from your family or friends? …you have other things you like to do in your spare time to do?	
Intention	I intend to participate in daily *physical activity* with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks. I will try to engage in daily *physical activity* with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks.	1 = Strongly disagree, 5 = Strongly agree.
Planning	I have made a detailed plan about when, where, and how I will do daily *physical activity* with a minimum of 30 minutes of planned exercise on each individual occasion over the next 6 weeks.	1 = Strongly disagree, 5 = Strongly agree.

1

2

Appendix B. Parameter estimates

Table 3. *Effect sizes and P values for the non-significant effects.*

Hypothesis	Independent variable	Dependent variable	Mediator/mediators
H_6	Risk perception	Intention	
H_{10}	Outcome expectancies	Planning	Intention
H_{11}	Risk perception	Planning	Intention
H_{13a}	Maintenance self-efficacy	Body fat mass	Planning
H_{13b}	Maintenance self-efficacy	Heart pulse	Planning
H_{13c}	Maintenance self-efficacy	Waist circumference	Planning
H_{13e}	Maintenance self-efficacy	Quality of life	Planning
H_{15a}	Action self-efficacy	Body fat mass	Intention & Planning
H_{15c}	Action self-efficacy	Waist circumference	Intention & Planning
H_{16a}	Outcome expectancies	Body fat mass	Intention & Planning
H_{16b}	Outcome expectancies	Heart pulse	Intention & Planning
H_{16c}	Outcome expectancies	Waist circumference	Intention & Planning
H_{16d}	Outcome expectancies	Cholesterol and low density lipoprotein	Intention & Planning
H_{16e}	Outcome expectancies	Quality of life	Intention & Planning
H_{16f}	Outcome expectancies	Depression, anxiety, and stress	Intention & Planning
H_{17a}	Risk perception	Body fat mass	Intention & Planning
H_{17b}	Risk perception	Heart pulse	Intention & Planning
H_{17c}	Risk perception	Waist circumference	Intention & Planning

H_{17d}	Risk perception	Cholesterol and low density lipoprotein	Intention & Planning
H_{17e}	Risk perception	Quality of life	Intention & Planning
H_{17f}	Risk perception	Depression, anxiety, and stress	Intention & Planning
H_{19c}	Action self-efficacy	Waist circumference	[a] Maintenance self-efficacy & Planning. Intention & Planning

[a] H_{19c} effect is comprised of indirect effects through the two three segment pathways involving maintenance self-efficacy and planning, and the three segment pathway involving intention and planning.

1