Impact of a male-only weight loss maintenance program on social-cognitive determinants of physical activity and healthy eating: A randomised controlled trial

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Abstract

Objectives: To examine the effect of a gender-tailored, Social Cognitive Theory (SCT)-based weight loss maintenance (WLM) intervention on men's: (i) cognitions, (ii) moderate-to-vigorous physical activity (MVPA), and (iii) energy-dense, nutrient-poor (discretionary) food intake, 12 months after completing a weight loss program. **Design**: A two-phase, assessor-blinded, randomised controlled trial. **Methods**: Ninety-two overweight/obese men (mean (SD) age: 49.2 years (10.1), BMI: 30.7 (3.3) kg/m^2) who lost at least 4 kg after receiving the 3-month SCT-based *SHED-IT Weight Loss Program* were randomly allocated to receive: (i) the SCT-based *SHED-IT WLM Program*, or (ii) no additional resources (self-help control group). The 6-month gender-tailored *SHED-IT WLM Program* included no personalised contact, and operationalised SCT behaviour change principles to assist men to increase MVPA and decrease discretionary food consumption after initial weight loss. After randomisation (baseline), men were re-assessed at 6 months (post-test) and 12 months (6-month follow-up). SCT cognitions (e.g. self-efficacy, goal setting), MVPA, and discretionary food consumption were assessed with validated measures. **Results**: Following significant improvements in cognitions, MVPA and discretionary food consumption during the weight loss phase, intention-to-treat, linear mixed models revealed no significant group-by-time differences in cognitions or behaviours during the WLM phase. Initial improvements in MVPA and some cognitions (e.g. goal setting, planning, social support) were largely maintained by both groups at the end of the study. Dietary effects were not as strongly maintained, with the intervention and control groups maintaining 57% and 75% of the Phase I improvements in discretionary food intake, respectively. **Conclusions**: An additional SCT-based WLM program did not elicit further improvements over a self-help control in the cognitions or behaviours for MVPA or discretionary food intake of men who had lost weight with a SCT-based weight loss program.

Rising male obesity rates are an international health concern (Ng et al., 2014). Between 1980 and 2013, the global prevalence of overweight and obesity in adult men increased from 29% to 37% (Ng et al., 2014). Although men have traditionally been under-represented in experimental weight loss research (Pagoto et al., 2012; Young, Morgan, Plotnikoff, Callister, & Collins, 2012), the field has progressed considerably in recent years with several methodologically rigorous male-only randomised controlled trials (RCTs) providing important insights of how best to engage and assist men to achieve clinically meaningful weight loss (Hunt et al., 2014; Morgan, Collins, et al., 2014; Patrick et al., 2011). However, weight regain after weight loss remains a major public health and research challenge. Indeed, systematic reviews show that approximately 50% of lost weight is regained in the first year after treatment alone (J. W. Anderson, Konz, Frederich, & Wood, 2001; Barte et al., 2010).

To address this problem, researchers are now testing weight loss maintenance (WLM) interventions, where participants are taught additional skills or provided with additional support in an attempt to reduce weight regain. In a recent meta-analytic review, Dombrowski and colleagues determined that participants who received a WLM program regained 1.6 kg less than controls on average in the 12 months after weight loss (Dombrowski, Knittle, Avenell, Araújo-Soares, & Sniehotta, 2014). However, in a review of dietary approaches to WLM, Collins and colleagues reported that only 14/56 studies reported significant intervention effects (Collins, Neve, et al., 2013), suggesting the field is still in its infancy. Notably, as men were under-represented in both of these WLM reviews, little is known about how to assist men achieve long-term success (Collins, Neve, et al., 2013; Dombrowski et al., 2014). This provides a strong rationale for the development and assessment of WLM programs that specifically target men.

Although genetic and environmental factors are important drivers of weight gain, cognitive and behavioural factors also play a significant role (National Health and Medical

Research Council, 2013). In this sense, health psychology can provide an important contribution to the development of effective weight management interventions (Sniehotta, Simpson, & Greaves, 2014). For example, systematic examinations of psychological theories have informed researchers on which cognitive, behavioural, social, and environmental factors may be most important to target in health-behaviour interventions (Connor & Norman, 2005). Further, the application of health psychology theory may have particular importance for WLM interventions, as people rely on effective cognitive strategies and further behavioural improvements to overcome the powerful physiological responses that influence weight regain (Sumithran et al., 2011). For example, research suggests that successful weight loss maintainers perform close to 300 minutes of moderate-to-vigorous physical activity (MVPA) per week (Catenacci et al., 2011), which is a considerably greater dose than is recommended for initial weight loss alone (i.e. 150 minutes of moderate-intensity activity per week) (Donnelly et al., 2009). However, despite these potential applications, most WLM interventions to date have not been explicitly informed by theory (Dombrowski et al., 2014). To progress the field, experimental research is needed to: (i) test the assumptions of behaviour change theories during WLM, and (ii) determine which social and cognitive determinants can be effectively targeted to increase the longevity of participants' weight loss and subsequent health outcomes (Sniehotta et al., 2014).

Bandura's (1986, 2004) *Social Cognitive Theory* (SCT) is one such theory, which has received considerable attention in the literature (Luszczynska & Schwarzer, 2005). The pivotal construct in SCT is self-efficacy, which represents the belief that one can exercise control over one's health habits (Bandura, 2004). In addition to directly influencing behaviour, self-efficacy is hypothesised to indirectly influence behaviour through interaction with: (i) outcome expectations (i.e. the perceived benefits and costs of performing a behaviour), (ii) goals (i.e. intentions and self-regulatory capabilities), and (iii) socio-structural

barriers and facilitators (e.g. perceived environment, social support) (Bandura, 1986, 2004).

Notably, SCT has shown good utility for understanding and predicting physical activity (Young, Plotnikoff, Collins, Callister, & Morgan, 2014) and healthy eating (e.g. (E. S. Anderson, Winett, & Wojcik, 2000)), which are the two key behaviours associated with weight management. Indeed, SCT has informed the development of several successful weight loss programs in recent years (e.g. (Anderson-Bill, Winett, Wojcik, & Winett, 2011; Morgan et al., 2010)). Although these factors also indicate that SCT may also be a useful theory to inform WLM interventions, this has yet to be confirmed, given the dearth of theory-based research in the field (Sniehotta et al., 2014). Indeed, to the authors' knowledge, no RCTs in men have tested the effectiveness of a WLM intervention that operationalises the core SCT behaviour change constructs or reported the impact of the intervention on these constructs.

The *SHED-IT Weight Loss Maintenance Trial* was conducted to investigate the utility of a gender-tailored, SCT-based WLM program for men. Although the core focus of the trial was on the maintenance of weight loss, and the anthropometric and physiological outcomes of this RCT are reported elsewhere (Morgan, Young, Collins, Plotnikoff, & Callister, under review), the aim of the current exploratory analysis was to examine the program's effect on men's physical activity and dietary cognitions and behaviours in the 12 months after initial weight loss. Compared to the self-help control group, it was hypothesised that men who received the *SHED-IT WLM Program* would demonstrate: i) significantly greater improvements in cognitions and behaviour relating to MVPA, and ii) significantly greater improvements in cognitions and behaviour relating to energy-dense, nutrient-poor 'discretionary' food during the WLM phase.

Methods

Study design

This investigation presents a secondary analysis of data from the *SHED-IT Weight Loss*

Maintenance Trial (Young, Collins, et al., 2014). The study was a two-phase, parallel group RCT (allocation ratio 1:1) that tested the effectiveness of the *SHED-IT WLM Program* to prevent weight regain in a sample of men who had previously lost weight (Figure 1). As noted above, the primary aim of this investigation was to examine the effect of the program on men's MVPA and discretionary food cognitions and behaviours. The study was granted institutional ethics approval, was prospectively registered with the *Australia New Zealand Clinical Trials Registry* (ACTRN12612000749808), and adhered to the guidelines provided in the *Consolidated Statement of Reporting Trials* (CONSORT). Extensive details on the study methods (Young, Collins, et al., 2014) and primary outcomes (Morgan et al., under review) are reported elsewhere.

Participants

Briefly, 209 overweight and obese men (18-65 years, BMI 25-40 kg/m^2) were recruited from the Hunter Region of New South Wales, Australia. Men were eligible for Phase I (i.e. the weight loss phase) if they: were aged 18-65 years, had a BMI 25-40 kg/m^2, had access to the internet and a mobile phone, were not currently taking medication to lose or gain weight, did not have diabetes requiring insulin treatment, and had not experienced recent weight loss (i.e. 5% of bodyweight in previous 6 months). Men were eligible for Phase II (i.e. the WLM RCT) if they had lost at least 4 kg during Phase I. All men provided written informed consent prior to enrolment (Young, Collins, et al., 2014).

Phase I: Weight loss

In Phase I, 209 overweight and obese men were provided with the 3-month *SHED-IT Weight Loss Program*, which was previously tested in both an efficacy trial (Morgan, Lubans, Collins, Warren, & Callister, 2009; Morgan, Lubans, Collins, Warren, & Callister, 2011) and an effectiveness trial (Morgan et al., 2013; Young et al., in press). Briefly, the program includes: i) The '*SHED-IT Weight Loss DVD for Men*', (ii) The '*SHED-IT Weight Loss*

Handbook for Men', (iii) The '*SHED-IT Weight Loss Log Book for Men*', (iv) weekly SCT-based texts to reinforce program messages, and (v) weight loss tools including a pedometer and a tape measure. Men are also encouraged to self-monitor their food intake and physical activity, using either the CalorieKing™ website or MyFitnessPal™ mobile phone app, to create a 2000kJ deficit on most days.

Phase II: Weight loss maintenance RCT

After 3 months, 92 men who had lost at least 4 kg during Phase I and were willing to participate in Phase II (i.e., the WLM RCT) were randomly allocated to: i) a WLM group, who received the *SHED-IT WLM Program*, or ii) a self-help control group, who received no additional support or resources.

The aim of the *SHED-IT WLM Program* was to provide evidence-based WLM recommendations in a style that was engaging and appealing to men. The program included the following components: (i) the '*SHED-IT WLM Handbook for Men'*, (ii) the *'SHED-IT WLM Log Book for Men'* (iii) weekly SCT-based emails, which included video messages from two study researchers (PJM and MDY), (iv) SCT-based bi-weekly text messages, (v) the '*SHED-IT Resistance Training Handbook for Men*', and (vi) a portable resistance training device (Gymstick^{TM}) and a pedometer (Digiwalker SW200). Men were encouraged to continue use the CalorieKing^{TM} website or MyFitnessPal^{TM} app as needed.

Program scalability and theoretical framework

To maximise scalability, neither program included any personal contact (e.g. face-to-face or group support, phone contacts, or exercise sessions) or individually-tailored components. In essence, the programs were identical for each participant and, aside from standardised text messages and emails, the men were not offered any additional support between assessments. This approach is considerably less intensive than previous studies (Dombrowski et al., 2014) and greatly increases the potential for dissemination. In addition, both programs were

explicitly informed by Bandura's SCT, including operationalisation of key SCT constructs, and designed specifically to appeal to men. Extensive detail on the development, intervention components, behaviour change techniques, and theoretical mapping of the programs is available elsewhere (Young, Collins, et al., 2014).

The programs explicitly targeted the core SCT constructs to generate changes in key weight-related behaviours. For example, as noted above, both included a *Log Book* where participants were advised to complete key SCT tasks. With reference to the latest behaviour change technique taxonomy (Michie et al., 2013), these tasks included setting graded tasks, goal setting (behaviour and outcome), planning social support, prompting self-monitoring (behaviour and outcome), and providing rewards contingent on successful behaviour. Although participants were encouraged to focus on any physical activity or dietary behaviours during the weight loss phase, the *SHED-IT WLM Program* explicitly focused on two recommendations which have been linked to successful WLM in the literature: (i) increasing structured MVPA after weight loss to at least 300 minutes of MVPA per week (Catenacci et al., 2011) and (ii) reducing consumption of discretionary foods (Wing & Phelan, 2005).

The gender tailoring process was guided by the men's health literature (e.g. (Gough & Conner, 2006; Smith, Braunack-Mayer, Wittert, & Warin, 2008)) and incorporated data from the qualitative (Morgan, Warren, Lubans, Collins, & Callister, 2011) and quantitative (Morgan, Scott, et al., 2014) process evaluations of previous SHED-IT weight loss trials. Consistent with the *SHED-IT Weight Loss Program*, gender-tailoring was applied to both surface-structure components (e.g., pictures of men, male health statistics) and deep-structure components, which appeal to men's health values (e.g. a frank approach, thoughtful use of humour, scientific legitimacy) (Resnicow, Baranowski, Ahluwalia, & Braithwaite, 1999).

Data collection and measures

Trained, blinded assessors conducted all assessments at the (University removed for blind review)'s Human Performance Laboratory. Before entering the laboratory, all participants were greeted by a member of the research team who answered any questions and reminded them not to reveal any information about their group assignment to the assessors. Assessments were held at 'study entry' (i.e. the start of Phase I; August 2012), 'baseline' (i.e. the start of Phase II [WLM RCT]; November 2012), '6 months' (post-test; May 2013) and '12 months' (6-month follow-up; November 2013).

Validated scales were used to assess the behaviour change cognitions described in Bandura's SCT (e.g. self-efficacy). Validation data and references are located in Table 1 (physical activity scales) and Table 2 (discretionary food scales). Before completing the physical activity scales, men were asked to read the study definition of 'regular physical activity' (i.e. 'at least 60 min of physical activity (at a moderate intensity or greater) on 5 or more days each week'). Similarly, before completing the 'discretionary food' scales, men were provided with a reference card containing definitions of 'healthy foods' and 'discretionary foods' adapted from the Australian Guide to Healthy Eating (Department of Health and Ageing, 2013). These cards also contained pictures of commonly consumed discretionary foods reported by Australian men in previous weight loss studies (e.g. pizza, potato chips, ice-cream) (Blomfield et al., 2014; Collins, Morgan, Warren, Lubans, & Callister, 2011).

[Approximate location for Table 1 and Table 2]

Time spent in *MVPA* was assessed with a slightly modified version of the validated Godin Leisure Time Exercise Questionnaire (GLTEQ) (Godin & Shephard, 1985). As in the original GLTEQ, men reported the number of times/week they engaged in moderate or vigorous physical activity for at least 10 minutes in the previous month. In the current version, participants also estimated the average session duration for each category. These

'frequency' and 'duration' categories were then multiplied within each category and summed to provide a measure of weekly MVPA minutes (Plotnikoff et al., 2006). This adapted measure has demonstrated good sensitivity to change in previous weight loss research with men (Morgan, Collins, et al., 2011). Total energy from *discretionary foods* was assessed using the Australian Eating Survey (AES), which is a validated 120-item food frequency questionnaire (Collins, Watson, et al., 2013). *Weight* was measured in light clothing, without shoes on a digital scale to 0.01 kg (CH-150kp, A&D Mercury Pty Ltd., Australia).

Statistical analysis

Phase I changes were assessed using paired-samples t-tests. For the WLM RCT data, linear mixed models were used to assess MVPA, discretionary food consumption and all SCT cognitions for the impact of treatment (i.e. WLM intervention vs. self-help control), time (i.e. 'baseline', '6 months', and '12 months'), and the treatment by time interaction. Linear mixed models are recommended for analysing experimental data as they are robust to the biases of missing data and model missing responses in the results, consistent with an intention-to-treat approach (White, Carpenter, & Horton, 2012). Age, socio-economic status, BMI, and Phase I change score were examined as covariates and adjusted for where significant. If a covariate was significant, two-way interactions with treatment and time also examined and significant effects were also added to the model. For the RCT results, a Bonferroni correction was applied to adjust for the multiple comparisons. Cohen's *d* effect sizes were calculated as the mean difference between groups divided by the pooled standard deviation of the outcome at baseline ($d = M_1–M_2/SD_{pooled}$). Effect sizes were interpreted as small (0.2-0.4), medium (0.5-0.7) and large (>0.8) (Cohen, 1988).

Sample size

The primary WLM study (Morgan et al., under review) was powered to detect a between-group difference of 3 kg (SD 4 kg) in weight regain during the RCT (i.e. Phase II). Assuming

a 25% attrition rate during Phase II, the study required 39 men to be randomised into each group for 80% power to detect a 3 kg difference in weight regain at 12 months (p=0.05, two-sided).

Randomisation and allocation

Participants were randomised at an individual level by an independent statistician who had no contact with participants during the study. The allocation sequence was generated by a computer-based random number-producing algorithm in randomly varied block lengths (stratified by BMI and Phase I weight loss). Information for the two study groups was pre-packed into identical opaque envelopes and ordered according to the randomisation schedule by a research assistant who was not involved in enrolment, assessment or allocation. Study participants completed all assessments before meeting with a member of the research team who was not involved in assessments. The researcher allocated the participant to the next available position in their stratification category before opening the corresponding envelope and providing details of the allocated group using a standardised protocol.

Results

As seen in Table 3, randomised men had a mean age of 49.2 years (range, 27-65 years), a mean weight of 98.3 kg (range, 70.9-138.9). At baseline (i.e. at the conclusion of Phase I), the men were performing an average of 207 minutes/week of MVPA (SD 147) and consuming an average of 3215 kJs/day of discretionary food (SD 1981). Phase II retention for the cognitive and behavioural outcomes was 76% at 6 months and 78% at 12 months (Figure 1). No significant differences in retention were observed between the intervention and control groups at 6 months (χ^2=1.20, *df*=1, *p*=0.27) or 12 months (χ^2=0.01, *df*=1, *p*=0.91). As reported elsewhere, intention-to-treat linear mixed models revealed a 1.5 kg mean between-group difference in weight regain at 12 months (95%CI -0.7, 3.7, *p*=0.18), with the intervention group regaining 0.6 kg (95%CI -0.9, 2.2) (92% maintenance of Phase I

reduction) and the control group regaining 2.1 kg (95%CI 0.5, 3.7) (72% maintenance of Phase I reduction) (Morgan et al., under review). Tables 4 and 5 present the social cognitive and behaviours results of the trial for MVPA and discretionary food intake, respectively.

Overall, the *SHED-IT WLM Program* was well received by the men. At post-test, 93% acknowledged that the program increased their knowledge and skills regarding WLM, 95% reported having a better understanding of what it takes to maintain weight loss and 85% believed it was a helpful addition to the Phase I *SHED-IT Weight Loss Program*.

[Approximate location for Table 4 and Table 5]

MVPA outcomes

Phase I changes for MVPA variables

In Phase I, randomised men reported a large increase in goal setting (d=0.93), and a medium increase in perceived family support (d=0.60). Small increases were also observed in social support from friends (d=0.36) and planning (d=0.46), but no changes were reported in self-efficacy, outcome expectations, or barriers. A small decrease was identified for behavioural goal (d=0.39). In addition to these cognition effects, the sample reported a significant, large mean increase in MVPA of 129.9 minutes/week (p<0.001; d=1.53).

Phase II changes for MVPA variables

No significant group-by-time effects were observed for any MVPA cognitions during the RCT (Table 4). Similarly, the group-by-time effects for MVPA were not significant at post-test (+27.4 mins/week; 95%CI -39.1, 93.9) or follow-up (-24.9 mins/week; -100.2, 50.4).

Maintenance of Phase I effects for MVPA variables

Table 6 presents a summary of the MVPA cognition effects for both groups from study entry to baseline (i.e. the start of the RCT; 3 months total) and from study entry to the 12 month assessment (i.e. the end of the RCT; 15 months total). At 12 months, both the intervention and control groups had maintained medium-to-large increases in physical activity goal setting

and small-to-medium increases in planning and social support. Conversely, both study groups reported medium-to-large decreases in behavioural goal from study entry to 12 months. Aside from a small reduction in perceived barriers for the intervention group, no clear effects were observed for self-efficacy, outcome expectations, or barriers from study entry to 12 months. Phase I increases in MVPA were largely maintained by both groups at 12 months, with the intervention group reducing MVPA by 16.1 minutes/week from baseline (87% maintenance of Phase I effect) and the control group increasing by 8.8 minutes/week above baseline levels (107% maintenance of Phase I effect).

[Approximate location for Table 6]

Discretionary food outcomes

Phase I changes for discretionary food variables

During Phase I, randomised men reported large increases in the use of behavioural strategies (e.g. goal setting, d=1.30) and social support from friends (d=0.90). In addition, medium positive effects were observed for self-efficacy (d=0.66), perceived barriers (d=0.65), and family social support (d=0.56) and small positive effects were observed for perceived environment and planning. No clear changes were reported for outcome expectations or social sabotage. In addition, the sample reported a significant, medium-sized mean decrease in discretionary food intake of 1765 kJ/day (p<0.001; d=0.74).

Phase II changes for discretionary food variables

As seen in Table 5, no significant group-by-time effects were observed for any discretionary food cognitions during the RCT. Similarly, the group-by-time effects for discretionary food consumption were not significant at post-test (+115 kJ/day; 95%CI -376, 606) or follow-up (499 kJ/day; 95% CI -97, 1096).

Maintenance of Phase I effects for discretionary food variables

At 12 months, the intervention and control groups had maintained a number of favourable

effects from study entry, including medium-to-large effects for behavioural strategies, medium effects for barriers, and small-to-medium effects for planning and perceived environment (Table 6). Although no improvements were maintained for outcome expectations, family support or family sabotage, the groups reported overall small-to-medium increases in friend support. Initial increases in self-efficacy were maintained in the control group, but not the intervention group (Table 6). At the conclusion of the RCT, the intervention group reported a mean increase in discretionary food consumption of 867.9 kJ/day (57% maintenance of Phase I effect) and the control group reported a 368.7 kJ/day increase (75% maintenance of Phase I effect).

Discussion

The aim of this study was to examine the effect of a gender-tailored, theory-based WLM intervention on men's SCT cognitions, MVPA, and discretionary food consumption, 6- and 12 months after successfully losing weight. Initial improvements in MVPA and some cognitions (e.g. goal setting, planning, social support) were largely maintained by both groups at the end of the study. Dietary effects were not as strongly maintained, with the intervention and control groups maintaining 57% and 75% of the Phase I improvements in discretionary food intake, respectively. The study hypotheses were not supported as no significant group-by-time effects were observed for cognitions or behaviours during the RCT. This study demonstrated that, for men who lost weight with the gender-tailored, theory-based *SHED-IT Weight Loss Program*, the *SHED-IT WLM Program* did not provide a significant additional benefit for MVPA, discretionary food intake, or the SCT cognitions in the 12 months post-weight loss.

In Phase I, men reported a number of improvements in key SCT cognitions for MVPA including goal setting, planning and social support. Although self-efficacy, outcome expectations and perceived barriers were unchanged, participants reported a large mean

increase in self-reported MVPA by the conclusion of the weight loss phase (+130 minutes/week). Similarly, men reported a number of favourable effects for discretionary food cognitions, including increases in self-efficacy, planning, use of behavioural strategies, and perceived social support. Decreases were also observed in perceived barriers and the availability of various discretionary foods in their environment. Although the intervention WLM group received an additional program that targeted these cognitions and behaviours, this was no more effective than receiving the initial *SHED-IT Weight Loss Program* alone. These findings may be due to a number of reasons including: (i) study design and the weight loss program in Phase 1, (ii) choice of behavioural referent and measurement issues, and (iii) operationalisation of SCT constructs and program adherence.

First, the null findings may be related to the weight loss program used in this trial. During Phase I, all men were provided with the *SHED-IT Weight Loss Program*, which was originally designed as a stand-alone program for men. As such, this program was also explicitly informed by the behaviour change principles outlined in SCT and focused on sustainable behaviour change, which may have obscured the effect of the maintenance program. For example, during Phase I men were encouraged to self-monitor their physical activity and energy intake, set goals for physical activity and healthy eating, and engage their family and friends in their weight loss efforts. Of note, a process evaluation from a previous trial revealed the participants' success in the *SHED-IT Weight Loss Program* was associated with engagement with key SCT tasks during the study (i.e. goal setting and self-monitoring) (Morgan, Scott, et al., 2014). As such, it is feasible that the control group may have continued to use these strategies throughout the WLM phase. This may explain why both groups maintained medium-to-large intervention effects for MVPA and discretionary food and small-to-medium effects for most SCT cognitions. Further, this may also explain why the self-help control group in this study, who received no additional resources after the 3-month

SHED-IT Weight Loss Program, only regained 2.1 kg by 12 months, which was comparable to other WLM intervention groups in the literature (Dombrowski et al., 2014)

The men's responses may also have been affected by the behavioural referents chosen. For example, given the men were only performing 77 minutes of MVPA per week at study entry, the physical activity referent in this study (regular physical activity = 300 minutes of MVPA/week) may have been too ambitious. Although the average increased to 208 minutes/week at baseline (270% increase), the men were still considerably short of the 300 minute target. If the participants felt this goal was unattainable, then it would have been much harder to elicit meaningful changes in the associated cognitions, particularly self-efficacy. However, this referent was chosen to reflect the best available recommendations for the required dose of physical activity to maintain weight loss (Catenacci et al., 2011; Donnelly et al., 2009). Thus, the challenge for future researchers is to educate men about the importance of reaching this difficult target, without negatively affecting their self-efficacy.

Although the dietary measures assessed cognitions for 'discretionary food intake', the majority of the scales were adapted from measures assessing cognitions for adherence to a low-fat diet (Table 2). The decision to switch this behavioural referent was both practical, given the lack of published scales assessing cognitions for discretionary food intake, and theoretical, given that discretionary food intake is a globally recognised dietary problem area for men (Blomfield et al., 2014; Gray et al., 2013) and research shows that dietary composition is not as important as overall energy intake for long-term WLM (Pirozza, Summerbell, Cameron, & Glasziou, 2003). While all scales demonstrated adequate psychometrics in an appropriate pilot sample (Young, Collins, et al., 2014), it is unclear how changing the referents from the original scales may have affected the results. Further, the men's answers may have been affected by response fatigue given that a large number of scales were required to capture the SCT cognitions for each behaviour. The act of measuring

these cognitions may also have served as motivational prompts for the control group.

Finally, although every effort was made to ensure the *SHED-IT WLM Program* adequately targeted the key SCT constructs (Young, Collins, et al., 2014), it is possible the men did not engage with the program components enough to receive the required dose. Notably, a process evaluation from a previous investigation of the *SHED-IT Weight Loss Program* revealed that, despite initial engagement, most men did not fully comply with the SCT tasks during weight loss, and engagement with reward setting and social support strategies was particularly poor (Morgan, Scott, et al., 2014). As men in the intervention group received the *SHED-IT WLM Program* after completing the *SHED-IT Weight Loss Program*, it is feasible that fatigue from Phase I may have resulted in reduced intervention compliance during Phase II, but this was not explored in the current study.

This investigation contained several strengths including use of data from a methodologically rigorous RCT and the use of valid and reliable measures for the SCT cognitions that were pilot tested in a representative sample of overweight and obese Australian men. The study had high retention, measurements were taken by blinded assessors, and linear mixed models were used for the analyses consistent with an intention-to-treat approach. In addition, the scalable interventions targeted an under-represented group and clear detail is available regarding the theoretical mapping of the program. The study also had some limitations. Although the RCT was powered to detect changes in weight, it was not powered a-priori to detect meaningful changes in the secondary outcomes presented in this paper. As such, the results of this isolated trial should be interpreted with caution. Further, although the study used validated measures, the key WLM behaviours (i.e. MVPA and discretionary food intake) were assessed via self-report, which may be associated with more measurement error than objective measures. Finally, although the study measured a wide range of cognitions, not all SCT cognitions were captured for each behaviour.

This study revealed that provision of a gender-tailored, SCT-based WLM intervention provided no additional benefit for men who had already received a SCT-based program for initial weight loss. Future research could explore the impact of this potential confounder by initially randomising men to a series of different weight loss interventions (e.g. *SHED-IT Weight Loss Program* vs. very-low energy diet), and then re-randomising successful participants to either receive the *SHED-IT WLM Program* or no additional resources. Indeed, the application of sequential research designs to examine WLM interventions has recently been recommended (Sniehotta et al., 2014). Second, to adequately assess men's cognitions for physical activity and specific dietary behaviours (e.g. discretionary food intake) there is a need for more psychometric scale development research in this under-studied group. Third, future research should examine: i) whether compliance to the SCT program tasks was associated with successful WLM, and ii) which particular behaviour change techniques are the most important to feature in future WLM programs.

In conclusion, this study revealed that men who only received the 3-month SCT-based *SHED-IT Weight Loss Program* demonstrated statistically comparable maintenance of key behaviours and cognitions over 12 months to men who also received the SCT-based *SHED-IT WLM Program*. More research is required to determine whether the program would provide some benefit to men who achieved initial weight loss with less sustainable approaches involving no cognitive-behavioural training, such as very-low energy diets or supervised exercise programs. Although WLM may require further improvements in physical activity and dietary behaviours after initial weight loss, this study suggests this may be too difficult for participants to implement in a short time frame. Future studies could consider including a 'behaviour stabilisation' phase, where participants are supported to maintain their initial changes before challenging themselves further. Although SCT has shown good utility to elicit health behaviour initiation, researchers could consider drawing on knowledge from

theories such as the ‘Health Action Process Approach’ for future interventions (Schwarzer, 2008), which explicitly examine social cognitive predictors of behaviour maintenance including maintenance self-efficacy and recovery self-efficacy.

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Table and figure headings

Table 1. Social cognitive theory measures for physical activity with validity and reliability statistics.

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Table 4. Intention-to-treat changes in MVPA cognitions and weekly MVPA during the SHED-IT Weight Loss Maintenance RCT (i.e. Phase II) (n = 92).

Table 5. Intention-to-treat changes in discretionary food cognitions and consumption during the SHED-IT Weight Loss Maintenance RCT (i.e. Phase II) (n = 92).

Table 6. Overall effects for Phase I (from study entry to baseline i.e. the start of the RCT) and for study duration (from study entry to 12 months i.e. the end of the RCT) for the SHED-IT Weight Loss Maintenance group and the SHED-IT Weight Loss-only self-help control group.

Figure 1. Study design and CONSORT flowchart for the cognitive and behavioural outcomes in the SHED-IT Weight Loss Maintenance trial.

Table 1.

Social cognitive theory measures for physical activity with validity and reliability statistics.

Construct (Source)	Items (Range)	Anchors	Validity and reliability statistics		Example
			α [a]	ICC (95% CI) [b]	
Self-efficacy (Plotnikoff, Blanchard, Hotz, & Rhodes, 2001)	8 (1-5)	Not at all confident – Completely confident	0.92	0.88 (0.68 to 0.95)	*e.g. I am confident that I can get 'regular physical activity' when I am a little tired*
Positive outcome expectations (Plotnikoff et al., 2001)	5 (1-5)	Strongly disagree – Strongly agree	0.78	0.74 (0.36 to 0.89)	*e.g. 'Regular physical activity' would help me control my weight*
Perceived barriers [c] (Plotnikoff et al., 2001)	3 (1-5)	Strongly disagree – Strongly agree	0.75	0.82 (0.58 to 0.93)	*e.g. 'Regular physical activity' would take up too much of my time*
Social support [d] (Sallis, Grossman, Pinski, Patterson, & Nader, 1987)	10 (1-5)	Never/does not apply – Very often	*Family:* 0.91	0.96 (0.91 to 0.98)	*e.g. During the past month, my family/friends were active with me*
			Friends: 0.91	0.92 (0.80 to 0.97)	
Behavioural goal [e] (Rhodes, Blanchard, Matheson, & Coble, 2006)	2 (1-7)	Extremely unmotivated / undetermined – Extremely motivated / determined	0.86	0.92 (0.80 to 0.97)	*e.g. I am motivated/determined to engage in 'regular physical activity'*
Goal setting [f] (Rovniak, Anderson, Winett, & Stephens, 2002)	10 (1-5)	Strongly disagree – Strongly agree	0.85	0.80 (0.50 to 0.92)	*e.g. I often set physical activity goals*
Planning (Rhodes, Courneya, Blanchard, & Plotnikoff, 2007)	4 (1-7)	Strongly disagree – Strongly agree	0.93	0.70 (0.30 to 0.87)	*e.g. I make plans concerning when I am going to engage in 'regular physical activity'*

α, Cronbach's alpha (internal consistency); ICC, intra-class correlation coefficient; CI, confidence interval

[a] Internal consistency of the scales in the current study weight loss maintenance RCT sample at study entry (n = 92). [b] Two-week test-retest reliability of the scales in an independent pilot sample of 22 overweight and obese Australian men (mean(SD) age 39.7 (14.8) years; BMI 29.1 (5.1) kg/m^2). [c] Scale adapted from a 5 item measure that demonstrated unacceptable internal consistency in the pilot sample (α = 0.46). [d] Scale measured separately for family and friends. [e] A validated measure of intention was used to represent the behavioural goal construct, as Bandura (2004) has acknowledged a considerable conceptual overlap between these two variables. [f] Original anchors ("does not describe me" to "describes me completely") were replaced as the pilot sample found them difficult to interpret.

Table 2.

Social cognitive theory measures for intake of discretionary foods with validity and reliability statistics.

Construct (Adapted from)	Items (Range)	Anchors	Validity and reliability statistics		Example
			α [a]	ICC (95% CI) [b]	
Self-efficacy (Plotnikoff et al., 2009)	12 (1-5)	Not at all tempted – Extremely tempted	0.84	0.76 (0.42 to 0.90)	*e.g. How tempted would you be to eat your favourite junk food while having a good time with friends at a party*
Positive outcome expectations (Anderson-Bill et al., 2011)	8 (1-5)	Strongly disagree – Strongly agree	0.80	0.77 (0.45 to 0.91)	*e.g. If I eat less junk food I expect I will lose weight*
Perceived barriers (Anderson-Bill et al., 2011)	12 (1-5)	Strongly disagree – Strongly agree	0.87	0.89 (0.74 to 0.96)	*e.g. If I eat less junk food I expect I will be bored with what I have to eat*
Social support [c] (Sallis et al., 1987)	5 (1-5)	Never – Very often	*Family:* 0.88	0.87 (0.69 to 0.95)	*e.g. In the past month, my family/friends encouraged me not to eat junk food when I was tempted to do so*
			Friends: 0.89	0.91 (0.79 to 0.96)	
Social sabotage [c] (Sallis et al., 1987)	5 (1-5)	Never – Very often	*Family:* 0.74	0.83 (0.58 to 0.93)	*e.g. In the past month, my family/friends offered me junk food I'm trying not to eat*
			Friends: 0.75	0.76 (0.41 to 0.90)	
Perceived environment [d] (Ball et al., 2009)	13 (1-4)	Never/rarely – Always	0.88	0.75 (0.39 to 0.90)	*Participants indicate how frequently various junk foods (e.g. chocolate, potato chips) are available in their day-to-day life*
Planning (Sniehotta, Schwarzer, Scholz, & Schuz, 2005)	5 (1-4)	Strongly disagree – Strongly agree	0.92	0.89 (0.74 to 0.96)	*e.g. When it comes to eating less junk food, I make detailed plans regarding when I have to pay attention to prevent lapses*
Behavioural strategies (Norman et al., 2010)	15 (1-5)	Never – Many times	0.85	0.77 (0.47 to 0.91)	*e.g. In the past month I set goals to eat less junk food*

α, Cronbach's alpha (internal consistency); ICC, intra-class correlation coefficient; CI, confidence interval

[a] Indicates the internal consistency of the scales in the weight loss maintenance RCT sample at study entry (n = 92). [b] Two-week test-retest reliability of the scales in an independent pilot sample of 22 overweight and obese Australian men (mean(SD) age 39.7 (14.8) years; BMI 29.1 (5.1) kg/m^2). [c] Scale measured separately for family and friends. [d] Items chosen to reflect the most commonly consumed discretionary foods reported by men in the SHED-IT Community RCT (Morgan et al., 2013).

Table 3.

Baseline characteristics of men randomised into the SHED-IT Weight Loss Maintenance RCT (n = 92).

Outcome	Baseline mean (SD) [a b]		
	SHED-IT WLM	Control	Total
Age (years)	49.5 (9.9)	49.0 (10.4)	49.2 (10.1)
Weight (kg)	98.1 (14.0)	98.5 (14.9)	98.3 (14.3)
Body Mass Index (kg/m^2)	30.8 (3.3)	30.6 (3.4)	30.7 (3.3)
MVPA (minutes/week)	207.9 (135.6)	205.9 (159.3)	206.9 (147.3)
Discretionary foods (kJ/day) [c]	3180.3 (2114.1)	3250.5 (1817.9)	3214.7 (1980.7)
Physical activity cognitions [possible range]			
Self-efficacy [1-5]	3.2 (0.9)	3.2 (0.8)	3.2 (0.9)
Positive outcome expectations [1-5]	4.3 (0.5)	4.2 (0.5)	4.3 (0.5)
Barriers [1-5] [d]	2.4 (0.8)	2.4 (0.8)	2.4 (0.8)
Social support (family) [1-5]	2.8 (1.0)	2.7 (1.0)	2.8 (1.0)
Social support (friends) [1-5]	1.9 (1.0)	1.9 (1.0)	1.9 (1.0)
Behavioural goal [1-7]	5.8 (1.1)	5.4 (1.3)	5.6 (1.2)
Goal setting [1-5]	3.1 (0.8)	3.1 (0.7)	3.1 (0.7)
Planning [1-7]	5.7 (1.2)	5.5 (1.3)	5.6 (1.3)
Discretionary food cognitions [possible range]			
Self-efficacy [1-5]	3.1 (0.8)	3.2 (0.7)	3.1 (0.7)
Positive outcome expectations [1-5]	4.0 (0.6)	4.1 (0.5)	4.1 (0.5)
Barriers [1-5] [d]	2.3 (0.7)	2.3 (0.5)	2.3 (0.6)
Perceived environment [1-4] [d]	2.0 (0.6)	2.0 (0.6)	2.0 (0.6)
Social support (family) [1-5]	2.9 (1.1)	3.1 (1.0)	3.0 (1.1)
Social support (friends) [1-5]	1.9 (1.0)	1.8 (1.0)	1.9 (1.0)
Social sabotage (family) [1-5] [d]	2.1 (1.0)	2.1 (0.8)	2.1 (0.9)
Social sabotage (friends) [1-5] [d]	1.8 (0.9)	2.0 (0.8)	1.9 (0.9)
Planning [1-4]	2.5 (0.5)	2.6 (0.5)	2.6 (0.5)
Behavioural strategies [1-5]	3.0 (0.7)	3.0 (0.6)	3.0 (0.7)

Note. SHED-IT WLM = SHED-IT Weight Loss Maintenance.
[a] 'Baseline' for this study was measured at randomisation into the WLM RCT (i.e. start of Phase II). [b] Phase I change score data for both groups is located in supplementary Table S1. [c] Energy-dense, nutrient poor, discretionary choices. [d] Reduction = favourable effect.

Table 4.

Intention-to-treat changes in MVPA cognitions and weekly MVPA during the SHED-IT Weight Loss Maintenance RCT (i.e. Phase II) (n = 92).

Outcome	Time	Mean change from randomisation (95% CI)		Mean difference between groups (95% CI) [Cohen's D]	Group x time *p*-value [a]
		SHED-IT WLM (n = 47)	Self-help Control (n = 45)		
MVPA cognitions					
Self-efficacy [b c]	6	-0.1 (-0.4, 0.1)	-0.4 (-0.6, -0.1)	0.2 (-0.1, 0.6) [0.26]	0.18
	12	-0.2 (-0.4, 0.1)	-0.2 (-0.4, 0.0)	0.0 (-0.3, 0.3) [0.03]	0.30
Positive outcome expectations [b c d e]	6	-0.0 (-0.2, 0.1)	-0.1 (-0.3, 0.0)	0.1 (-0.1, 0.3) [0.21]	0.34
	12	0.1 (-0.1, 0.2)	-0.1 (-0.2, 0.1)	0.1 (-0.1, 0.3) [0.17]	0.26
Barriers [b c d]	6	0.1 (-0.1, 0.3)	0.2 (-0.0, 0.4)	-0.1 (-0.4, 0.2) [0.14]	0.47
	12	-0.1 (-0.3, 0.1)	0.2 (-0.0, 0.4)	-0.2 (-0.5, 0.0) [0.30]	0.08
Social support (family) [b c d f]	6	-0.3 (-0.6, -0.1)	-0.3 (-0.6, -0.0)	-0.0 (-0.4, 0.3) [0.02]	0.91
	12	-0.2 (-0.5, 0.1)	-0.2 (-0.5, 0.1)	-0.0 (-0.4, 0.4) [0.01]	0.97
Social support (friends) [b c d e g]	6	-0.1 (-0.3, 0.1)	-0.3 (-0.5, -0.1)	0.2 (-0.1, 0.5) [0.22]	0.17
	12	0.0 (-0.2, 0.2)	-0.0 (-0.3, 0.2)	0.0 (-0.3, 0.4) [0.01]	0.94
Behavioural goal [b c h]	6	-0.2 (-0.5, 0.1)	-0.3 (-0.7, 0.0)	0.1 (-0.3, 0.6) [0.11]	0.58
	12	-0.4 (-0.7, -0.1)	-0.2 (-0.5, 0.2)	-0.3 (-0.7, 0.2) [0.21]	0.26
Goal setting [b c h]	6	-0.1 (-0.3, 0.0)	-0.0 (-0.2, 0.2)	-0.1 (-0.3, 0.1) [0.14]	0.42
	12	-0.1 (-0.2, 0.1)	-0.1 (-0.3, 0.0)	0.1 (-0.2, 0.3) [0.09]	0.55
Planning [b c h]	6	-0.3 (-0.8, 0.2)	0.1 (-0.4, 0.6)	-0.4 (-1.1, 0.3) [0.32]	0.26
	12	-0.2 (-0.7, 0.2)	-0.1 (-0.5, 0.4)	-0.1 (-0.8, 0.5) [0.11]	0.65
MVPA (minutes/week) [b c]	6	1.6 (-43.4, 46.7)	-25.8 (-74.7, 23.1)	27.4 (-39.1, 93.9) [0.19]	0.41
	12	-16.1 (-68.5, 36.3)	8.8 (-45.3, 62.9)	-24.9 (-100.2, 50.4) [0.17]	0.43

Note. MVPA = moderate-to-vigorous physical activity.

[a] Bonferroni adjusted significance level set to $p < 0.00125$. [b] Adjusted for phase I change. [c] Adjusted for phase I change x time. [d] Adjusted for age. [e] Adjusted for age x time. [f] Adjusted for socio-economic status. [g] Adjusted for age x group. [h] Adjusted for phase I change x group.

Table 5.

Intention-to-treat changes in discretionary food cognitions and consumption during the SHED-IT Weight Loss Maintenance RCT (i.e. Phase II) (n = 92).

Outcome	Time	Mean change from randomisation (95% CI) SHED-IT WLM (n = 47)	Self-help Control (n = 45)	Mean difference between groups (95% CI) [Cohen's D]	Group x time *p*-value [a]
Discretionary food cognitions					
Self-efficacy [b c d]	6	-0.1 (-0.3, 0.0)	-0.2 (-0.4, -0.1)	0.1 (-0.1, 0.3) [0.10]	0.46
	12	-0.3 (-0.5, -0.2)	-0.1 (-0.3, 0.0)	-0.2 (-0.4, 0.0) [0.29]	0.03
Positive outcome expectations [b c]	6	0.0 (-0.1, 0.2)	0.1 (-0.1, 0.2)	-0.1 (-0.3, 0.2) [0.09]	0.65
	12	0.1 (-0.0, 0.2)	0.0 (-0.1, 0.1)	0.1 (-0.1, 0.2) [0.15]	0.29
Barriers [b c]	6	0.0 (-0.1, 0.2)	0.1 (-0.0, 0.3)	-0.1 (-0.3, 0.1) [0.17]	0.32
	12	0.1 (-0.1, 0.2)	0.1 (-0.2, 0.3)	-0.0 (-0.3, 0.2) [0.07]	0.59
Perceived environment [b c d]	6	0.0 (-0.1, 0.1)	-0.0 (-0.2, 0.1)	0.1 (-0.1, 0.2) [0.13]	0.35
	12	0.0 (-0.1, 0.1)	-0.1 (-0.2, 0.1)	0.1 (-0.1, 0.3) [0.13]	0.58
Social support (family) [b c d e]	6	-0.3 (-0.5, -0.1)	-0.3 (-0.5, -0.1)	-0.0 (-0.3, 0.3) [0.01]	0.94
	12	-0.5 (-0.8, -0.2)	-0.4 (-0.7, -0.1)	-0.0 (-0.4, 0.4) [0.04]	0.98
Social support (friends) [b c d f]	6	-0.2 (-0.4, 0.1)	-0.1 (-0.4, 0.1)	-0.1 (-0.4, 0.3) [0.05]	0.78
	12	-0.2 (-0.4, -0.1)	-0.3 (-0.4, -0.1)	0.1 (-0.1, 0.3) [0.07]	0.64
Social sabotage (family) [b c d]	6	0.2 (-0.0, 0.3)	-0.0 (-0.2, 0.2)	0.2 (-0.1, 0.4) [0.20]	0.15
	12	0.1 (-0.1, 0.2)	0.1 (-0.1, 0.2)	0.0 (-0.2, 0.3) [0.02]	0.29
Social sabotage (friends) [b c d]	6	0.1 (-0.2, 0.3)	0.0 (-0.3, 0.3)	0.1 (-0.3, 0.5) [0.07]	0.75
	12	0.2 (-0.0, 0.4)	0.1 (-0.1, 0.3)	0.1 (-0.2, 0.4) [0.09]	0.83
Planning [b c]	6	-0.1 (-0.3, 0.1)	-0.1 (-0.3, 0.1)	0.0 (-0.3, 0.3) [0.04]	0.90
	12	0.0 (-0.2, 0.2)	-0.1 (-0.3, 0.0)	0.1 (-0.1, 0.4) [0.27]	0.26
Behavioural strategies [b c g]	6	-0.3 (-0.5, -0.1)	-0.2 (-0.4, -0.0)	-0.1 (-0.3, 0.2) [0.12]	0.56
	12	-0.3 (-0.5, -0.2)	-0.4 (-0.5, -0.2)	0.0 (-0.2, 0.3) [0.03]	0.76
Discretionary food (kJ/day)	6	315.0 (-13.6, 643.5)	200.3 (-164.6, 565.1)	114.7 (-376.3, 605.7)	0.64
	12	867.9 (461.1, 1274.6)	368.7 (-67.5, 804.8)	499.2 (-97.2, 1095.5)	0.25

[a] Bonferroni adjusted significance level set to $p < 0.00125$. [b] Adjusted for *phase I change*. [c] Adjusted for phase I change x time. [d] Adjusted for age. [e] Adjusted for socio-economic status. [f] Adjusted for age x time. [g] Adjusted for phase I change x group.

Table 6. Overall effects for Phase I (from study entry to baseline i.e. the start of the RCT) and for study duration (from study entry to 12 months i.e. the end of the RCT) for the *SHED-IT Weight Loss Maintenance* group and the *SHED-IT Weight Loss*-only self-help control group.

	SHED-IT WLM (n =47)		**Self-help Control (n = 45)**	
	Entry to Baseline [a]	**Entry to 12 months [b]**	**Entry to Baseline [a]**	**Entry to 12 months [b]**
Physical activity				
Self-efficacy	✓	-	✓	-
Outcome expectations	×	-	-	-
Barriers [c]	-	✓	✓	-
Social support (family)	✓✓	✓	✓✓	✓
Social support (friends)	✓✓	✓✓	✓	✓
Behavioural goal	×	× × ×	× ×	× ×
Goal setting	✓✓✓	✓✓✓	✓✓✓	✓✓
Planning	✓✓	✓✓	✓	✓
MVPA (minutes/week)	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Discretionary food				
Self-efficacy	✓✓	-	✓✓✓	✓✓
Outcome expectations	×	×	-	-
Barriers [a]	✓✓	✓	✓✓✓	✓✓
Perceived environment [c]	✓	✓	✓✓	✓✓
Social support (family)	✓✓	-	✓✓	✓
Social support (friends)	✓✓✓	✓✓	✓✓✓	✓
Social sabotage (family) [c]	-	-	-	-
Social sabotage (friends) [c]	-	-	-	×
Planning	✓	✓	✓✓	✓
Behavioural strategies	✓✓✓	✓✓	✓✓✓	✓✓✓
Discretionary food (kJ/day)	✓✓✓	✓✓	✓✓	✓✓

Note. ✓ = small favourable effect (d = 0.2-0.4); ✓✓ = medium favourable effect (d = 0.5-0.7); ✓✓✓ = large favourable effect ($d \geq 0.8$); × = small unfavourable effect (d = 0.2-0.4); ×× = medium unfavourable effect (d = 0.5-0.7); ××× = large unfavourable effect ($d \geq 0.8$+); - (dash) = no effect (d < 0.2).

[a] Change from 'study entry' (i.e. start of Phase I, weight loss) to 'baseline' (i.e. start of Phase II, weight loss maintenance RCT, 3 months total). [b] Change from 'study entry' (i.e. start of Phase I, weight loss) to '12 months' (i.e. end of Phase II, weight loss maintenance RCT, 15 months total). [c] Favourable effect = decrease.

Figure 1.
Study design and CONSORT flowchart for the cognitive and behavioural outcomes in the SHED-IT Weight Loss Maintenance trial.