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Habit-based interventions for weight loss maintenance in adults with overweight and obesity: a randomized controlled trial

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Abstract

Objectives: The objective of this study was to determine whether habit-based interventions are clinically beneficial in achieving long-term (12-month) weight loss maintenance and explore whether making new habits, or breaking old habits is more effective.

Methods: Volunteer community members aged 18-75 years who had overweight or obesity (BMI ≥25kg/m2) were randomized in a single-blind, 3-arm, randomized controlled trial. Ten Top Tips (TTT), Do Something Different (DSD) and the attention-only waitlist (WL) control groups were conducted for 12 weeks from July to October 2015. Participants were followed up post-intervention (all groups), and at 6 and 12-months post-intervention (Ten Top Tips and Do Something Different only). The primary outcome was weight-loss maintenance at 12-month follow-up. Secondary outcomes included weight loss at all time points, fruit and vegetable consumption, exercise, wellbeing, depression, anxiety, habit strength and openness to change.

Results: Of 130 participants assessed for eligibility, 75 adults (mean BMI 34.5 kg/m2 [SD 6.2]), with a mean age of 51 years were recruited. Assessments were completed post-intervention by 66/75 (88%) of participants and by 43/50 (86%) at 12-months. At post-intervention, participants in the Ten Top Tips (-3.3kg; 95% CI -5.2, -1.4) and Do Something Different (-2.9kg; 95% CI -4.3, -1.4) interventions lost significantly more weight (P= <.001) than those on the waitlist control (-0.4kg; 95% CI -1.2, 0.3). Both intervention groups continued to lose further weight to the 12-month follow-up; TTT lost an additional -2.4kg (95% CI -5.1, 0.4) and DSD lost -1.7kg (95% CI -3.4, -0.1). At 12-months post-intervention, 28/43 (65%) of participants in both intervention groups had reduced their total body weight by ≥5%, a clinically important change.

Conclusions: Habit-based weight-loss interventions - forming new habits (TTT) and breaking old habits (DSD), resulted in clinically important weight-loss maintenance at 12-month follow-up.

Introduction

The weight loss – weight regain cycle can defeat many. The majority of individuals with overweight or obesity, who lose weight, regain 40% of the loss in the first year after treatment and most of the rest in the following three years[1,2]. Hence addressing the determinants for weight-loss maintenance is essential. Knowing what diet and exercise behaviors are necessary for long-term weight loss, does not seem to equate to healthy behavior or predict health outcomes[3]. Weight management recommendations are usually based on advising patients on what to change and why (e.g. reduce daily calorie intake to achieve weight loss). Acting on this advice requires conscious, deliberative thoughts [4]. However, motivation and attention to change behaviors wane, so the behavior changes are typically short-lived and weight is regained [4]. A recent study on the psychosocial determinants for maintaining weight loss showed, nutritional knowledge and motivation did not differ between individuals with obesity who reduced weight and individuals who regained weight [5]. The loss of all 'excess weight' is not essential to achieve health benefits: a 5% reduction in body weight in individuals with overweight or obesity is associated with significant improvements in LDL and total cholesterol, blood pressure, blood glucose and other health indices [6,7].

Psychological studies show that habitual behaviors strongly influence health outcomes [8-10]. Habit-based interventions may therefore be effective – focused either on forming new healthy habits, breaking old unhealthy habits, or a combination of both [11]. Interventions which offer advice on lifestyle change whilst engaging automatic behaviors (including efficiency, lack of awareness, unintentionality and uncontrollability [12]) may offer more benefit 4 because automatic behaviors do not require self-control or willpower and strengthen with repetition [11]. Furthermore, breaking old habits by re-structuring daily routines and engaging in novel behaviors, increases an individual's mindful behaviors through conscious, deliberative thought [13]. This increase in conscious thought is proposed to draw attention to the behavior, making it easier to recognize compliance with behavioral goals [14]. Despite good evidence for short-term effectiveness, habit-based weight-loss studies with data beyond 6-months post-intervention are scarce; only two studies to date provide weight loss outcomes for 8 months [15] and [24] months post-intervention [16], of which both are the same intervention focusing solely on habit formation.

We conducted a randomized controlled trial to evaluate the effectiveness of two habit-based weight-loss interventions, Ten Top Tips (TTT) (forming new habits) and Do Something Different (DSD) (breaking old habits), for weight loss maintenance up to 12-months. A waitlist control group (WL) was included for comparison during the active phase of the intervention (12-weeks). We compared weight-loss of the three groups at post-treatment and then followed-up the active treatments for 12 months to assess weight-loss maintenance. Secondarily, we compared the two active interventions to explore if forming new habits, or breaking old habits is more effective.

Methods

Recruitment

We identified potential participants via local televised news and radio interviews. Participants were initially screened on the telephone for eligibility. Eligible participants were between 18 and 75 years of age, able to consent, had a BMI ≥25.0kg/m2, lived locally or could attend all required appointments, had daily access to email and/or phone and free from exercise limiting comorbidities. Participants were recruited regardless of obesity-related comorbidities (e.g., cardiovascular disease and diabetes). Exclusion criteria included participants who were or could be pregnant, significantly ill, participating in other weight management programs, or taking any medications affecting appetite, metabolism or

weight. Participants were recruited between July and October 2015 and attended an initial interview to provided informed consent prior to randomization. Computer generated randomization occurred after baseline assessment to allocate participants to either: TTT, DSD or WL control (allocation ratio 1:1:1). We used minimization stratified on BMI categories (overweight, obese class I, II, III), age (18-32, 33-47, 48-62, 63-75 years); and gender.

The trial was conducted at Bond University, Institute of Health and Sport in Gold Coast, Australia. There were no changes to methodology after trial commencement.

Sample Size

We aimed to observe a difference between either intervention group and WL at 12-months post-intervention, however, it was not reasonable to keep the WL for 12-months with no weight loss intervention. Hence, we used the assumption that the WL would not lose weight during the intervention period. We also expected any weight lost during the intervention to be maintained at the 12-month post-intervention time-point. Therefore, sample size calculations were based on the mean weigh loss from previous DSD and TTT studies at the last available time-point (4 weeks for DSD and 8 weeks for TTT) [13,15]. Our power calculation suggested 19 participants were required in each of the 3 arms to achieve a 90% power and 5% significance criterion to detect a 2.4kg (SD 2.2) weight loss difference between either intervention group and control. To account for 30% attrition, [17] we recruited 75 participants.

Interventions

The Ten Top Tips (TTT)

The Ten Top Tips is a self-guided, leaflet-based intervention focusing on the recommendations of habit-formation theory. Founded on eating and activity behaviors associated with weight loss, the tips are a list of seven behaviors associated with negative energy balance, two behaviors designed to improve awareness of food intake and one behavior to promote routines [15] (Supplementary Table 2; www.weightconcern.org.uk/tentoptips). To encourage habit development, participants were advised to plan ahead to effectively incorporate the tips into their daily routines and repeat the behaviors in a consistent context. Self-monitoring is a valuable component of behavior change programs [18,19]. A logbook was provided to participants for recording tips adherence [16]. If participants were consistently failing to achieve a tip they had space to make notes and plan how to achieve it the following week. Space was also provided to record weight weekly. TTT was originally a single-session intervention with no further contact. However, to control for intervention length and to aid in habit formation, we implemented TTT for 12 weeks. Participants attended a 2-hour group induction meeting in groups of 5, facilitated by GC to receive information, booklets and to complete baseline assessments.

Do Something Different (DSD)

DSD, focuses on increasing participants' behavioral flexibility by breaking daily habits [13] purported to play a role in unhealthy dietary and exercise behaviors [20]. DSD requires participants to do something different each day and to engage in novel, weekly activities to expand their behavioral repertoire [21]. What makes this intervention particularly novel is that these activities are not diet or exercise related and can include 'drive a different way to work today', 'choose a charity or local group to help' or 'write a short story on any subject'.

DSD is implemented and managed via online software where participants complete pre and post intervention measures which records personal behaviors and habits and tailors the program to each individual. For example, a participant might report they are 'extroverted', and may receive the task 'be more introverted

today'. When logged into the software (https://dsd.me/), participants are able to see the tasks they are required to perform, mark off their compliance and make comments each day. Originally DSD was conducted for 4 weeks; however, the average length of time to alter habits is reported as 66 days [14]. Therefore, we requested to conduct an extended 9-week program. As participants were recruited, they attended a 2-hour group induction meeting in groups of 5 facilitated by GC where they individually completed the baseline assessments. Three to four tasks per week were automatically sent out to each participant via text message and/or email.

During the intervention period, participants in all three arms received a weekly phone call from GC to promote accountability and help preclude attrition. In the active interventions, phone calls commenced with "How have you managed on the program this week?" opening discussion regarding the barriers and facilitators of program adherence. Problem solving strategies were discussed as necessary; although GC is a dietitian, no specific diets or exercise regimens were offered. For self-monitoring purposes, participants were encouraged to record a food diary [18]; which were not analyzed. Intervention adherence was monitored by the weekly phone calls, the logbook (TTT) and DSD online software. GC checked log book completions fortnightly and monitored DSD compliance with the online software. Intervention fidelity was not formally measured; however, GC followed procedure manuals provided by the original developers and used standardized introductory presentations and resources for each intervention. No training was provided in implementing the interventions and all were delivered as intended.

Interventions commenced July to October 2015 and concluded September to December 2015; 12-month follow-up was conducted from September to December 2016.

Attention-only waitlist

The WL group was instructed to continue as usual during the 12-week intervention period. This was to enhance the robustness of the study and to confirm that the initial weight loss within the current study was significantly greater within the two intervention groups. The WL group were contacted weekly via telephone for 12 weeks (by GC) and at their discretion offered either the DSD or TTT intervention after this time. They received no weight-loss advice.

Outcome measures

The primary outcome was weight-loss maintenance from post-intervention (12-weeks) to 12-month follow-up in the two active intervention groups. Secondary outcomes included changes in weight, BMI, waist circumference, daily fruit and vegetables consumption, weekly exercise, and psychological data (wellbeing, depression, anxiety, habits and openness to change) from baseline to post-intervention, baseline to 12-month follow-up and post intervention to 12-month follow-up, and proportion of participants achieving ≥5% total body weight loss.

Anthropometric measures were body weight (measured to the nearest 0.1 kg using Seca 700 medical scales), BMI (weight [kg] ÷ height [m2]), and waist circumference (soft tape over light clothing) [22]. These data were collected by a research assistant blind to group allocation.

Self-reported data were collected for diet, exercise, and psychometric measures. Following Australian dietary guidelines, fruit and vegetable intakes were measured as a count of serves, from 0 to 3+ for fruit and 0 to 5+ for vegetables [23]. Exercise was recorded as hours of exercise performed per week. Psychometrics were used to collect data for participant wellbeing, depression, anxiety, habit strength and openness to change [24].

The 8-item wellbeing questionnaire assesses an individual's perceived level of quality of life,

including ability to cope with problems/issues, ease in making decisions, personal value and happiness [24]. Each item is scored on a 0-100 scale where the larger number suggests better wellbeing (max score 800). Depression and anxiety are measured using a four-point ordinal scale ranging from 'Very frequently/often' to 'Never', the lower score representing less depression and anxiety (max score 16). There are 4 items for each [24]. The 12-item habit rater questionnaire measures daily healthy behaviors and frequency of behaviors ranging from "a little" (0) to "a lot" (100). Values are totaled and range from 0 to 1200 where the greater value represents more healthy behaviors [24]. The openness to change scale is an 8-item questionnaire assessing an individual's behaviors and attitudes to change. Scores range from 'a little' (0), to 'a lot' (100) with a maximum score of 800, where larger scores represent more healthy behaviors and attitudes to change [24]. See supplementary material for all questionnaires.

Statistical analysis

The pre-planned statistical analysis aimed to compare treatment outcomes between the three groups, we used two strategies. First, we conducted 2-way mixed factorial analyses of covariance (ANCOVAs); three groups (TTT vs DSD vs WL) by two time points (i.e., post-intervention vs 12-month follow-up [primary outcome], or baseline vs post-intervention [secondary outcomes]) with baseline data as the covariate. If statistically significant results were observed, we then conducted a two group (i.e., WL vs TTT) by two time point (i.e., baseline vs post-intervention) direct group comparison for each group and time point. To determine any baseline differences between intervention completers and non-completers, we conducted independent t-tests and chi-squared tests. As intervention dropouts occurred prior to intervention commencement and because there were only a small number of missing data, we conducted available case analyses. Post-hoc analyses were conducted using 2 (Group) x2 (time) ANCOVAs with baseline data as the covariate, to assess differences on measures from baseline to 12-month follow-up. Statistical software used to perform analysis was, IBM SPSS Statistics v23.

Patient involvement

The acceptability of the TTT and DSD interventions were assessed by participants in a preceding pilot study. Qualitative data were collected from semi-structured interviews conducted with the pilot study participants and helped inform the present study. Specifically, the addition of weekly phone calls (which was not part of the original study designs of TTT or DSD) to increase accountability and support, and the removal of daily food and exercise diaries to lower participant burden.

Table 1 Baseline characteristics of participants by intervention group

	TTT, $n = 25$	DSD, $n = 25$	WL, $n = 25$
Age, years (SD)	48.2 (11.3)	51.3 (10.0)	52.0 (12.3)
Gender			
Male	5 (20%)	6 (24%)	5 (20%)
Female	20 (80%)	19 (76%)	20 (80%)
Weight, kg (SD)	95.8 (18.5)	97.9 (22.4)	94.7 (20.4)
BMI, kg/m^2 (SD)	34.6 (5.2)	35.2 (7.4)	33.6 (6.1)
Waist circumference, cm (SD)	111.8 (13.4)	117.5 (14.1)	114.8 (16.1)
Exercise performed/ week, hours (SD)	2.7 (2.9)	2.5 (2.5)	3.9 (4.4)
Fruit consumed/day, serves (SD)	1.4 (1.1)	1.3 (0.8)	1.5 (8.3)
Vegetables consumed/ day, serves (SD)	2.7 (1.5)	2.6 (1.3)	2.6 (1.3)
Education level			
Did not complete school	2 (8%)	2 (8%)	4 (16%)
High school	12 (48%)	15 (60%)	16 (64%)
University degree	11 (44%)	8 (32%)	5 (20%)

Values are mean

TTT Ten Top Tips, *DSD* Do Something Different, *WL* waitlist, *SD* standard deviation, *BMI* body mass index

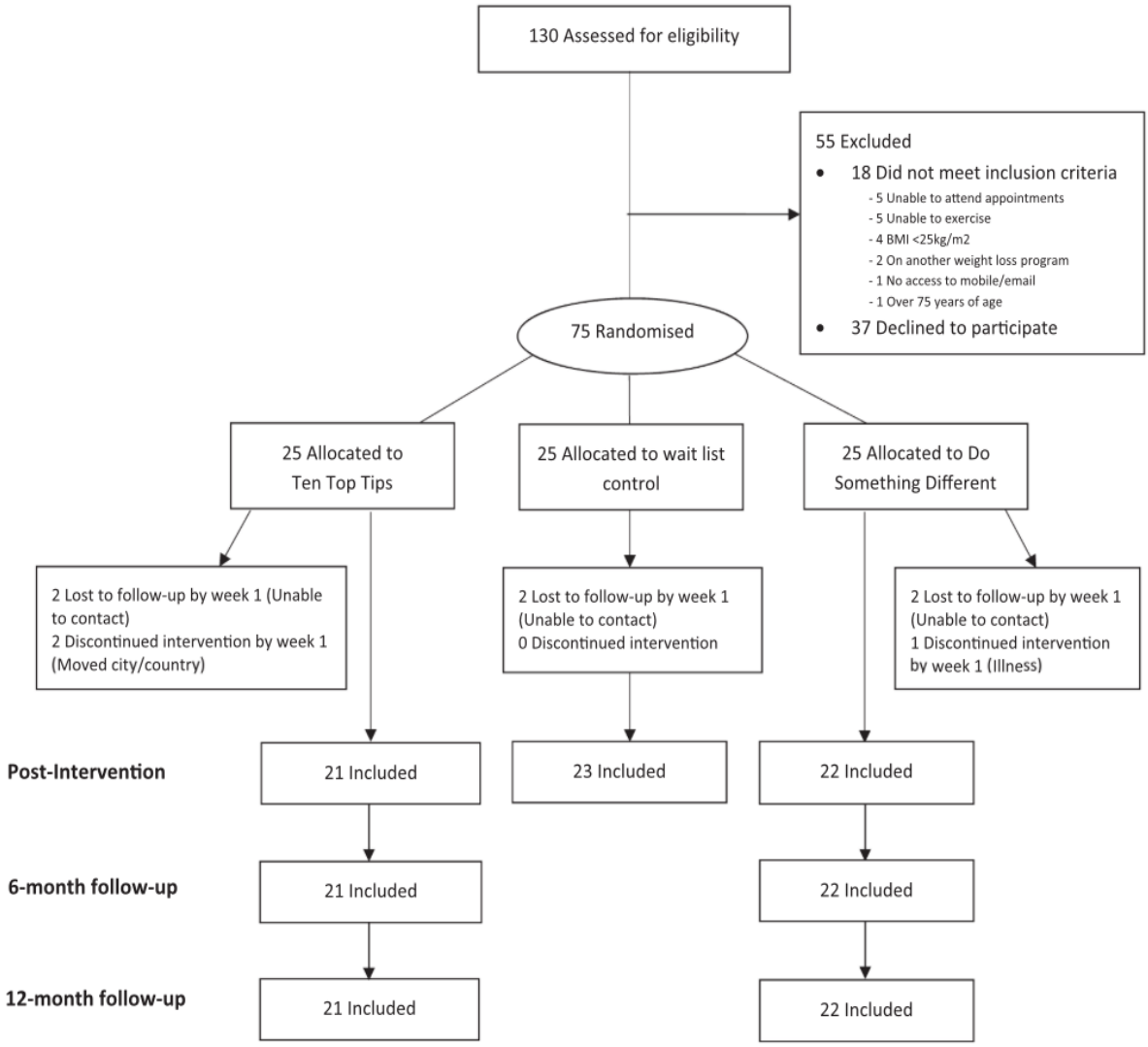


Fig. 1 Participants' flow diagram

Results

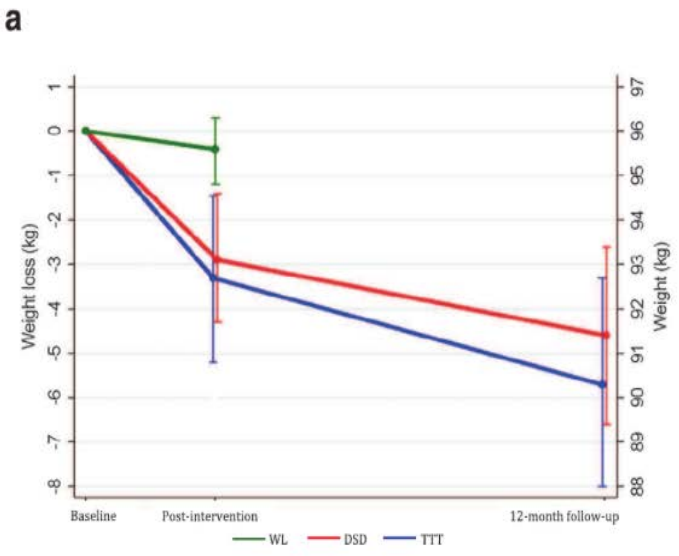
We assessed 130 community members for eligibility between June and October 2015. Of these, 18 did not meet inclusion criteria and 37 declined to participate. We included 75 eligible participants with a mean BMI 34.5 kg/m2 (SD 6.2) and mean age of 51 years (SD 11) who were randomized to one of three groups (Figure 1).

Baseline characteristics were similar in the 3 groups (Table 1). All participants received intervention information; however, after initial interview nine participants failed to commence the intervention (4 TTT, 3 DSD, 2 WL). There were no significant differences in baseline characteristics between non-completers and completers (Supplementary Table 1).

Primary outcome

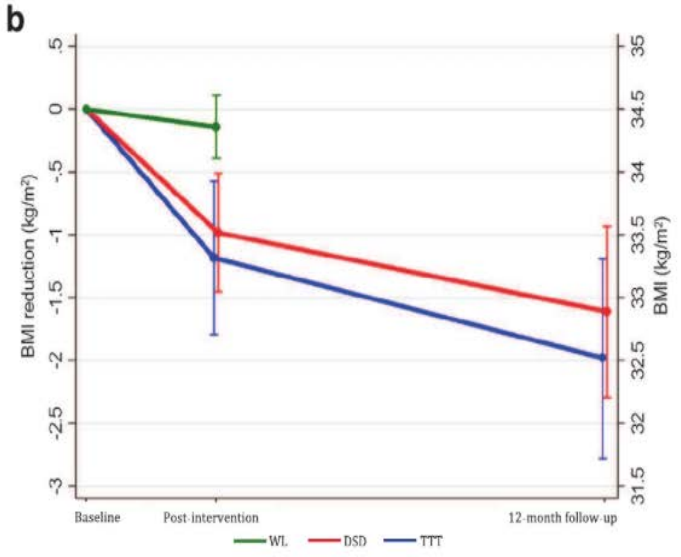
Post-intervention to 12-month follow-up weight loss and waist circumference

After the interventions concluded, participants continued to lose weight up to 12-month follow-up. TTT participants lost a further -2.4kg (95% CI 0.4 to 5.1) and DSD participants lost -1.7kg (95% CI -3.4 to -0.1). BMI and waist circumference also continued to decrease at 12-month follow-up (BMI: TTT -0.8kg/m2 [95% CI -1.8 to 0.1], DSD -0.6kg/m2 [95% CI -1.2 to -0.04]; waist circumference: TTT -3.1cm [95% CI -5.6 to -0.6], DSD -2.0cm [95% CI -4.7 to 0.7]) (Figure 2).



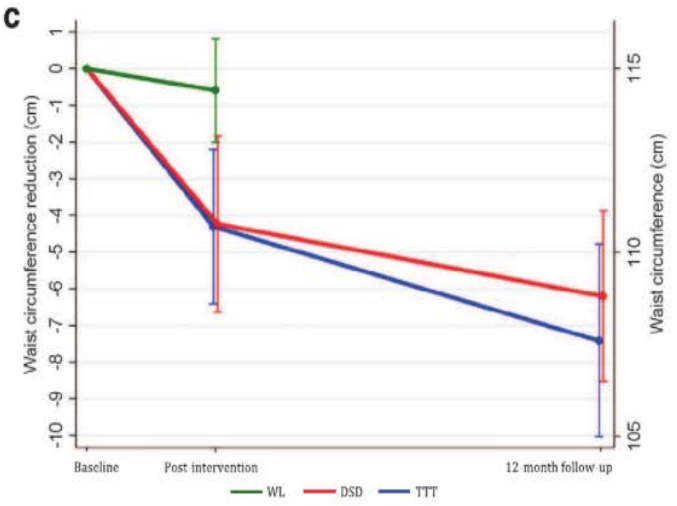
	Post-intervention (PI)			12 months from baseline			12 months from PI		
Weight (kg)	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups
TTT - DSD	-0.6	-2.9, 1.7	.62	-1.4	-4.1, 1.4	.33	0.7	-2.5, 3.9	.66
TTT - WL	-2.9	-4.8, -0.9	<.001	-	-	-	-	-	-
DSD - WL	-2.3	-3.9, -0.8	<.001	-	-	-	-	-	-

Abbreviations: TTT = Ten Top Tips; DSD = Do Something Different; WL = Waitlist; kg = kilogram; PI = Post-intervention; CI = Confidence Interval.



	Post-intervention (PI)			12 months from baseline			12 months from PI		
BMI (kg/m²)	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups
TTT - DSD	-0.2	-1.0, 0.5	.59	-0.4	-1.4, 0.6	.40	0.2	-0.9, 1.2	.76
TTT - WL	-1.0	-1.7, -0.4	<.001	-	-	-	-	-	-
DSD - WL	-0.8	-1.4, -0.3	<.001	-	-	-	-	-	-

Abbreviations: TTT = Ten Top Tips; DSD = Do Something Different; WL = Waitlist; BMI = Body Mass Index; PI = Post-intervention; CI = Confidence Interval.



	Post-intervention (PI)			12 months from baseline			12 months from PI		
Waist circumference (cm)	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups	Adjusted Mean difference	95% CI	*P*-value between groups
TTT - DSD	-0.1	-3.3, 3.1	.95	-1.7	-5.1, 1.7	.31	1.1	-2.7, 4.8	.57
TTT - WL	-3.8	-6.2, -1.3	<.001	-	-	-	-	-	-
DSD - WL	-3.6	-6.3, -0.9	.01	-	-	-	-	-	-

Abbreviations: TTT = Ten Top Tips; DSD = Do Something Different; WL = Waitlist; cm = centimetre; PI = Post-intervention; CI = Confidence Interval.

Fig. 2 a Mean weight and adjusted mean differences between TTT, DSD and WL at post-intervention and 12-month follow-up. **b** Mean body mass index (BMI) and adjusted mean differences between TTT, DSD and WL at post-intervention and 12-month follow-up. **c** Mean waist circumference and adjusted mean differences between TTT, DSD and WL at post-intervention and 12-month follow-up

Secondary outcomes

Baseline to post-intervention

Weight and waist circumference

At post-intervention, participants in the TTT (-3.3kg) and DSD (-2.9kg) interventions lost significantly more weight (P= <.001) than those on the WL control (-0.4kg). BMI (TTT -1.2kg/m2; DSD -1.0kg/m2) and waist circumference were also reduced significantly in the active interventions compared with the WL group (BMI -0.1kg/m2, waist circumference -0.6cm) (Figure 2).

Psychometric measures

Mean WL participant wellbeing and openness to change decreased between baseline and post-intervention but improved in the TTT and DSD groups. Active interventions did not differ significantly from each other, but both showed statistically significant increases compared with control (Supplementary Table 3).

Compared with DSD, TTT participants improved significantly more in healthy behavior, depression and anxiety and in habits and depression only when compared with WL participants. There were no statistically significant differences between DSD and WL groups for habits, depression or anxiety.

Post-intervention to 12-month follow-up

Weight and waist circumference differences between groups

Adjusted mean differences between TTT and DSD from post-intervention to 12-month follow-up were: weight, 0.7kg (95% CI -2.5 to 3.9, P= .66), BMI, 0.2kg/m2 (95% CI –0.9 to 1.2, P= .76) and waist circumference, 1.1cm (95% CI -2.7 to 4.8, P= .66) (Figure 2).

Psychometric measures

There were slight improvements in wellbeing and depression in both groups between post-intervention and 12-month follow-up, with mixed results for anxiety. Although there were positive changes in healthy behaviors post intervention, there was a decrease in the engagement of healthy behaviors in the TTT group from post-intervention to 12-month follow-up (-81.9 points [95% CI -172 to 8.3]) (Table 2). However, there were no statistically significant differences between groups for any of the psychometric measures (Supplementary Table 3).

Baseline to 12-month follow-up

Weight and waist circumference

A large proportion of participants in both intervention groups had clinically important weight loss from baseline to 12-month follow-up. Total body weight loss of ≥5% was achieved by 14/21 (67%) participants in the TTT group and 14/22 (64%) in DSD, with the majority of participants (24/43, 65%) losing between 5.0-9.9% body weight in both interventions (Supplementary Table 4).

Psychometric measures

All psychometric measures (wellbeing, depression, anxiety, habits and openness to change) improved from baseline to 12-month follow-up in both TTT and DSD (Table 2), with no significant differences between groups (Supplementary Table 3).

Discussion

Our primary outcome was weight loss maintenance at 12-months post-intervention and we found, participants in both habit-based interventions - forming new habits (TTT) and breaking old habits (DSD) - achieved weight-loss maintenance and lost further weight.

Table 2 Comparison of changes in outcomes measured between TTT, DSD, and WL at post-intervention and 12-month follow-up

	Baseline	Post-intervention (PI)			12 months from baseline			12 months from PI	
Variable	Mean (SD)	n[a]	Mean change	95% CI	n[a]	Mean change	95% CI	Mean change	95% CI
Secondary analysis of primary outcome									
Weight (kg)									
TTT	95.8 (18.5)	21	−3.3	−5.2, −1.4	21	−5.7	−8.0, −3.3	−2.4	−5.1, 0.4
DSD	97.9 (22.4)	22	−2.9	−4.3, −1.4	22	−4.6	−6.6, −2.6	−1.7	−3.4, −0.1
WL	94.7 (20.4)	23	−0.4	−1.2, 0.3	—	—	—	—	—
BMI (kg/m^2)									
TTT	34.6 (5.2)	21	−1.2	−1.8, −0.6	21	−2	−2.8, −1.2	−0.8	−1.8, 0.1
DSD	35.2 (7.4)	22	−1	−1.5, −0.5	22	−1.6	−2.3, −0.9	−0.6	−1.2, −0.04
WL	33.6 (6.1)	23	−0.1	−0.4, 0.1	—	—	—	—	—
Waist (cm)									
TTT	111.8 (13.4)	21	−4.3	−6.4, −2.2	21	−7.4	−10.0, −4.8	−3.1	−5.6, −0.6
DSD	117.5 (14.1)	22	−4.2	−6.6, −1.8	22	−6.2	−8.5, −3.9	−2	−4.7, 0.7
WL	114.8 (16.1)	23	−0.6	−2.0, 0.8	—	—	—	—	—
Secondary outcomes									
Fruits (serves/day)									
TTT	1.4 (1.1)	21	0.5	0.1, 0.9	21	0.1	−0.5, 0.6	−0.4	−0.8, −0.006
DSD	1.3 (0.8)	22	0.2	−0.1, 0.6	22	0.3	−0.03, 0.7	0.1	−0.2, 0.4
WL	1.5 (0.8)	23	−0.2	−0.5, 0.2	—	—	—	—	—
Vege (serves/day)									
TTT	2.7 (1.5)	21	0.9	0.4, 1.4	21	0.7	0.1, 1.4	−0.1	−0.7, 0.4
DSD	2.6 (1.3)	22	0.1	0.3, 0.6	22	0.4	−0.1, 0.8	0.2	0.4, 0.8
WL	2.6 (1.3)	23	0	−0.5, 0.5	—	—	—	—	—
Exercise (h/week)									
TTT	2.7 (2.9)	21	2.6	1.6, 3.7	21	2.5	1.4, 3.6	−0.1	−1.1, 0.9
DSD	2.5 (2.5)	22	2.4	−0.02, 4.7	22	2.8	1.5, 4.1	0.5	−1.3, 2.2
WL	3.9 (3.4)	23	−0.8	−1.7, 0.1	—	—	—	—	—
Wellbeing/800									
TTT	525.1 (150.0)	17	93	38.2, 147.8	17	112.2	28.2, 196.1	24.6	−41.0, 90.1
DSD	486.0 (137.8)	22	66.8	30.1, 103.6	22	65.6	−21.7, 153.0	−1.2	−72.9, 70.6
WL	535.9 (183.4)	18	−38.7	−114.3, 37.0	—	—	—	—	—
Depression/16									
TTT	10.3 (2.7)	20	−1.9	−3.0, −0.7	21	−2.6	−4.0, −1.1	−0.9	−2.1, 0.3
DSD	10.4 (2.6)	22	0.4	−0.7, 1.5	22	−1.7	3.9, 0.4	−2.1	4.2, 0.1
WL	10.5 (3.0)	22	0.5	−0.9, 1.8	—	—	—	—	—
Anxiety/16									
TTT	9.0 (2.3)	20	−1	−2.1, 0.1	21	−0.1	−1.4, 1.2	0.7	-0.5, 1.8
DSD	10.7 (2.2)	22	0.1	1.1, 1.4	22	−0.7	2.3, 1.0	−0.8	2.6, 1.0
WL	9.7 (2.6)	22	0.2	−1.3, 1.8	—	—	—	—	—
Habits/1200									
TTT	694.0 (150.6)	20	208.3	142.9, 273.7	21	111.5	0.3, 223.4	−81.9	−172.0, 8.3
DSD	656.9 (140.3)	22	65.5	−1.7, 132.7	22	88.5	−1.2, 150.4	4.4	−50.7, 68.9
WL	714.5 (171.3)	22	10.9	−48.7, 70.5	—	—	—	—	—
Openness to change/800									
TTT	550.0 (114.2)	21	52.4	7.2, 97.5	21	41.9	−24.7, 108.4	−0.8	−47.9, 46.3
DSD	484.5 (123.6)	25	66.5	19.3, 113.7	22	79.9	15.5, 124.9	−6.3	−51.2, 58.5
WL	542.8 (125.9)	22	−14.4	−55.5, 26.8	—	—	—	—	—

TTT Ten Top Tips, *DSD* Do Something Different, *WL* waitlist, *PI* post-intervention, *SD* standard deviation, *CI* confidence interval, *Vege* vegetables

Note: PI data are change from baseline. 12-month data are change from baseline and change from PI

[a] Number reflects number of participants who completed assessment or questionnaire and not reflective of number of participants in the study.

Corresponding with the changes in weight, participants in the TTT and DSD programs had reductions in BMI and waist circumference. These results are promising against the background of most weight-loss programs reporting weight regain post-intervention and failing to keep the weight off long-term [1,7,25,26]. We also explored whether making new habits, or breaking old habits is more effective for weight loss and weight loss maintenance and found no statistically significant difference between groups.

The active interventions in this study were not directly compared to a non-habit-based weight-loss intervention at the final time-point; however, we can compare the results with systematic reviews which evaluated long-term weight-loss maintenance after lifestyle interventions. Previous results show that 12-months post-treatment, an average of 46-50% of weight loss is regained [7,25,26]. In contrast, participants in our study continued to lose weight at 12-months post-intervention, suggesting habit-based interventions are promising interventions to combat the weight loss – weight regain cycle over more conventional weight-loss programs. Although interest is growing in habit-change strategies, and habits consistently correlate with behavior [27], weight loss interventions applying this approach are still scarce and their mechanisms of action are not completely understood; therefore, the mechanisms influencing the relationship between habit change and weight loss, are still not known. There has been one study to date, which explicitly assessed the potential mechanisms of a habit-based intervention for weight loss [28]; the study focused on TTT. Overall the results showed, TTT promoted changes in self-regulatory skills and these changes, alongside changes in automaticity, mediated the effect of TTT on weight loss. These findings support the theoretical basis of the intervention and are in line with the suggestion that interventions which require the development of goals, planning and monitoring of behavior, improve self-regulatory capacity [14,18,29]. No mediator analyses for DSD or other habit-based weight loss interventions have been published. We hypothesize that although the aim of DSD is to promote behavioral flexibility and increase behavioral repertoire, it does not aim to break previously established healthy habits, such as eating breakfast, or engaging in physical activity. In fact, as an individual behaves from a heightened state of awareness, as opposed to mindlessly (habit), they are more likely to perform behaviors which align with their health and weight goals [30]. Therefore, the observation of participants in DSD increasing their healthy behaviors according to the habit rater, was to be expected.

This study was not powered for secondary outcomes; therefore, these analyses should be regarded as exploratory. We observed an increase in engagement in healthy behaviors and openness to change in both active interventions, even at 12-month follow-up. A qualitative analysis in a previous TTT study showed the participants reported the target behaviors became more habitual gradually and acquired characteristics of habits including automaticity, repetition and 'feeling strange' for not doing the behavior [29]. The increase in openness to change and sustained change in habits could correspond to the long-term weight-loss maintenance observed in our study. Of note, TTT participants received direct recommendations to improve their healthy habits (e.g., 'walk 10,000 steps per day' and 'eat 2 fruits and 5 vegetables a day'); while DSD participants did not receive targeted recommendations instead receiving daily individualized text messages to disrupt daily routines. Despite not receiving habit-forming recommendations, DSD still improved their overall engagement in healthy behaviors. For example, both interventions doubled the hours of exercise performed per week from baseline to follow-up and doubled the global recommendations on physical activity for health[31]. This suggests that explicit advice on how to form new healthy habits may not be necessary to improve an individual's healthy behaviors. By simply altering an individual's

current habits, new habits can be established and ultimately disrupt unhealthy habits.

There are several strengths to our study. First, we included an adequate sample size to detect important changes in dependent variables; second, we conducted a rigorous 3-armed randomized controlled trial design with good retention and accountability; and finally, we endeavored to replicate previous research.

However, there were limitations. We did not collect data for body composition or cardiometabolic risk factors. Although this limits the scientific scope of the study, the correlation between weight and waist reduction and cardiometabolic risk factors is well documented[32-34]. There is currently no clear definition for 'successful long-term weight loss'[35]. For the purpose of this study, we defined 'long-term weight loss' as 12-months post-intervention as proposed by Wing RR, 2005. We acknowledge however, that 12-months may not represent 'long-term'. DSD and TTT differ in length. We acknowledge that differences between the two interventions could have been different had they both been the same duration. But there were no significant differences between groups in weight loss and weight-loss maintenance. Groups were equivalent and intervention duration was still around 66 days, which is the average time it takes to change a habit [14], so it is possible that habit change occurred. It is also plausible that a dietitian/facilitator may have contributed to the weight loss and maintenance success of participants. However, we did not offer specific dietary advice and believe health practitioners following the prescribed manuals would achieve similar outcomes. This will need to be explored in future research. Finally, we do not know the mechanisms that influenced the weight loss outcomes in our study. Building on the work of Kliemann and colleagues [28], to improve the theoretical understanding of how habit-based interventions might bring about weight loss, is essential to provide guidance on the development of effective weight-management interventions.

To aid in study retention and to increase accountability, we included weekly check-in phone calls for the 12-week intervention to all three groups. These phone calls are not in the original study designs of either TTT or DSD [13,15]. We hypothesized this difference would achieve greater weight loss than previous TTT and DSD trials as accountability has consistently demonstrated to be a key facilitator for weight loss [36]. This appeared to be the case for TTT, but did not apply for DSD. Previous studies show, TTT participants [16] (*n*= 153) lost, 2.4kg ± 5.5 and DSD participants [13] (*n*= 31) lost, 5.0kg ± 2.7 from baseline to 12-month follow-up. We conclude that weekly monitoring may not achieve greater weight-loss results however could have improved retention. Whether weekly monitoring influenced retention requires further research.

Conclusion

Despite the different underlying mechanisms of TTT and DSD, participants in both interventions achieved significant weight-loss maintenance for 12-months post-intervention and improved their diet and exercise habits. Approximately 65% of participants in the active intervention groups lost over 5% of their total body weight which is the benchmark of successful and healthful weight loss and kept it off 12-months after the intervention completed. Habit-based interventions have the potential to change how we think about weight management and importantly, how we behave.

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Acquisition of data: Cleo. Analysis and interpretation of data: Cleo, Thomas, Beller. Drafting of the manuscript: Cleo, Thomas, Isenring. Critical revision of the manuscript for important intellectual content: Cleo, Thomas, Beller, Isenring, Glasziou. Statistical analysis: Cleo, Thomas, Beller

Registered clinical trial: This study was registered on the 10th of February 2015 through the Australian New Zealand Clinical Trials Registry (ANZCTR). The allocated Australian Clinical Trial Registry Number (ACTRN) is: ACTRN12615000114549.

Ethics: This study complied with the ethics guidelines recommended by the National Health and Medical Research Council (NHMRC) and Bond University Research Ethics Committee (BUHREC). This study was granted ethical approval by BUHREC (No. RO1888B) on 17 February, 2015.

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References

1. Roqué i Figuls M MGL, Martinez-Zapata MJ, Pacheco R, Mauricio D, Bonfill CX. . Interventions for treating overweight or obesity in adults: an overview of systematic review (Protocol). Cochrane Libr. 2013;(8):CD010665.
2. Cooper Z, Fairburn CG. A new cognitive behavioural approach to the treatment of obesity. Behav Res Ther. 2001;39(5):499-511.
3. Quinn JA, Pascoe A, Wood W, Neal DT. Can't Control Yourself ? Monitor Those Bad Habits. Pers Soc Psychol Bull. 2009;36(4):499-511.
4. Gardner B, Lally P, Wardle J. Making health habitual: the psychology of 'habit-formation' and general practice. Br J Gen Pract. 2012;62(605):664–6.
5. Christensen BJ, Iepsen EW, Lundgren J, Holm L, Madsbad S, Holst JJ, et al. Instrumentalization of Eating Improves Weight Loss Maintenance in Obesity. Obes Facts. 2017;10(6):633-647.
6. Avenell A, Brown TJ, McGee MA, Campbell MK, Grant AM, Broom RT, et al. What are the long-term benefits of weight reducing diets in adults? A systematic review of randomised controlled trials. J Hum Nutr Diet. 2004;17(4):317-35.
7. Barte JC, ter Bogt NC, Bogers RP, Teixeira PH, Blissmer B, Mori TA, et al. Maintenance of weight loss after lifestyle interventions for overweight and obesity, a systematic review. Obes Rev. 2010;11(12):899-906.
8. Baumeister RF, Masicampo EJ, Vohs KD. Do conscious thoughts cause behavior? Annu Rev Psychol. 2011;62:331-61.
9. Wood W, Witt MG, Tam L. Changing circumstances, disrupting habits. J Pers Soc Psychol. 2005;88(6):918-33.
10. Ouellette JA, Wood W. Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. Psychol Bull. 1998;124(1):54-74.
11. Cleo G, Isenring L, Thomas R, Glasziou P. Could habits hold the key to weight loss maintenance? A narrative review. J Hum Nutr Diet. 2017;doi:10.1111/jhn.12456.
12. Lally P, Van Jaarsveld CHM, Potts HWW, Wardle J. How are habits formed: Modelling habit formation in the real world. Eur J Soc Psychol. 2010;40(6):998-1009.
13. Fletcher BC, Hanson J, Page N, Pine K. FIT - do something different: A new behavioral program for sustained weight loss. Swiss J Psychol. 2011;70(1):25-34.
14. Lally P, Gardner B. Promoting habit formation. Health Psychol Rev. 2013;7(Sup1):S137-5

15. Lally P, Chipperfield A, Wardle J. Healthy habits: efficacy of simple advice on weight control based on a habit-formation model. Int J Obes (Lond). 2008;32(4):700-7.
16. Beeken RJ, Leurent B, Vickerstaff V, Wilson R, Croker H, Morris S, et al. A brief intervention for weight control based on habit-formation theory delivered through primary care: Results from a randomised controlled trial. Int J obes. 2017;41(2):246-54.
17. Miller BML, Brennan L. Measuring and reporting attrition from obesity treatment programs: A call to action! Obes Res Clin Pract. 2015;9(3):187-202.
18. Burke LE, Wang J, Sevick MA. Self-Monitoring in Weight Loss: A Systematic Review of the Literature. J Am Diet Assoc. 2011;111(1):92-102.
19. VanWormer J, French S, Pereira M, Welsh E. The Impact of Regular Self-weighing on Weight Management: A Systematic Literature Review. Int J Behav Nutr Phys Act. 2008;5(1):1-10.
20. Fletcher BC, Penman D, Pine K. The no diet diet- Do something different. 2 ed. London, UK: Orion Publishing Group Ltd; 2007.
21. Fletcher B, Page N, Pine K. A new behavioural intervention for tackling obesity: Do something different. Agro Food Ind Hi-Tech. 2007;18(5):8-9.
22. National Health and Medical Research Council. Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children in Australia. Canberra, Australia: Australian National Dept of Health; 2013.
23. National Health and Medical Research Council. Australian Dietary Guidelines. Canberra, Australia: Australian National Dept of Health and Ageing; 2013.
24. Charlton N, Kingston J, Petridis M, Fletcher B. Flexibility, personality and subjective wellbeing in the context of behaviour change interventions. Paper presented at: 7th International Conference on Digital Health; July 3, 2017; London, UK.
25. Curioni CC, Lourenco PM. Long-term weight loss after diet and exercise: a systematic review. Int J Obes. 2005;29(10):1168-74.
26. Anderson JW, Konz EC, Frederich RC, Wood CL. Long-term weight-loss maintenance: a meta-analysis of US studies. Am J Clin Nutr. 2001;74(5):579-84.
27. Gardner B, de Bruijn GJ, Lally P. A systematic review and meta-analysis of applications of the Self-Report Habit Index to nutrition and physical activity behaviors. Ann Behav Med. 2011;42(2):174-87.
28. Kliemann N, Vickerstaff V, Croker H, Johnson F, Nazareth I, Beeken RJ. The role of self-regulatory skills and automaticity on the effectiveness of a brief weight loss habit-based intervention: secondary analysis of the 10 top tips randomised trial. Int J Behav Nutr Phys Act. 2017;14(1):119.
29. Lally P, Wardle J, Gardner B. Experiences of habit formation: A qualitative study. Psychol Health Med. 2011;16(4):484-9.
30. Lange D, Richert J, Koring M. Self-regulation prompts can increase fruit consumption: a one-hour randomised controlled online trial. Psychol Health. 2013;28.
31. World Health Organization. Global Recommendations on Physical Activity for Health. Geneva, Switzerland: World Health Organization; 2010.
32. Poobalan A, Aucott L, Smith WCS, Avenell A, Jung R, Broom J, et al. Effects of weight loss in overweight/obese individuals and long-term lipid outcomes – a systematic review. Obes Rev. 2004;5(1):43-50.
33. Ross R, Bradshaw AJ. The future of obesity reduction: beyond weight loss. Nat Rev Endocrinol. 2009;5(6):319-325.
34. Klein S, Allison DB, Heymsfield SB, Kelley D, Leibel R, Nonas C, et al. Waist Circumference and Cardiometabolic Risk: A Consensus Statement from Shaping America's Health: Association for Weight Management and Obesity Prevention; NAASO, The Obesity Society; the American Society for Nutrition; and the American Diabetes Association. Obesity. 2007;15(5):1061-1067.
35. Wing, RR, Phelan S. Long-term weight loss maintenance. Am J Clin Nutr. 2005;82(1):222-225.
36. Metzga CJ, Perston AG, Miller DL, Nickol Richardson SM. Facilitators and barriers to weight loss and weight lossmaintenance: a qualitative exploration. J Hum Nutr Diet. 2014;28(6):593-603.

Electronic supplementary material

1. Supplementary Table 1. Statistical comparison of completes vs non-completers
2. Supplementary Table 2. Ten Top Tips
3. Supplementary Table 3. Adjusted mean differences for secondary outcomes
4. Supplementary Table 4. Proportion of weight loss on TTT and DSD at 12-month follow-up
5. Supplementary File. Participant information sheet
6. Supplementary File. Psychometrics