Original Article
CLINICAL TRIALS AND INVESTIGATIONS

Obesity

The Effects of If-Then Plans on Weight Loss: Results of the McGill CHIP Healthy Weight Program Randomized Controlled Trial

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Objective: The NIH-developed Diabetes Prevention Program (DPP) is successful in achieving clinically significant weight loss in individuals with overweight/obesity when delivered one-on-one. The group-based DPP is less effective, with average weight losses of only 3.5%. The objective of this study was to increase weight loss outcomes of the group-based DPP by integrating habit formation tools (i.e., if-then plans). This two-arm randomized controlled trial tested the efficacy of the habit formation–enhanced group-based DPP compared with the standard group-based DPP on changes in body weight (primary outcome). This study presents the 3- and 12-month results of this 24-month trial.
Methods: A total of 208 participants were randomly assigned to the standard or enhanced DPP, and 172 participated. Participants were men and women with overweight/obesity who self-reported less than 200 min/wk of exercise.
Results: Both groups achieved high weight losses at 3 (5.76%) and 12 (9.98%) months, with no differences between groups ($\chi^2 < 1$). Both groups improved in blood pressure and physical activity.
Conclusions: If-then plans did not result in higher weight loss. Both program versions resulted in higher weight loss than the group-based DPP. This may suggest that cognitive behavioral therapy skills of the coaches (clinical psychology doctoral students) was a key factor in treatment outcome.

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Introduction

Overweight (i.e., BMI $\geq$ 25 kg/m^2) and obesity (i.e., BMI $\geq$ 30 kg/m^2) are among the leading preventable causes of death in North America, with approximately 500,000 premature deaths each year in the United States (1,2). They carry the risk of health complications including type 2 diabetes, cardiovascular disease (e.g., heart attack, stroke), hypertension, dyslipidemia, osteoarthritis, and certain forms of cancer (3,4), making such chronic diseases responsible for approximately 39 million deaths annually worldwide (5).

Effective behavioral weight loss programs such as the NIH-developed Diabetes Prevention Program (DPP) result in clinically significant weight losses of 5% to 7% body weight (6). The DPP is a lifestyle change program delivered one-on-one in sixteen 1-hour sessions followed by monthly follow-ups. Trained lifestyle coaches teach participants how to eat healthier and be more physically active following a standardized curriculum. The group-based version of the DPP is less effective. It results in average weight losses of only 3.5% (6). Our new intervention therefore aims to further increase the weight loss outcomes of the group-based DPP.

Weight loss requires the change of eating and physical activity habits that lead to weight gain and the formation of new eating and physical activity habits that lead to weight loss and weight loss maintenance. Habit change can be achieved through the application of habit formation tools. The habit formation tool that has been empirically shown to be most effective in creating lasting habits is if-then plans (also called implementation intentions) (7,8). If-then plans are concrete action plans that are worded in an if-then contingency format and outline what one will do when a certain situation

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arises (7,8). For example, "If it is Monday, Wednesday, and Thursday at 5:00 PM, then I will run for 30 minutes in Centennial Park." Meta-analyses have found medium to large effects of if-then plans on goal achievement across a wide area of behaviors (9-11).

We integrated if-then plans into the group-based DPP to achieve greater weight loss (primary outcome) and improvements in other weight-related outcomes (goal achievement, diabetes risk factors, physical activity, self-monitoring, behavior change, and habit strength). This randomized controlled trial tested the hypothesis that compared with the standard group-based DPP (active control group), the group-based DPP that uses if-then plans (enhanced DPP) will result in greater weight loss from baseline to 3 months (end of core program of 12 sessions) and to 12 months (end of 22 sessions). The program is called the McGill Comprehensive Health Improvement Program (CHIP) Healthy Weight Program. Twenty-four–month follow-up results are forthcoming.

Methods

This prospective, two-arm randomized controlled trial was conducted from 2014 to 2017. The study protocol was approved by the Research Ethics and Compliance Board of the Faculty of Medicine Research and Graduate Studies Office at McGill University (Montreal, Quebec, Canada). A detailed description of the intervention, methods, procedures, and measures can be found in the published study protocol (12). Participants gave written informed consent prior to beginning the program.

Study population

Individuals with overweight or obesity (BMI of 28-45, waist circumference $\geq$ 88 cm for women, $\geq$ 102 cm for men, 18-75 years of age) were eligible if they engaged in fewer than 200 minutes of self-reported moderate or vigorous physical activity per week. Exclusion criteria included any limitation that would preclude full participation in the intervention or could have a confounding effect on the primary outcomes, including having been diagnosed with diabetes, taking metformin, and planning to become pregnant. The published study protocol (12) includes the full list of exclusion criteria. Study participants were recruited from the community through the use of flyers and email announcements (e.g., at local YMCAs).

Study procedures

The McGill Healthy Weight Program was administered in 22 sessions over 12 months following the manual of the group-based DPP (13). The DPP facilitates weight loss through cognitive behavioral strategies that help individuals to improve their diet and physical activity. It promotes weight loss through healthy eating (e.g., increased consumption of fruits and vegetables, decreased consumption of foods high in fat, sugar, and calories) and participation in moderate physical activity (150 min/wk).

If-then planning was integrated into all sessions of the program for the enhanced DPP group. The manual and handouts are available from the authors. All coaches were clinical psychology PhD students trained in cognitive behavioral therapy (CBT). Two of the coaches were certified in the delivery of the group-based DPP and trained the remaining coaches. This paper reports on the primary (percentage of body weight lost) and secondary outcomes that were assessed at 3 and 12 months.

Randomization and blinding

Participants were randomly assigned by computer-generated 1:1 sequence either to the standard or the enhanced DPP. Figure 1 presents a flowchart of the study design, including randomization. Participants and medical staff (e.g., staff who administered the exercise stress tests [ESTs]) were blind to group assignment. Because of the nature of the randomized controlled trial, group facilitators (coaches and their assistants) were not blind to group assignment. All coaches led an equal number of standard and enhanced DPP groups. One coach only led one group (a standard DPP group).

Intervention

The intervention and data collection took place at the CHIP or the downtown campus of McGill University. Groups comprised approximately 6 to 10 individuals, and the sessions lasted for approximately 1 hour. The active control group received the standard group-based DPP (13) delivered over 1 year (12 weekly core sessions, 4 transitional sessions over 3 months, and 6 monthly support sessions). The enhanced DPP group followed the same program as the standard DPP group, but instructions for if-then planning were integrated into it. Instructions for the delivery of if-then planning were based on previous studies (14-16). Specifically, the concepts of if-then planning were introduced to participants in Session 1 and subsequently practiced through the example of weighing oneself and tracking one's food intake. In subsequent sessions, participants made individualized if-then plans targeting eating and exercise behaviors. Coaches guided participants through the formation of if-then plans by using structured handout sheets that were revised throughout the program.

Measures

All measures are described in detail in the published study protocol (12). For the assessment of physical activity and for self-monitoring and behavior change of eating and physical activity, participants were asked to record their pedometer steps and activity minutes as well as their daily dietary intake using a paper diary or online food tracking. Habit strength was assessed via five items from the Self Report Index of Habit Strength (automaticity and identity items) (17).

Statistical analyses

All analyses were conducted using Mplus version 8.0 (Muthén and Muthén). Multigroup analysis was employed to examine change from baseline to 3 and 12 months and group differences in this change. A total of 25 participants had missing weight data at both 3 and 12 months; 6 had missing weight data only at 3 months, and 43 had missing data only at 12 months (for a total of 99 missing values). These missing data were handled with the estimation procedure "use full information maximum likelihood" with robust standard errors, which allows all data to be included in the estimation (18,19). As part of this estimation procedure, the missing data were imputed internally in the same model examining change in weight over time, with information from other weight measurements assessed at other time points used to predict the missing weight data. Because Little's missing completely at random test was not significant ($P = 0.651$), the pattern of

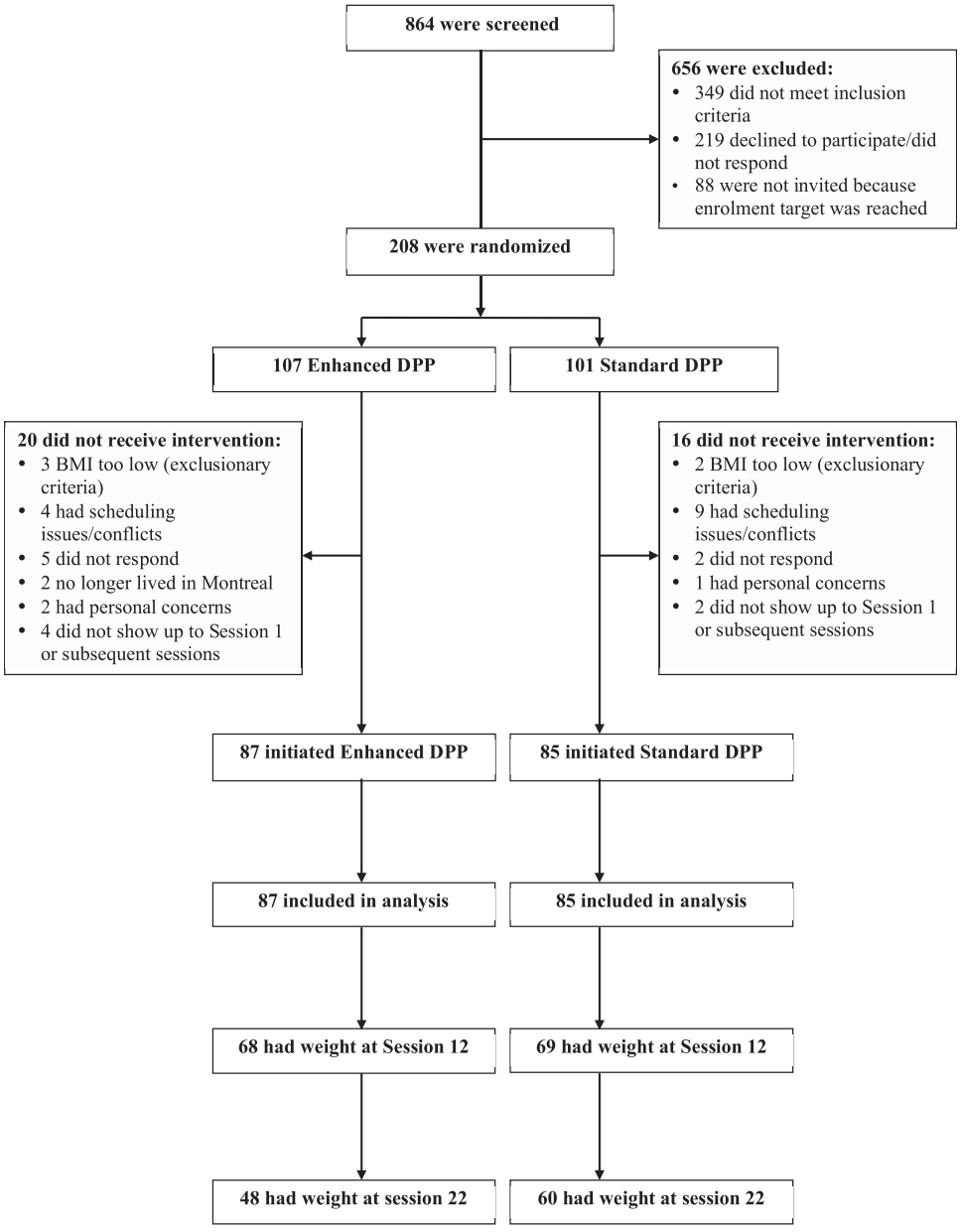

Figure 1 CONSORT flow diagram of the screening, group randomization, and follow-up data of this two-arm randomized controlled trial.

missingness was assumed to follow an MCAR pattern. The full information maximum likelihood method performs equally well as listwise (or pairwise) deletion under MCAR (19,20). Two dummy variables were created; the first took the value of 1 for the 3-month outcome measure score and otherwise took the value of 0; the second was coded as 1 to indicate the 12-month outcome measure score and otherwise took the value of 0. These dummy variables were used to model change in the outcome from baseline to 3 months and from baseline to 12 months within each group. We examined whether these changes varied between groups using the rescaled −2 log likelihood difference test. This test is distributed as χ^2 with degrees of freedom equal to the rescaled difference in the number of parameters between models (21). Differences in change were examined by comparing the fit of a model in which an estimate (e.g., change from baseline to 3 months) was permitted to differ between groups with the fit of a model in which the estimate was restricted to be equal in both groups. A nonsignificant χ^2 test value at $\alpha = 0.05$ indicated no group difference in the estimate examined. When no difference in a change score was found, we computed the average (pooled) change score across groups. Lastly, the models were re-estimated to examine whether gender moderated change across time and between groups. Nesting within standard/enhanced DPP groups or group coaches was not examined because the coaches were a homogeneous group of female clinical psychology graduate students who each led equal numbers of standard and

TABLE 1 Baseline characteristics

	Standard DPP ($n = 85$)	Enhanced DPP ($n = 87$)
Demographics		
Age, y, mean (SD) (y)	50.90 (12.12)	49.43 (11.78)
Gender, female, *n* (%) female	65 (76.5%)	73 (83.9%)
Caucasian, *n* (%)	66 (77.7%)	69 (79.3%)
Married, *n* (%)	48 (56.5%)	51 (58.6%)
Education, bachelor's degree *n* (%)	32 (37.7%)	41 (47.1%)
Employed, *n* (%)	53 (62.34%)	61 (70.1%)
Household income > $40,001, *n* (%)	57 (67.1%)	60 (68.0%)
Smoker, *n* (%)	5 (5.8%)	4 (4.6%)
Primary outcome		
Weight, mean (SD) (lb)	208.81 (31.35)	199.36 (31.71)
Overweight, BMI 25-29.99, *n* (%)	11 (12.9%)	18 (20.7%)
Obesity class 1, BMI 30-34.99, *n* (%)	44 (51.8%)	39 (44.8%)
Obesity class 2, BMI 35-39.99, *n* (%)	22 (25.9%)	22 (25.3%)
Obesity class 3, BMI > 40, *n* (%)	8 (9.4%)	8 (9.2%)
Diabetes risk factors		
Waist circumference, mean (SD) (cm)	109.16 (11.69)	108.43 (10.78)
Hemoglobin A_{1c}, mean (SD) (%)	5.37 (0.43)	5.35 (0.39)
Diastolic blood pressure, mean (SD) (mm Hg)	84.47 (8.73)	83.18 (8.13)
Systolic blood pressure, mean (SD) (mm Hg)	130.11 (15.36)	127.46 (16.04)
HDL cholesterol, mean (SD)	1.54 (0.48)	1.52 (0.50)
Total cholesterol, mean (SD)	5.20 (0.98)	5.40 (1.07)
Cholesterol ratio, mean (SD)	3.61 (1.06)	3.83 (1.20)
Physical activity		
Physical activity total duration, mean (SD) (min/wk)	103.83 (146.36)	93.86 (147.00)
Physical activity pedometer steps, mean (SD) (per d)	7,170.75 (2,969.61)	7,630.43 (3,151.94)
Physical activity step equivalents, mean (SD) (per d)	9,061.69 (1.06)	9,055.11 (3,994.96)
METs, mean (SD)	10.76 (1.56)	10.30 (1.78)
Self-monitoring index		
Food tracking frequency, mean (SD) (d/wk)	5.58 (2.52)	5.28 (2.62)
Activity tracking frequency, mean (SD) (d/wk)	6.16 (2.02)	6.44 (1.60)
Behavior change index		
Average fat intake, mean (SD) (g/d)	53.02 (15.85)	50.88 (15.39)
Average caloric intake, mean (SD) (per d)	1,526.41 (347.07)	1,405.61 (331.85)
Habit strength index		
Total score, mean (SD)	2.81 (0.91)	2.89 (0.86)
Automaticity subscale, mean (SD)	2.80 (0.91)	2.88 (0.86)
Identity subscale, mean (SD)	2.84 (1.00)	2.90 (0.92)

$N = 172$. No significant differences were observed between groups at baseline using independent samples t tests ($P < 0.05$), except for weight, which was slightly higher in standard DPP group ($t[170] = 1.97$, $P = 0.051$).

enhanced DPP groups. They had been trained in the administration of the DPP and were supervised to ensure fidelity to the protocol. Fidelity was facilitated by the sessions being manualized, highly structured, and not aimed at targeting interpersonal processes. An effect of coaching was thus not expected.

In exploratory analysis, a two-level time series model was used to explore group differences in the rate of weight change from baseline to 12 months. The model was fitted using the Bayes estimator. Weight at each treatment of the 22 sessions constituted the lower-level scores, nested within each participant, which is the higher level. Weight change was modeled as a function of linear and quadratic time effects. Both these time effects were modeled as random (i.e., varying across individuals). The lower-level predictor variable, time, was centered such that the baseline (first session) score took a value of 0 up to 47 (last session). To add convergence, time scores were transformed by dividing them by 10. The intercept represented baseline weight; the slope for the linear time effect indicated rate of weight change for each unit of time measured in weeks. A first-order autoregressive [i.e., AR(1)] effect was modeled. Specifically,

TABLE 2 Percent weight change and goal achievement

	Standard DPP	Enhanced DPP	χ^2	*P*
Weight change, %				
3 mo	5.51	6.02	0.01	0.920
12 mo	9.42	10.63	0.05	0.823
% Achieved weight loss goal (≥ 7%)				
3 mo	30.4	26.5	0.26	0.607
12 mo	53.3	52.1	0.02	0.897
% Achieved exercise goal (≥ 150 min/wk)				
Baseline	30.8	25.3	0.60	0.440
3 mo	42.3	41.2	0.02	0.898
12 mo	46.8	48.5	0.02	0.882

$N = 172$.

weight at session t was regressed on weight at the previous session, $t - 1$. This effect was modeled as random. The intercept, the linear time effect, and the first-order autoregressive effect were regressed on group membership (standard DPP = 0 vs. enhanced DPP = 1) at the higher level. The model was re-estimated by entering gender and its interaction with group membership as predictors of the intercept, linear time effect, and first-order autoregressive effect.

Results

Sample

Required sample size determination is described in the published study protocol (12). Recruitment started in April 2013 and ended in November 2014. Last follow-ups were completed in November 2017. The trial was ended after all participants completed the follow-up. No important harms or unintended effects occurred.

A total of 172 participants were enrolled in the study. Of these, 85 participants were randomly assigned to the standard DPP group, and 87 were randomly assigned to the enhanced DPP group. The majority of the sample was female (80.2%), 78.5% were Caucasian, and their average age was 50.2 years (SD = 11.94). Detailed demographic information can be found in Table 1.

Primary outcome

Table 2 describes the results of the intervention on percentage of body weight lost at 3 and 12 months. On average, participants lost 9.98% of their initial body weight in the program. At baseline, the standard DPP group had a slightly higher mean weight than the enhanced DPP group (Table 1). Controlling for this difference, weight loss did not differ between the groups over the course of the intervention. Both groups displayed significant reductions in weight from baseline to 3 months and 12 months, losing on average 20.36 pounds over the course of the program. Table 3 presents mean weight change in pounds in each group; Table 4 presents pooled mean weight change across both groups.

Results from the two-level time series analysis indicated that weight change followed a linear downward trajectory over the entire treatment period, $b = 0.57$, SD = 0.02, $P < 0.001$. For b, standard estimates are presented. The SD is the posterior distribution of the regression coefficient, and P is a one-tailed P value. A significant quadratic time effect ($b = 0.43$, SD = 0.03, $P < 0.001$) suggested that the decrease in weight plateaued over time. A significant positive autoregressive effect was also found ($b = 0.23$, SD = 0.03, $P < 0.001$), suggesting that higher weight values at one session were predictive of higher weight values at the subsequent session. No group differences in the linear rate of weight change ($b = 0.01$, SD = 0.07, $P = 0.45$) and autoregressive effect ($b = -0.11$, SD = 0.07, $P = 0.07$) were found. As previously reported, there was a small group difference in weight at the baseline ($b = -0.10$, SD = 0.06, $P = 0.03$), with the standard DPP group measuring on average heavier than the experimental group. The effects of the interaction between group membership and gender on the linear rate of weight change and autoregressive effect were not significant ($b = -0.33$, SD = 0.33, $P = 0.23$; $b = 0.49$, SD = 0.27, $P = 0.10$, respectively). No group membership by gender interaction on baseline weight was found ($b = -0.11$, SD = 0.11, $P = 0.16$). Figure 2 displays the weight in pounds for both groups and for each session over the course of the intervention.

Secondary outcomes

Results for the secondary outcomes are reported in Tables 3 and 4. Table 3 contains the mean changes for all variables in both the standard and the enhanced DPP groups. χ^2 values indicate that these mean changes did not differ between groups; thus, Table 4 contains the results pooled between groups.

Goal achievement. The groups did not statistically differ in reaching the weight goal of 7% weight loss of initial body weight (a clinically significant reduction) and 150 min/wk of physical activity at 3 or 12 months. Combining both groups, 52.8% of participants met the weight loss goal at 12 months and 47.5% met the physical activity goal.

Diabetes risk factors. Both groups experienced a significant decrease in waist circumference from baseline to 3 months and 12 months, respectively; this decrease was not different between groups. Hemoglobin A_{1c} did not change from baseline to 3 months or 12 months for either group. Both diastolic blood pressure and systolic blood pressure decreased significantly for both groups from baseline to both 3 months and 12 months and this decrease was not different across groups. Total cholesterol decreased from baseline to 3 months; groups did not differ in the extent of decrease. However, total cholesterol returned to baseline levels at 12 months, as indicated by a nonsignificant difference between baseline and 12-month total cholesterol values. High-density lipoprotein (HDL) cholesterol did not change from baseline to 3 months for either group. It increased from baseline to the 12-month period in both groups. Cholesterol ratio did not change from baseline to 3 months or 12 months for either group.

Physical activity. All participants recorded their physical activity online using a pedometer (provided free of charge) and tracked the time spent in specific physical activities, which was then converted

TABLE 3 Mean changes in weight and secondary outcomes by group

	Standard DPP					Enhanced DPP						
	Mean (SE)	*z*	*P*	R^2	95% CI	Mean (SE)	*z*	*P*	R^2	95% CI	χ^2	*P*
Primary outcome												
Weight (lb)												
Change at 3 mo	−11.51 (5.00)	−2.30	0.021	0.07	−21.32, −1.71	−12.01 (5.16)	−2.33	0.02	0.07	−22.12, −1.90	0.01	0.920
Change at 12 mo	−19.66 (4.96)	−3.96	< 0.001		−29.39, −9.93	−21.19 (5.24)	−4.04	< 0.001		−31.46, −10.91	0.05	0.823
Diabetes risk factors												
Waist circumference (cm)												
Change at 3 mo	−5.24 (1.73)	−3.03	0.002	0.05	−8.64, −1.85	−5.44 (1.75)	−3.1	0.002	0.13	−8.87, −2.00	0.01	0.920
Change at 12 mo	−5.75 (2.26)	−2.54	0.011		−10.19, −1.32	−10.07 (2.69)	−3.75	< 0.001		−15.34, −4.81	1.52	0.218
Hemoglobin A_{1c} (%)												
Change at 3 mo	−0.01 (0.06)	−0.1	0.922	0.00	−0.13, 0.12	−0.03 (0.06)	−0.47	0.648	0.01	−0.15, 0.09	0.07	0.791
Change at 12 mo	0.00 (0.08)	0.06	0.956		−0.14, 0.15	0.06 (0.07)	0.91	0.365		−0.07, 0.20	0.32	0.572
Diastolic blood pressure (mm Hg)												
Change at 3 mo	−4.31 (1.38)	−3.12	0.002	0.04	−7.01, −1.60	−5.46 (1.27)	−4.29	< 0.001	0.08	−7.96, −2.97	0.38	0.538
Change at 12 mo	−3.31 (1.69)	−1.96	0.050		−6.63, 0.00	−3.55 (1.76)	−2.02	0.044		−6.99, −0.10	0.01	0.920
Systolic blood pressure (mm Hg)												
Change at 3 mo	−7.73 (2.32)	−3.34	0.001	0.05	−12.27, −3.19	−8.64 (2.61)	−3.24	0.001	0.06	−13.58, −3.35	0.04	0.841
Change at 12 mo	−3.52 (2.79)	−1.26	0.207		−8.99, 1.95	−7.39 (3.38)	−2.19	0.029		−14.01, −0.76	0.78	0.377
HDL cholesterol												
Change at 3 mo	−0.01 (0.07)	−0.17	0.863	0.01	−0.16, 0.13	0.01 (0.08)	0.1	0.925	0.08	−0.15, 0.17	0.04	0.841
Change at 12 mo	0.09 (0.09)	1.02	0.307		−0.09, 0.27	0.33 (0.15)	2.17	0.030		0.03, 0.63	1.96	0.162
Total cholesterol												
Change at 3 mo	−0.19 (0.16)	−1.25	0.212	0.02	−0.50, 0.11	−0.28 (0.18)	−1.56	0.119	0.02	−0.62, 0.07	0.12	0.729
Change at 12 mo	0.14 (0.21)	0.68	0.497		−0.27, 0.56	0.09 (0.26)	0.37	0.715		−0.41, 0.60	0.02	0.888
Cholesterol ratio												
Change at 3 mo	−0.13 (0.17)	−0.80	0.425	0.00	−0.46, 0.19	−0.28 (0.19)	−1.49	0.136	0.04	−0.64, 0.09	0.34	0.560
Change at 12 mo	−0.14 (0.21)	−0.66	0.510		−0.56, 0.28	−0.59 (0.27)	−2.18	0.029		−1.12, −0.06	1.74	0.187
Physical activity												
Physical activity total duration (min/wk)												
Change at 3 mo	71.19 (30.87)	2.31	0.021	0.04	10.69, 131.69	118.03 (39.85)	2.96	0.003	0.08	39.92, 196.14	0.92	0.339
Change at 12 mo	94.47 (36.51)	2.59	0.010		22.91, 166.04	171.44 (51.73)	3.31	0.001		70.05, 272.82	1.55	0.213
Physical activity pedometer steps (per d)												
Change at 3 mo	1,797.12 (528.12)	3.40	0.001	0.05	762.01, 2,832.24	1,447.10 (523.80)	2.76	0.006	0.05	420.46, 2,473.74	0.22	0.640
Change at 12 mo	1,321.79 (674.59)	1.96	0.050		−4.10, 2,643.99	1,371.86 (500.38)	2.74	0.006		391.11, 2,352.61	0.00	0.953
Physical activity step equivalents (per d)												
Change at 3 mo	3,292.19 (852.27)	3.86	< 0.001	0.08	1,621.73, 4,962.64	3,471.47 (851.91)	4.08	< 0.001	0.14	1,801.72, 5,141.22	0.02	0.882
Change at 12 mo	3,632.85 (1,176.37)	3.09	0.002		1,327.17, 5,938.52	4,986.96 (1,104.57)	4.52	< 0.001		2,822.01, 7,151.91	0.66	0.418

TABLE 3. (continued).

	Standard DPP					Enhanced DPP						
	Mean (SE)	*z*	*P*	R^2	95% CI	Mean (SE)	*z*	*P*	R^2	95% CI	χ^2	*P*
METs												
Change at 3 mo	0.61 (0.25)	2.39	0.017	0.03	0.11, 1.10	0.92 (0.30)	3.10	0.002	0.06	0.34, 1.50	0.64	0.424
Change at 12 mo	-	-	-	-	-	-	-	-	-	-	-	
Self-monitoring index												
Food tracking frequency (d/wk)												
Change at 3 mo	−1.11 (0.44)	−2.54	0.011	0.33	−1.96, −0.25	−1.69 (0.43)	−3.96	< 0.001	0.37	−2.53, −0.85	0.91	0.342
Change at 12 mo	−4.46 (0.37)	−11.92	< 0.001		−5.19, −3.73	−4.70 (0.33)	−14.21	< 0.001		−5.35, −4.05	0.24	0.626
Activity tracking frequency (d/wk)												
Change at 3 mo	−1.40 (0.39)	−3.57	< 0.001	0.33	−2.17, −0.63	−2.32 (0.38)	−6.13	< 0.001	0.40	−3.06, −1.58	2.83	0.093
Change at 12 mo	−4.53 (0.38)	−11.83	< 0.001		−5.28, −3.78	−5.08 (0.34)	−15.09	< 0.001		−5.74, −4.42	1.18	0.278
Behavior change index												
Average fat intake (g/d)												
Change at 3 mo	−4.95 (2.50)	−1.98	0.048	0.02	−9.86, −0.05	−4.97 (2.33)	−2.13	0.033	0.02	−9.54, −0.40	0.00	0.996
Change at 12 mo	−1.84 (2.82)	−0.65	0.515		−7.37, 3.70	−3.37 (2.90)	−1.16	0.245		−9.04, 2.31	0.14	0.706
Average caloric intake (per d)												
Change at 3 mo	−129.95 (50.35)	−2.58	0.010	0.03	−228.63, −31.26	−70.70(50.50)	−1.40	0.161	0.01	−169.67, 28.27	0.68	0.409
Change at 12 mo	−38.20 (64.93)	−0.59	0.556		−165.47, 89.06	−24.48 (62.78)	−0.39	0.697		−147.52, 98.57	0.02	0.880
Habit strength index												
Total score												
Change at 3 mo	1.71 (0.16)	10.57	< 0.001	0.31	1.39, 2.02	1.77 (0.16)	10.88	< 0.001	0.38	1.45, 2.09	0.07	0.791
Change at 12 mo	1.43 (0.20)	7.31	< 0.001		1.05, 1.82	1.69 (0.19)	9.04	< 0.001		1.32, 2.05	0.87	0.351

N = 172. No diabetes risk factors data or METs data were collected at 12 mo for *n* = 74 because of funding constraints.

TABLE 4 Mean changes in weight and secondary outcomes pooled across groups

	Pooled estimates					
	Mean (SE)	*z*	*P*	95% CI	R^2 – standard DPP	R^2 – enhanced DPP
Primary outcome						
Weight (lb)						
Change at 3 mo	−11.76 (3.59)	−3.27	0.001	−18.80, −4.72	0.07	0.07
Change at 12 mo	−20.36 (3.61)	−5.65	< 0.001	−27.42, −13.39		
Diabetes risk factors						
Waist circumference (cm)						
Change at 3 mo	−5.37 (1.23)	−4.36	< 0.001	−7.79, −2.96	0.08	0.08
Change at 12 mo	−7.54 (1.75)	−4.32	< 0.001	−10.96, −4.12		
Hemoglobin A_{1c}(%)						
Change at 3 mo	−0.02 (0.04)	−0.40	0.691	−0.10, 0.07	0	0
Change at 12 mo	0.03 (0.05)	0.55	0.585	−0.07, 0.13		
Diastolic blood pressure (mm Hg)						
Change at 3 mo	−4.92 (0.94)	−5.22	< 0.001	−6.77, −3.07	0.06	0.07
Change at 12 mo	−3.48 (1.22)	−2.85	0.004	−5.86, −1.09		
Systolic blood pressure (mm Hg)						
Change at 3 mo	−8.08 (1.73)	−4.66	< 0.001	−11.48, −4.68	0.05	0.05
Change at 12 mo	−4.96 (2.17)	−2.29	0.022	−9.20, −0.71		
HDL cholesterol						
Change at 3 mo	−0.00 (0.06)	−0.04	0.966	−0.11, 0.11	0.03	0.03
Change at 12 mo	0.18 (0.08)	2.25	0.024	0.02, 0.33		
Total cholesterol						
Change at 3 mo	−0.23 (0.12)	−1.97	0.049	−0.46, −0.00	0.02	0.02
Change at 12 mo	0.12 (0.16)	0.75	0.455	−0.20, 0.44		
Cholesterol ratio						
Change at 3 mo	−0.20 (0.12)	−1.61	0.108	−0.44, 0.04	0.02	0.01
Change at 12 mo	−0.31 (0.17)	−1.83	0.067	−0.64, 0.02		
Physical activity						
Physical activity total duration (min/wk)						
Change at 3 mo	89.78 (24.48)	3.67	< 0.001	41.80, 137.76	0.07	0.04
Change at 12 mo	122.10 (30.49)	4.00	< .001	62.34, 181.87		
Physical activity pedometer steps (per d)						
Change at 3 mo	1,602.25 (375.59)	4.26	< .001	865.67, 2,339.23	0.04	0.05
Change at 12 mo	1,336.99 (420.16)	3.18	0.001	513.47, 2,160.51		
Physical activity step equivalents (per d)						
Change at 3 mo	3,396.55 (605.77)	5.62	< 0.001	2,209.24, 4,583.86	0.10	0.11
Change at 12 mo	4,310.81 (838.25)	5.14	< 0.001	2,667.84, 5,953.77		
METs						
Change at 3 mo	0.74 (0.19)	3.83	< 0.001	0.36, 1.11	0.05	0.04
Change at 12 mo	-	-	-	-	-	
Self-monitoring index						
Food tracking frequency (d/wk)						
Change at 3 mo	−1.42 (0.31)	−4.60	< 0.001	−2.03, −0.82	0.34	0.37
Change at 12 mo	−4.59 (0.25)	−18.47	< 0.001	−5.08, −4.10		
Activity tracking frequency (d/wk)						
Change at 3 mo	−1.89 (0.28)	−6.83	< 0.001	−2.43, −1.35	0.35	0.37
Change at 12 mo	−4.82 (0.25)	−18.89	< 0.001	−5.32, −4.32		

TABLE 4. (continued).

	Pooled estimates					
	Mean (SE)	*z*	*P*	95% CI	R^2 – standard DPP	R^2 – enhanced DPP
Behavior change index						
Average fat intake (g/d)						
Change at 3 mo	−4.97 (1.71)	−2.91	0.004	−8.31, −1.62	0.02	0.02
Change at 12 mo	−2.60 (2.03)	−1.28	0.201	−6.58, 1.38		
Average caloric intake (per d)						
Change at 3 mo	−99.52 (35.93)	−2.77	0.006	−169.94, −29.10	0.02	0.02
Change at 12 mo	−30.46 (45.22)	−0.67	0.501	−119.10, 58.18		
Habit strength index						
Total score						
Change at 3 mo	1.74 (0.12)	15.10	< 0.001	1.51, 1.97	0.33	0.36
Change at 12 mo	1.56 (0.14)	11.46	< 0.001	1.29, 1.83		

$N = 172$. No diabetes risk factors data or METs data were collected at 12 mo for $n = 74$ because of funding constraints.

into step equivalents using metabolic equivalent (MET) intensities (22).

Step equivalents increased from baseline to 3 months and baseline to 12 months for both groups. Similarly, average pedometer steps per day also increased from baseline to 3 and 12 months, with no observed group differences. METs (assessed through ESTs) increased from baseline to 3 months for both groups. ESTs were not conducted at 12 months.

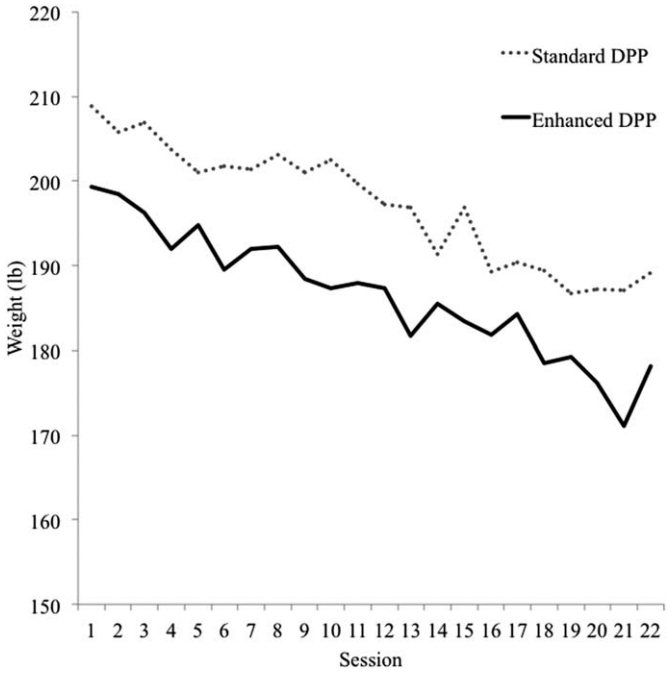

Figure 2 Weight in pounds for the standard DPP and enhanced DPP groups from Session 1 (baseline) to Session 22 (post intervention).

Self-monitoring index. On average, participants tracked their diet for 5 d/wk at the baseline time point. Over the course of the intervention, food tracking frequency decreased for both groups from baseline to 3 months and baseline to 12 months. Regarding physical activity, at baseline participants tracked their activity for 6 d/wk on average. This frequency also decreased for both groups over the course of the intervention, down to approximately 2 d/wk at the 12-month time point.

Behavior change index. Average caloric consumption per day decreased from baseline to 3 months for both groups. At 12 months, however, participants appeared to have regained their initial caloric consumption loss. No difference between baseline and 12-month caloric consumption was found. Average fat consumption (in grams) decreased from baseline to 3 months and baseline to 12 months; no group difference in this decrease was observed.

Habit strength index. Habit strength increased from baseline to 3 and 12 months and groups showed similar levels of increase in habit strength.

Discussion

Both standard and enhanced DPP groups displayed significant weight reductions over the course of 12 months, with participants losing an average of 9.98% of their initial body weight. Total weight loss did not, however, differ between groups. No significant group differences were found for secondary outcomes. Both groups significantly decreased in waist circumference, diastolic blood pressure, and systolic blood pressure at 3 and 12 months. Total cholesterol also significantly decreased in the standard and enhanced DPP group at 3 months, but not at 12 months. HDL cholesterol did not change.

Both groups additionally experienced an increase in habit strength and physical activity minutes at 12 months. Frequency of self-monitoring decreased over the course of the 12 months. At 3 months, both groups decreased their average caloric consumption. There was no significant change in calorie consumption for either group at 12 months. Below we highlight possible reasons for a lack of group differences.

Implicit creation of if-then plans in standard DPP group

There are several possible reasons for a lack of group differences, and there are several future directions to address these. Effective habit change requires an individual to specifically determine (using a set of contingencies) what changes they are going to enact, as well as when and how they are going to enact these changes. This process was explicitly taught to the enhanced DPP group in the form of if-then planning and not explicitly taught to the standard DPP group. However, participants in the standard DPP group might have implicitly created if-then contingencies to change the cognitions and the behaviors of participants given that if-then contingencies are a natural part of cognitive restructuring in CBT (23,24). In this way, the standard and enhanced DPP groups were likely not distinct enough from each other to show differential effects. Rather, our results suggest that greater weight loss can be achieved if coaches are well trained to help individuals to act in response to predetermined internal and external cues.

Flexibility in formation of if-then plans

In our study, participants were afforded the flexibility to make their own plans that optimally applied to their unique, personal situations. Previous if-then plan studies did not permit such freedom (25). Rather, they provided participants with specific choices for the "if" and the "then" sections of the plan, thus resulting in more structured, standardized plans. Having personally relevant plans may be advantageous but also requires significant coaching time to ensure the creation of specific, usable plans. This time for one-on-one consultation was not always available during the group sessions because of the sheer amount of session material to be covered. As a result of time restrictions, if-then plans were not always correctly formed and this may have undermined their effectiveness. In comparison, Dombrowski et al. (25) asked participants to create if-then plans from a predetermined list of lifestyle techniques for eating or physical activity behaviors, guiding them strictly to put in the when, where, and how. Although this approach ensures a higher fidelity of if-then plan formation, it limits participants' autonomy to select internal and external cues that are personally relevant for them in their everyday life. Future research could determine whether personalized if-then plans are more effective when created in one-on-one coaching sessions, where the coach has more time to allocate to the specific participant than in a group setting.

Short- versus long-term outcomes

If-then plans are designed to promote long-term habit formation. Thus, the intervention effects of the if-then plans may emerge on weight maintenance at 24 months after baseline, which is a 1-year no-contact follow-up period. Weight regain usually begins to occur approximately 6 to 12 months after the completion of lifestyle intervention (26). Although there were no differences between the groups at 3 and 12 months, if-then plans may provide a protective barrier against weight loss relapse and thus promote weight maintenance. Participants in the enhanced DPP group were encouraged to review their if-then plans when they experienced "slip-ups" in their dietary and physical activity habits. In other words, having prepared if-then plans and knowing how to create new ones may assist the enhanced DPP group in maintaining their weight loss outcomes from 12 months. The 24-month follow-up data are still being collected.

Highly trained coaches

Clinical psychology PhD students trained in CBT and other behavior change strategies such as motivational interviewing were responsible for delivering the program. The large effects in weight loss in both groups may point to the fact that both programs were delivered by coaches with extensive training and background in the field of behavior change. Knowledge and experience in teaching effective techniques to facilitate behavior change, such as action planning and problem solving, were inevitably applied in the administration of the program and likely increased its effectiveness. Future research needs to assess the effects of staff training and background to facilitate the DPP.

If-then plan adherence

The enhanced DPP group participants created if-then plans and were encouraged to incorporate these plans into their daily lives. However, we did not assess to what extent participants enacted their plans in their daily life or whether those who did experienced greater weight loss than those who did not. Future research should assess if-then plan use to control for these discrepancies in later analyses.

Conclusion

This McGill Healthy Weight Program led to large reductions in the percentage of body weight lost from baseline to 3 and 12 months. In fact, the average percentage of weight loss exceeded the 7% weight loss found in the one-on-one DPP (6). The current program also achieved a 4% greater average weight loss compared with the group-based DPP (7). We suspect that the delivery of the program by clinical psychology PhD students trained in behavior change techniques may have contributed to the large mean weight loss. Future research may examine the effects of knowledge and skills of clinical psychology doctoral students on group-based DPP effectiveness and invest efforts in creating collaborations between clinical psychology PhD programs and community organizations or primary care providers to offer weight loss programs more effectively. O

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