Short-Term Weight Loss with Diet and Physical Activity in Young Adults: The IDEA Study

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Objective: This study examined the effect of a behavioral weight loss intervention (BWLI) on young adults (age = 18-35 years).

Methods: Participants (N = 470) enrolled in a 6-month BWLI that included weekly group sessions, a prescribed energy-restricted diet, and moderate to vigorous physical activity (MVPA). Assessments included weight, body composition, fitness, lipids, glucose, insulin, resting blood pressure and heart rate, physical activity, and dietary intake. Data are presented as median [25th, 75th percentiles].

Results: Retention was 90% (N = 424; age: 30.9 [27.8, 33.7] years; BMI: 31.2 [28.4, 34.3] kg m⁻²). Participants completed 87.5% [76.1%, 95.5%] of scheduled intervention contacts. Weight and body fat decreased while fitness increased (P < 0.0001). MVPA in bouts ≥10 min increased (P < 0.0001), though total MVPA did not change significantly. Sedentary time decreased (P = 0.03). Energy and percent fat intake decreased, while percent carbohydrate and protein intake increased (P < 0.0001). Systolic and diastolic blood pressure, total cholesterol, LDL cholesterol, triglycerides, glucose, and insulin decreased (P < 0.0001).

Conclusions: A 6-month BWLI produced favorable changes in dietary intake and physical activity and elicited favorable changes in weight and other health outcomes in young adults. MVPA performed in bouts of ≥10 min was associated with greater weight loss, but sedentary behavior was not.

Introduction

Overweight and obesity are significant public health concerns in the United States (1). Young adults are not immune to being overweight or obese, with 60.3% of 20- to 39-year-old adults meeting these clinical classifications based on population-based data (1), and young adults may be prone to gain weight (2). Thus, there is a need for interventions that treat young adults with overweight and obesity.

Lifestyle interventions for weight loss combine reduced energy intake and increased energy expenditure, resulting in an average weight loss of ~8-10% of initial body weight within the initial 6 months of treatment (3). The majority of these interventions have been implemented in middle-age or older adults (4-13). Whether these interventions are effective for weight loss among younger adults is unclear.

This report examined whether a 6-month behavioral intervention would result in an increase in physical activity, reduction in energy intake, and favorable changes in weight, body composition, fitness, and cardiovascular disease risk factors in young adults. In addition, exploratory analyses were conducted to examine non-modifiable demographic characteristics (i.e., age, gender, race, and ethnicity) and intervention components as predictors of change in weight.

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Methods

A consortium of studies was formed to focus on weight loss or preventing weight gain in young adults (EARLY Trials) (14). Young adults were defined as individuals 18-35 years at study enrollment. Each study in the consortium implemented different interventions. In IDEA (Innovative approaches to Diet, Exercise, and Activity), participants received the same behavioral weight loss intervention for 6 months after which two different interventions were implemented to examine outcomes at month 24. This study reports on the initial 6 months of the intervention during which all participants received the identical weight loss intervention.

Participants

Participants were recruited between October 2010 and October 2012 using direct mail strategies, mass media advertisements, or referral from clinical research registries, friends, family, or other study participants. Medical history and a physical activity readiness questionnaire were completed, and clearance from the participant’s physician was obtained prior to study participation. Procedures were approved by the University of Pittsburgh Institutional Review Board.

Eligibility criteria included age between 18 and 35 years and body mass index (BMI) within 25.0 to <40.0 kg m$^{-2}$. Exclusion criteria included: (1) past or planned weight loss surgery; (2) current use of systemic steroids or weight loss medication, (3) current treatment for an eating disorder, (4) cardiovascular event (heart attack, stroke, episode of heart failure, or revascularization procedure) within the prior 6 months; (5) current treatment for malignancy other than non-melanoma skin cancer; (6) currently pregnant or gave birth within the last 6 months, currently lactating or breastfeeding within the last 3 months, actively planning a pregnancy during the study period; (7) taking medication that would affect heart rate or blood pressure responses to exercise (e.g., beta blockers); (8) self-reported weight loss of >5% of current body weight in the previous 3 months; (9) current treatment for psychological issues or taking psychotropic medications within the previous 6 months; (10) current treatment for psychological issues or taking psychotropic medications within the previous 6 months; (11) current treatment for diabetes mellitus; (12) history of heart disease, angina, heart attack, stroke, or cancer; (13) investigator discretion due to concerns related to study compliance; (14) unable or unwilling to provide written consent; (15) household member on the study staff.

This study conducted 4,164 telephone interviews to identify 470 eligible study participants (Figure 1). Demographic characteristics are presented in Table 1.

Outcome assessments

Outcomes were assessed at 0 and 6 months. Participants were compensated $100 for completing 6-month assessments.

Weight, height, BMI. Weight was assessed on a digital scale to the nearest 0.1 kg with the participant clothed in a hospital gown or light-weight clothing. Height was measured only at baseline to the nearest 0.1 cm. BMI was computed as kg m$^{-2}$.

Body composition. Body composition was assessed using dual-energy X-ray absorptiometry (DXA) from a total body scan (GE Lunar iDXA, Madison, WI).
Resting blood pressure and heart rate. Resting blood pressure and heart rate were assessed following a 5-min seated resting period using an automated system. Participants with systolic blood pressure of ≥140 mmHg or <90 mmHg, or diastolic blood pressure ≥90 mmHg were referred to their physician for follow-up evaluation.

| TABLE 1 Baseline characteristics of young adults participating in a behavioral weight loss intervention |
|-----------------------------------------------------------------------------------------------------|
| Subjects eligible to initiate the intervention (N = 470) | Analysis sample: Subjects with body weight assessed at 6 months (N = 424) |
| Age, years | |
| Median (25th, 75th percentile) | 30.9 (27.8, 33.7) | 31.0 (27.6, 33.7) |
| Range | 18.5-35.9 | 18.5-35.9 |
| BMI (kg m⁻²) | |
| Median (25th, 75th percentile) | 31.2 (28.4, 34.3) | 31.2 (28.4, 34.3) |
| Range | 24.4-39.9 | 24.4-39.9 |
| Gender | |
| Male | 136 (28.9%) | 127 (30.0%) |
| Female | 334 (71.1%) | 297 (70.0%) |
| Race | |
| White | 363 (77.2%) | 333 (78.5%) |
| Non-white | 107 (22.8%) | 91 (21.5%) |
| Hispanic/Latino | |
| Yes | 20 (4.3%) | 19 (4.5%) |
| No | 450 (95.7%) | 405 (95.5%) |
| Relationship status | |
| Married/like married | 233 (49.6%) | 211 (49.8%) |
| Single/separated/divorced | 237 (50.4%) | 213 (50.2%) |
| Number of adults in home | |
| 1 | 149 (31.7%) | 130 (30.7%) |
| 2 | 266 (56.6%) | 244 (57.5%) |
| 3 or more | 55 (11.7%) | 50 (11.8%) |
| Children in home | |
| 0 | 271 (57.7%) | 247 (58.3%) |
| 1 | 71 (15.1%) | 58 (13.7%) |
| 2 | 82 (17.4%) | 77 (18.2%) |
| 3 or more | 46 (9.8%) | 42 (9.9%) |
| Education | |
| High school graduate or general equivalency diploma (GED) | 117 (24.9%) | 102 (24.1%) |
| College graduate or higher | 323 (75.1%) | 322 (75.9%) |
| Student status | |
| Not a student | 349 (74.3%) | 314 (74.1%) |
| Currently a student (part time or full time) | 121 (25.7%) | 110 (25.9%) |
| Current employment status | |
| Full time for pay | 357 (76.0%) | 323 (76.2%) |
| Part time for pay | 65 (13.8%) | 57 (13.4%) |
| Other | 44 (9.4%) | 40 (9.4%) |
| Missing | 4 (0.9%) | 2 (0.5%) |
| Household income | |
| Missing | 4 (0.9%) | 4 (0.9%) |
| <$25,000 | 58 (12.4%) | 50 (11.8%) |
| $25,000-$49,999 | 132 (28.3%) | 120 (28.6%) |
| $50,000-$74,999 | 101 (21.7%) | 91 (21.7%) |
| $75,000-$99,999 | 97 (20.8%) | 89 (21.2%) |
| $100,000 or more | 78 (16.7%) | 70 (16.7%) |

*Values are expressed as number of subjects (%).*
Blood analysis. Blood samples were analyzed for lipids (total cholesterol, HDL cholesterol, triglycerides), glucose, and insulin, with LDL cholesterol calculated using the Friedwald equation (15). Participants were instructed to fast, other than water, and to abstain from exercise for 12 h prior to their assessment.

Cardiorespiratory fitness. A submaximal graded exercise test performed on a motorized treadmill. The speed was constant at 80.4 m min$^{-1}$, with grade starting at 0% and increasing by 1% until the point of test termination. Test termination occurred when the participant achieved 85% of age-predicted maximal heart rate (age-predicted maximal heart rate = 220—age). Oxygen consumption was assessed using a metabolic cart.

Physical activity. Physical activity was measured using a device worn for 1 week (SenseWear Pro Armband, BodyMedia), which has been shown to provide a valid measure of energy expenditure when compared to indirect calorimetry (16) and to doubly-labeled water (17). Data were used to identify minutes of sedentary (1.5 METs), light-intensity physical activity (LPA = 1.5 to <3.0 METs) and moderate- to vigorous-intensity physical activity (MVPA: ≥3.0 METs) physical activity. Only data from participants who wore the device for ≥10 h per day for ≥4 days were used for data analysis (18,19).

Dietary intake and macronutrient composition were assessed using the Diet History Questionnaire (20,21). Participants reported the frequency and amount of various foods consumed over the prior month. DietCalc software (version 1.5.0) was used to analyze these data.

Behavior weight loss intervention
Participants received a 6-month intervention that included group-based behavioral sessions, prescribed diet, and prescribed physical activity. These components are described below and also within the Supporting Information.

Intervention sessions. Weekly group-based behavioral sessions were provided to promote engagement and adherence to the prescribed diet and physical activity. If unable to attend a scheduled group session, attempts were made to engage the participant in an individual or telephone-based make up session. Participants were weighed at each session to allow for feedback on weight loss progress. Group sessions focused on educating participants on the components of the prescribed diet and physical activity, along with a focus on behavioral strategies to promote adherence to these weight loss behaviors. The intervention was based on a multi-theoretical approach that included social-cognitive theory (22), health belief model (23,24), problem-solving theory (25), and relapse prevention (26).

Dietary intervention. Calorie intake was prescribed at 1,200, 1,500, and 1,800 kcal day$^{-1}$ for individuals with a baseline weight of <90.7 kg, 90.7 to <113.4 kg, and ≥113.5 kg, respectively. Individual calorie intake was adjusted upward if weight loss exceeded 6% at the end of each 4-week period or to prevent further weight loss when BMI was ≤22 kg m$^{-2}$. Dietary fat was prescribed at 20-30% of total calorie intake. Participants were instructed to self-monitor dietary intake in a diary that was returned to the investigators at the conclusion of each week. The intervention staff provided feedback on these diaries prior to returning them to the participant.

Physical activity. Non-supervised physical activity was initially prescribed at 100 min per week and increased by 50 min per week at 4-week intervals until a prescription of 300 min per week was achieved. Participants were instructed to engage in structured forms of physical activity that were ≥10 min in duration. Physical activity was prescribed at a MVPA intensity. Participants were instructed to self-monitor their daily MVPA in a diary that was returned to the intervention staff at the conclusion of each week. The intervention staff provided feedback on these diaries prior to returning them to the participant.

Statistical analysis
Analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC). Descriptive statistics (frequencies and percentages for categorical variables; medians, 25th and 75th percentiles, minima and maxima for continuous variables) were used to summarize baseline characteristics. Those excluded from the analysis sample ($n = 46$) were compared to those in the analysis sample ($n = 424$) using the chi square test for categorical variables or the Wilcoxon signed-rank test for continuous variables.

Statistical significance of change in weight, body composition, cardiometabolic risk factors, physical activity, and dietary intake from baseline to 6 months was assessed with McNemar’s test for paired dichotomous variables, or the Wilcoxon signed-rank test for continuous variables. Distributions for several of the variables were skewed such that the mean was not a useful measure of central tendency. To avoid potential confusion the median for all variables was reported, which equals the mean for normally distributed data.

Linear mixed models were used to examine associations between factors and percentage weight change from baseline to 6 months. Intervention was delivered in groups, so models controlled for group as a random effect to account for possible clustering effects. Four models were constructed. The first three models evaluated pre-intervention predictors. Model 1 included sociodemographics (age, sex, race, ethnicity, education, employment, household income, student status, marital status, and number of children in the home). Categories of the sociodemographic factors that did not differ significantly in percent weight loss in univariate analysis were combined, and therefore categories of household income were collapsed as <$25,000 and ≥$25,000. Model 2 added baseline BMI to the variables in model 1. Model 3 added baseline behavioral factors (percentage sedentary time, LPA [MET-min/week], MVPA [MET-min/week] completed in sessions at least 10 minutes in duration, energy intake (kcal day$^{-1}$), percentage of calories consumed as fat, and percentage of calories consumed as protein) to the variables in model 2. Because the percentage of calories from carbohydrates is 100% minus the sum of the percentage calories from fat and protein, it was not included in the model to avoid collinearity. An alternative version of model 3 substituted total MVPA (MET-min/week) for MVPA (MET-min/week) completed in sessions at least 10 min. Model 4 examined the association of percent weight loss at 6 months with intervention adherence variables (percentage of intervention sessions attended, percentage of intervention diaries returned), and pre- to post-intervention changes in sedentary

Supporting Information

Dietary intervention. Dietary intake (kcal) was calculated using the Diet History Questionnaire. The Diet History Questionnaire was completed at each session to assess adherence to the prescribed diet. Participants were instructed to self-monitor their dietary intake in a diary that was returned to the investigator at the conclusion of each week. The intervention staff provided feedback on these diaries prior to returning them to the participant.

Cardiorespiratory fitness. A submaximal graded exercise test performed on a motorized treadmill. The speed was constant at 80.4 m min$^{-1}$, with grade starting at 0% and increasing by 1% until the point of test termination. Test termination occurred when the participant achieved 85% of age-predicted maximal heart rate (age-predicted maximal heart rate = 220—age). Oxygen consumption was assessed using a metabolic cart.

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Analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC). Descriptive statistics (frequencies and percentages for categorical variables; medians, 25th and 75th percentiles, minima and maxima for continuous variables) were used to summarize baseline characteristics. Those excluded from the analysis sample ($n = 46$) were compared to those in the analysis sample ($n = 424$) using the chi square test for categorical variables or the Wilcoxon signed-rank test for continuous variables.

Statistical significance of change in weight, body composition, cardiometabolic risk factors, physical activity, and dietary intake from baseline to 6 months was assessed with McNemar’s test for paired dichotomous variables, or the Wilcoxon signed-rank test for continuous variables. Distributions for several of the variables were skewed such that the mean was not a useful measure of central tendency. To avoid potential confusion the median for all variables was reported, which equals the mean for normally distributed data.

Linear mixed models were used to examine associations between factors and percentage weight change from baseline to 6 months. Intervention was delivered in groups, so models controlled for group as a random effect to account for possible clustering effects. Four models were constructed. The first three models evaluated pre-intervention predictors. Model 1 included sociodemographics (age, sex, race, ethnicity, education, employment, household income, student status, marital status, and number of children in the home). Categories of the sociodemographic factors that did not differ significantly in percent weight loss in univariate analysis were combined, and therefore categories of household income were collapsed as <$25,000 and ≥$25,000. Model 2 added baseline BMI to the variables in model 1. Model 3 added baseline behavioral factors (percentage sedentary time, LPA [MET-min/week], MVPA [MET-min/week] completed in sessions at least 10 minutes in duration, energy intake (kcal day$^{-1}$), percentage of calories consumed as fat, and percentage of calories consumed as protein) to the variables in model 2. Because the percentage of calories from carbohydrates is 100% minus the sum of the percentage calories from fat and protein, it was not included in the model to avoid collinearity. An alternative version of model 3 substituted total MVPA (MET-min/week) for MVPA (MET-min/week) completed in sessions at least 10 min. Model 4 examined the association of percent weight loss at 6 months with intervention adherence variables (percentage of intervention sessions attended, percentage of intervention diaries returned), and pre- to post-intervention changes in sedentary.
behavior, physical activity, and dietary intake, while controlling for factors included in model 3. Interactions between significant main effects were tested and included if they reached statistical significance. All reported $P$ values are two-sided. $P$ values $<$ 0.05 are considered to be statistically significant.

Results

This study recruited 471 participants. Prior to initiating the intervention, one participant was found to be ineligible and is excluded from these analyses. Thus, 470 initiated the weight loss intervention, with 46 participants not completing the 6-month assessment (Figure 1). Participant characteristics are shown in Table 1. There were no significant differences in characteristics between those included ($n = 424$) and excluded from analysis ($n = 46$), with the exception of race. Black participants had lower representation in the analysis sample compared to those who did not complete the 6-month assessment (21.5% vs. 34.8%; $P = 0.04$).

Weight and body composition

Weight and body composition are shown in Table 2. Median weight change at 6 months of $-27.8$ (25th, 75th percentiles: $-212.2$, $-3.7$) kg and percentage weight change of $-8.8\%$ (25th, 75th percentiles: $-13.4\%$, $-3.8\%$) were significantly different from 0 ($P < 0.0001$). There was a reduction in fat mass ($P < 0.0001$), a modest but significant reduction in lean body mass ($P < 0.0001$), and a reduction in percent body fat ($P < 0.0001$). Bone mass ($P < 0.0001$) and total

| TABLE 2 Weight-related measures and body composition of young adults in a 6-month behavioral weight loss intervention |
|---------------------------------------------------------------|
|                                                                  |
| **N**  | **Baseline** | **6 months** | **Change** | **P value** |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Weight (kg)** | 424 | 90.3 (79.5, 101.9) | 81.3 (72.2, 92.7) | $-7.8$ ($-12.2$, $-3.7$) | $<0.0001$ |
| **BMI (kg m$^{-2}$)** | 424 | 31.2 (28.4, 34.4) | 28.1 (25.7, 31.4) | $-2.7$ ($-4.2$, $-1.2$) | $<0.0001$ |
| **Fat mass (kg)** | 422 | 36.4 (30.2, 42.5) | 29.6 (23.5, 35.8) | $-6.0$ ($-10.0$, $-2.8$) | $<0.0001$ |
| **Lean mass (kg)** | 422 | 48.6 (43.5, 58.1) | 47.2 (42.6, 56.1) | $-1.1$ ($-2.3$, $-0.1$) | $<0.0001$ |
| **Total mass (kg)** | 422 | 89.6 (79.2, 101.4) | 81.2 (72.2, 92.2) | $-7.3$ ($-11.8$, $-3.5$) | $<0.0001$ |
| **Percent body fat (%)** | 422 | 40.7 (36.5, 45.1) | 37.2 (30.9, 41.9) | $-3.8$ ($-6.4$, $-1.7$) | $<0.0001$ |
| **Tissue percent body fat (%)** | 422 | 42.0 (37.8, 46.5) | 38.5 (32.1, 43.3) | $-3.8$ ($-6.4$, $-1.7$) | $<0.0001$ |
| **Percent lean mass (%)** | 422 | 59.3 (54.9, 63.5) | 62.8 (58.1, 69.1) | $3.8$ ($1.7$, $6.4$) | $<0.0001$ |
| **Tissue percent lean mass (%)** | 422 | 58.0 (53.5, 62.2) | 61.5 (56.7, 67.9) | $3.8$ ($1.7$, $6.4$) | $<0.0001$ |
| **Bone mass (g)** | 422 | 2767.1 (2517.3, 3103.5) | 2765.6 (2524.8, 3080.5) | $-11.6$ ($-34.9$, $10.3$) | $<0.0001$ |
| **Total body bone mineral density (g cm$^{-2}$)** | 422 | 1.3 (1.2, 1.4) | 1.3 (1.2, 1.4) | $-0.002$ ($-0.014$, $0.009$) | 0.008 |

$^a$Wilcoxon signed-rank test.
$^b$Participants were deemed eligible based on assessment of BMI at the orientation session; however, outcome measures are based on data collected at the assessment session, which at baseline may reflect a BMI $< 25$ kg m$^{-2}$.
$^c$Excluding bone mass.
| Physical activity                      | N   | Baseline               | 6 months              | Change        | P value<sup>a</sup> |
|---------------------------------------|-----|------------------------|-----------------------|---------------|----------------------|
| **Sedentary (% of monitor wear time)**| 385 | 65.4 (57.4, 72.7)      | 65.0 (52.2, 74.7)     | −0.6 (−10.6, 6.9) | 0.03                 |
| Range                                 |    | 7.0-91.3               | 3.9-95.5              |               |                      |
| **Sedentary (h/day)**                 | 385 | 9.1 (7.9, 10.2)        | 8.8 (7.3, 10.4)       | −0.2 (−1.6, 1.0) | 0.02                 |
| Range                                 |    | 1.0-13.4               | 0.6-14.6              |               |                      |
| **LPA (min/week)**                    | 386 | 1537.0 (1149.0, 1961.0)| 1583.0 (1123.0, 2184.0)| 59.2 (−320.0, 523.0) | 0.01                |
| Range                                 |    | 415.0-3848.0           | 175.0-4581.0          | −1842.0-3215.0 |                      |
| **LPA (MET-min/week)**                | 386 | 3132.6 (2355.6, 4010.9)| 3099.5 (2202.5, 4268.0)| 20.0 (−778.1, 884.5) | 0.66                |
| Range                                 |    | 757.7-8663.1           | 325.7-9692.1          | −4788.0-6172.9 |                      |
| **Total MVPA (min/week)**             | 386 | 422.2 (289.0, 611.0)   | 423.3 (254.0, 666.0)  | −22.6 (−156.0, 172.0) | 0.94                |
| Range                                 |    | 66.0-3168.0            | 8.0-3019.0            | −2542.0-1880.0 |                      |
| **Total MVPA (MET-min/week)**         | 386 | 1532.9 (1040.8, 2287.5)| 1537.8 (895.0, 2440.0)| −95.0 (−609.8, 661.4) | 0.82                |
| Range                                 |    | 231.0-13362.8          | 29.6-10697.9          | −10093.2-7344.6 |                      |
| ≥10-min sessions of MVPA (min/week)   | 386 | 100.0 (26.0, 192.0)    | 214.5 (99.0, 389.0)   | 103.4 (3.0, 247.0) | <0.0001             |
| Range                                 |    | 0-1889.0               | 0-2182.8              | −1521.0-1823.0 |                      |
| ≥10-min sessions of MVPA (MET-min/week)| 386 | 427.7 (118.2, 859.4)   | 945.3 (415.0, 1753.8) | 420.6 (0, 1035.8) | <0.0001             |
| Range                                 |    | 0-11393.3              | 0-10225.3             | −7709.8-7378.8 |                      |
| **Dietary intake**                    |     |                        |                       |               |                      |
| **Total calories (kcal/day)**         | 417 | 1655.1 (1224.9, 2284.4)| 1257.6 (909.6, 1677.3)| −397.2 (−800.4, −63.1) | <0.0001             |
| Range                                 |    | 458.3-13317.3          | 96.6-6247.7           | −9743.3-2330.5 |                      |
| % calories carbohydrates              | 417 | 47.6 (42.9, 52.4)      | 50.3 (45.4, 56.8)     | 2.5 (−2.4, 7.5) | <0.0001             |
| Range                                 |    | 24.7-75.2              | 26.7-77.3             | −36.8-33.7    |                      |
| % calories protein                    | 417 | 15.9 (14.1, 18.0)      | 16.8 (14.8, 18.4)     | 0.8 (−1.4, 2.8) | <0.0001             |
| Range                                 |    | 6.5-34.6               | 7.7-27.4              | −20.6-14.2    |                      |
| % calories fat                        | 417 | 35.3 (30.3, 39.0)      | 31.4 (27.2, 35.6)     | −3.5 (−7.8, 0.6) | <0.0001             |
| Range                                 |    | 15.9-57.3              | 13.4-59.6             | −25.3-32.2    |                      |

MET: metabolic equivalent; LPA: light-intensity physical activity (1.5 to <3.0 METs); MVPA: moderate to vigorous physical activity (≥3.0 METs).

<sup>a</sup>Wilcoxon signed-rank test.
Dietary intake and physical activity

Dietary intake data at baseline and 6 months were available for 417 participants (Table 3). There was a reduction in daily energy intake ($P < 0.0001$) and percent dietary fat intake ($P < 0.0001$), and an increase in percent carbohydrate intake ($P < 0.0001$) and percent protein intake ($P < 0.0001$).

The device to assess physical activity was worn by 415 participants at both baseline and 6 months, with 386 participants having sufficient wear time (at least 4 days and for at least 10 h per day) at both assessment periods (Table 3). When compared to those participants providing usable physical activity data, a higher percentage of those not providing usable data were female, non-white, a high school graduate or earning general equivalency diploma (GED), and currently a student. Reasons for missing data included lack of sufficient wear time of ≥4 days for ≥10 h per day ($n = 6$ at baseline, $n = 19$ at 6 months, $n = 4$ at both baseline and 6 months), with 55 missing due to the participant not wearing the device or failing to return the device. The device was worn for 7, 6, 5, or 4 days by 54.0% (25th, 75th percentiles: 13.2, 14.6) hours per day.

There was a modest but significant reduction in sedentary behavior defined as percentage of the non-sleeping time that the device was worn for which energy expenditure was <1.5 METs ($P = 0.03$). MET-minutes per week of total LPA or MVPA did not change; however, there was a significant increase of 103.4 (3.0, 247.0) min/week and 420.6 (25th, 75th percentiles: 0, 1035.8) MET-min/week of MVPA performed in bouts of ≥10 min ($P < 0.0001$). Participants engaging in at least 150 min of MVPA performed in bouts of ≥10 min increased from 132 (34.2%) at baseline to 256 (66.3%) at 6 months. Significantly more participants not engaging in at least 150 min of MVPA performed in bouts of ≥10 min at baseline increased to this level at 6 months ($n = 141$), than participants engaging in at least 150 min of MVPA performed in bouts of ≥10 min at baseline and then not achieving this level at 6 months ($n = 17$, $P < 0.0001$).

Intervention process data

Participants returned a median of 87.5% (25th, 75th percentiles: 58.3%, 95.8%) of the expected 24 intervention diaries and attended 87.5% (25th, 75th percentiles: 76.1%, 95.5%) of the scheduled intervention contacts. Intervention contact consisted of attendance at a median of 17.0 (25th, 75th percentiles: 13.0, 20.0) group sessions and 2.0 (25th, 75th percentiles: 1.0, 4.0) as individual make-up sessions, with 9.0% ($n = 38$) completing 1 make-up session via telephone and 9.4% ($n = 40$) completing ≥2 make-up sessions via telephone.

Other health-related outcomes

Changes in resting heart rate and blood pressure were available for 422 participants (Table 4). There was a decrease is resting heart rate, systolic blood pressure, and diastolic blood pressure.
| Weight change category | Participants with weight gain or no weight loss | Participants with <5% weight loss | Participants with 5% to <10% weight loss | Participants with ≥10% weight loss | P value\textsuperscript{a} |
|------------------------|---------------------------------------------|---------------------------------|-------------------------------------|----------------------------------|-------------------|
| Body weight change (kg) |                                             |                                 |                                     |                                  |                   |
| N                      | 30                                          | 94                              | 121                                 | 179                              |                   |
| Median change          | 1.2 (0.4, 2.5)                              | -2.4 (-3.5, -1.2)               | -6.4 (-8.0, -5.5)                   | -13.2 (-17.8, -10.5)             | NA\textsuperscript{b} |
| Fat mass (kg)          |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 5 (17.2%)                                   | 80 (85.1%)                      | 120 (100%)                          | 179 (100%)                       | <0.0001           |
| Median reduction       | -0.9 (-1.2, -0.4)                           | -2.2 (-3.1, -1.4)               | -5.5 (-6.7, -4.2)                   | -10.7 (-13.8, -8.4)              | <0.0001           |
| Lean mass (kg)         |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 10 (34.5%)                                  | 55 (58.5%)                      | 95 (79.2%)                          | 166 (94.7%)                      | <0.0001           |
| Median loss            | -0.6 (-1.0, -0.3)                           | -1.5 (-2.0, -0.9)               | -3.2 (-4.6, -2.3)                   | -6.9 (-9.5, -5.2)                | <0.0001           |
| Percent body fat (%)   |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 8 (27.6%)                                   | 77 (81.9%)                      | 119 (99.2%)                         | 179 (100%)                       | <0.0001           |
| Median reduction       | -0.6 (-0.3, -0.1)                           | -0.8 (-1.2, -0.5)               | -1.3 (-1.9, -0.6)                   | -2.4 (-3.6, -1.5)                | <0.0001           |
| Tissue percent body fat (%)\textsuperscript{c} |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 9 (31.0%)                                   | 76 (80.9%)                      | 119 (99.2%)                         | 179 (100%)                       | <0.0001           |
| Median reduction       | -0.6 (-0.3, -0.2)                           | -1.5 (-2.1, -0.9)               | -3.2 (-4.7, -2.3)                   | -6.9 (-9.7, -5.2)                | <0.0001           |
| Percent lean mass (%)  |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 21 (72.4%)                                  | 17 (18.1%)                      | 1 (0.8%)                            | 0 (0%)                           | <0.0001           |
| Median loss            | -1.0 (-1.6, -0.5)                           | -0.6 (-1.2, -0.4)               | -0.4 (NA)                           | NA                               | 0.21              |
| Tissue percent lean mass (%)\textsuperscript{d} |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 20 (69.0%)                                  | 18 (19.2%)                      | 1 (0.8%)                            | 0 (0%)                           | <0.0001           |
| Median reduction       | -1.0 (-1.6, -0.5)                           | -0.6 (-1.3, -0.5)               | -0.5 (NA)                           | NA                               | 0.12              |
| Bone mass (kg)         |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 11 (37.9%)                                  | 47 (50.0%)                      | 76 (63.3%)                          | 140 (78.2%)                      | <0.0001           |
| Median reduction       | -0.018 (-0.035, -0.008)                     | -0.018 (-0.030, -0.009)         | -0.024 (-0.042, -0.011)             | -0.032 (-0.054, -0.017)          | <0.0001           |
| Total body bone mineral density (g cm\textsuperscript{-2}) |                                             |                                 |                                     |                                  |                   |
| N with data available  | 29                                          | 94                              | 120                                 | 179                              |                   |
| N with reduction       | 15 (51.7%)                                  | 48 (51.1%)                      | 62 (51.7%)                          | 70 (39.1%)                       | 0.04              |
| Median reduction       | 0.010 (0.005, 0.020)                         | 0.009 (0.005, 0.017)            | 0.006 (0.003, 0.016)                | 0.015 (0.008, 0.020)             | 0.17              |
| Weight change category | Participants with weight gain or no weight loss | Participants with <5% weight loss | Participants with 5% to <10% weight loss | Participants with ≥10% weight loss | P value<sup>a</sup> |
|------------------------|-----------------------------------------------|----------------------------------|------------------------------------------|----------------------------------|-------------|
| Resting heart rate (beats/min) | | | | | |
| N with data available | 29 | 93 | 121 | 179 | |
| N with reduction (% with reduction) | | | | | |
| 11 (37.9%) | 65 (69.9%) | 90 (74.4%) | 149 (83.2%) | | <0.0001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -7.5 (-13.5, -3.5) | -6.5 (-11.0, -4.0) | -7.5 (-12.0, -4.0) | -9.0 (-14.5, -4.0) | 0.01 |
| Systolic blood pressure (mmHg) | | | | | |
| N with data available | 29 | 93 | 121 | 179 | |
| N with reduction (% with reduction) | | | | | |
| 17 (56.7%) | 60 (64.5%) | 79 (65.3%) | 136 (76.0%) | | 0.01 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -5.0 (-9.5, -1.5) | -5.5 (-8.3, -3.0) | -6.0 (-9.0, -2.5) | -8.0 (-12.0, -4.5) | 0.0001 |
| Diastolic blood pressure (mmHg) | | | | | |
| N with data available | 29 | 93 | 121 | 179 | |
| N with reduction (% with reduction) | | | | | |
| 17 (56.7%) | 62 (66.0%) | 83 (68.6%) | 130 (72.6%) | | 0.05 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -5.5 (-8.3, -2.3) | -4.0 (-7.0, -2.0) | -5.5 (-8.2, -3.0) | -6.1 (-9.5, -3.0) | 0.01 |
| Total cholesterol (mg dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with reduction (% with reduction) | | | | | |
| 15 (53.6%) | 52 (57.1%) | 85 (70.0%) | 151 (85.3%) | | <0.0001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -21.0 (-32.0, -6.0) | -14.5 (-23.5, -8.0) | -16.0 (-29.0, -8.0) | -28.0 (-40.0, -15.0) | <0.0001 |
| LDL cholesterol (mg dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with reduction (% with reduction) | | | | | |
| 15 (53.6%) | 48 (52.8%) | 84 (70.0%) | 142 (79.1%) | | <0.0001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -12.0 (-24.8, -8.0) | -14.9 (-21.4, -7.9) | -11.4 (-22.0, -5.9) | -20.2 (-32.2, -12.0) | <0.0001 |
| HDL cholesterol (mg dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with increase (% with reduction) | | | | | |
| 13 (46.4%) | 42 (46.2%) | 62 (51.7%) | 90 (59.9%) | | 0.47 |
| Median increase (25th, 75th percentiles)<sup>c</sup> | 5.4 (4.3, 7.4) | 7.0 (3.6, 10.4) | 4.7 (2.5, 8.0) | 6.7 (2.6, 11.1) | 0.84 |
| Triglycerides (mg dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with reduction (% with reduction) | | | | | |
| 15 (53.6%) | 46 (50.6%) | 74 (61.7%) | 127 (71.8%) | | <0.001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -16.0 (-29.0, -5.0) | -18.0 (-34.0, -11.0) | -17.5 (-47.0, -7.0) | -48.0 (-80.0, -21.0) | <0.0001 |
| Glucose (mg dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with reduction (% with reduction) | | | | | |
| 15 (53.6%) | 52 (57.1%) | 80 (66.7%) | 132 (74.6%) | | 0.001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -5.0 (-9.0, -3.0) | -5.0 (-8.0, -3.0) | -6.0 (-8.5, -4.0) | -8.0 (-11.0, -4.5) | <0.001 |
| Insulin (U dl<sup>-1</sup>) | | | | | |
| N with data available | 28 | 91 | 120 | 177 | |
| N with reduction (% with reduction) | | | | | |
| 15 (53.6%) | 52 (57.1%) | 84 (70.0%) | 146 (82.5%) | | <0.0001 |
| Median reduction (25th, 75th percentiles)<sup>c</sup> | -2.5 (-2.9, -0.8) | -3.1 (-4.7, -1.5) | -3.7 (-6.4, -2.2) | -5.9 (-9.0, -2.8) | <0.0001 |
Change in blood parameters was available on 416 participants (Table 4). Total cholesterol, LDL cholesterol, triglycerides, glucose, and insulin decreased ($P < 0.0001$). There was not a significant change in HDL cholesterol ($P = 0.72$). At baseline six participants reported taking lipid-lowering medication, whereas 4 participants reported taking this type of medication at 6 months.

Data on change in cardiorespiratory fitness were available for 416 participants (Table 4). There was an increase in cardiorespiratory fitness (median: 3.6, 25th, 75th percentiles: 0.8, 6.2 ml kg$^{-1}$ min$^{-1}$, $P < 0.0001$).

**Change in outcomes by magnitude of weight loss**

Participants were also categorized by magnitude of weight loss (Table 5). There were significant trends for a greater proportion of participants at higher magnitudes of weight loss to have reductions in resting heart rate and blood pressure, total cholesterol, LDL cholesterol, triglycerides, glucose, and insulin, and a greater proportion having an increase in fitness. Moreover, there were significant trends for the magnitude of change in these outcomes to be greater as weight loss increased.

**Baseline predictors of weight change**

Associations between baseline factors and 6-month percent weight change are shown in Table 6. Being male, white, and having at least a college education were significantly related to greater percent weight loss at 6 months, than females, non-whites, and less than college education, respectively, when sociodemographic characteristics were considered (model 1). Baseline BMI was not significantly associated with percent weight loss when added to the model (model 2), nor were baseline physical activity and dietary intake parameters (model 3). In the final baseline predictors model (model 3), only sex and race were statistically associated with percent weight loss.

**Intervention predictors of weight change**

Associations between intervention adherence and changes in sedentary behavior, physical activity, and dietary intake with weight loss at 6 months are shown in Table 7. A greater percentage of intervention sessions completed ($P = 0.003$) and diaries returned ($P = 0.0003$), increases in MET-minutes per week of LPA ($P = 0.046$) and MVPA completed in sessions at least 10 min in duration ($P = 0.004$), and decreases in daily calories ($P = 0.04$) and percentage of calories consumed as dietary fat ($P = 0.01$) were independently related to greater percent weight loss at 6 months. When change in MET-minutes per week of total MVPA replaced MET-minutes per week of MVPA completed in sessions at least 10 min in duration, MVPA was no longer significantly related to percent weight loss ($P = 0.13$).

**Discussion**

Young adults are responsive to an in-person, group-based behavioral weight loss intervention. The median weight loss of 8.8% is...
TABLE 6 Baseline factors related to 6-month percent weight changea in young adults in a behavioral weight loss intervention

| Model 1: Sociodemographic characteristics | Model 2: Plus BMI | Model 3a: Plus physical activity and dietary intake | Model 3b: Plus physical activity and dietary intake |
|------------------------------------------|------------------|-------------------------------------------------|-------------------------------------------------|
| Model 1                                 | Model 2 addition | Model 3a addition                               | Model 3b addition                               |
| Age (per 10 years)                      | Sex (reference = female) | Hispanic (reference = no)                       | Race (reference = non-white)                     |
| −1.82 0.054                             | −2.09 0.004       | 0.11 0.94                                       | −3.08 0.0002                                     |
| −1.64 0.08                            | −1.95 0.001       | 0.13 0.93                                       | −3.12 0.0002                                     |
| −1.40 0.15                             | 1.92 0.01         | 0.10 0.95                                       | 2.69 0.002                                       |
| −1.43 0.14                             | 1.78 0.02         | 0.10 0.95                                       | 2.69 0.002                                       |
| Model 2 addition                        | Model 3 additions | Model 3b additions                               |                                                 |
| BMI, per 5 kg/m²                        | Sedentary: % of monitor wear time (per 10%) | LPA (per 180 MET-min/week)                        | Total MVPA (per 180 MET-min/week)                |
| −0.64 0.10                             | −1.40 0.19        | −0.29 0.09                                       | −0.05 0.61                                       |
| −0.80 0.07                             | −1.88 0.13        | −0.35 0.051                                      | −0.08 0.40                                       |
| Model 3 additions                      | ≥10-min sessions of MVPA (per 180 MET-min/week) | Dietary intake (per 250 kcal/day)                | MVPA in young adults. Participants may not have consistently achieved ≥3.0 METs when engaging in what they perceived to be MVPA, resulting in some of this activity being classified as LPA. Moreover, despite the use of objective methods to assess physical activity, there may be measurement error due to the instrumentation when assessing physical activity in this study. This study also did not exclude participants based on level of physical activity at baseline. In fact, 34.2% of participants were engaging in at least 150 min/week of physical activity at baseline, which may have influenced further adoption of physical activity in some of the study participants. Thus, a more extensive analysis of the data is warranted to understand how physical activity was impacted by this intervention in young adults.

Despite the observed increase in MVPA performed in bouts of ≥10 min, there was no significant change in HDL cholesterol. The lack of an increase in the presence of an increase in MVPA is consistent with clinical guidelines that concluded that there is no consistent effect of physical activity on change in HDL cholesterol (28).

Young adults engaged in the behavioral weight loss intervention over the period of 6 months. Retention was 90%, and after correcting for those who could not complete the intervention due to

comparable to the weight loss observed across a broader age range (3), and it exceeds the magnitude that has been shown to result in health improvements (3). The weight loss achieved was accompanied by reductions in fasting blood lipids, glucose, insulin, and resting heart rate and blood pressure, and increased cardiorespiratory fitness.

This study of young adults supports that a dietary intervention should focus on reductions in total energy intake and percent dietary fat to achieve weight loss. This study also shows that more MVPA performed in bouts that were at least 10 min in duration was associated with greater weight loss. This should be an important intervention target, because total MVPA was not predictive of weight loss, and this has recently been observed in another large trial (27). Sedentary behavior was also not predictive of weight change, which may suggest that solely targeting this component of physical activity limits the impact on body weight.

MVPA performed in bouts of ≥10 min increased from approximately 100 min/week to 214 min/week, and there was a reduction in sedentary behavior. Why the intervention did not result in an increase in total MVPA is not clear. Widely accepted MET levels were used to define LPA and MVPA, and it is possible that use of these MET levels leads to classification error when defining LPA or
TABLE 7 Adjusted associations between intervention participation and change in physical activity and dietary intake and 6-month percent weight change

| Modelb (includes ≥10-min sessions of MVPA) | Modelb (includes total MVPA) |
|-------------------------------------------|-------------------------------|
| Percentage of intervention contacts completed (per 10% of intervention contacts completed) | -0.74 0.003 | -0.72 0.004 |
| Percentage of intervention diaries returned (per 10% of intervention diaries returned) | -0.58 0.0003 | -0.64 <.0001 |
| Physical activity variables | | |
| Decrease in percentage of time sedentary (per 10% decrease) | 1.21 0.20 | -0.16 0.89 |
| Increase in LPA (per 180 MET-min/week increase) | -0.32 0.046 | -0.15 0.34 |
| Increase in total MVPA (per 180 MET-min/week increase) | - | -0.10 0.13 |
| Increase in ≥10-min sessions of MVPA (per 180 MET-min/week increase) | -0.21 0.004 | | |
| Dietary intake variables | | |
| Decrease in energy intake (per 250 kcal/day decrease) | -0.28 0.04 | -0.25 0.07 |
| Decrease in percentage of calories from protein (per 5% decrease) | 0.91 0.06 | 0.94 0.053 |
| Decrease in percentage of calories from fat (per 5% decrease) | -0.59 0.01 | -0.55 0.02 |

MET: metabolic equivalent; LPA: light-intensity physical activity (1.5 to <3.0 METs); MVPA: moderate to vigorous physical activity (≥3.0 METs).
*aNegative value indicates higher percent weight loss.
*bControlling for intervention group and baseline age, sex, race, ethnicity, education, employment, household income, student status, marital status, children, BMI, percentage of time sedentary, LPA MET-min/week, MVPA MET-min/week in ≥10-min sessions, caloric intake, percentage of calories from protein, and percentage of calories from fat.

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