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LONG-TERM MAINTENANCE OF WEIGHT LOSS AFTER LIFESTYLE INTERVENTION IN FRAIL, OBESE OLDER ADULTS

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Abstract: *Objectives:* To determine if long-term weight loss with associated improvement in physical and metabolic health can be maintained after lifestyle intervention in frail, obese older adults. *Design:* Thirty-month follow-up pilot study of a 1-year lifestyle intervention trial. *Setting:* Community. *Participants:* Sixteen frail, obese (body mass index=36±2 kg/m2) older (71±1 yr.) adults. *Measurements:* Body weight and composition, physical function, markers of the metabolic syndrome, glucose and insulin response to an oral glucose tolerance test, bone mineral density (BMD), liver and renal function tests, and food diaries. *Results:* At 30-month follow-up, weight (101.5±3.8 vs. 94.5±3.9 kg) and BMI (36.0 ±1.7 vs. 33.5±1.7 kg/m^2) remained significantly below baseline (all p<0.05). No significant change in fat-free mass (56.7±2.1 vs. 56.9±2.2 kg) or appendicular lean mass (24.1±1.0 vs. 24.1±1.1kg, all p>0.05) occurred between 12 months (end of trial) and 30 months. Improvements in the physical performance test (PPT 27±0.7 vs. 30.2±0.6), insulin sensitivity (4.1±0.8 vs. 3.0±0.6), and insulin area under the curve (12484±2042 vs. 9270±1139 min.mg/dl) remained at 30 months compared to baseline (all p<0.05). Waist circumference (116±3 vs. 109±3 cm) and systolic blood pressure (134±6 vs. 123±5 mm HG) remained decreased at 30 months compared to baseline (all p<0.05). Whole body and lumbar spine BMD did not change; however, total hip BMD progressively decreased at 30 months compared to baseline (0.985±.026 vs. 0.941±.024 g/cm^2; p<0.05). There were no adverse effects on liver or renal function. Food frequency questionnaire data showed lower overall caloric intake (-619±157 kcal/day) at 30 months compared to baseline (p<0.05). *Conclusion:* These findings suggest that long-term maintenance of clinically important weight loss is possible in frail, obese older adults. Weight maintenance appears to be achieved through continued caloric restriction. Larger, long-term studies are needed to follow up on these findings and investigate mechanisms and behaviors underlying maintenance of weight loss and physical function.

Key words: Obesity, frailty, older adults, lifestyle intervention, weight maintenance.

Introduction

The aging population and prevalence of obesity in later life will continue to create challenges for both society and health care systems (1, 2). There is mounting evidence that obese older adults can successfully lose weight during intensive lifestyle interventions, and weight loss improves health outcomes such as physical function, insulin sensitivity, and coronary heart disease (3-8). Despite these positive findings, the debate remains whether the benefits of weight loss interventions outweigh the risks in older adults (9, 10). The challenge in addressing this question is the lack of long-term follow up studies. Previously, we reported that a 1-year intervention consisting of diet-induced weight loss and regular exercise resulted in the greatest improvement in physical function (5). This follow-up pilot study aimed to determine if weight loss and improved health outcomes that occurred during the 1-year intervention (5) would be maintained following an additional 18 months with no intervention or formal contact in frail, obese older adults.

Methods

Study Sample

Inclusion and exclusion criteria for the parent study have been previously reported (5). Briefly, participants were obese (BMI≥30 kg/m^2), older (age≥65 yrs) men and women with physical frailty (on the bases of the modified physical performance test [PPT], peak endurance power, and functional status questionnaire) (5, 11), who had stable weight (±2 kg) and medications for ~6 months prior to the study. Volunteers taking bisphosphonates were excluded. The aim of this pilot study was to provide preliminary information on maintenance of long-term weight loss at 30 months (i.e. 18 months following the 1-year lifestyle intervention). Thus, only the first 26 of 52 participants randomized to the weight loss groups (diet group [n=13] and diet-exercise [n=13]) (5) were recruited for this study. All participants received diet-behavioral therapy with the goal of achieving weight loss of ~10% at 6 months and maintaining that weight loss for an additional 6 months. Participants randomized to the diet-exercise group also underwent supervised aerobic/resistance exercise three times a week during the intervention period. After the 1-year lifestyle

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Table 1
Effect of weight loss and long-term weight maintenance on physical and metabolic outcomes in frail obese older adults*

	Baseline	6-months	12-months	30-months
Demographics				
Age (years)	70.6 ± 1.0			
Male/Female	5/11			
Caucasian/African American	14/2			
Body weight and composition				
Body mass index (kg/m^2)	36.0 ± 1.7	32.5 ± 1.7†	32.1 ± 1.7†	33.5 ± 1.7†
Weight (kg)	101.5 ± 3.8	91.4 ± 3.8†	90.1 ± 3.8†	94.5 ± 3.9†
Fat mass (kg)	40.9 ± 3.3	34.8 ± 3.3†	33.7 ± 3.2†	37.6 ± 3.2†
Fat free mass (kg)	59.9 ± 2.3	56.7 ± 2.1†	56.7 ± 2.1†	56.9 ± 2.2†
Trunk fat (kg)	21.6 ± 1.4	17.7 ± 1.6†	17.1 ± 1.6†	18.9 ± 1.5†
Appendicular lean mass (kg)	26.0 ± 1.0	24.1 ± 1.0†	24.1 ± 1.0†	24.1 ± 1.1†
Physical function and quality of life				
Physical performance test score	27.9 ± 0.7	30.3 ± 0.6†	30.9 ± 0.7†	30.2 ± 0.6†
Functional status questionnaire	32.1 ± 0.6	32.9 ± 0.4†	33.0 ± 0.4†	32.1 ± 0.7
SF-36 quality of life, physical component (%)	74.5 ± 3.0	77.8 ± 2.3	80.5 ± 1.7†	75.4 ± 3.6
Metabolic syndrome components				
Waist circumference (cm)	116.8 ± 3.2	108.6 ± 3.3†	105.9 ± 3.5†	108.9 ± 3.4†
Systolic blood pressure (mm HG)	134 ± 6.3	118.1 ± 4.6†	118.5 ± 5.0†	123.4 ± 5.4†
Diastolic blood pressure (mm HG)	73.0 ± 2.7	67.5 ± 1.8†	68.6 ± 1.7†	70.2 ± 2.4
HDL-cholesterol (mg/dL)	51.6 ± 2.7	52.9 ± 3.3	55.2 ± 3.0†	49.1 ± 3.0
Triglyceride (mg/dL)	125.5 ± 12.9	107.1 ± 15.1†	102.4 ± 8.8†	113.7 ± 13.2
Plasma glucose (mg/dL)	95.4 ± 3.2	91.7 ± 2.3	91.4 ± 2.1	94.1 ± 2.2
Insulin sensitivity and glucose tolerance				
HOMA-IR	4.1 ± 0.8	2.8 ± 0.5†	2.7 ± 0.5†	3.0 ± 0.6†
Glucose AUC (min·mg/dl)	17958 ± 724	16257 ± 797†	16155 ± 696†	17491 ± 603
Insulin AUC (min·mg/dl)	12484 ± 2042	8891 ± 942†	7636 ± 876†	9270 ± 1139†
Bone mineral density				
Total body (g/cm^2)	1.256 ± 0.056	1.250 ± 0.052	1.258 ± 0.047	1.248 ± 0.054
Lumbar spine (g/cm^2)	1.146 ± 0.042	1.153 ± 0.041	1.150 ± 0.039	1.157 ± 0.042
Total hip (g/cm^2)	0.985 ± 0.026	0.971 ± 0.025†	0.966 ± 0.025†	0.941 ± 0.024†
Liver and renal function				
Alkaline Phosphatase (U/L)	75.7 ± 5.0	70.9 ± 4.2	69.8 ± 3.9†	72.1 ± 4.7
Alanine aminotransferase (U/L)	35.6 ± 6.8	27.0 ± 3.5†	24.4 ± 2.9‡	24.1 ± 3.3†
Aspartate aminotransferase (U/L)	27.2 ± 2.0	24.8 ± 2.0	25.3 ± 1.7	26.1 ± 2.6
Bilirubin (g/dL)	0.5 ± 0.1	0.5 ± 0.1	0.8 ± 0.3	0.5 ± 0.1
Blood urea nitrogen (mg/dL)	26.1 ± 9.6	17.7 ± 1.2	16.7 ± 1.2	19.1 ± 1.5
Creatinine (mg/dL)	0.9 ± 0.0	0.9 ± 0.0	0.9 ± 0.0	0.9 ± 0.0

Abbreviation: HOMA-IR, homeostasis model assessment of insulin resistance; AUC, area under the curve. *Plus-minus values are means ± SEM. Scores on the modified Physical Performance Test (PPT, the primary outcome) range from 0 to 36, with higher scores indicating better physical function. Scores on the Functional Status Questionnaire (FSQ) range from 0 to 36, with higher scores indicating better functional status. †P<0.05 compared to baseline values

intervention, participants remained in the community with no contact by study personnel, until the 30-month follow-up period. During the follow-up phase, 10 (38%) participants were lost to follow-up due to time commitment (2), personal reasons (3), medical (2), relocation (1), or unknown reasons (2). The remaining 16 participants (Table 1) were representative of the original cohort in respect to age, gender, and other demographic characteristics (5).

Measurements

The primary outcome in the parent study was change in PPT score from baseline. Secondary outcomes included other measures of frailty, body composition, bone mineral density (BMD), specific physical functions, and quality of life (QOL) (5). Baseline energy intake was assessed using 4-day food records. Participants reviewed records with the dietitian to ensure completeness and accuracy. Average caloric intake was determined using Nutrition Data Systems for Research (Minneapolis, MN).

Outcomes of interest in the 30-month follow-up study were changes in body weight and composition, physical function tests, QOL, components of the metabolic syndrome, glucose tolerance including insulin sensitivity, BMD, and renal and liver function tests. Details of these methods including the PPT have been previously described (5, 12, 13). Body composition and BMD were measured by dual energy x-ray absorptiometry. Metabolic syndrome was determined using the NCEP ATP III criteria (14). Glucose and insulin areas under the curve (AUC) were calculated by the trapezoid method (15). Insulin sensitivity index was calculated using the HOMA-IR (16). At 30-month follow up, participants completed the Block Brief 2000 Food Frequency Questionnaire (FFQ) (Berkely, CA) to quantify average daily intake over the previous year.18 Participants were included if they completed at least 3 days of food records, submitted the FFQ, and had daily energy intakes >500 kcal/day for women and 800 kcal/day for men.

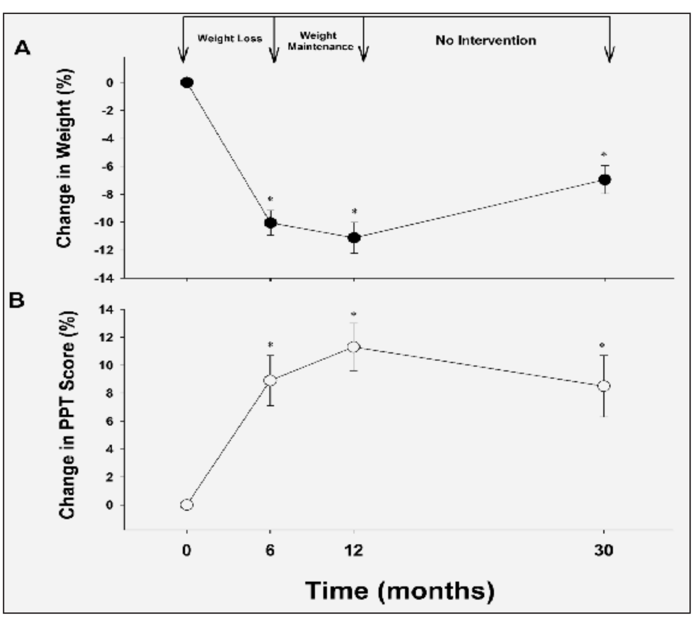
Statistical analyses

Analyses testing for within-group changes were performed using mixed-model repeated-measures analysis of variance with linear contrasts. Statistical significance was $P<0.05$. Results are reported as mean ± SEM.

Results

Our results showed that participants maintained a significant amount of weight loss from baseline at the 30 month follow-up despite 18 months of no active intervention (Fig. 1A, Table 1). Body mass index (BMI) and parameters of body composition such as fat mass, fat-free mass (FFM), trunk fat, and appendicular lean mass, which significantly decreased from baseline at 6 months and 12 months, remained significantly below baseline at 30 months (Table 1).

Figure 1
Effect of weight loss and long-term weight maintenance on body weight (Panel A) and scores in the modified physical performance test (PPT) (Panel B) in frail, obese older adults



Values are mean ± SEM. *P<0.05 compared to baseline value

These changes in body weight and composition were accompanied by similar positive changes in physical function. Participants maintained the significant improvement in PPT noted at the end of the 12-month intervention through the following 18 months of no intervention, albeit at a slightly reduced level (Fig 1B, Table 1). Alternatively, self-reported functional status and health-related QOL, which achieved highest scores at 12 months (both $p<0.05$), returned to baseline at 30 months.

Table 1 shows the changes in the other outcome variables during the 30-month study, (i.e. 12 months of active intervention followed by 18 months of no intervention). In terms of components of the metabolic syndrome, waist circumference, which significantly decreased at 6 months and 12 months of intervention, remained significantly lower than baseline at 30 months. Both systolic and diastolic blood pressures were significantly decreased from baseline at 6 and 12 months of intervention, but only systolic blood pressure remained significantly lower at 30 months. HDL-cholesterol significantly increased from baseline at 12 months, but returned close to baseline at 30 months. Triglycerides, which decreased at 6 and 12 months, also returned to baseline levels at 30 months. The prevalence of the metabolic syndrome was 56%, 31%, 43%, and 31% at baseline, 6 months, 12 months, and 30 months, respectively.

HOMA-IR, which significantly improved at 6 months and 12 months of intervention, remained significantly improved compared to baseline at 30 months. Likewise, insulin AUC also remained significantly improved at 30 months compared to baseline. On the other hand, glucose AUC, which significantly improved throughout the 12 month intervention, returned to baseline at 30 months. Alanine aminotransferase, a parameter of liver function, showed sustained improvement, while serum creatinine showed no changes from baseline to the end of 30 months.

Areal BMD showed no significant change at the whole body and lumbar spine throughout the 30-month study period. However, BMD at the total hip showed a progressive decline over the 30-month period.

Thirteen participants met inclusion requirements for dietary analysis. Average caloric intake at baseline, was 2045±178 kcal/day. At 30 month follow-up, FFQ estimated mean daily intake was 1427±142 kcal/ day. Overall, participants consumed an average of 619±157 kcal/day less at follow-up compared to baseline ($p<0.05$).

Discussion

The results of this 18-month of no active intervention after a 12-month of intensive lifestyle therapy provide encouraging evidence that frail, obese older adults can maintain not only long-term weight loss, but also the associated improvement in physical function and metabolic profile. After ~10% weight loss in response to the 1-year lifestyle intervention, ~7% weight loss was maintained at the 30-month non-intervention period. This maintenance of weight loss was clinically significant based on findings such as preservation of improved PPT scores and insulin sensitivity. An additional reassuring observation was that lean body mass (e.g. FFM) did not further decrease at the 30-month follow up period. However, total hip BMD decreased, of which the clinical impact needs further investigation. There were no long-term adverse effects on liver or renal function.

The data also suggest that weight loss was maintained by continued lower caloric intake. This would agree with behaviors to either lose weight or not to regain weight with eating less food reported by US adults, compared to other strategies such as exercising, consuming less fat and switching to lower calorie foods (19). In a rural population of 50-75 year old, at 3.5 year follow up, after 10% weight loss over 6 months, those successful at maintaining weight reduction of ≥5%, reported frequent weight and food intake monitoring, choosing lower calorie foods and advance meal planning (20). Thus, self-regulation appears a key component to successful behavioral change (21). However, much of this research has been in middle-aged adults, with short duration follow-up (22).

The Look AHEAD trial is one study that specifically investigated factors associated with long-term (4 year) maintenance of intentional weight loss in middle-aged and older patients with Type 2 diabetes (23). The oldest participants (65-76 years) had more treatment contacts across the 4 years and reported lower caloric intake than younger individuals. Greater weight loss in the first year (≥10%) was strongly related to weight loss at 4 years. They also found that weight loss maintainers reported eating significantly fewer calories at year 4 than participants who gained above their baseline weight. However, this trial had continuing contact with these participants, whereas the current pilot study did not.

Continued increase in physical activity may also help with weight maintenance and preservation of physical function and FFM (24). Unfortunately, we did not collect data on self-reported physical activity during the 30-month follow up. The Life-style Interventions and Independence for Elders Pilot (LIFE-P), which was not specifically a weight loss trial, reported that 2 years after the formal 12-month intervention ended, participants in the physical activity arm continued to engage in more minutes of physical activity and had better functional performance tests than the control group (25). The data reported in the LIFE-P trial combined with the current findings are encouraging and warrant further investigations into long-term physical activity changes following an intensive intervention.

The results of this pilot study suggest that changes in weight, body composition, dietary intake, physical function, and insulin sensitivity resulting from an intensive lifestyle therapy may be sustained long-term even after cessation of the intervention. However, it is important to note that our study is limited by the small sample size, potential for selection bias, lack of control group, and under-reporting of food intake . In addition, the participants who did not return for follow-up evaluation may have outcomes that are different from those participating in this pilot study. It is also possible the results overstate the degree to which participants maintained low calorie eating habits as the FFQ is known to underestimate total macronutrient intake (18). Moreover, without a non-weight loss control group, it is not possible to completely separate out some of the unwanted effects of weight loss from that of the aging process per se (e.g. hip BMD loss).

Conclusions

Larger, long-term studies with appropriate controls are needed to confirm these preliminary findings and to determine how best to achieve sustained lifestyle change (e.g. length of intervention, frequency of contact) associated with optimal health outcomes in frail, obese older adults. These studies could inform translation into communities, and also investigate mechanisms underlying the maintenance of physical function and FFM concurrent with loses in hip BMD.

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