ORIGINAL INVESTIGATION

Effect of Weight Loss and Exercise on Frailty in Obese Older Adults

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Background: Obesity exacerbates the age-related decline in physical function and causes frailty in older persons. However, appropriate treatment for obese older persons is unknown. We evaluated the effects of weight loss and exercise therapy on physical function and body composition in obese older persons.

Methods: We screened 40 obese older volunteers and eventually randomized 27 frail obese older volunteers to treatment or control groups. Treatment consisted of 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week. Physical function was evaluated with measurements of frailty (Physical Performance Test, peak oxygen consumption, and Functional Status Questionnaire); strength, gait, and balance tests; body composition with dual-energy x-ray absorptiometry; and quality of life using the Medical Outcomes Survey 36-Item Short-Form Health Survey. Results are reported as mean±SD.

Results: Two subjects in the treatment group did not comply with the intervention, and 1 subject in the control group withdrew. Analyses included all 27 subjects originally randomized to the treatment and control groups. The treatment group lost 8.4%±5.6% of body weight, whereas weight did not change in the control group (+0.5%±2.8%; $P<.001$). Compared with the control group, fat mass decreased (−6.6±3.4 vs +1.7±4.1 kg; $P<.001$), without a change in fat-free mass (−1.2±2.1 vs −1.0±3.5 kg; $P=.75$) in the treatment group. The Physical Performance Test score (2.6±2.5 vs 0.1±1.0; $P=.001$), peak oxygen consumption (1.7±1.6 vs 0.3±1.1 mL/min per kilogram; $P=.02$), and Functional Status Questionnaire score (2.9±3.7 vs −0.2±3.9; $P=.02$) improved in treated subjects compared with control subjects. Treatment also improved strength, walking speed, obstacle course, 1-leg limb stance time, and health survey physical subscale scores (all $P<.05$).

Conclusion: These findings suggest that weight loss and exercise can ameliorate frailty in obese older adults.

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THE NUMBER OF OBESE OLDER persons in the United States has markedly increased in the last 25 years because of an increase both in the total number of older persons and in the percentage of the older population who are obese.[1,2] It is estimated that 20.3% of US adults aged 65 or older are obese.[3] Obesity has important functional implications in older men and women because it exacerbates the age-related decline in physical function.[4] Data from cross-sectional studies[5-7] and longitudinal studies[8,9] have consistently demonstrated a strong link between increasing body mass index (calculated as weight in kilograms divided by the square of height in meters) and worsening physical function in older persons. High body mass index is associated with self-reported impairment in activities of daily living (ADLs), limitations in mobility,decreased physical performance, and increased risk for functional decline.[7-11] Moreover, obesity is associated with increased nursing home admissions.[12] Although obesity is an important cause of disability in older persons, it is unknown whether weight loss improves physical function. Weight loss could worsen frailty by accelerating the usual age-related loss of fat-free mass, which leads to sarcopenia.[13,14]

We evaluated the effect of diet-induced weight loss in conjunction with regular exercise on physical function, body composition, and quality of life in frail obese older adults. We hypothesized that weight loss and exercise training will improve physical function and ameliorate frailty while preserving fat-free mass.

METHODS

SUBJECTS

This study was conducted at Washington University School of Medicine, St Louis, Mo, from January 2003 to July 2004 and was approved by the institutional review board. Written in-

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formed consent was obtained from each subject. Obese (body mass index, ≥30), older (age, ≥65 years) men and women were recruited from the community through advertisements. Subjects underwent a comprehensive medical evaluation, including medical history and physical examination, standard biochemistry tests, and electrocardiography. The presence of chronic health conditions common in older subjects, including arthritis, hypertension, diabetes mellitus, coronary artery disease, congestive heart failure, and chronic lung disease,[15,16] was determined. All subjects were sedentary (ie, did not participate in regular exercise more than twice a week) and had a stable body weight (±2 kg) over the past year. Participants had not had any changes in medications for at least 6 months before enrolling in the study. Subjects with severe cardiopulmonary disease; musculoskeletal or neuromuscular impairments that preclude exercise training; visual, hearing, or cognitive impairments; history of malignant neoplasms; and recent use of corticosteroid agents or sex-steroid compounds were excluded.

All subjects had evidence of mild to moderate frailty, as defined by meeting at least 2 of 3 criteria: modified Physical Performance Test (PPT) score of 18 to 32, peak oxygen consumption of 11 to 18 mL/min per kilogram of body weight, and self-reported difficulty or need for assistance in 2 instrumental ADLs or 1 basic ADL.[15-19] These criteria are based on measures that have established predictive validity for disability and mortality in older populations.[20-23]

STUDY DESIGN

Baseline Assessments

Physical Function. An assessment of frailty (ie, PPT score, peak oxygen consumption, and Functional Status Questionnaire score) was performed during the screening process. The modified PPT includes 7 standardized tasks that are timed (50-ft walk, putting on and removing a laboratory coat, picking up a penny, standing up 5 times from a 16-in chair, lifting a 7-lb book to a shelf, climbing 1 flight of stairs, and standing with feet in side-by-side, semitandem, and full-tandem positions) and 2 additional tasks (climbing up and down 4 flights of stairs and performing a 360° turn). Each item is scored on a scale of 0 (best) to 4 (worse); thus, a perfect total test score is 36.[16-18,24-26] Peak oxygen consumption was assessed during graded treadmill walking. During an approximately 5-minute warm-up at 0% grade, the speed was adjusted to identify the fastest comfortable walking speed. Speed was held constant and treadmill incline was increased by 3% every 2 minutes. Cardiorespiratory data were collected by using a computerized system.[27] Information about the ability to perform ADLs was collected by using the Functional Status Questionnaire, which is a standardized, validated instrument that evaluates difficulty in performing 9 ADLs.[28] The Functional Status Questionnaire has a score range of 0 (worse) to 36 (best); a score of 36 indicates no difficulty with any ADLs. In addition, assessment of specific physical functions, including strength, balance, and gait, was performed. Knee extensor and flexor strength was evaluated by using an isokinetic dynamometer (Cybex II; Cybex International, Medway, Mass).[29] One-repetition maximum values, the maximal amount of weight lifted 1 time, were also determined. Static balance was assessed by using the single-limb leg stance time.[15] Dynamic balance was assessed as the time needed to complete an obstacle course.[26] Walking speed was measured as the time needed to walk 25 feet as rapidly and safely as possible.

Body Composition Analyses. Total fat mass, percentage of body fat, and fat-free mass were measured by using dual-energy x-ray absorptiometry (Delphi 4500-W; Hologic Inc, Waltham, Mass). Total body scans were analyzed by using Hologic software version 11.2. The variability in assessing both fat-free mass and fat mass by using dual-energy x-ray absorptiometry in our laboratory is 1.5%.

Health-Related Quality-of-Life Assessment. The Medical Outcomes Survery 36-Item Short-Form Health Survey (SF-36) was used to evaluate the perception of general health, functional ability, and well-being.[30-32] This survey consists of the following 8 domains: physical functioning, role limitations due to physical problems, social functioning, bodily pain, general mental health, role limitations due to emotional problems, vitality, and general health perceptions.

Intervention

Subjects were randomized to receive either 26 weeks of diet and exercise therapy (treatment group) or no treatment (control group), in a 1.5:1 ratio, by using a computer-generated block random permutation procedure stratified for sex.[33] More subjects were assigned to the treatment group to increase the number of subjects in whom diet and exercise therapy could be evaluated. The randomization algorithm was maintained by a member of the research team who did not interact with the participants.

Treatment Group Intervention. Each participant was prescribed a balanced diet to provide an energy deficit of approximately 750 kcal/d.[34] Daily calorie requirement was determined by estimating resting energy expenditure and multiplying the obtained value by 1.3.[35] The diet contained approximately 30% of energy as fat, 50% as carbohydrate, and 20% as protein. Total calorie intake was adjusted to prevent more than a 1.5% loss of body weight per week, with the goal of 10% weight loss at the completion of the study. Participants were instructed to take a multivitamin supplement daily.The curriculum from the the Diabetes Prevention Program's Lifestyle Change Program[36] was used and modified for this study. Subjects met weekly as a group with a study dietitian experienced in group behavioral therapy. Standard behavioral strategies, including goal setting, self-monitoring, stimulus control techniques, problem-solving skills, identification of high-risk situations, and relapse prevention training, were used to modify eating habits. Each participant was given the 2003 edition of *The Doctors Pocket Guide of Calorie, Fat and Carbohydrate Counter*,[37] a book with information on the calorie content of foods, food diary sheets, and a binder in which to file educational materials distributed during group sessions. Subjects participated in group exercise training sessions on 3 nonconsecutive days each week. Each session was supervised by a physical therapist. The exercise program focused on improving flexibility, endurance, strength, and balance. Each session lasted 90 minutes and began with 15 minutes of warm-up flexibility exercises followed by 30 minutes of endurance exercise, 30 minutes of strength training, and 15 minutes of balance exercises.

Control Group Intervention. Subjects assigned to the control group were instructed to maintain their usual diet and activities during the study period. They were prohibited from participating in any weight loss or exercise program.

EVALUATION OF INTERVENTION

After 26 weeks, all assessments performed at baseline were repeated in the treatment and control groups. The research personnel who conducted the assessments were blinded to group assignment.

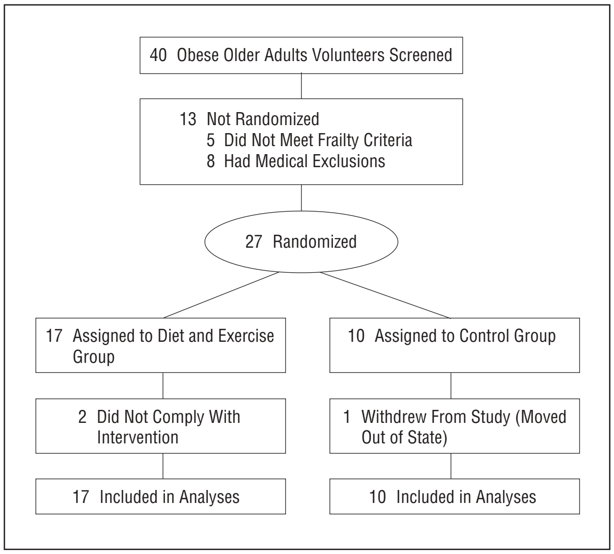

Figure 1. Flowchart shows status of subjects throughout the study.

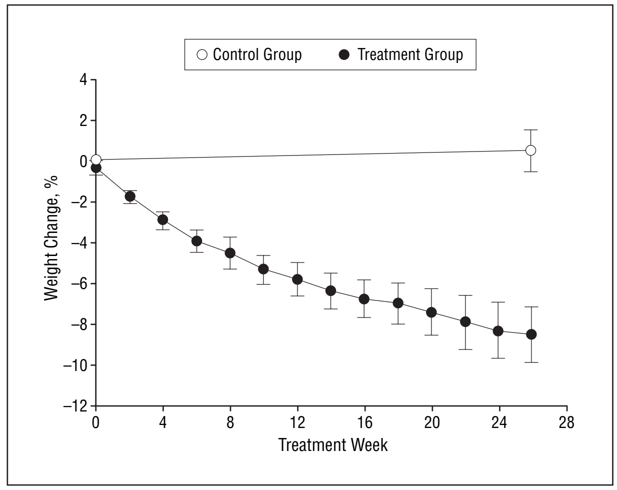

Figure 2. Percent change in body weight (mean ± SE) from baseline in control and treatment groups.

Table 1. Baseline Characteristics of Study in Obese Older Adults*

Variable	Control Group (n = 10)	Treatment Group (n = 17)	*P* Value
Age, y	71.1 ± 5.1	69.4 ± 4.6	.37
Female sex, No. (%)	6 (60)	12 (71)	.57
White race, No. (%)	9 (90)	14 (83)	.83
Height, cm	151.2 ± 19.7	155.4 ± 29.8	.70
Weight, kg	103.2 ± 19.8	99.7 ± 13.6	.60
Body mass index†	39.0 ± 5.0	38.5 ± 5.3	.81
Chronic diseases, No.	1.6 ± 0.8	2.0 ± 0.7	.20

*Data are given as mean ± SD unless otherwise indicated. Obese older adults in the control group received no lifestyle changes; those in the treatment group received 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week.

†Calculated as weight in kilograms divided by the square of height in meters.

STATISTICAL ANALYSIS

The number of subjects enrolled in this study was based on PPT data we obtained previously in frail older subjects.[16,17] We estimated that 14 treatment subjects and 9 control subjects would be needed to detect a clinically meaningful (mean ± SD) 3.0 ± 2.1 difference in PPT score change between groups, with a power of 0.9 and an α level of .05.

The effect of the intervention was evaluated by using intention-to-treat analysis. When follow-up data were unavailable, the last observation was carried forward. Baseline characteristics between groups were compared by using the *t* test for unpaired samples for continuous variables and the χ^2 test for categorical variables. Analysis of variance was used to determine whether the change in outcomes was significantly different in response to intervention compared with control. Age and baseline values were entered as covariates in the analysis of variance. The *t* test for paired samples was also performed to determine whether there were significant within-group changes in outcomes. Partial correlation analysis was used to assess the potential independent contributions of weight loss and exercise on changes in PPT. We used SPSS software (version 12.0; SPSS Inc, Chicago, Ill) for all statistical analyses. $P \leq .05$ was considered statistically significant. Results are reported as mean ± SD, unless otherwise indicated.

RESULTS

STUDY POPULATION

Forty obese older adult volunteers underwent screening evaluations (**Figure 1**). Five subjects did not meet frailty criteria, and an additional 8 subjects had medical illnesses. A total of 27 subjects were randomized to either the treatment group (n = 17) or the control group (n = 10). Of these subjects, 24 successfully completed the study. Three subjects dropped out of the study: 2 in the treatment group who were not compliant with the intervention and 1 in the control group who moved out of state. Treatment and control groups did not differ on baseline demographic and clinical characteristics (**Table 1**).

COMPLIANCE AND ADVERSE EVENTS

Mean attendance at diet and group behavioral therapy sessions was 86.5% ± 7.8%, and mean attendance at exercise sessions was 84.1% ± 7.6%. None of the participants experienced any adverse effects in serum electrolyte concentrations or in renal or liver function test results. One participant fell during an exercise session, which resulted in a small forehead laceration. However, this injury did not interrupt her participation in the diet and exercise program.

BODY WEIGHT AND COMPOSITION

The treatment group lost 8.2 ± 5.7 kg (8.4% ± 5.6%) of body weight (**Figure 2**), whereas the control group maintained a constant body weight (**Table 2**). Body fat but not fat-free mass decreased in the treatment group (Table 2).

Table 2. Effect of Diet and Exercise Therapy on Body Weight and Body Composition*

Variable Control	Control Group	Treatment Group	P Value
Body weight, kg			
Baseline	103.2 ± 19.8	99.7 ± 13.6	
Final	103.9 ± 21.3	91.5 ± 15.4†	
Absolute change	0.7 ± 2.7	−8.2 ± 5.7	<.001
% Change	0.5 ± 2.8	−8.4 ± 5.6	
Fat mass, kg			
Baseline	47.5 ± 8.9	42.6 ± 7.9	
Final	49.1 ± 13.4	35.9 ± 10.1†	
Absolute change	1.7 ± 4.1	−6.6 ± 3.4	<.001
% Change	2.6 ± 6.9	−17.1 ± 11.3	
Fat-free mass, kg			
Baseline	55.7 ± 13.1	57.1 ± 10.9	
Final	54.7 ± 12.8	55.9 ± 10.9‡	
Absolute change	−1.0 ± 3.5	−1.2 ± 2.1	.75
% Change	−1.5 ± 5.3	−2.1 ± 3.7	

*Data are given as mean ± SD. Obese older adults in the control group received no lifestyle changes; those in the treatment group received 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week.
†Final value significantly different from baseline, $P<.001$.
‡Final value significantly different from baseline, $P = .04$.

Table 3. Effect of Diet and Exercise Therapy on Measures of Physical Frailty*

Variable	Control Group	Treatment Group	P Value
Physical Performance			
Test score			
Baseline	29.8 ± 2.0	29.4 ± 2.2	
Final	29.9 ± 1.9	31.9 ± 2.2†	
Absolute change	0.1 ± 1.0	2.6 ± 2.5	.001
% Change	0.4 ± 3.4	9.2 ± 8.4	
Vo_{2peak}, mL/kg per min			
Baseline	15.7 ± 3.0	16.4 ± 2.3	
Final	16.0 ± 3.4	18.1 ± 3.2†	
Absolute change	0.3 ± 1.1	1.7 ± 1.6	.02
% Change	1.8 ± 8.4	10.4 ± 9.6	
Functional Status			
Questionnaire score			
Baseline	32.9 ± 1.9	31.0 ± 4.0	
Final	32.7 ± 4.5	33.9 ± 3.2‡	
Change	−0.2 ± 3.9	2.9 ± 3.7	.02
% Change	−0.8 ± 123	10.7 ± 14.7	

Abbreviation: Vo_{2peak}, peak oxygen consumption.
*Data are given as mean ± SD. Obese older adults in the control group received no lifestyle changes; those in the treatment group received 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week.
†Final value significantly different from baseline, $P = .001$.
‡Final value significantly different from baseline, $P = .005$.

PHYSICAL FUNCTION

Weight loss and exercise training improved both objective and subjective measures of frailty, including the PPT score, peak oxygen consumption, and Functional Status Questionnaire score (**Table 3**). Moreover, treatment improved all objective measures of physical function and strength; lower extremity strength, gait, and balance improved markedly in subjects randomized to diet and exercise therapy, but these parameters did not change in the control group (**Table 4**). In addition, treatment significantly increased 6 different 1-repetition maximum tests that evaluated upper and lower body strength: leg press, 48%±40%; bench press, 22%±23%; bench curl, 25%±23%; knee extension, 36%±38%; knee flexion, 26%±28%; and seated row, 20%±20% (all $P<.05$)

HEALTH-RELATED QUALITY OF LIFE

Diet and exercise therapy produced significant improvements in physical function domains and in change in health, assessed by using the SF-36 (**Table 5**).

INDEPENDENT EFFECTS OF WEIGHT LOSS AND EXERCISE

Increase in knee strength was used as a marker for improved physical fitness. Changes in weight correlated with changes in PPT while controlling for changes in knee strength (partial correlation, $r=-0.51$; $P=.01$). Likewise, changes in knee strength correlated with changes in PPT while controlling for changes in weight (partial correlation, $r=0.42$; $P=.04$).

COMMENT

Obesity is an important cause of frailty in older men and women.[4,15,38,39] The results of this 6-month randomized, controlled trial demonstrate that diet-induced weight loss and exercise training improves physical function and ameliorates frailty in the obese older adults. Moreover, the improvements in objective measures of function, such as endurance, strength, gait, and balance, were accompanied by subjective improvements in the ability to function. These findings demonstrate that weight loss and regular exercise have important beneficial effects in the frail obese older adults by improving functional status and health-related quality of life.

Frailty, defined as diminished ability to perform the important practical and social ADLs,[40] is an important problem in the older population because it leads to loss of independence[26,41] and to increased morbidity and mortality.[42] Obesity increases the risk for functional disability in older persons[5-9] because of having to carry excess weight, along with age-related decreases in muscle mass and strength.[15,38] Therefore, physical frailty is common in community-living obese older adults,[15] and obesity is associated with increased nursing care facility admissions.[12] To our knowledge, our study is the first randomized controlled trial to evaluate the effects of weight loss and exercise on the frail obese older adults. The results demonstrate that diet and exercise therapy can reverse frailty and should be considered a primary therapy in frail obese older men and women. In addition, data from other studies indicate that moderate (5%-10%) weight loss and exercise reduced knee pain and improved physical performance in overweight and

Table 4. Effect of Diet and Exercise Therapy on Strength, Gait, and Balance*

Variable	Control Group	Treatment Group	*P* Value
Knee extension, ft/lb			
Baseline	71.5 ± 23.5	80.2 ± 17.1	
Final	73.7 ± 22.2	89.3 ± 15.3†	
Absolute change	2.2 ± 7.3	9.1 ± 8.0	.04
% Change	4.3 ± 13.0	12.9 ± 12.5	
Knee flexion, ft/lb			
Baseline	44.9 ± 16.41	50.3 ± 16.1	
Final	50.3 ± 16.1	61.0 ± 15.1†	
Absolute change	0.9 ± 5.6	10.3 ± 11.3	.008
% Change	1.1 ± 17.9	25.5 ± 26.6	
Walking speed, m/min			
Baseline	71.6 ± 8.4	71.5 ± 12.9	
Final	70.4 ± 12.7	76.4 ± 11.8‡	
Absolute change	1.3 ± 8.6	4.9 ± 6.5	.04
% Change	−1.9 ± 12.5	7.6 ± 10.2	
One leg limb stand, s			
Baseline	5.5 ± 5.9	6.8 ± 8.0	
Final	5.2 ± 5.21	2.2 ± 9.8§	
Absolute change	−0.3 ± 3.9	5.4 ± 9.3	.04
% Change	−5.5 ± 61.0	79.5 ± 120.0	
Obstacle course, s			
Baseline	11.8 ± 2.1	11.9 ± 1.9	
Final	11.6 ± 1.7	10.5 ± 1.7‖	
Absolute change	−0.2 ± 0.8	−1.4 ± 1.4	.03
% Change	−0.8 ± 6.9	−11.3 ± 9.6	

*Data are given as mean ± SD. Obese older adults in the control group received no lifestyle changes; those in the treatment group received 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week.
†Final value significantly different from baseline, *P* = .001.
‡Final value significantly different from baseline, *P* = .04.
§Final value significantly different from baseline, *P* = .03.
‖Final value significantly different from baseline, *P* = .002.

Table 5. Effect of Diet and Exercise Therapy on the 36-Item Short-Form Health Survey*

Variable	Control Group	Treatment Group	*P* Value
Physical function			
Baseline	67.0 ± 15.1	60.0 ± 21.0	
Final	69.5 ± 22.1	83.2 ± 13.9†	
Change	2.5 ± 26.4	23.2 ± 20.9	.03
Role limitations, physical			
Baseline	62.5 ± 44.5	54.4 ± 43.5	
Final	67.5 ± 42.6	78.0 ± 36.3‡	
Change	5.0 ± 19.7	23.6 ± 35.9	.03
Bodily pain			
Baseline	74.7 ± 22.1	63.3 ± 19.3	
Final	71.0 ± 18.5	73.8 ± 21.4§	
Change	−3.7 ± 12.4	10.4 ± 10.4	.02
Vitality			
Baseline	45.4 ± 16.5	44.1 ± 17.5	
Final	47.3 ± 25.5	56.3 ± 11.2‖	
Change	2.3 ± 6.8	12.2 ± 16.6	.04
Social functioning			
Baseline	93.0 ± 15.6	93.0 ± 15.7	
Final	77.8 ± 22.8	92.2 ± 15.7	
Change	−15.3 ± 21.9	−1.3 ± 8.8	.11
Mental health			
Baseline	75.6 ± 20.9	85.5 ± 8.1	
Final	77.2 ± 24.3	87.9 ± 10.7	
Change	2.8 ± 13.2	2.4 ± 11.0	.93
Role limitations, emotional			
Baseline	81.7 ± 31.6	84.1 ± 34.1	
Final	75.0 ± 40.8	98.0 ± 8.1	
Change	−6.7 ± 34.4	14.0 ± 31.3	.12
Change in health			
Baseline	38.0 ± 6.3	38.2 ± 12.3	
Final	38.0 ± 11.4	65.7 ± 12.2†	
Change	0.0 ± 9.4	25.3 ± 13.2	<.001

*Data are given as mean ± SD. Obese older adults in the control group received no lifestyle changes; those in the treatment group received 6 months of weekly behavioral therapy for weight loss in conjunction with exercise training 3 times per week.
†Final value significantly different from baseline, *P*<.001.
‡Final value significantly different from baseline, *P* = .02.
§Final value significantly different from baseline, *P* = .001.
‖Final value significantly different from baseline, *P* = .008.

obese older adults with severe knee osteoarthritis.[43-45] Therefore, the most important goal of weight loss therapy in obese older adults may be to improve physical function and health-related quality of life rather than to improve the medical complications of obesity, which is often the major goal in younger adults.

Diet-induced weight loss causes a decrease in both fat mass and fat-free mass; approximately 75% of weight lost is composed of fat and 25% of fat-free mass.[46] Therefore, there is concern that weight loss will exacerbate sarcopenia and impair physical function in older persons.[47] However, we found that fat-free mass was maintained in our subjects after diet therapy plus exercise training. This preservation of fat-free mass is consistent with the results from studies conducted in younger subjects, which showed that exercise training reduces diet-induced loss of lean tissue.[46,48] In addition, diet and exercise therapy in our subjects resulted in a significant increase in muscle strength and muscle quality (ie, strength per amount of muscle mass), presumably owing to exercise-induced changes in neuromuscular activation and muscle energetics, and possibly to the effect of weight loss on intramuscular fat content.[49-51] The increases in muscle strength observed in our obese older adults subjects were equal to or greater than those we previously found in nonobese older adults subjects who completed a similar exercise program.[16-18]

It has been suggested that successful weight loss is difficult to achieve in the older population because of ingrained, lifelong diet and activity habits, and attempts to change these habits will cause distress and anxiety.[52] In contrast, we found that most of our subjects looked forward to the weekly group meetings and regular exercise sessions, and embraced lifestyle change. However, these results may not necessarily apply to the general obese older adults population because we selected subjects who volunteered for the study and were able to participate in a weight loss and exercise program. Nevertheless, our results provide evidence that successful weight loss and adherence with exercise training are feasible in the obese older adults, and a group intervention program may provide important social interactions that enhance compliance.

The strengths of our study include the randomized controlled design, the comprehensive weight loss and exer-

cise program, the high rate of compliance of our study subjects, and the use of both objective and subjective measures of physical function. Our sample size was small, yet we were able to detect significant improvements in functional outcome, demonstrating the marked efficacy of therapy. A limitation of our study is that we evaluated a combined intervention of weight loss and exercise, which does not allow rigorous assessment of the independent effects of each therapy. However, data from partial correlation analyses suggest that the effect of each therapy was independent of each other. The duration of our study was only 6 months; therefore, additional studies are needed to evaluate long-term maintenance of weight loss and exercise therapy.

CONCLUSIONS

Moderate weight loss and exercise training improves both objective and subjective measures of physical function and ameliorates frailty in obese older adults. Therefore, diet and exercise should be considered as primary therapy in frail obese older adults. Additional studies are needed to determine the independent and additive effects of weight loss and regular exercise on physical function and whether lifestyle intervention can prevent institutionalization of the growing number of obese older adults in our population.[53]

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