

Effects of Resistance Exercise and Protein on Body Composition Following Weight Loss

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ABSTRACT

Background: Research indicates that weight loss programs are effective for reducing body weight temporarily, but weight maintenance studies have been almost uniformly unsuccessful in preventing weight regain.

Methods: Subjects who completed a 6-month weight loss study were invited to continue with a weight maintenance program. The weight loss study examined the effects of exercise (20 min strength, 20 min aerobics, twice weekly) and nutrition (1,200 to 1,800 kcal·d⁻¹, 2 daily meal replacement protein shakes) on body weight and body composition. Weight loss program completers experienced improvements ($P < 0.05$) in body weight, percent fat, fat mass, lean mass, waist girth, and hip girth. Subjects who participated in the weight maintenance program performed the same strength and aerobic exercise protocol, but discontinued caloric restriction and decreased daily meal replacement protein shakes from 2 to 1.

Results: After 6 months on the weight maintenance program, participants experienced improvement ($P < 0.05$) in percent fat, fat mass, lean mass, waist girth, and hip girth, with no significant change in body weight. A subgroup of subjects who continued the weight maintenance program for an additional 3 months experienced additional improvement ($P < 0.05$) in percent fat, fat mass, lean mass, waist girth, and hip girth, with no significant change in body weight.

Conclusion: These findings indicated that a postdiet weight maintenance program incorporating 2 weekly resistance and aerobic exercise sessions coupled with a daily meal replacement protein shake was effective for avoiding weight regain and for improving body composition, with concurrent fat mass decrease and lean mass increase. *Journal of Clinical Exercise Physiology*. 2018;7(2):25–32.

Keywords: weight maintenance, nutrition, diet

INTRODUCTION

Based on body mass index (BMI), approximately 70% of American adults are overweight or obese (1), and this percentage is increasing (2). Due to the progressive loss of muscle during inactive aging, which averages more than 5% per decade (3,4), BMI clearly underestimates the actual percentage of men and women who have excess fat. Although almost 70% of Americans are attempting to reduce body weight by means of various diet plans (5), this strategy has mixed results. On the positive side, low calorie diets

generally result in significant weight loss over the short term (6–8). On the negative side, dieting has a poor record for long-term weight maintenance (8–11). Dieting typically leads to muscle loss (12,13), with association between the degree of caloric restriction and the percent of lean mass reduction (14). Muscle loss results in lower resting metabolism (15,16), which is an underlying cause of fat gain (17,18). There is evidence that approximately 25% of the weight lost through diet programs is lean weight (19,20), which may partially explain why most dieters have difficulty

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maintaining their lower body weight (21–25). Reviews of more than 25 weight loss studies (14) and more than 50 weight loss studies (26) indicated that intervention programs with exercise components reduced muscle loss by about 50%.

With respect to exercise type, a 2017 study examined the effects of aerobic activity, resistance training, and a combination of both exercise modes on body composition changes during dietary intervention in obese older adults (27). After a 6-month program of diet (500 to 750 kcal·d⁻¹ deficit) and exercise, the aerobic activity group lost 6.3 kg of fat mass and 2.7 kg of lean mass, the resistance training group lost 7.3 kg of fat mass and 1.0 kg of lean mass, and the combined exercise group lost 7.0 kg of fat mass and 1.7 kg of lean mass. These findings indicated that resistance training is more effective than aerobic training for attenuating muscle loss during dieting.

Research suggests that resistance exercise with higher daily protein intake may be instrumental in preserving or increasing lean mass during reduced calorie diet programs (27,28). In our preceding weight loss study (29), 75 overweight adults followed different applications of an exercise and nutrition program. Participants who performed 6 months of strength and aerobic exercise coupled with moderate caloric reduction and 2 daily meal replacement protein shakes attained significant improvements in body weight and body composition. Specifically, these subjects experienced a 6.4 kg decrease in fat mass and a 1.7 kg increase in lean mass, indicating that an appropriately designed exercise and nutrition program may result in concurrent fat mass loss and lean mass gain.

These findings may have implications for postdiet weight maintenance, as research demonstrates that almost all dieters return to their prediet body weight within 1 to 2 years (8). Meta-analyses of weight loss and weight maintenance studies reveal that the lowest body weight is attained at approximately 6 months of dietary intervention, after which most participants experience progressive weight regain (11).

Studies have found that aerobic activity does not play a major role in weight loss (20,23,24), but may be an important factor in the prevention of weight regain (9,25). Behavioral interventions featuring aerobic activity and nutrition have been shown to modestly slow weight regain (11). In a classic study, 1,450 overweight adults lost approximately 7 kg of body weight after 6 months of diet and aerobic activity (22). The 1,032 participants who lost more than 4 kg of body weight were placed into behavioral groups for weight maintenance, with encouragement to follow the recommended nutrition program and to perform at least 225 minutes of weekly aerobic activity. Although average body weight increased throughout the maintenance period, 71% of the study participants remained below their prediet weight for 2.5 years.

These results are consistent with other studies that found exercise instrumental in reducing postdiet weight regain (9,25). However, many people may find it challenging to perform 225 minutes of aerobic activity on a weekly basis.

We considered that a lesser amount of combined resistance and aerobic exercise (40 min, twice weekly) coupled with a meal replacement protein shake may be a more practical means for maintaining postdiet body weight. As this approach has been effective for weight loss participants during caloric restriction (28,29), we postulated that a similar program may be beneficial for weight maintenance participants during normal caloric consumption. Resistance exercise benefits weight maintenance by expending calories during the training session, as well as through muscle remodeling processes that increase resting energy expenditure by 5 to 9% for 3 d after each training session (30,31).

The purpose of the present study was to determine whether successful weight loss program completers could maintain their postdiet body weight and body composition during a maintenance period in which they performed resistance and aerobic exercise, consumed a daily meal replacement protein shake, and did not intentionally reduce caloric intake. We hypothesized that the study participants would not experience significant gain in body weight, significant gain in fat mass, or significant loss of lean mass during the maintenance period.

METHODS

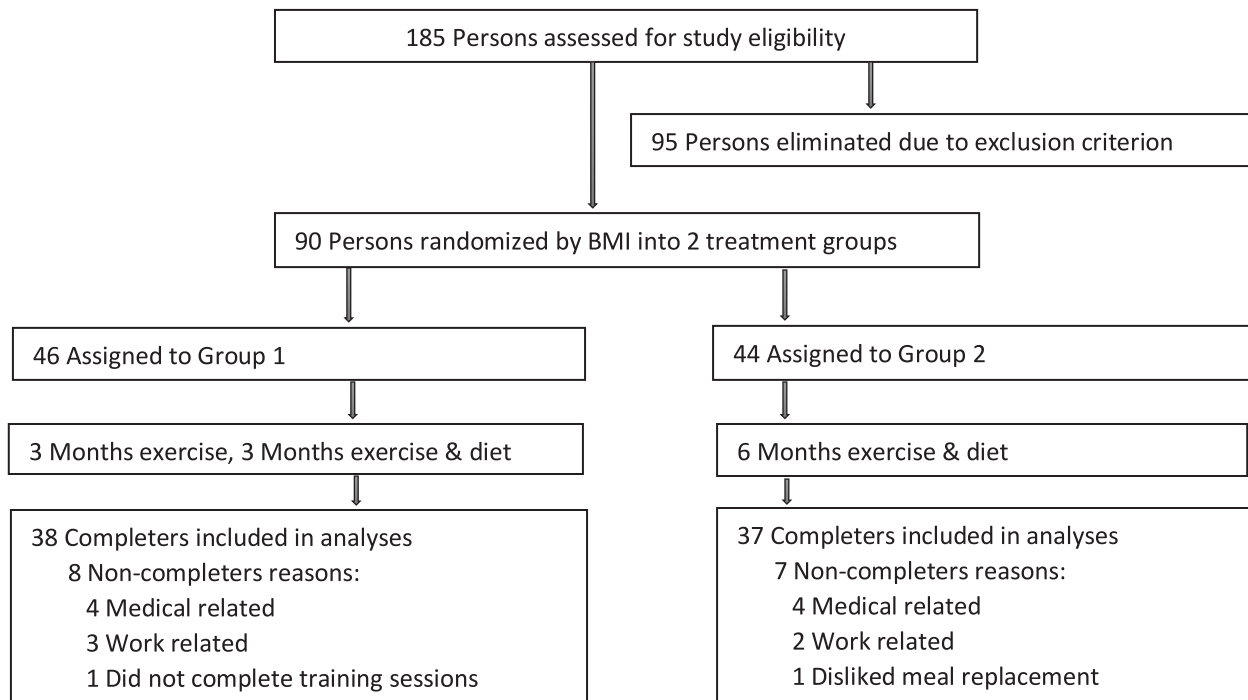
This study was approved by the Quincy College Institutional Review Board and was conducted in complete compliance with the Board guidelines. Each subject provided informed, written consent prior to study participation.

Subjects

The previous phase of this study (weight loss program) included 90 otherwise healthy overweight or obese men and women between 18 and 75 years, BMI between 27 and 40, total blood cholesterol less than 240 mg·dL⁻¹, systolic blood pressure less than 140 mmHg, diastolic blood pressure less than 90 mmHg, and physically capable of performing standard strength and aerobic exercise (29). Exclusion criteria encompassed hypertension, cardiovascular disease, cancer, asthma, glaucoma, thyroid, kidney, liver, and pancreatic disease, statin medications, weight loss medications, smoking more than 1 pack of cigarettes daily, consuming more than 1 (women) or 2 (men) alcoholic drinks daily, pregnancy, or breastfeeding. All of the study participants performed 6 months of the strength and aerobic exercise program. Half of the subjects followed the nutrition program for all 6 months of the study, and half of the subjects followed the nutrition program for (only) the last 3 months of the study.

Seventy-five men and women completed the 6-month weight loss study, and 53 of these subjects enrolled in the weight maintenance study. Forty-five men and women completed the 6-month weight maintenance program, and 18 of these subjects (who began the meal replacement protein shakes at month 3 of the weight loss study) continued the weight maintenance program for an additional 3 months. This ensured that all of the weight maintenance program participants experienced 12 months of meal replacement protein shakes. Figure 1 presents the flow chart, and Table 1

Weight Loss Study



Weight Maintenance Study

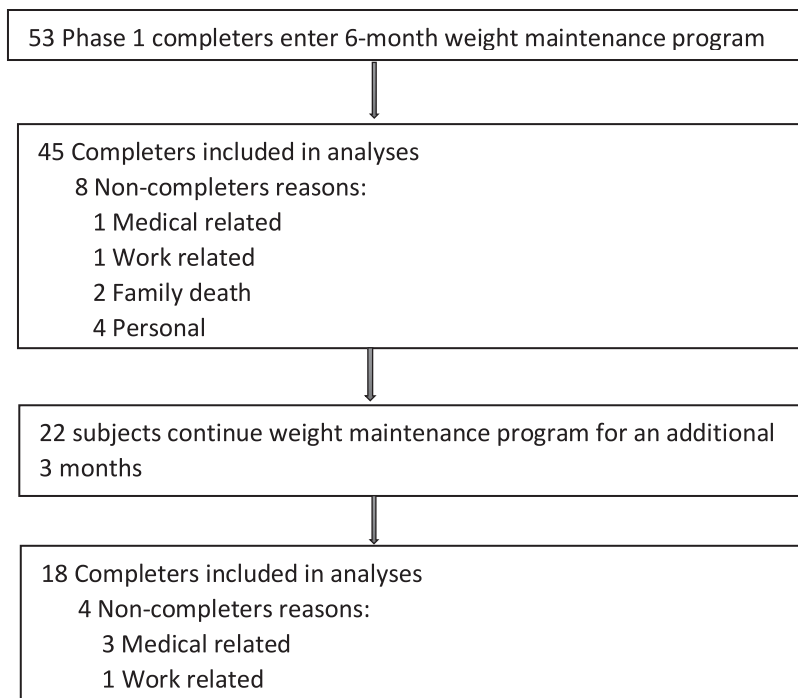


FIGURE 1. Consort diagram of subjects in the weight loss study and the weight maintenance study.

TABLE 1. Treatments timeline during weight loss and weight maintenance studies.

Time	Group 1	Group 2
0–3 Months Weight Loss Study Between Groups Comparisons	Exercise No Diet No Shakes	Exercise Diet 2 Daily Shakes
3–6 Months Weight Loss Study Within Group Comparisons (0-3 Mos. vs 3-6 Mos.)	Exercise Diet 2 Daily Shakes	Exercise Diet 2 Daily Shakes
6–12 Months Weight Maintenance Study Groups Combined	Exercise No Diet 1 Daily Shake	Exercise No Diet 1 Daily Shake
12–15 Months Weight Maintenance Study	Exercise No Diet 1 Daily Shake	

presents the treatment timeline for participants in the sequential weight loss and weight maintenance studies.

Procedures

All of the weight maintenance study subjects continued the same exercise program that they performed during the weight loss study. Additionally, all of the weight maintenance program participants discontinued the reduced-calorie diet program and changed from 2 daily meal replacement protein shakes to 1 daily meal replacement protein shake.

Exercise Program

The weight maintenance exercise program was conducted in the college fitness research facility under close supervision of nationally certified fitness instructors and in accordance with training guidelines recommended by the American College of Sports Medicine and the American Heart Association (32). Subjects trained twice each week on Mondays and Wednesdays or Tuesdays and Thursdays, with makeup sessions available on Fridays and Saturdays. Each exercise session included approximately 20 min of resistance machine training and approximately 20 min of aerobic activity, performed in a circuit format. Subjects performed 1 set of 3 successive leg exercises (leg extension, leg curl, leg press) followed by 6 to 7 min of aerobic activity (cycle, treadmill, or rower); 1 set of 3 successive upper body exercises (chest press, lat pulldown, shoulder press) followed by 6 to 7 min of aerobic activity (cycle, treadmill, or rower); and 1 set of 3 successive core exercises (abdominal curl, low back extension, torso rotation) followed by 6 to 7 min of aerobic activity (cycle, treadmill, or rower). Each set of resistance exercise was performed for 8 to 12 repetitions using appropriate weight load, moderate movement speed (2 to 3 s concentric muscle actions and 2 to 3 s eccentric muscle actions) and full (pain-free) movement range. The weight load was increased by about 5% whenever 12 repetitions were completed with correct technique. Each bout of aerobic activity was performed with an interval training protocol that alternated approximately 20 s of higher-effort exercise (7 to 8 on a 10-point intensity scale) with approximately 20 s of

lower-effort exercise (3 to 4 on a 10-point intensity scale), without exceeding the age-associated heart rate training range.

Nutrition Program

The weight maintenance nutrition program was limited to a single intervention. Subjects substituted a protein shake for 1 daily meal (typically breakfast or lunch). The meal replacement protein shake contained 260 kcal, 24 g protein, 36 g carbohydrate, 3 g fat, and 6 g dietary fiber. Meal replacement protein shakes were personalized for protein type (whey, soy, plant-based blend) and flavor preferences (vanilla, chocolate, strawberry, coffee).

Assessments

Participants in the weight maintenance study completed the preceding 6-month weight loss study, in which both intervention groups lost similar and significant amounts of body weight. Maintenance study subjects from the 2 weight loss groups were statistically similar in all measures, so they were treated as a single group for the initial and 6-month weight maintenance assessments. Only subjects who started meal replacement protein shakes at month 3 of the weight loss study were included in the 9-month assessments. Assessment measures included body weight, percent fat, fat mass, lean mass, waist girth, and hip girth. All assessments were conducted in our fitness testing office by the same experienced and nationally certified exercise science professional. Body weight was measured to the nearest 0.2 pounds on a calibrated electronic scale, body composition was measured by means of computerized ultrasound technology, and waist girth and hip girth were measured by a standard measuring tape at the umbilicus and the largest hip circumference, respectively.

Statistical Analyses

All data are presented as means (m) \pm standard deviation (SD). Independent samples *t* tests were performed to discover any significant differences in measurements between the former Group 1 and Group 2 subjects at the conclusion of the 6-month weight loss program. Paired samples *t* tests

TABLE 2. Baseline physical characteristics for weight maintenance program subjects (N = 45).^a

Characteristic	Weight Maintenance Group
Age (years)	59.30 ± 8.84
Height (cm)	169.67 ± 8.71
Body Weight (kg)	86.21 ± 14.35
Body Mass Index (kg)	29.92 ± 4.66
Percent Fat (%)	24.10 ± 0.06
Fat Mass (kg)	20.95 ± 7.21
Lean Mass (kg)	65.26 ± 11.04
Waist Circumference (cm)	98.17 ± 10.89
Hip Circumference (cm)	108.89 ± 11.66

^aAll values given as mean ± SD

were conducted to compare changes in the assessment areas for the combined group over the 6-month weight maintenance period, and for former Group 1 participants over the additional 3-month weight maintenance period. The α level for statistically significant differences was set at $P < 0.05$. All data analyses were performed using IBM SPSS Statistics 23 software.

RESULTS

Following the weight loss study, independent samples t tests revealed no significant differences in any measure between the 2 groups of program completers. Therefore, these data were pooled to provide the initial measures of body weight, percent fat, fat mass, lean mass, waist girth, and hip girth for the weight maintenance study (see Table 2).

As presented in Table 3, paired samples t tests revealed that the 45 subjects who completed 6 months of weight maintenance attained significant improvements ($P < 0.05$) in percent fat (−0.89 percentage points), fat mass (−0.75 kg), lean mass (+1.40 kg), waist girth (−1.07 cm), and hip girth (−0.91 cm). There was no significant change in body weight during this 6-month weight maintenance period.

As presented in Table 4, paired samples t tests revealed that the 18 subjects who completed an additional 3 months of weight maintenance attained significant improvements ($P < 0.05$) in percent fat (−1.02 percentage points), fat mass (−1.00 kg), lean mass (+0.65 kg), waist girth (−1.22 cm), and hip girth (−1.05 cm). There was no significant change in body weight during this 3-month weight maintenance period.

DISCUSSION

Most weight loss programs feature reduced calorie diet plans that result in significant body weight reduction (6–8). However, diet programs that include exercise attenuate muscle loss (12,13), which may otherwise account for approximately 25% of the weight loss (19,20). Although combined diet and exercise programs may reduce muscle loss by about 50% (14,26), the type of physical activity performed appears to influence changes in lean mass. A weight loss study by Villareal et al. (27) found that dieting with aerobic activity resulted in a 9.0 kg weight loss, 30% of which came from lean mass, whereas dieting with resistance exercise resulted in an 8.5 kg weight loss, only 12% of which came from lean mass. Subjects who performed dieting combined with resistance and aerobic exercise experienced a 7.0 kg loss of fat mass and a 1.7 kg loss of lean mass over the 6 month intervention period. Participants in our preceding weight loss study (29) who performed dieting combined with resistance and aerobic exercise experienced a 6.4 kg loss of fat mass and 1.7 kg gain of lean mass over the 6-month intervention period. The difference in lean mass response between these 2 weight loss studies may have been due to the resistance training intensity, the daily protein intake, or a combination of these factors. Our weight loss subjects performed each resistance exercise set to the point of momentary muscle failure and consumed 2 daily meal replacement protein shakes to ensure relatively high protein intake throughout each day.

There is evidence that people over age 50 who perform resistance exercise require up to 50% more protein than the recommended dietary allowance (RDA) of 0.8 g·kg^{−1}·d^{−1} in order to experience muscle hypertrophy (33–35). Several

TABLE 3. Changes in subject physical characteristics from start to month 6 of weight maintenance program (N = 45).^a

Characteristic	Initial Measurement	6-Month Measurement
Body Weight (kg)	86.21 ± 14.35	86.91 ± 14.79
Percent Fat (%)	24.10 ± 0.06	23.21 ± 0.06 ^b
Fat Mass (kg)	20.95 ± 7.21	20.25 ± 6.70 ^b
Lean Mass (kg)	65.26 ± 11.04	66.66 ± 12.06 ^b
Waist Girth (cm)	98.17 ± 10.87	97.10 ± 11.18 ^b
Hip Girth (cm)	108.89 ± 11.66	107.98 ± 11.00 ^b

^aAll values given as mean ± SD^bSignificant change ($P < 0.05$)

TABLE 4. Changes in subject physical characteristics from months 6 to 9 of weight maintenance program (N = 18).^a

Characteristic	6-Month Measurement	9-Month Measurement
Body Weight (kg)	87.14 ± 12.79	86.79 ± 13.04
Percent Fat (%)	24.43 ± 0.05	23.41 ± 0.05 ^b
Fat Mass (kg)	21.12 ± 4.75	20.12 ± 4.71 ^b
Lean Mass (kg)	66.02 ± 12.31	66.67 ± 12.86 ^b
Waist Girth (cm)	96.04 ± 8.89	94.82 ± 9.65 ^b
Hip Girth (cm)	108.92 ± 7.52	107.87 ± 7.24 ^b

^aAll values given as mean ± SD^bSignificant change ($P < 0.05$)

studies have indicated that increased protein ingestion enhances the effects of resistance exercise on muscle development (36–39). Subjects in our previous studies (28,40) who performed resistance and aerobic exercise with additional protein gained significantly greater lean mass than subjects who performed the same exercise program without increased protein intake.

Subjects in our preceding 6-month weight loss study (29) experienced a significant decrease in body weight, percent fat, fat mass, waist girth, and hip girth, along with significant increase in lean mass. Subjects in our 6-month weight maintenance study experienced significant decrease in percent fat, fat mass, waist girth, and hip girth, along with significant increase in lean mass, and no significant change in body weight. At this point, all of the weight maintenance program participants had completed 12 months of the same exercise program, half had completed 12 months of meal replacement protein shakes (6 months weight loss phase, 6 months weight maintenance phase), and half had completed 9 months of meal replacement protein shakes (3 months weight loss phase, 6 months weight maintenance phase). Subjects who had used meal replacement protein shakes for only 9 months were invited to continue the weight maintenance program for an additional 3 months. These subjects again experienced significant decrease in percent fat, fat mass, waist girth, and hip girth, along with significant increase in lean mass, and no significant change in body weight. Although the weight maintenance program participants received no extrinsic reinforcement during these successive studies, they did not indicate any dissatisfaction with the exercise and nutrition program. The subject completion rate for the 6-month weight loss program was 83%, the subject completion rate for the 6-month weight maintenance program was 85%, and the subject completion rate for the additional 3-month weight maintenance program was 82%. It would appear that, for most of our study subjects, the relatively basic, brief, and infrequent exercise protocol was an acceptable lifestyle adaptation and that their improvement in body composition, physical fitness, and personal appearance provided sufficient motivation for continued training. Whereas a typical physical activity recommendation is daily

walking sessions, our twice-weekly strength and aerobic exercise program seemed to present a more manageable time commitment for the study subjects. It would also appear that, for most of our program participants, the relatively easy substitution of a protein shake for breakfast or lunch was an acceptable dietary modification and that their reduction in body fat provided sufficient motivation for continued use. It is noted that the program participants maintained their post-diet body weight throughout the Thanksgiving, Christmas, and New Year's holidays.

A comparison of our research results with those attained in 2 notable weight loss and weight maintenance studies provides the following information. Cooper et al. (41) conducted a long-term study based on the Oxford University Cognitive Behavioral Therapy protocol. Subjects in this study significantly reduced their body weight by 9.1 kg during the 6-month weight loss program and regained (nonsignificant) 1.0 kg during 6 months of weight maintenance. This study did not emphasize exercise, so if we assume that approximately 25 percent of the weight loss was attributable to lean mass (19,20), then the subjects lost approximately 6.8 kg of fat mass.

Annesi et al. (42) conducted a long-term study based on the Coach Approach protocol that included exercise, nutrition, and behavioral interventions. Subjects in this study significantly reduced their body weight by 5.7 kg during the 6-month weight loss program and regained (nonsignificant) 0.2 kg during 6 months of weight maintenance. Although the exercise program did not include resistance training, we assume that the subjects lost 5.7 kg of fat mass.

Subjects in our study significantly reduced their body weight by 4.7 kg during the 6-month weight loss program (29), and regained (nonsignificant) 0.7 kg during 6 months of weight maintenance. During the weight loss period, the subjects decreased their fat mass by 6.4 kg and increased their lean mass by 1.7 kg. During the weight maintenance period, the subjects decreased their fat mass by 0.7 kg and increased their lean mass by 1.4 kg.

Subjects in these 3 studies (29,41,42) lost approximately the same amount of fat mass during the 6-month weight loss programs and avoided significant weight regain during 6

months of weight maintenance. However, our study participants decreased fat mass and increased lean mass, indicating additional advantages for weight loss and weight maintenance programs that feature resistance exercise and meal replacement protein shakes. Resistance exercise attenuates age-related muscle loss (3,4) and resting metabolic-rate reduction (15,16), which should be beneficial for continued weight management. It is noted that the subjects who completed 9 months of our maintenance program continued to lose fat mass and gain lean mass, while maintaining their postdiet body weight.

Based on our preceding study (29), weight loss programs that feature basic resistance exercise, moderate caloric reduction, and 2 daily meal replacement protein shakes appear to be effective for reducing body weight, with concurrent fat mass decrease and lean mass increase, over a period of 6 months. Based on our present study, weight maintenance programs that feature basic resistance exercise and 1 daily meal replacement protein shake appear to be effective for preventing postdiet weight regain, with continued fat mass loss and lean mass gain, over a period of 9 months.

Methodologic Considerations

A possible limitation of our study may have been giving the weight loss program completers the option of not participating in the weight maintenance program. Another possible study limitation may have been including only program completers in the data analyses. Although our program was effective for the subjects who complied, combined resistance and aerobic exercise coupled with a daily meal replacement

protein shake may have been less successful for those who did not enroll in the weight maintenance program. It is also likely that behavioral strategies, such as those employed in the Annesi study (42), may have enhanced the weight maintenance program compliance and elicited better results.

Clinical Implications

Excessive body fat is associated with a variety of risk factors including elevated plasma cholesterol, plasma glucose, and resting blood pressure, which are associated with development of type 2 diabetes and cardiovascular disease (21). Although almost 70% of Americans are presently following reduced calorie diet plans (5), approximately 70% of our adult population remain overweight or obese (1). Diet programs are effective for temporary weight reduction (8,11), but almost all successful dieters return to their prediet weight within a relatively short time period (8–11). Unlike most weight maintenance programs, our protocol involved 2 weekly exercise sessions (40 min of combined resistance and aerobic exercise) and a daily meal replacement protein shake. This program maintained the subjects' postdiet body weight over a 9-month period, with a significant decrease in fat mass and a significant increase in lean mass. This weight maintenance approach appears to present a sustainable lifestyle change that may be particularly beneficial for participants in clinical exercise programs whose progress may be enhanced by body weight maintenance and body composition improvement.

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