Effect of Dietary Adherence with or without Exercise on Weight Loss: A Mechanistic Approach to a Global Problem

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Context: Weight loss using low-calorie diets produces variable results, presumably due to a wide range of energy deficits and low-dietary adherence.

Objective: Our objective was to quantify the relationship between dietary adherence, weight loss, and severity of caloric restriction.

Design and Setting: Participants were randomized to diet only, diet-endurance training, or diet-resistance training until body mass index (BMI) was less than 25 kg/m^2.

Participants: Healthy overweight (BMI 27–30) premenopausal women (n = 141) were included in the study.

Interventions: An 800-kcal/d^{-1} diet was provided, and the exercise groups were engaged in three sessions per week.

Main Outcomes: Dietary adherence, calculated from total energy expenditure determined by doubly labeled water measurements and dual-energy x-ray absorptiometry body composition changes, and degree of caloric restriction were determined.

Results: All groups had similar weight loss (~12.1 ± 2.5 kg) and length of time to reach target BMI (~158 ± 70 d). Caloric restriction averaged 59 ± 9%, and adherence to diet was 73 ± 34%. Adherence to diet was inversely associated to days to reach target BMI (r = −0.687; $P < 0.01$) and caloric restriction (r = −0.349; $P < 0.01$). Association between adherence to diet and percent weight lost as fat was positive for the diet-endurance training (r = 0.364; $P < 0.05$) but negatively correlated for the diet-only group (r = −0.387; $P < 0.05$).

Conclusions: Dietary adherence is strongly associated with rates of weight loss and adversely affected by the severity of caloric restriction. Weight loss programs should consider moderate caloric restriction relative to estimates of energy requirements, rather than generic low-calorie diets. **(*J Clin Endocrinol Metab* 94: 1602–1607, 2009)**

Low-energy diets (800–1500 kcal/d^{-1}) and physical activity are important for weight loss, defining successful efficacy either by absolute kilograms lost or by percentage of weight loss. These lifestyle changes require a significant commitment by the individual, and adherence to these programs may be problematic (1–4). For instance, Dansinger *et al.* (5) showed strong curvilinear associations between self-reported dietary adherence and weight lost in overweight and obese patients, indicating that subjects who reported high scores of adherence lost substantially more weight than those who reported low scores. There is a need

ISSN Print 0021-972X ISSN Online 1945-7197
Printed in U.S.A.

doi: 10.1210/jc.2008-1057 Received May 16, 2008. Accepted February 23, 2009.
First Published Online March 3, 2009

Abbreviations: BMI, Body mass index; DE, diet-endurance exercise; DLW, doubly labeled water; DO, diet-only; DR, diet-resistance exercise; DXA, dual-energy x-ray absorptiometry; GCRC, General Clinical Research Center; TEE, total energy expenditure.

to extend this behavioral finding to biological measures of adherence (intake-expenditure), and to determine whether dietary adherence is associated with the degree of caloric restriction.

Relatively few studies have effectively quantified dietary adherence by coupling doubly labeled water (DLW) measurements of energy expenditure to body energy stores before and after a dietary intervention (6–10). The literature consistently shows low to moderate adherence to diet when subjects are calorically restricted at 20–70% relative to their energy requirements.

The aforementioned studies were not designed to examine the relationship between degree of caloric restriction and dietary adherence, and had small sample sizes. In addition, some (6, 8), but not all (10), of these studies suggested that endurance exercise enhanced dietary adherence, compared with a diet-only (DO) intervention. The effects of diet and exercise need to be examined within the context of adherence. The hypotheses of this study were to examine whether adherence to diet: 1) is associated with the time to reach target weight loss, 2) is associated with degree of caloric restriction, 3) is modulated by concurrent endurance or resistance training, and 4) modulates the quality of weight loss. To this end, we used DLW to measure energy expenditure and dual-energy x-ray absorptiometry (DXA) to measure body composition at baseline and post-weight loss intervention.

Subjects and Methods

Subjects

The present study was part of an ongoing randomized clinical investigation designed to examine metabolic factors that predispose overweight premenopausal women to weight regain after a diet-based weight loss intervention. Subjects were healthy, overweight [body mass index (BMI) 27–30 kg/m^2], premenopausal African-American and European-American women. The women had regular menstrual cycles, were nonsmokers, sedentary (one or less exercise bout per week), normoglycemic, and not taking prescription medication known to alter energy metabolism. Data were collected at baseline and immediately after weight loss at an inpatient visit at the Pittman General Clinical Research Center (GCRC), at the University of Alabama at Birmingham. This study was approved by the University of Alabama at Birmingham Institutional Review Board for Human Use, and subject consent was obtained before all testing. To screen subjects and identify possible health problems (*i.e.* diabetes, cardiovascular disease, and metabolic diseases), subjects underwent a physical examination, completed health questionnaires, provided blood samples for complete blood count and blood chemistry, and underwent an oral glucose tolerance test and electrocardiogram.

Study design

Before baseline assessment, women completed 4 wk supervised weight maintenance. During the first 2 wk, subjects consumed their own foods, and during the final 2 wk, the GCRC provided a macronutrient-controlled diet. The energy content was adjusted by a dietitian to ensure a stable body weight. Subjects were weighed three to five times weekly. During the last 2 wk, DLW was used to estimate energy requirements. The 4-wk weight maintenance phase ended with a 4-d inpatient stay at the GCRC, where comprehensive metabolic and fitness testing occurred. After the inpatient visit, participants were randomly assigned to a diet-endurance exercise (DE), diet-resistance exercise (DR), or DO group. All subjects were provided all meals for the period of weight loss intervention and were maintained on the diet until a BMI less than 25 kg/m^2 was achieved. Once attaining BMI less than 25 kg/m^2, subjects repeated the 4-wk protocol of energy balance designed to maintain subjects at their normal weight, followed by the 4-d inpatient stay at the GCRC for metabolic-DLW and fitness testing.

Weight loss intervention

The weight loss diet was provided by the GCRC. It consisted of 3350 kJ (800 kcal, with a 10 d menu rotation), and the macronutrient distribution consisted of 20–23% of energy from fat, 20–23% from protein, and 56–59% from carbohydrate. Subjects visited the GCRC twice a week to obtain all their meals, monitor body weight, and were reminded to consume only meals provided. The period of time between the onset of the intervention and the achievement of target BMI was defined as "days to goal." The exercise interventions have been previously described in detail (11). Briefly, the exercise regimens consisted of three supervised training sessions per week at our exercise research facility. For the DR group, sessions consisted of whole body resistance training (10 exercise stations, two sets of 10 repetitions with 2 min rest between sets at 80% of one repetition maximum weight lifted). The DE group sessions consisted of stationary cycling, stair stepping, and treadmill walking/running for 40 min, where the intensity was gradually increased from 67–80% of maximum heart rate.

Body composition

Body composition was assessed at baseline and immediately after weight loss by DXA (GE Lunar Prodigy; GE Healthcare, Madison, WI). Scans were analyzed for total fat and total lean mass using the software (Encore 2002, version 6.10.029).

DLW

The DLW technique was used to measure total energy expenditure (TEE) both immediately before and after the weight loss intervention (*i.e.* during the last 2 wk of the 4 wk supervised weight maintenance, see *Study design* section). The technical aspect has been previously described (12). In brief, a baseline urine sample (10 ml) was collected, followed by a mixed oral dose (~0.10 g/kg ^{18}O and 0.08 g ^2H/kg body mass) administration of DLW. The average initial isotope enrichments of two urine samples were obtained the morning after dosing, and on the 14th day, two additional final samples were obtained and results averaged. All urine samples were analyzed in triplicate for ^2H and ^{18}O by isotope ratio mass spectrometry at the Metabolic Core Laboratory of the Clinical Research Nutrition Center and the GCRC at our institution.

Adherence to diet and exercise

Dietary adherence was determined as follows. First, the average TEE was assessed by DLW during energy balance immediately before and after the interventions. The average of the two TEE values was used along with the provided energy intake to calculate the expected daily kilocalorie loss: expected daily kilocalorie loss = average TEE − 800 kcal (diet). Second, to convert losses of fat mass and fat-free mass to energy (*i.e.* kilocalories lost), we used energy coefficients of 9.3 and 1.1 kcal/g, respectively. For subjects accruing fat-free mass, an energy coefficient of 1.8 kcal/g was used (13, 14): total kilocalorie lost = [fat mass lost (g) × 9.3 kcal/g] + [Δ fat-free mass (kg) × 1.1 or 1.8 kcal/g]. Third, using the total kilocalories lost during the intervention and days to goal, we calculated the rate of energy loss per day: actual daily kilocalorie loss = total kilocalorie loss/d to goal = kilocalorie loss/d^{-1}. Fourth, knowing the actual daily kilocalorie loss and the expected daily kilocalorie loss, we can calculate the daily kilocalorie discrepancy, an index of dietary adherence: daily kilocalorie discrepancy = actual daily kilocalorie loss − expected daily kilocalorie loss. A daily kilocalorie discrepancy of zero represents 100% adherence. A positive number indicates a greater than expected daily kilocalorie loss, whereas a negative number suggests less than expected daily kilocalorie loss. Fifth, we expressed dietary adherence in relative terms: percent daily kilocalorie adherence = (actual daily kilocalorie loss/expected daily kilocalorie loss) 100.

Adherence to exercise was defined as the proportion of sessions completed *vs.* sessions scheduled. All exercise training occurred in a facility dedicated to research under the supervision of a research exercise physiologist. The subjects' prescribed exercise heart rate and duration were overseen via heart rate monitors (Polar, Vantaa, Finland) to ensure adherence for the appropriate intensity and duration. Resistance training was recorded in training logs.

adherence to exercise =

actual number of completed sessions/number of sessions scheduled

Statistics

Changes in anthropometric parameters (body weight, BMI, fat mass, fat-free mass, percent body fat) were assessed by repeated measures ANOVA using group as a categorical variable and Tukey *post hoc* follow-up tests. One-way ANOVA was used to examine group differences in age, days to goal, rate of weight/fat/lean mass loss, baseline TEE, total kilocalories lost, percent caloric restriction, actual daily kilocalorie lost, expected daily kilocalorie loss, daily kilocalorie excess, and percent dietary adherence. Pearson correlations were used to examine associations between percent dietary adherence and percent exercise adherence with: days to goal, percent caloric restriction, and percent of weight/fat/lean mass loss. All analyses were conducted using SPSS statistical package (version 16.0; SPSS, Inc., Chicago, IL). Results are expressed as means ± SD.

Results

A total of 227 subjects completed baseline testing and was randomized to one of three groups. Of these, 141 subjects successfully completed the weight loss intervention: 46 of 88 in the DE, 61 of 88 in DR, and 34 of 51 in DO groups, with no significant difference among groups noted. Most dropouts were secondary to loss of interest in diet (79 of 86); other reasons included: pregnancy (two), injury (one), fatality (one), divorce (one), went to medical school (one), and one was expelled for providing false information. Their weight loss was 5.6 ± 3.1 kg. Table 1 shows the demographical and anthropometric characteristics at baseline (all study participants) and post-weight loss (141 study participants), by group. At baseline there were no significant differences noted between groups. The table also shows baseline data on "dropouts" subjects lost to follow-up. *t* tests suggested no significant differences between "dropouts" and participants who completed the study. The interventions resulted in significant ($P < 0.05$) weight loss of 12.5 ± 2.2, 11.7 ± 2.4, and 12.2 ± 3.0 kg, representing 16.3 ± 2.6, 15.0 ± 2.5, and 15.6 ± 3.4% weight reductions from baseline for the DE, DR, and DO groups, respectively. Significant ($P < 0.01$) decreases were noted for percent body fat in all groups, with a significantly ($P < 0.01$) greater decrease in the DR compared with the DE and DO groups. Change in fat-free mass was significantly higher ($P < 0.05$) in the DR group (256 ± 1447 g) compared with DE (−476 ± 1390 g) and DO (−987 ± 1822 g) groups. Consequently, fat mass loss represented a significantly higher percentage of weight loss for the DR group (102.6 ± 12.3%) compared with the DE (96.8 ± 10.6%; $P < 0.05$) and DO (93.9 ± 13.7%; $P < 0.05$) groups. Specific rates of body weight, fat mass, and fat-free mass change are presented in Table 2.

Adherence to exercise and diet

Table 2 illustrates adherence to diet-related variables and adherence to exercise. Adherence to the exercise programs was similar between groups approximately 79%. At baseline, the 800-kcal diet restricted the DO slightly more than the DR group (62.4 ± 5.8 *vs.* 57.2 ± 9.5%; $P = 0.052$). The total and daily kilocalorie loss from energy stores calculated from fat and fat-free tissue did not differ between groups. Similarly, no group differences were noted on actual daily kilocalorie lost and expected daily kilocalorie loss. The daily kilocalorie discrepancy, an index of dietary adherence, was similar: 368 ± 487, 295 ± 367, and 424 ± 442 kcal/d^{-1} ($P = 0.422$) for the DE, DR, and DO groups, respectively. However, for all groups combined, a one-sample *t* test indicated that the daily kilocalorie discrepancy was different from zero ($P < 0.001$). The percent daily kilocalorie adherence was similar 74.4 ± 38.8, 75.8 ± 32.1, and 68.9 ± 32.8% for the DE, DR, and DO groups, respectively. The average for days to goal was not different among groups.

Associations between weight loss and adherence to diet and exercise

Dietary adherence correlates are shown in Table 3. When participants were analyzed together, there were significant cor-

TABLE 1. Demographical and anthropometric characteristics of 141 subjects that completed baseline and post-weight loss evaluations

	DE baseline	DE weight loss	DR baseline	DR weight loss	DO baseline	DO weight loss	*P* value
Age	35.2 ± 7.0		33.8 ± 6.0		35.6 ± 5.4		
Dropouts	34.1 ± 6.0		32.0 ± 5.6		34.1 ± 6.6		
BMI	28.47 ± 1.53	23.84 ± 1.12[a]	28.07 ± 1.16	23.87 ± 1.05[a]	28.23 ± 1.37	23.87 ± 1.08[a]	t < 0.01, g = 0.71, tg = 0.06
Dropouts	28.80 ± 1.00		27.40 ± 1.24		28.74 ± 2.05		
Body weight (kg)	76.9 ± 6.6	64.3 ± 6.1[a]	77.8 ± 7.7	66.0 ± 6.5[a]	78.1 ± 6.9	65.8 ± 6.3[a]	t < 0.01, g = 0.51, tg = 0.27
Dropouts	77.1 ± 6.4		74.2 ± 6.3		77.7 ± 7.4		
Fat-free mass (kg)	42.86 ± 3.72	42.47 ± 3.53[a]	44.16 ± 4.10	44.45 ± 4.04[a,b]	44.69 ± 3.67	43.71 ± 4.00[a]	t < 0.01, g < 0.01, tg = 0.08
Dropouts	42.39 ± 4.81		43.54 ± 4.31		43.50 ± 5.10		
Fat mass (kg)	34.06 ± 5.05	22.01 ± 4.59[a]	33.59 ± 5.24	21.57 ± 4.45[a]	33.42 ± 4.78	22.16 ± 4.46[a]	t < 0.01, g = 0.96, tg = 0.28
Dropouts	34.70 ± 4.12		30.67 ± 4.01		34.22 ± 4.38		
Body fat (%)	44.1 ± 3.8	33.9 ± 4.5[a]	43.0 ± 3.6	32.4 ± 4.6[a,b]	42.7 ± 3.4	33.4 ± 4.5[a]	t < 0.01, g = 0.30, tg = 0.03
Dropouts	44.9 ± 4.0		41.2 ± 3.7		44.0 ± 3.9		

Values are expressed as means± SD for the dropouts at baseline, across groups. g, Group effect; tg, time × group interaction; t, time effect.

[a] Significantly different from corresponding baseline value.

[b] Significantly different change from DE and DO.

TABLE 2. Adherence to interventions, rates of body composition change, days to goal, and kilocalorie-based calculations

	DE	DR	DO
Adherence exercise (%)	81 ± 2	77 ± 2	N/A
Rate of weight loss (g/d^{-1})	92.2 ± 41.7	87.0 ± 38.0	93.1 ± 48.8
Rate of fat mass loss (g/d^{-1})	91.2 ± 44.8	89.8 ± 40.5	84.5 ± 37.3
Rate of fat-free mass loss (g/d^{-1})	1.8 ± 10.7	−2.7 ± 11.6	8.6 ± 16.0[a]
Baseline TEE (kcal)	2,010 ± 432	1,955 ± 407	2,172 ± 270[b]
Weight loss TEE (kcal)	1,967 ± 399	1,954 ± 377	1,883 ± 412
% Caloric restriction	57.9 ± 11.0	57.2 ± 9.5	62.5 ± 5.5[c]
Total kilocalories lost	110,915 ± 15,878	110,793 ± 23,158	105,560 ± 20,591
Actual daily kilocalories lost	854 ± 412	834 ± 373	802 ± 365
Expected daily kilocalories loss	1,198 ± 343	1,162 ± 264	1,235 ± 310
Daily kilocalorie discrepancy	368 ± 487	295 ± 367	424 ± 442
% Kilocalorie adherence	74.4 ± 38.8	75.8 ± 32.1	68.9 ± 32.8
Days to goal	164.3 ± 80.7	159.0 ± 73.8	150.2 ± 48.3

N/A, Not applicable.

[a] *Post hoc* DO significantly different from DE ($P < 0.05$) and DR ($P < 0.01$).

[b] *Post hoc* DO significantly different from DR ($P = 0.055$).

[c] *Post hoc* DO significantly different from DR ($P = 0.052$).

relations between percent adherence to diet and days to goal, percent caloric restriction, percent weight lost, and fat mass loss. Given the inverse association between percent adherence to diet and percent caloric restriction, it is plausible that the subjects with greater fat mass (adjusted for fat-free mass) adhered less to diet. The analysis revealed no association (r = 0.08; $P = 0.365$).

Exercise adherence correlates are shown in Table 4. When the exercise groups were analyzed in unity, percent exercise adherence was correlated to days to goal, percent adherence to the diet, percent weight lost as fat mass, and percent weight lost as fat-free mass. The data were also analyzed by group. For the DE group, percent dietary adherence was correlated with percent weight lost as fat, percent weight lost as fat-free tissue, percent adherence to exercise, and percent caloric restriction. For the DR group, percent exercise adherence, but not percent dietary adherence, was correlated with percent weight lost as fat and percent weight lost as fat-free tissue. The percent adherence to diet was not correlated with percent exercise adherence or percent caloric restriction. For the DO group, percent dietary adherence was inversely correlated with percent caloric restriction and percent weight lost as fat, and positively correlated to percent weight lost as fat-free tissue.

Discussion

This study presents three key findings. First, the greater the dietary adherence of our subjects, the lower the number of days required to reach target weight. Second, it appears that the greater severity of caloric restriction, as measured by the proportion of energy not met by the 800-kcal/d diet, the less the dietary adherence. This suggests that moderate restriction relative to individual needs, rather than prescribing absolute energy intakes (*i.e.* 800-1200 kcal/d), would be preferable for optimal dietary adherence, in overweight women. Third, dietary adherence among the three groups was not significantly different whether subjects exercised or not. However, dietary adherence appears to have a differential effect on the quality of weight loss partitioning depending on whether exercise is included and its modality. To the best of our knowledge, our findings reflect the first attempt to quantify dietary adherence throughout a wide range of percent caloric restriction, in which food was provided throughout the intervention, and dietary adherence was compared among endurance training, resistance training, and DO groups.

We observed a wide range of dietary adherence in all three groups with no significant difference among groups. This wide range of adherence to diet translated into a wide range of days to reach target BMI, with no significant difference among groups. Indeed, we found significant inverse associations between dietary adherence and the number of days to reach target BMI. This was observed whether the subjects were pooled together or analyzed by group. Dansinger *et al.* (5) showed strong curvilinear associations (r = 0.60) between self-reports of dietary adherence and weight loss in overweight and obese patients, indicating that those subjects who reported high scores of adherence lost substantially more weight than those that reported low scores. Despite differences in methodology between the two studies, the

TABLE 3. Correlates of percent dietary adherence, all subjects and by individual groups

Variable	All subjects	DE	DR	DO
Days to goal	r = −0.687; $P < 0.001$	r = −0.672; $P < 0.001$	r = −0.736; $P < 0.001$	r = −0.679; $P < 0.001$
% Weight lost	r = 0.300; $P = 0.001$	r = 0.170; $P = 0.29$	r = 0.415; $P < 0.01$	r = 0.362; $P = 0.058$
% Weight lost as fat mass	r = 0.144; $P = 0.12$	r = 0.364; $P < 0.05$	r = 0.228; $P = 0.127$	r = −0.387; $P < 0.05$
% Weight lost as fat-free mass	r = −0.114; $P = 0.22$	r = −0.367; $P < 0.05$	r = −0.178; $P = 0.237$	r = 0.417; $P < 0.05$
% Caloric restriction	r = −0.349; $P < 0.001$	r = −0.467; $P < 0.01$	r = −0.142; $P = 0.36$	r = −0.508; $P < 0.01$

TABLE 4. Correlates of percent exercise adherence in both groups combined and by group

Variables	DE and DR	DE	DR
% Dietary adherence	r = 0.292; $P < 0.01$	r = 0.425; $P < 0.01$	r = 0.153; $P = 0.309$
Days to goal	r = −0.326; $P = 0.001$	r = −0.431; $P < 0.01$	r = −0.247; $P = 0.055$
% Weight lost as fat mass	r = 0.210; $P < 0.05$	r = 0.112; $P = 0.465$	r = 0.343; $P < 0.01$
% Weight lost fat-free mass	r = −0.193; $P < 0.05$	r = 0.118; $P = 0.438$	r = −0.318; $P < 0.05$
% Caloric restriction	r = 0.040; $P = 0.691$	r = −0.055; $P = 0.726$	r = 0.126; $P = 0.346$

results of both studies provide robust evidence indicating that adherence to diet is a strong predictor of weight loss during a wide range of dietary restriction. Heymsfield *et al.* (4) systematically analyzed fractional energy absorption and TEE in patients undergoing weight loss with low-calorie diets, and then used this information to model energy balance and applied it to probe for adherence to low-calorie diets. Their findings indicated that the suboptimal weight loss is likely due to difficulties with patient adherence and, to a less extent, to metabolic adaptations to negative energy balance. Strengths of our study are that we carefully controlled dietary intake and exercise adherence (often self-report is inaccurate), providing a quantitative analysis linking low-dietary adherence and low rates of weight loss.

Previous studies in obese women have hinted that the greater the severity of caloric restriction, the lower the dietary adherence (15–17). Although these studies suggest a relationship between energy deficits and dietary adherence, the studies did not directly measure TEE and were subject to substantial error in interpreting weight loss from fixed low-calorie diets (18). It is also important to note that the aforementioned studies had small samples of obese, not overweight, women without comorbidities, which may also modulate the effect of the exercise training response. The present study used DLW to obtain precise measures of TEE and a fixed calorie diet to generate a wide range (23–72%) of caloric restriction in overweight women. Although our interpretation is limited by the fact that multiple levels of restriction were not tested, the current data do support and strengthen hypotheses drawn from previous work that an inverse association exists between percent caloric restriction and adherence to diet.

We examined the relationship between dietary adherence and body composition change. The percent weight lost as fat mass and as fat-free mass was positively and negatively, respectively, associated with percent dietary adherence in the DE group. Conversely, the associations followed the opposite pattern in the DO group, indicating that the more the subjects adhere to the diet, the less body weight lost as fat and the more body weight lost as fat-free mass. However, for the DR group, the percent weight lost as fat mass and as fat-free mass was significantly correlated to exercise adherence, not to dietary adherence. Our findings in the DR group suggest that lean tissue was preserved, and 100% of the weight lost was lost as fat tissue, as previously reported under similar experimental conditions (19). The anabolic effect of resistance training was probably enhanced by the slightly less calorically restricted diet (57.2 *vs.* 62.5%), compared with the DO group. Together, it is suggested that dietary adherence modulates the partitioning of tissue loss for DO and diet plus endurance exercise interventions, whereas exercise adherence plays a greater role in the partitioning of tissue loss in a diet plus resistance exercise intervention.

Exercise adherence in the DE group was positively associated with dietary adherence, suggesting that those women who adhere to diet also tended to adhere to the endurance exercise program. The significant association is intriguing in light of no significant mean difference for percent dietary adherence or days to goal among groups. Similar dietary adherences to a 25% energy deficit have been reported in exercise and nonexercise groups (10). Although their energy deficit was substantially lower than ours (25 *vs.* ~60%) and the endurance exercise caloric contribution higher (287 *vs.* 85 kcal/d), both studies suggest that exercise does not enhance dietary adherence. In contrast, Racette (6) and Kempen (8) *et al.* have reported greater dietary adherence in obese women undergoing short-term (12 and 8 wk) caloric restriction with endurance exercise, suggesting that exercise might enhance dietary adherence in short-term dietary interventions. Together, the short-term intervention (6, 8) and the fixed caloric restriction (6, 10) of these studies *vs.* the long-term (average 22.6 wk) and fixed 800 kcal intake, producing a varying degree of energy restriction, are likely to account for the discrepancy.

Several strengths were included in the present study. First, food was provided with careful control of macronutrient content throughout the study. Second, the 14-d assessment of energy requirements during weight maintenance by DLW, which along with DXA determined body composition changes, allowed us to carefully quantify dietary adherence. Third, the large sample size allowed detection of relationships that might have been missed with fewer subjects. Fourth, comparisons could be made for adherence to diet between the different exercise groups. Finally, close supervision of exercise training throughout the study allowed us to evaluate exercise adherence.

Our study also had limitations. First, dietary adherence was calculated over a wide range of days. Because we did not perform serial measurements, our values provide an average, and one cannot discern the temporal resolution of low-dietary adherence or that exercise might enhance dietary adherence during the first few months of the intervention. Second, random measurement error in TEE was minimized by performing all the analyses at the same institution. However, we cannot exclude that during weight loss there might have been changes in the resting energy expenditure not captured in our pre- and post-weight loss measurements. Indeed, based on our prior research with 800 kcal/d calorie restriction, the decrease in resting energy expenditure would be relatively small, between 60 and 70 kcal/d (20). More importantly, the SE of measurement for this decrease was less than 5 kcal/d, even though some of the subjects were exercise training, suggesting that the low volume of training used in this study results in a relatively small deviation from the sedentary decrease in resting energy expenditure that would be expected, if no training occurred. Although some exercise training bias in energy expenditure energy reduction may have occurred, it is likely that the bias was small (*i.e.* magnitude of ~5 kcal/d) and did not significantly affect the relationship with percent dietary adherence. This would especially be the case for the relationship within groups, which would not have any potential bias from exercise training (*i.e.* everyone either trained or did not train). Finally, our study included only premenopausal women who concluded the study, and generalizations should be made with caution.

The study participants' calculated mean dietary adherence was 69–76% among interventions, in which approximately 40% of our subjects had a dietary adherence of 75% or more. The mean dietary adherence of the three groups translated to a noncompliance of 295–424 kcal/d^{-1} and has practical implications. Based on the total kilocalorie lost and the expected daily kilocalorie loss, the calculated expected number of days to reach goal would have been 91–102 d, compared with actual 150–164 d. This noncompliance prolonged the achievement of days to goal by nearly 2 months, and it might actually be an underestimate under real-world conditions because we provided all food, and subjects were closely monitored by a registered dietician. This indicates that if we are to attenuate successfully the degree of overweight, novel approaches to increase dietary adherence are urgently needed. For instance, our data show that the low-calorie diets create wide ranges of energy deficits, and those with the greatest degrees of restriction adhered the least. Moreover, among nonexercising subjects, those that adhere the most lost less fat and more fat-free mass. This underscores the need for individualized (21) moderate (*i.e.* 25–45%) caloric restriction.

In summary, in our diet-based weight loss intervention, dietary adherence is inversely associated with the time to reach target BMI and with the severity of caloric restriction. The latter suggests that individualized caloric restriction based on energy expenditure, rather than a fixed energy level, should be recommended by health care professionals. Future studies with two or more levels of caloric restriction are warranted. Although neither exercise mode *per se* enhanced dietary adherence, it prevented the loss of lean mass common of low-calorie diets.

Acknowledgments

We are grateful to Paul Zuckerman, program coordinator, David Bryan, exercise physiologist, Alexandra I. Vyazovkina for conducting doubly labeled water analysis, Betty Darnell, R.D., for coordinating the dietary intervention, and to Jose Fernandez, Ph.D., for his editorial input on this manuscript.

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This work was supported by the National Institutes of Health Grants R01 DK49779 and R01 DK 51684, DRR General Clinical Research Center Grant M01 RR-00032 from the National Center for Research Resources, and the Clinical Nutrition Research Unit P30 DK 56336.

Disclosure Summary: The authors have nothing to disclose.

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