

Exercise Motivation, Eating, and Body Image Variables as Predictors of Weight Control

PEDRO J. TEIXEIRA¹, SCOTT B. GOING², LINDA B. HOUTKOOPER², ELLEN C. CUSSLER³, LAUVE L. METCALFE³, ROB M. BLEW³, LUIS B. SARDINHA¹, and TIMOTHY G. LOHMAN³

¹Department of Exercise and Health, Faculty of Human Movement, Technical University of Lisbon, Lisbon, PORTUGAL; and ²Departments of Nutritional Sciences and ³Physiology, Body Composition Research Laboratory, University of Arizona, Tucson, AZ

ABSTRACT

TEIXEIRA, P. J., S. B. GOING, L. B. HOUTKOOPER, E. C. CUSSLER, L. L. METCALFE, R. M. BLEW, L. B. SARDINHA, and T. G. LOHMAN. *Med. Sci. Sports Exerc.*, Vol. 38, No. 1, pp. 179–188, 2006. **Purpose:** This study investigated changes in psychosocial variables related to exercise, eating, and body image during a weight reduction program and evaluated their association with weight loss in middle-aged overweight and obese women up to 1 yr after intervention. **Methods:** The 136 participants (age, 48.1 ± 4.4 yr; weight, 30.6 ± 5.6 kg·m⁻²) who completed the 4-month lifestyle weight reduction program (86% retention), losing $-6.2 \pm 4.6\%$ ($P < 0.001$) of their initial weight, were followed up for 12 additional months. Of these, 82% completed 16-month assessments (weight change, $-5.5 \pm 7.7\%$, $P < 0.001$). Psychosocial variables were assessed by validated instruments in standardized conditions at baseline and after the intervention (4 months). **Results:** Compared with 4-month assessments, body weight did not change at 16 months ($P > 0.09$). Changes in eating restraint, disinhibition, and hunger; exercise, self-efficacy, and intrinsic motivation; body shape concerns; and physical self-worth were associated with weight change at 4 months ($P < 0.001$, except hunger, $P < 0.05$). Baseline-adjusted 4-month scores in all psychosocial variables also predicted weight change from baseline to 16 months ($P < 0.01$, except hunger ($P > 0.05$)). After controlling for 4-month weight change and other covariates, increases in exercise intrinsic motivation remained predictive of weight loss at 16 months ($P < 0.05$). Multiple linear regression showed that eating variables were significant and independent correlates of short-term weight change, whereas changes in exercise variables were stronger predictors of longer term weight outcomes. **Conclusions:** Results highlight the importance of cognitive processes during weight control and support the notion that initial focus on diet is associated with short-term weight loss, while change in exercise-related motivational factors, with a special emphasis on intrinsic sources of motivation (e.g., interest and enjoyment in exercise), play a more important role in longer term weight management. **Key Words:** OBESITY, TREATMENT, PHYSICAL ACTIVITY, SELF-DETERMINATION, PSYCHOSOCIAL, MEDIATORS

Behavioral and cognitive-behavioral programs are popular treatment options for overweight and moderately obese individuals. In these programs, sometimes referred to as “lifestyle” or “behavior modification” programs, altering participants’ eating and physical activity behaviors and influencing cognitive factors (e.g., goals and expectations, self-evaluations, motivation, knowledge, and beliefs) thought to contribute to lasting behavior change are common treatment targets. Considering the available evidence regarding behavioral correlates of successful weight loss (38), comparatively little is known regarding psychological processes associated with long-lasting weight management. Given the large variability in individual obesity treatment programs, identifying variables that help explain why some people are successful while so many others is not is a clear research priority (2).

One possible reason why interventions are not more effective is that they do not sufficiently target true causal mechanisms of behavior change. Identification of reliable predictors of success in obesity treatment could help future programs in several ways. For example, an increased focus could be placed on those intervention components more likely to produce desired outcomes while discarding redundant ones. Also, understanding the time course of individual changes (e.g., thoughts, attitudes) during treatment and how they relate to outcomes would allow programs to target critical specific processes at the times when they are most important. With a description of critical mechanisms of change, researchers and clinicians may not only improve treatment efficacy and cost-effectiveness, but also gain insight into aspects that contribute to the persistence of the disorder in the first place.

Psychological variables (e.g., cognitive, attitudinal, affect related) related to exercise/physical activity and eating behaviors are good candidates to emerge as individual predictors of weight loss success. Failure to maintain adequate energy expenditure levels, particularly through volitional physical exercise (i.e., occupational, transportation, leisure time), is generally thought to be at the root of the obesity epidemic and physical activity has been positively associated with successful long-term weight control in cross-sectional, longitudinal, and retrospective studies (9). Self-

Address for correspondence: Pedro J. Teixeira, Ph.D., Faculdade de Motricidade Humana, Estrada da Costa, Cruz Quebrada, 1495-688 Lisbon, Portugal; E-mail: pteixeira@fmh.utl.pt.

Submitted for publication March 2005.

Accepted for publication July 2005.

0195-9131/06/3801-0179/0

MEDICINE & SCIENCE IN SPORTS & EXERCISE®

Copyright © 2006 by the American College of Sports Medicine

DOI: 10.1249/01.mss.0000180906.10445.8d

efficacy, (reduced) perceived barriers, and enjoyment are among the most consistent correlates of participation in physical activity (3) and have also been recommended as useful intervention targets for exercise promotion in weight management (4). However, limited empirical data are available to show the extent to which change in these variables are predictive of weight control, especially in the long term (30). Likewise, the ability to cognitively restrain dietary intake (e.g., limit caloric and fat intake) and avoid binge and emotional eating are regarded as positive processes for weight control (20). Variables from the Eating Inventory, especially cognitive eating restraint and disinhibition, have been used extensively in obesity behavioral research; increases in eating restraint and reduced disinhibition (i.e., emotional overeating) are frequently correlated with improved weight control when assessed concurrently (10). Improvement in body image has also been suggested as a critical intervention goal in the cognitive-behavioral treatment of obesity (7), but whether it is associated with additional weight loss and/or maintenance remains unclear (21).

The goal of the present study was to investigate changes in easily assessed psychosocial variables related to exercise, eating, and body image occurring during short-term weight loss and assess their ability to predict outcomes up to 16 months after the start of a behavioral weight reduction program in overweight and obese, middle-aged women. Considering the beneficial role of exercise and physical activity in the long-term management of obesity, we were particularly interested in analyzing the extent that treatment-related (i.e., 0–4 months) changes in psychosocial variables related to exercise were associated with success at follow-up *beyond* what could be accounted by more established eating behavior measures. We also hypothesized that improvements in body image would provide additional benefits in weight loss, after exercise and eating psychosocial variables were controlled.

METHODS

Subjects

Participants were recruited through newspaper and TV advertisements to participate in a university-based behavioral weight loss program. Subjects were required to be between 40 and 55 yr of age, have a body mass index (BMI) between 25.0 and 38.0 kg·m⁻², be a nonsmoker, and be free from major illnesses to be eligible. The University of Arizona's human subjects protection institutional review board approved the study, and all participants gave written informed consent before participation. One hundred fifty-eight women started the intervention, of which 136 completed the face-to-face 4-month program. This group of women, for whom complete data were available at baseline and treatment end (i.e., at 4 months), constituted the primary sample in the present study. The weight loss program was followed by a 1-yr follow-up/maintenance phase in which subjects were randomly assigned to ongoing online contact or no contact (control group). No difference in weight

change was observed between the two groups, so data were pooled for the present analysis. All participants agreed to refrain from participating in any other weight loss program for the duration of the study.

Intervention

Subjects met weekly with the intervention team in groups of approximately 25 subjects, for 150 min per session. Sessions were educational and experiential and participants were encouraged to adopt small but lasting changes in eating and physical activity patterns, leading to a moderate daily energy deficit (less 1260–2090 kJ·d⁻¹ (300–500 kcal·d⁻¹)). Dietary goals were to reduce energy intake by about 850–1650 kJ·d⁻¹ (200–400 kcal·d⁻¹) compared with habitual intake, and individualized dietary intake targets were set for all participants. Exercise prescription was directed at progressively increasing leisure-time moderate/vigorous physical activity to reach a minimum of about 6300 kJ·wk⁻¹ (1500 kcal·wk⁻¹) in exercise energy expenditure by the end of the program (about 900 kJ·d⁻¹ (200 kcal·d⁻¹)). A weight loss of about approximately 0.5 kg·wk⁻¹ was targeted. Weight was monitored weekly.

Topics on physical activity/exercise included planning and implementing a structured exercise plan to reach caloric expenditure goals; increasing daily walking and lifestyle physical activity; dealing with safety, weather, and equipment issues; and adopting self-monitoring strategies (e.g., using activity logs). The overarching goal was to increase subjects' competence and autonomy to levels sufficient to sustain regular participation in physical activity once the program was terminated. Some sessions included brief periods of physical activity (e.g., learning the basics of walking and setting up and using the pedometer, aerobics, dance sessions), although most activity was home or community based and unsupervised. Increases in self-efficacy toward exercise and physical activity (and related decreases in perceived barriers) were expected as a direct consequence of actual and vicarious exercise experiences during the program, regular verbal and social persuasion and encouragement from the intervention team and fellow participants, and functional/psychological benefits experienced upon increasing physical activity levels. For example, at the beginning of every session, participants were invited to share with the group their program-related experiences in the previous week. Often, subjects reported on how their participation in physical activities had affected their lives (e.g., improved mood and "energy," sleep quality, ability to complete physical daily tasks); these were often highly motivating accounts that clearly contributed to the group's intention to become more physically active. Subjects were also offered a list of strategies to overcome typical barriers to exercise (e.g., time, boredom, lack of facilities) and engaged in problem-solving group activities to identify their personal obstacles and develop contingency plans for future difficulties. Additionally, participants were explicitly and repeatedly advised to choose from a variety of options the activities that they most enjoyed and those in which significant

others could also participate, aiming at increasing intrinsic interest in and satisfaction with their activity experiences.

Nutrition and eating behavior topics included reducing portion sizes, increasing meal partitioning, reducing dietary fat content, preventing binge and emotional eating, planning for special occasions, monitoring hunger and avoiding severe hunger states, the importance of breakfast, choosing low-energy density and less processed foods, and increasing meal satiety (e.g., increasing a meal's water and fiber content), among many others. Also part of the curriculum were cognitive and behavioral aspects such as learning to self-monitor one's eating, physical activity, and body weight; facing lapses and relapses constructively; setting appropriate goals; managing daily stress; and eliciting social support. Finally, body image topics such as the identification of early sources of body image, how to deal with unrealistic social norms for body weight and shape, valuing the uniqueness of one's body features and functions independent of weight and fatness, overcoming body avoidance and repetitive body checking, and learning to enjoy physical movement (e.g., through dance, which was the topic of one practical session) were also addressed in the intervention. Mean attendance to the weekly sessions was 90.8% (range 26.7–100%).

Measurements

Weight was measured twice, to the nearest 0.1 kg (average was used) using an electronic scale (SECA model 770, Hamburg, Germany) and height was also measured twice, to the nearest 0.1 cm (average was used). BMI ($\text{kg}\cdot\text{m}^{-2}$) was calculated from weight (kg) and height (m). Subjects completed a battery of psychosocial questionnaire before the first weekly treatment session and again after the last session (approximately 4 months after the start of treatment) following a standard protocol and with a study technician attending every assessment period. Leisure-time physical activity was assessed at baseline and throughout follow-up, using the 7-d physical activity recall interview (25) and dietary intake was assessed from three randomly assigned days, using 24-h diet records (Minnesota Nutrient Data System (NDS) versions 2.8–2.92).

Eating-related variables. Eating (cognitive) restraint, eating disinhibition, and perceived hunger were assessed with the 51-item eating inventory (EI), also known as the three-factor eating questionnaire (31). The cognitive restraint scale (21 items) measures conscious attempts to monitor and regulate food intake, the disinhibition scale (16 items) measures uncontrolled eating in response to cognitive or emotional clues, and the perceived hunger scale (14 items) measures the extent to which respondents experience feelings of hunger in their daily lives. Higher scores indicate higher levels of restraint, disinhibition, and perceived hunger. Binge and uncontrolled eating was assessed with the binge eating scale (BES), which measures the severity of binge eating symptoms related to feelings, cognitions, and behavioral manifestations (15). Each of the 16 items from the BES contains statements that reflect a range of severity for each characteristic and have assigned weights. High

scores in this scale (sum of all items) indicate more binge eating symptoms. Scores above 17 indicate moderate binge eating symptoms and a score of 26 or more indicates severe binge eating (15).

Exercise-related variables. Self-efficacy for exercise was assessed with the self-efficacy for exercise behaviors scale (SEEB) (26), measuring beliefs that a person can “stick with” an exercise program for at least 6 months under varying circumstances. The questionnaire has two dimensions (“resisting relapse” ($\alpha = 0.79$), and “making time” ($\alpha = 0.72$)) with five items each. The average of the 10 items was used for the self-efficacy score, with high scores indicating high self-efficacy. Exercise perceived barriers were assessed with items from a previously validated scale, the exercise perceived barriers scale (EPB) (29). A two-item “obstacles” subscale from the original instrument was not included in analyses due to very low internal consistency ($\alpha = 0.05$); the dimensions of “time” (three items, $\alpha = 0.83$) and “effort” (six items, $\alpha = 0.76$) were measured, and the average of all nine items was calculated for the total EPB score. High values indicate a high number and/or degree of perceived barriers to regularly engage in physical activities.

Exercise motivation was assessed with a version of the intrinsic motivation inventory (IMI) (18) adapted to specifically measure an individual's level of motivation for exercise and physical activity in the dimensions of interest/enjoyment (e.g., “I enjoy getting involved in physical activities very much”), perceived competence (e.g., “I think I do pretty well at physical activities, compared to others”), effort/importance (e.g., “It is important for me to do well at physical activities”), and pressure/tension (e.g., “I am usually anxious when I engage in physical activities”), each with four items (alphas between 0.77 and 0.84). The interest/enjoyment scale is considered the effective measure of intrinsic motivation. Perceived competence and pressure/tension are considered precursors of intrinsic motivation, while effort/importance is a separate scale also correlated with general motivation for a given task. Analyses were performed for the four subscales and the average of all 16 items was also computed to provide a single score indicating overall level of exercise motivation, with higher scores indicating a more internal, self-regulated type of motivation. Because the pressure/tension scale is negatively correlated with all other scales of the IMI and with intrinsic motivation, responses to the four items from this scale were reversed for analyses.

Body image variables. Body image is a multidimensional construct and was assessed with the body shape questionnaire (BSQ) (6) and with two scales from the physical self-perception profile questionnaire (13). The BSQ measures concerns with body shape, in particular the experience of “feeling fat,” and consists of 34 items (e.g., “Has being with thin women made you feel self-conscious about your shape?”; “Has being naked, such as when taking a bath, made you feel fat?”) providing a total score for body shape concerns, with higher scores (sum of all items) indicating poorer body image. The physical self-perception profile

questionnaire (PSPP) measures self-esteem in several dimensions of the physical domain including a global physical self-worth scale (e.g., “some people feel extremely proud of who they are and what they can do physically”) and a body attractiveness scale (e.g., “some people feel that compared to most they have an attractive body”), which were used in this study. Each has six items and the average was calculated for each scale, with higher scores indicating higher physical self-worth and higher satisfaction with one’s body. The PSPP includes three additional scales (physical strength, sports competence, and physical condition), which were not analyzed in the present study.

Statistical Analyses

Measures of central tendency and distribution were examined for body weight and psychosocial variables at the different measurement periods. Weight outcomes were assessed by three different variables: weight change from baseline to 4 months (short-term weight loss), weight change from baseline to 16 months (longer term weight management), and also weight changes from 4 to 16 months, a marker for weight maintenance. These dependent measures were calculated as the residual value for the endpoint weight value (4 or 16 months) after the effect of initial weight for each period (baseline or 4 months) was “regressed out” by linear regression. For example, weight change from 4 to 16 months is expressed as the residual value from the regression of 16-month weight onto 4-month weight. The same procedure was used to calculate scores for all psychosocial predictors used in statistical analyses. This method is preferable to the use of subtraction scores, which can induce overcorrection of the post by the prescore (5); by design, the residual method creates a variable that adequately represents the change in the measure of choice and that is orthogonal with the pretreatment value.

Primary analysis included only subjects for whom weight data were available at 16 months (completers, $N = 111$). Additionally, to account for potential selective dropout biases known to limit completers-only analyses (36), we also performed analyses including all 136 women who had finished the initial treatment. To this end, a modified version of the last observation carried forward method (LOCF) was used, in which the last measured weight was used as the final measured weight plus 0.2 kg added for each month passed since the last laboratory assessment (LOCF+). The value of 0.2 kg per month is an estimated average for weight regain during follow-up, based on a review of behavioral obesity treatment studies (38). Despite some limitations, variations of the LOCF are commonly used in obesity longitudinal trials (34). For further insight into attrition-related bias, statistical comparisons of weight loss and psychosocial variables at 4 months (adjusted for baseline values) were conducted between the 111 16-month completers and the 25 women who dropped out after 4 months. Completers had lost 6.7% of their initial weight at 4 months while subjects who later dropped out had lost 4.1% during the same period ($P = 0.017$). Except for weight loss and self-efficacy ($P =$

0.034, completers displaying slightly higher values), no other significant differences were found between the two groups. Considering these results and also the similarity of correlations between psychosocial scores and weight outcomes between completers-only versus LOCF+ analyses, we used completers-only data for all subsequent analyses.

Paired t -tests were used to test the significance of change in mean psychosocial scores from baseline to 4 months. Pearson correlation assessed the linear bivariate relationship among psychosocial variables and between psychosocial predictors and weight outcomes. Multiple regression models were derived to evaluate multivariate estimates for the association between psychosocial predictors and weight change. *A priori* hierarchical regression models were used, where variables were entered (individually or in sets) in successive blocks, either forced in or presented to the model in stepwise fashion (F to enter, $P < 0.05$). Semipart correlation squared was used to determine the independent contribution of each predictor to the variance in the dependent variable. With 136 subjects, this study had a statistical power of 0.75 and 0.96 to detect as significant ($P < 0.05$) true correlation coefficients of 0.22 (5% variance accounted) and 0.31 (10% variance accounted), critical values in the behavioral sciences for *moderate* and *strong* levels of association, respectively (16). With 111 subjects (completers-only analysis), power to detect *moderate* and *strong* associations was reduced to 0.65 and 0.92.

RESULTS

Mean age (\pm SD) for the 136 participants was 48.1 ± 4.4 yr, mean BMI was $30.6 \pm 5.6 \text{ kg}\cdot\text{m}^{-2}$, and mean weight was 83.5 ± 11.6 kg. Participants had engaged in 2.2 ± 2.4 diets in the year before the program, had consciously started restricting their dietary intake at age 24.7 ± 10.6 yr, and about 62% of women reported they “felt pressure to lose/maintain weight.” According to the BES scale, about 30% of all subjects reported moderate binge eating symptoms (BES score 18–26), while only one woman had a score that suggested severe binge eating problems (BES >26).

Treatment effects. At the end of the 4-month treatment program, average weight change from baseline was -5.1 kg (-6.2% of initial weight). During the same period, mean dietary energy intake was reduced by $1670 \text{ kJ}\cdot\text{d}^{-1}$ ($406 \text{ kcal}\cdot\text{d}^{-1}$) and exercise energy expenditure increased by $640 \text{ kJ}\cdot\text{d}^{-1}$ ($153 \text{ kcal}\cdot\text{d}^{-1}$). At 4 months, about 36% of participants were reaching the goal of about $850 \text{ kJ}\cdot\text{d}^{-1}$ ($200 \text{ kcal}\cdot\text{d}^{-1}$) in exercise-related energy expenditure. Of all 136 women measured at treatment’s end, 111 (82%) completed body weight measurements at 16 months (overall program completion rate was 70%). At this final assessment period, body weight was an average of 4.6 kg (5.5%) lower than baseline weight, while the weight of all 136 participants was 4.0 kg (4.8%) lower than baseline using LOCF+. Weight change between 4 and 16 months was 0.8 kg (+1.1%) for the 111 women who completed the program. Individual variability in weight change was large at every assessment period, ranging from approximately -16 kg (-19%) to $+4$

TABLE 1. Scores, effect sizes, and intercorrelations for change in psychosocial variables ($N = 136$).

Psychosocial Variables	Baseline		4 month ¹		Effect Size	Intercorrelations ²								
	α	Mean \pm SD	α	Mean \pm SD		1	2	3	4	5	6	7	8	9
Eating variables														
1 Cognitive restraint	0.75	8.89 \pm 4.07	0.71	13.8 \pm 4.02	1.21									
2 Eating disinhibition	0.75	9.71 \pm 3.39	0.78	6.37 \pm 3.43	-0.98	-0.28								
3 Perceived hunger	0.79	6.60 \pm 3.51	0.78	3.77 \pm 2.99	-0.87	-0.19	0.73							
4 Binge eating	0.85	13.94 \pm 6.89	0.89	7.81 \pm 6.18	-0.94	-0.35	0.69	0.61						
Exercise variables														
5 Exercise self-efficacy	0.84	3.88 \pm 0.54	0.88	4.05 \pm 0.57	0.31	0.32	-0.43	-0.32	-0.33					
6 Exercise perceived barriers	0.74	2.99 \pm 0.67	0.84	2.39 \pm 0.74	-0.84	-0.35	0.50	0.39	0.43	-0.71				
7 Exercise motivation	0.90	3.40 \pm 0.66	0.91	3.75 \pm 0.62	0.55	0.27	-0.42	-0.36	-0.38	0.50	-0.57			
Body image variables														
8 Body shape concerns	0.95	104.9 \pm 26.8	0.96	79.8 \pm 26.2	-0.94	-0.27	0.55	0.50	0.64	-0.30	0.37	-0.36		
9 Physical self-worth	0.83	1.97 \pm 0.51	0.88	2.46 \pm 0.56	0.93	0.25	-0.49	-0.37	-0.53	0.46	-0.51	0.58	-0.45	
10 Body attractiveness	0.84	1.63 \pm 0.5	0.91	2.09 \pm 0.58	0.84	0.28	-0.38	-0.22	-0.47	0.34	-0.36	0.38	-0.48	0.67

¹ $P < 0.001$ for all changes from baseline to 4 months, except for exercise self-efficacy ($P = 0.001$).

² $P < 0.05$ for all bivariate associations. Change scores were calculated as 4-month score adjusted for baseline score.

α , Cronbach's alpha.

kg (+4%) at 4 months and from about -29 kg (-31%) to +8 kg (+8%) at 16 months for completers. Mean change, effect size, and intercorrelations for all psychosocial measures (4-month change score) are shown in Table 1. Except for exercise self-efficacy (small effects) and exercise intrinsic motivation (moderate effects), all other change effect sizes are considered large (i.e., > 0.5) (5). The largest effects were found for eating cognitive restraint and eating disinhibition. Correlation coefficients among psychosocial measures were generally strong (0.3 to 0.6). In some cases coefficients were higher (0.7), such as between perceived hunger and eating disinhibition and between exercise barriers and exercise self-efficacy.

Bivariate associations. Weight change from baseline to 4 months was associated with total weight change at 16 months ($r = 0.67$, $P < 0.001$) but not with weight change taking place during follow-up/maintenance (4-16 months, $r = 0.13$, $P = 0.179$). Neither age nor baseline BMI was significantly associated with weight outcomes. Table 2 shows correlation coefficients between psychosocial variables and weight outcomes for completers-only and for all women who finished treatment (LOCF+). The two sets of results (first three columns on the left vs last three columns on the right) are quite comparable, in agreement with the

findings that 16-month completers and 4-month completers who later dropped out displayed similar psychosocial profiles, as assessed by our battery (see Methods). For completers, attendance rate to the intervention sessions was correlated to weight change at 0-4 months ($r = 0.41$, $P < 0.001$), 0-16 months ($r = 0.39$, $P < 0.001$), and 4-16 months ($r = 0.20$, $P = 0.037$).

All psychosocial predictors were associated with 4-month body weight change and many were also correlated with 16-month weight change. Eating- (except perceived hunger) and exercise-related variables were related to short-term weight outcomes at similar magnitudes. However, exercise variables correlated the strongest with overall 16-month changes. Regarding weight change during the follow-up/maintenance period (4-16 months), only exercise variables and physical self-worth were significant predictors. Noticeably, exercise motivation was the best predictor ($P = 0.002$) compared with other significant correlates: perceived barriers ($P = 0.02$), self-efficacy ($P = 0.045$), and physical self-worth ($P = 0.049$). Among body image scores, the three measures were consistently associated with 4-month weight, whereas physical self-worth was clearly the best predictor of longer term results. Physical self-worth (with items like "when it comes to the physical part of themselves,

TABLE 2. Correlation between psychosocial variables and weight outcomes.

Psychosocial Variables ¹	Weight Outcomes ²					
	Completers ($N = 111$)			All Subjects ³ (LOCF+, $N = 136$)		
	0-4 months	0-16 months	4-16 months	0-4 months	0-16 months	4-16 months
Cognitive restraint	-0.50***	-0.30**	-0.03	-0.46***	-0.29**	-0.03
Eating disinhibition	0.44***	0.35***	0.15	0.29**	0.24**	0.12
Perceived hunger	0.23*	0.12	-0.01	0.17*	0.08	-0.02
Binge eating	0.48***	0.34***	0.10	0.46***	0.33***	0.08
Exercise self-efficacy	-0.47***	-0.41***	-0.19*	-0.34***	-0.33***	-0.16
Exercise perceived barriers	0.51***	0.45***	0.22*	0.39***	0.36***	0.18*
Exercise motivation	-0.42***	-0.46***	-0.29**	-0.37***	-0.41***	-0.26**
Body shape concerns	0.41***	0.29**	0.07	0.39**	0.28**	0.06
Physical self-worth	-0.48***	-0.42***	-0.19*	-0.42***	-0.36***	-0.17*
Body attractiveness	-0.43***	-0.23**	0.02	-0.35***	-0.20*	0.00

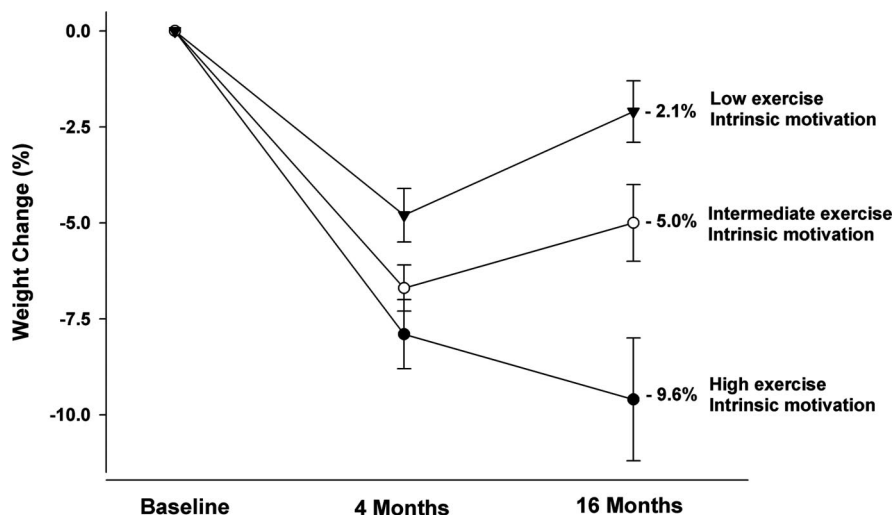
¹ Calculated as 4-month score adjusted for baseline score.

² Calculated as endpoint weight value (4-month or 16-month) adjusted for the initial value (baseline or 4-month). LOCF+, last observation carried forward plus 0.2 kg per month used as 16-month weight for 25 noncompleters.

³ Primary sample for this study, that is, participants who finished 4-month treatment.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

FIGURE 1—Weight loss at 4 and 16 months for groups defined by tertile of change in exercise intrinsic motivation (interest/enjoyment) during treatment ($N = 111$). Full circles indicate group with the largest change in exercise interest/enjoyment during treatment ($N = 36$); open circles indicate intermediate group ($N = 40$); triangles indicate group with the smallest change in interest/enjoyment ($N = 35$). Differences in weight change among groups (ANOVA) were significant at 4 ($P = 0.003$) and 16 ($P < 0.001$) months. At 4 months, only means for highest and lowest motivation groups were different from each other ($P = 0.002$, Tukey *post hoc* test). At 16 months, highest motivation group mean was different from both the intermediate ($P = 0.015$) and lowest ($P < 0.001$) groups (intermediate and lowest groups did not differ). Graph shows mean and SE for the three groups. Percentages on the right indicate overall mean weight change (0–16 months) for each group.



some people feel very confident” or “some people have great respect for their physical selves”) was more highly correlated with exercise predictors (e.g., exercise motivation) than the other two body image measures (Table 1). Among the four dimensions of the exercise motivation scale (IMI), exercise interest/enjoyment correlated the strongest with all weight outcomes ($r = -0.45$, $P < 0.001$ for interest/enjoyment vs $r = -0.33$ to -0.36 , $P \leq 0.001$, for the correlation with 16-month weight change).

For a more specific analysis of how exercise intrinsic motivation related to weight loss during the study, three groups of similar size, split by tertiles of change in exercise interest/enjoyment during treatment, were created. Figure 1 shows weight change for these groups at 4 and 16 months (mean and SE). Despite a large variability in weight loss within each of the three groups, only the group displaying the greatest increase in exercise intrinsic motivation continued to lose weight during the 1 yr following treatment.

Multivariate analysis. One aim was to assess whether exercise-related variables accounted for an additional amount of variance in weight loss, beyond that explained by eating-related variables. Additionally, it was of interest to evaluate whether 4-month changes in body image were

associated with weight loss and maintenance, after other variables (exercise and eating) were in the prediction models. Therefore, in multivariate models for 0- to 4- and 0- to 16-month weight change, after forced entry of eating-related variables, exercise variables were presented to the model (stepwise method), followed by the set of three body image variables (stepwise). Because perceived hunger was highly collinear with eating disinhibition and showed instability within prediction models (sign change when disinhibition was also present), perceived hunger was removed from the multivariate analyses.

For weight changes taking place exclusively during the maintenance/follow-up period (4–16 months dependent variable), a different procedure was used. To control for the potentially confounding effect of short-term weight loss on subsequent weight change, 0–4 month weight change was forced into the model at step 1. Then, based on results from the bivariate relationships, exercise variables and physical self-worth were entered at step two (stepwise), followed by all remaining variables (step three, stepwise). This procedure was conducted to test whether psychosocial changes during treatment explained weight change during the maintenance/follow-up, independent of their association with

TABLE 3. Hierarchical multiple regression models for weight outcomes ($N = 111$).

Independent Variables	Weight 0–4 months			Weight 0–16 months			Weight 4–16 months		
	B	P	sr ²	B	P	sr ²	B	P	sr ²
Weight 0–4 months	—	—	—	—	—	—	0.04	0.730	0.1
Cognitive restraint	-1.20	<0.001	8.0	-1.06	0.088	2.0			
Eating disinhibition	0.37	0.368	0.4	0.93	0.235	1.0			
Binge eating	0.73	0.050	2.1	0.50	0.503	0.3			
Exercise self-efficacy									
Exercise perceived barriers	1.12	0.002	5.6						
Exercise motivation				-2.18	<0.001	9.2	-1.34	0.008	6.2
Body shape concerns									
Physical self-worth									
Body attractiveness									
R ² (adjusted R ²)		43.3 (41.2)			27.0 (24.2)			8.4 (6.7)	
Model F		21.6 ($P < 0.001$)			7.7 ($P < 0.001$)			4.9 ($P = 0.009$)	

In models for 0–4 and 0–16 months weight change, eating-related variables were forced into the model at step 1, then exercise variables were presented to the model in step 2 (stepwise, F to enter $P < 0.05$), followed by body image variables in step 3 (stepwise, F to enter $P < 0.05$). In the 4–16 months weight model, weight change during treatment was forced in first, followed by exercise variables and physical self-worth (step 2, stepwise), after which all other variables were presented to the model (step 3, stepwise). See text for additional details.

short-term weight loss and also independent of weight loss itself during the initial 4 months.

Results in Table 3 show that high scores for eating (cognitive) restraint, low scores for binge eating, and low scores for exercise perceived barriers were independent significant predictors of short-term weight loss. Given the high intercorrelation between exercise barriers and self-efficacy, we also tested a similar model in which exercise self-efficacy was introduced instead of perceived barriers. Results were very similar for the model parameters ($R^2 = 43.8$ compared with 43.3 , $P < 0.001$ in both cases) and also for self-efficacy as a predictor in the model ($sr^2 = 4.7$, $P < 0.005$), compared with perceived barriers ($sr^2 = 5.6$, $P < 0.002$). When overall weight change (0–16 months) was used as the dependent variable, only exercise motivation significantly predicted outcomes. To test the association of exercise motivation with overall weight loss independent of exercise perceived barriers and self-efficacy, two additional models were tested. In the first, perceived barriers score was entered as a predictor together with eating variables; only exercise motivation was a significant predictor ($sr^2 = 4.4$, $P < 0.012$) of residual 0–16 weight change. Similar results were obtained when self-efficacy change was included instead of perceived barriers ($sr^2 = 5.2$, $P < 0.006$ for exercise motivation). When the four IMI subscales were presented in stepwise fashion to the previous model (i.e., after eating variables and self-efficacy were already in the model) instead of the summary motivation score, only exercise interest/enjoyment was a significant predictor ($sr^2 = 6.7$, $P < 0.002$) (data not shown).

For changes during the follow-up/maintenance and accounting for short-term weight change, again exercise motivation was the only significant independent predictor in the primary model (Table 3). A second regression procedure was conducted in which exercise motivation subscales were presented to the model in stepwise fashion after 0- to 4-month weight change had been already forced in. Only interest/enjoyment significantly entered the model at step 2 ($sr^2 = 6.8$, $P < 0.005$), with the full model accounting for 9.0% of the variance in 4- to 16-month weight change ($F = 5.3$, $P = 0.006$). Finally, using 4- to 16-month weight change as the dependent variable, regression models were conducted in which eating (restraint, disinhibition, and binge eating) and body image (BSQ and PSPP scales) variables were each entered in models that only included 0- to 4-month weight change as the other independent variable. The goal was to evaluate whether changes in each of these variables during treatment explained weight change during follow-up, after short-term weight loss was controlled. In all cases, no significant increases in the model's adjusted R^2 were observed when either eating or body image variables were added to initial weight change.

DISCUSSION

This study identified several psychosocial correlates of short- and long-term weight loss during obesity treatment in women. Main results show that (i) increases in cognitive

eating restraint and in exercise self-efficacy (and reductions in perceived barriers), and to a lesser degree a reduction in binge eating symptoms, significantly and independently predict short-term weight loss; (ii) increases in exercise motivation during treatment, particularly feelings of enjoyment and interest (i.e., *intrinsic motivation* for physical activity/exercise), explain some of the long-term effects of the intervention on weight control, above and beyond changes in weight and eating-related variables; (iii) a significant part of the association between exercise motivation and 16-month outcomes is due to processes taking place exclusively *after* treatment, before and after controlling for weight change during initial treatment; and (iv) positive changes in body image parallel weight loss but do not add explanatory power after exercise and eating variables are present in the predictive models.

It is generally accepted that reducing energy intake is a necessary condition for weight loss to occur in overweight and obese individuals. Indeed, it was not surprising to observe change in variables from the EI and also scores in the BES associated with weight loss. Other investigators have consistently shown that eating restraint in particular is a strong correlate of weight control (11). Reductions in binge eating (a variable typically highly intercorrelated with eating disinhibition from the EI) have also been shown to predict weight changes (28). We were able to demonstrate that these associations are due primarily to processes taking place while treatment is ongoing, as no additional relationship could be detected between eating-related variables and changes in body weight after treatment was completed.

Despite the cumulative evidence of the positive role of regular physical activity and exercise in long-term weight management, it remains unclear why only some individuals seeking weight loss are ultimately able to adopt and successfully integrate activity behaviors into their lifestyles. We explored the role of treatment-related changes in variables such as exercise self-efficacy, perceived barriers, feelings of competence, enjoyment, and perceived pressure for exercise, as potential predictors of weight outcomes, during and after the behavioral program. Exercise self-efficacy and perceived barriers were highly intercorrelated in our sample and their associations with weight outcomes, both in the short and long term, were also very similar and to some degree interchangeable. This is not surprising given the similarities between the two measures; the SEEB asks how confident respondents are that they will be able to exercise regularly in the face of several impediments (e.g., time constraints, being tired, being bored), most of which are also listed as potential barriers in the EPB. Self-efficacy in particular is a mature construct in social psychology and describes an individual's perceived ability to organize and execute processes (cognitive, motivational, affective, and decisional) necessary to reach a certain goal (1). More efficacious persons possess a high level of self-regulatory skills such as the ability to set appropriate goals, monitor their progress, and enlist sources of support, all of which can influence motivation for the targeted behaviors and behavior change itself. Our results suggest that some or all of the

previous processes, specifically for exercise behaviors, were influenced by the 4-month intervention program and that these changes were significantly associated with level of success in weight management.

Consistent evidence exists for exercise self-efficacy as a predictor of exercise and physical activity in populations other than the overweight/obese (3,27). However, few previous studies have analyzed exercise self-efficacy in the context of obesity treatment. Baseline exercise self-efficacy and motivation for exercise predicted 4-month, but not 12-month, changes in physical activity in overweight men and women undergoing a very brief (three 20-min sessions) nurse-conducted counseling program (30). Two other previous studies have shown that baseline measures of exercise self-efficacy predict both short- and long-term weight loss (32,33). The present results expand on previous work by showing that *changes* in exercise efficacy beliefs do occur during a short-term intervention and are significantly and positively related to weight control, independent of baseline scores. It must, however, be noted that efficacy expectations are strongly influenced by mastery experiences in the behavior itself (i.e., there are reciprocal effects between efficacy and behavior) and also by physiological and emotional states (1). Thus, positive exercise experiences during treatment and improvements in mood, physical fitness, and self-/body image could in turn have influenced changes in efficacy scores for many women.

While gains in exercise self-efficacy and a reduction in perceived barriers were good correlates of short-term weight loss, increases in intrinsic motivation for physical activities was the strongest predictor of longer term results among the variables analyzed. A central tenet of the self-determination theory (SDT), intrinsic motivation describes a person's overall satisfaction from participating in a given activity for the sake of the activity itself (23). Whereas extrinsic types of motivation are contingent on reaching a goal separated from the behavior (e.g., getting a reward, compliance with others' expectations, not feeling guilty), intrinsically motivated behaviors originate in the person (i.e., they have an internal locus of causality), are internally regulated, and are inherently enjoyable and interesting. Importantly, according to SDT, engaging in activities that are intrinsically motivated (or well integrated with one's values) and not externally controlled is central to fulfill human beings' fundamental needs for competence and autonomy (23).

In the context of exercise adherence, understanding which motivational aspects are more important for long-lasting participation is a key question, whether subjects are involved in a weight management program or in recreational physical activity (e.g., fitness class, walking group, school setting). Because few data are available concerning exercise motivation in the context of weight control, results from other settings are helpful in understanding the present study's findings. For example, Ryan et al. (24) showed that adherence to exercise in individuals participating in fitness classes was higher when intrinsic motives related to enjoyment and feelings of competence were reported, compared to when body-related outcomes (conceptualized as extrin-

sic) were the primary motivation. In a different study, the relationship between intrinsic and extrinsic exercise motives and exercise stage of change was analyzed in 425 British government employees (17). Extrinsic motives such as appearance and weight management predominated in the early stages of adoption, while reasons related to intrinsic motivation (described as "enjoyment and revitalization") were clearly stronger for subjects in the maintenance stage (17). Comparable results were observed very recently in a trial in young male and female adults (22). With direct relevance to the present findings, McAuley and Jacobson (19) analyzed the relationships among self-efficacy, intrinsic motivation, and perception of success in participants in aerobics classes, showing that self-efficacy contributes to the development of intrinsic motivation (independent of estimations of success) primarily through increases in feelings of competence. Very recently, in a randomized clinical trial, increases in enjoyment mediated physical activity in female adolescents involved in a school-based intervention (8). Overall, enjoyment, perceptions of competence, and intrinsic reasons for participation appear to play a central role in the maintenance of exercise and physical activity behaviors.

In a study specifically designed to study the effects of motivational factors during a weight control program, Williams et al. (37) showed that having a stronger autonomy orientation and maintaining autonomous reasons for participation throughout the program (as opposed to controlling motivations) were predictors of better weight loss and maintenance in multivariate path analysis models. A high sense of autonomy is a hallmark of behaviors that are intrinsically regulated (23). Autonomous reasons for continuing to follow the program's guidelines during the follow-up period were also associated with exercise participation at follow-up. Although not directly addressing motivation for exercise, this well-conducted study provides support for the utility of SDT in the context of weight management (37). The study of specific characteristics of motivation (e.g., autonomous vs controlled, intrinsic vs extrinsic) and further applications of SDT in the behavioral treatment of obesity are potentially fruitful areas to explore in future research.

Many overweight and obese persons dislike their bodies and a poor body image has been associated with binge eating (35) and low self-esteem (12), and may partially explain the level of psychological distress in obese individuals (14). One previous study evaluated the independent effects of including a body image therapy component into a behavioral program (21). Results showed that interventions both with and without the body image component produced significant improvements in body image and resulted in similar weight loss after the 16-wk treatment program and at the 1-yr follow-up. The authors suggested that weight loss treatment could alone be "good body image therapy," if well-rounded and if a behavioral component was included (21). In the present study, measures of body image shared about 10–25% of the variance in weight change, a significant association. However, results indicate that changes in body/fat concerns and body attractiveness are mainly associated with short-term weight loss and thus may be a con-

sequence as much as a cause of weight loss. In slight contrast, increases in the *physical* dimension of self-evaluation (e.g., “some people feel proud of what they are and what they can do physically”), perhaps due to its close association with exercise behaviors and attitudes, may be a better predictor of long-term success with weight control. On the whole, we believe these results should not be interpreted as proof that improvements in body image are irrelevant to the efficacy of behavioral programs for obesity. In the current study, changes in body image variables were clearly positive and may have interacted with other variables, including some that were not analyzed such as mood and self-esteem, to influence long-term outcomes (14).

This study is limited by a relatively small sample size and moderate levels of attrition and most especially by the absence of a control group, which would have made possible the evaluation of true mediation effects for the variables under scrutiny. Findings from this study should be most applicable to middle-aged, overweight and moderately obese females enrolled in programs similar to the one described in the current study.

In conclusion, the present findings provide empirical support of the notion that influencing individuals’ sense of

efficacy and their (type of) motivation for regular exercise, from early on in the program, are related to overall success in lifestyle obesity programs. Importantly, these relationships appear to be independent of initial changes in weight and eating-related cognitive changes. Strategies to increase self-efficacy are well described (4) and include the use of vicarious/enactive experiences (e.g., learning from or observing others who have been regularly active), inducing emotional activation (e.g., experiencing the psychological benefits from regular exercise), and also verbal/social persuasion, all of which can be used in obesity treatment. Moreover, ensuring that individuals ultimately take on physical activities that they intrinsically enjoy and feel competent at and that contribute positively to their sense of autonomy and self-determination may be key factors for greater success in the difficult task of long-lasting weight control.

The authors thank all the women who participated in the Healthy Weight 4 Life study. The first author also personally acknowledges Dr. “Chuck” B. Corbin for his lifetime promoting of intrinsic sources of motivation for physical activity and exercise.

This study was supported by NIH grant DK57453.

REFERENCES

- BANDURA, A. SELF-EFFICACY: THE EXERCISE OF CONTROL. NEW YORK: W. H. FREEMAN, 1997.
- BARANOWSKI, T., K. W. CULLEN, T. NICKLAS, D. THOMPSON, and J. BARANOWSKI. Are current health behavioral change models helpful in guiding prevention of weight gain efforts? *Obes. Res.* 11(Suppl 1):23S–43S, 2003.
- BAUMAN, A. E., J. F. SALLIS, D. A. DZEWALTOWSKI, and N. OWEN. Toward a better understanding of the influences on physical activity: the role of determinants, correlates, causal variables, mediators, moderators, and confounders. *Am. J. Prev. Med.* 23:5–14, 2002.
- BIDDLE, S. J., and K. R. FOX. Motivation for physical activity and weight management. *Int. J. Obes. Relat. Metab. Disord.* 22(suppl 2):S39–47, 1998.
- COHEN, J., and P. COHEN. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates, 1983, pp. 414–417.
- COOPER, P. J., M. J. TAYLOR, Z. COOPER, and C. G. FAIRBURN. The development and validation of a body shape questionnaire. *Int. J. Eat. Disord.* 6:485–494, 1987.
- COOPER, Z., and C. G. FAIRBURN. A new cognitive behavioural approach to the treatment of obesity. *Behav. Res. Ther.* 39:499–511, 2001.
- DISHMAN, R. K., R. W. MOTL, R. SAUNDERS, et al. Enjoyment mediates effects of a school-based physical-activity intervention. *Med. Sci. Sports Exerc.* 37:478–487, 2005.
- DONNELLY, J. E., B. SMITH, D. J. JACOBSEN, et al. The role of exercise for weight loss and maintenance. *Best Pract. Res. Clin. Gastroenterol.* 18:1009–1029, 2004.
- ELFHAG, K., and S. ROSSNER. Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. *Obes. Rev.* 6:67–85, 2005.
- FOSTER, G. D., T. A. WADDEN, R. M. SWAIN, A. J. STUNKARD, P. PLATTE, and R. A. VOGT. The Eating Inventory in obese women: clinical correlates and relationship to weight loss. *Int. J. Obes. Relat. Metab. Disord.* 22:778–785, 1998.
- FOSTER, G. D., T. A. WADDEN, and R. A. VOGT. Body image in obese women before, during, and after weight loss treatment. *Health Psychol.* 16:226–229, 1997.
- FOX, K. R., and C. B. CORBIN. The physical self-perception profile: development and preliminary validation. *J. Sport Exerc. Psychol.* 11:408–430, 1989.
- FRIEDMAN, K. E., S. K. REICHMANN, P. R. COSTANZO, and G. J. MUSANTE. Body image partially mediates the relationship between obesity and psychological distress. *Obes. Res.* 10:33–41, 2002.
- GORMALLY, J., S. BLACK, S. DASTON, and D. RARDIN. The assessment of binge eating severity among obese persons. *Addict. Behav.* 7:47–55, 1982.
- GOULD, J. E. *Concise Handbook of Experimental Methods for the Behavioral and Biological Sciences*. Boca Raton, FL: CRC Press, 2002, pp. 366–370.
- INGLEDEW, D. K. I., D. MARKLAND, and A. MEDLEY. Exercise motives and stages of change. *J. Health Psychol.* 3:477–489, 1998.
- MCAULEY, E., T. DUNCAN, and V. V. TAMMEN. Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: a confirmatory factor analysis. *Res. Q. Exerc. Sport.* 60:48–58, 1989.
- MCAULEY, E., and L. JACOBSON. Self-efficacy and exercise participation in sedentary adult females. *Am. J. Health Promot.* 5:185–191, 1991.
- MCGUIRE, M. T., R. R. WING, M. L. KLEM, W. LANG, and J. O. HILL. What predicts weight regain in a group of successful weight losers? *J. Consult. Clin. Psychol.* 67:177–185, 1999.
- RAMIREZ, E. M., and J. C. ROSEN. A comparison of weight control and weight control plus body image therapy for obese men and women. *J. Consult. Clin. Psychol.* 69:440–446, 2001.
- ROSE, E. A., G. PARFITT, and S. WILLIAMS. Exercise causality orientations, behavioural regulation for exercise and stage of change for exercise: exploring their relationships. *Psychol. Sport Exerc.* 6:399–414, 2005.
- RYAN, R. M., and E. L. DECI. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* 55:68–78, 2000.
- RYAN, R. M., C. M. FREDERICK, D. LEPES, N. RUBIO, and K. M. SHELDON. Intrinsic motivation and exercise adherence. *Int. J. Sport Psychol.* 28:335–254, 1997.
- SALLIS, J. F., W. L. HASKELL, P. D. WOOD, et al. Jr. Physical activity assessment methodology in the Five-City Project. *Am. J. Epidemiol.* 121:91–106, 1985.
- SALLIS, J. F., M. A. PINSKI, R. B. GROSSMAN, T. L. PATTERSON, and P. R. NADER. The development of self-efficacy scales for health-

- related diet and exercise behaviors. *Health Educ. Res.* 3:283–292, 1988.
27. SHERWOOD, N. E., and R. W. JEFFERY. The behavioral determinants of exercise: implications for physical activity interventions. *Annu. Rev. Nutr.* 20:21–44, 2000.
 28. SHERWOOD, N. E., R. W. JEFFERY, and R. R. WING. Binge status as a predictor of weight loss treatment outcome. *Int. J. Obes. Relat. Metab. Disord.* 23:485–493, 1999.
 29. STEINHARDT, M. A., R. K. DISHMAN. Reliability and validity of expected outcomes and barriers for habitual physical activity. *J. Occup. Med.* 31:536–546, 1989.
 30. STEPTOE, A., E. RINK, and S. KERRY. Psychosocial predictors of changes in physical activity in overweight sedentary adults following counseling in primary care. *Prev. Med.* 31:183–194, 2000.
 31. STUNKARD, A. J., and S. MESSICK. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J. Psychosom. Res.* 29:71–83, 1985.
 32. TEIXEIRA, P. J., S. B. GOING, L. B. HOUTKOOPER, et al. Weight loss readiness in middle-aged women: psychosocial predictors of success for behavioral weight reduction. *J. Behav. Med.* 25:499–523, 2002.
 33. TEIXEIRA, P. J., S. B. GOING, L. B. HOUTKOOPER, et al. Pretreatment predictors of attrition and successful weight management in women. *Int. J. Obes. Relat. Metab. Disord.* 28:1124–1133, 2004.
 34. WADDEN, T. A., G. D. FOSTER, D. B. SARWER, et al. Dieting and the development of eating disorders in obese women: results of a randomized controlled trial. *Am. J. Clin. Nutr.* 80:560–568, 2004.
 35. WARDLE, J., J. WALLER, and L. RAPOPORT. Body dissatisfaction and binge eating in obese women: the role of restraint and depression. *Obes. Res.* 9:778–787, 2001.
 36. WARE, J. H. Interpreting incomplete data in studies of diet and weight loss. *N. Engl. J. Med.* 348:2136–2137, 2003.
 37. WILLIAMS, G. C., V. M. GROW, Z. R. FREEDMAN, R. M. RYAN, E. L. DECI. Motivational predictors of weight loss and weight-loss maintenance. *J. Pers. Soc. Psychol.* 70:115–126, 1996.
 38. WING, R. R., and J. O. HILL. Successful weight loss maintenance. *Annu. Rev. Nutr.* 21:323–341, 2001.