Effects of Exercise during Weight Loss Maintenance on Appetite Regulation in Women

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ABSTRACT

Exercise is accepted as a method to improve weight loss maintenance; however, the mechanisms by which this occurs have yet to be elucidated. In this pilot study, 13 women with obesity underwent a structured weight loss program (goal 8%–10% weight loss) and were then randomized to either a 12-wk diet ($n = 7$) or an aerobic exercise training ($n = 6$) intervention aimed at maintaining weight loss. At baseline, post–weight loss, and following the weight loss maintenance interventions, measurements of appetite (hunger and satiety) and appetite-regulating hormones (leptin, ghrelin, peptide tyrosine tyrosine, and glucagon-like peptide 1) were obtained after an overnight fast and for 3 h after a standardized test meal. *Ad libitum* energy intake was measured at a lunch meal. During the weight loss phase, participants lost 9.1% ± 1.1% of baseline body weight. Participants in both groups maintained weight loss during the 12-wk weight loss maintenance intervention. No differences in fasting leptin ($P = 0.68$) or in ghrelin ($P = 0.30$), peptide tyrosine tyrosine ($P = 0.93$), and glucagon-like peptide 1 ($P = 0.98$) area under the curve were detected between groups. Similarly, ratings of hunger ($P = 0.99$) and satiety ($P = 0.65$) area under the curve after the standardized test meal also did not differ between the groups nor did *ad libitum* energy intake at lunch. In summary, the 12-wk diet and exercise interventions were equally effective at maintaining weight loss in women, and no differences in measures of appetite regulation and food intake were found.

INTRODUCTION

One of the greatest obstacles in overcoming the obesity epidemic is the unsustainability of maintaining weight loss. It is estimated that 80% of individuals that undergo significant weight loss are unable to maintain that weight loss for longer than 1 yr (1). A working group from the National Institutes of Health organized to identify factors contributing to the high recidivism rate found both metabolic and behavioral factors contribute to weight regain (2). First, the biological and behavioral adaptations, including long-term changes in appetite-regulating hormones (3), that occur after calorie-restricted weight loss promote increased appetite and decreased energy expenditure (2,4). Second, adherence to weight loss strategies diminishes over time because the perceived benefits decline compared with the cost of adherence as the goal changes from weight loss to weight loss maintenance (WLM) (2). To improve WLM, researchers and clinicians must identify sustainable strategies that combat the biological and behavioral adaptations that promote weight regain.

Epidemiological and observational data suggest that exercise is a promising method to improve WLM because it targets several of these maladaptive biological responses to weight loss (5) and appears to allow for improved matching of energy intake to energy expenditure (6,7). The National Weight Control Registry is the largest prospective investigation of successful, long-term, WLM (8). Studies from the registry have identified a program of regular exercise as a key characteristic of successful WLM (9,10). Population studies of long-term WLM corroborate the National Weight Control Registry findings (11) and suggest that sustained WLM is unlikely unless regular exercise is used as a WLM strategy (5).

Acute exercise has been shown to alter the release of gastrointestinal appetite-regulating hormones in a manner that supports decreased hunger and food intake. This effect of acute exercise is a promising mechansim by which exercise could improve WLM. A meta-analysis investigating the acute effects of exercise on gastrointestinal hormones in healthy individuals found a supression of the orexigneic hormone ghrelin along with a

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potentiation of peptide tyrosine tyrosine (PYY), glucagon-like peptide 1 (GLP-1), and pancreatic polypeptide (12). These changes in hormone secretion are in directions that could support decreased hunger and food intake. A similar analysis of studies conducted in individuals with overweight and obesity found ghrelin secretion was supressed, and PYY and GLP-1 were not significantly affected (13). These acute studies have been largely conducted in men and in individuals that had not undergone weight loss. Much less is known about how exercise may chronically affect these appetite-regulating hormones particuarly during WLM.

To address this, the current pilot study assessed WLM success in weight-reduced women with obesity who were randomized to either a diet or an exercise intervention during WLM. We compared hormonal (ghrelin, PYY, GLP-1, and leptin) and subjective (hunger and satiety) appetite-related responses to a standardized test meal. We hypothesized that exercise would improve measures of hormonal and appetite regulation in a manner that favored a reduced energy intake. This pilot study warrants replication in a larger sample and for a longer duration but is an important step toward facilitating the development of improved WLM therapies and allow for better outcomes in women-specific obesity treatments.

METHODS

Study Participants

Participants included women with obesity (body mass index, 30–40 kg·m^{-2}), 21–65 yr old, that were otherwise healthy, as assessed by the absence of diabetes (HbA1c), eating disorders (EATS-26), or depression (CES-D). Participants were weight stable (<5% change in body mass) by self-report for a minimum of 6 months before entering the study and reported they did not take part in planned exercise more than 3 h·wk^{-1}.

Study Design

The study consisted of three study phases, as shown in Figure 1. Briefly, after baseline testing, weight loss was initiated until an 8%–10% reduction in body weight was achieved. After the weight loss phase, body weight was stabilized (±2 kg) for 2–4 wk. Participants were then randomized to a 12-wk WLM intervention consisting of continuing diet support (WLM-D) or an aerobic exercise intervention (WLM-Ex). Assessments were repeated after both the weight stabilization and the WLM phases. Details of attrition rates during each phase are provided in Figure 2.

Weight Loss Phase

After baseline testing, participants entered the weight loss phase of the study. To ensure weight loss of 8%–10% of baseline body mass over a 12- to 16-wk period, participants were placed on a low-calorie meal replacement diet (Health One, Health Nutrition Technologies, CA). The meal replacements provided 1050 kcal and 100% of all essential vitamins and minerals. Weight loss instructions and supervision were provided by the Clinical Core of the Nutrition Obesity Research Center (NORC) at the Anschutz Health and Wellness Center (AHWC). Participants met with a research dietitian weekly for weigh-ins. When participants had successfully achieved an 8%–10% weight loss, they were then weight stabilized (±2 kg) for 2–4 wk before weight loss phase testing to minimize the acute effects of weight loss on the outcome variables. Participants were then randomized to either a diet (WLM-D, n = 7) or an exercise training (WLM-Ex, n = 6) intervention during the WLM phase of the study. At the end of 12 wk, all participants underwent repeat testing.

Diet WLM Intervention (WLM-D)

The diet intervention included continued biweekly follow-up with study personnel consisting of weigh-ins and ongoing diet-specific support from a research dietitian to maintain weight loss. Participants were provided individualized calorie goals and given the option to continue using liquid meal replacements as part of their WLM strategy. Attendance at these weekly/biweekly meetings was not recorded. Participants were instructed to not change their physical activity for the duration of the WLM-D.

Exercise Training WLM Intervention (WLM-Ex)

The exercise intervention was a supervised program performed in the Fitness Center at the AHWC. The goal of the intervention was to increase energy expenditure by 2000 kcal·wk^{-1}. This was achieved through a gradual increase (over the first 6 wk) in exercise energy expenditure from 150 kcal·d^{-1} to a target of 400 kcal·d^{-1}, 5 d·wk^{-1}. Individualized exercise prescriptions were provided based on a VO_{2max} test (Blake treadmill protocol) completed post–weight loss phase testing, and exercise intensity was set at 75% VO_{2max}. Exercise consisted primarily of walking on an inclined motor-driven treadmill with alternate activities (e.g., stationary bike, elliptical) permitted for 20% of the exercise sessions (1 of 5 d). Participants wore heartrate monitors during exercise sessions and met weekly/biweekly with study personnel to monitor exercise adherence. Acceptable adherence was defined as four or more exercise sessions per week. Participants in the WLM-Ex group did not receive any ongoing dietary support beyond what they had received during the weight loss phase of the study.

Study Day

Before each of the three study phase testing visits, participants consumed a eucaloric run-in diet for 3 d provided by the University of Colorado's Clinical and Translational Research Center (CTRC) Metabolic Kitchen to ensure energy and macronutrient balance (15% protein, 35% fat, and 50% carbohydrate). Physical activity and alcohol intake were controlled during the last 24 h leading up to the study day. After the run-in diet, participants reported to the CTRC outpatient clinic after a 10-h overnight fast. Height was measured without shoes, to the nearest 0.1 cm on a wall-mounted stadiometer. Body mass was measured in light clothing, to the nearest 0.1 kg using a digital scale. Body composition was assessed using dual-energy x-ray absorption (DPX whole-body scanner; Lunar Radiation Corp., Madison, WI). A fasting blood sample was obtained for hormone and metabolite analyses. Fasting food-related behavioral questionnaires, visual food stimuli evaluations,

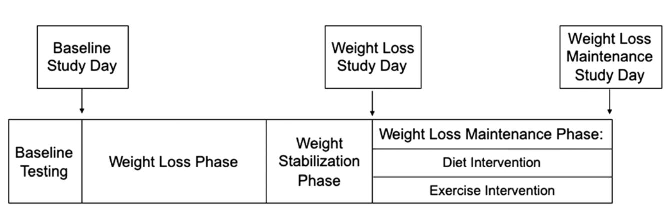

Figure 1: Study design.

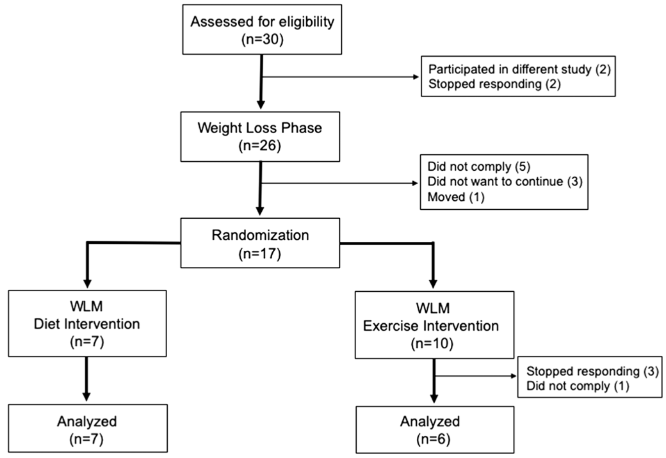

Figure 2: Consort diagram.

and appetite assessments were also collected (details below). Participants then consumed a standard breakfast meal over 20 min. The caloric content was equivalent to 25% of the total daily requirement and had a macronutrient composition identical with the run-in diet. Repeat appetite assessments and blood sampling occurred at 30, 60, 90, 120, 150, and 180 min after the breakfast meal. Visual food stimuli evaluations were repeated in the fed state, approximately 115 min after breakfast. Finally, participants were provided an *ad libitum* lunch meal to evaluate energy intake (details in the following sections).

Eating Behaviors and Food Cravings

The Three Factor Eating Questionnaire (14) was used to evaluate eating behaviors, including dietary restraint, disinhibition, and hedonic hunger. Cravings were evaluated based on the Food Craving Inventory (FCI), which contains questions such as "I have an intense desire to eat one of my favorite foods" (15).

Visual Stimuli Evaluations

Participants were asked to rate visual stimuli consisting of previously validated images of highly appealing foods such as pizza, cake, ice cream, and steak (16), in both the fasted state. The images were evaluated by 100-mm visual analog scale on "food appeal" and "desire to eat" using the computer program ImageRate (Microsoft Access, Seattle, WA). Food appeal was assessed through the question "How appealing is this food?," anchored by "Not appealing at all" to "Extremely appealing." To measure desire the question was phrased, "How much do you desire to eat this food?" anchored by "I have no desire to eat this food" to "I have a strong desire to eat this food."

Appetite Ratings

Participants completed subjective appetite ratings using a visual analog scale (17). Appetite ratings included hunger and satiety as previously described (18–20). To rate hunger, a 100-mm line was preceded by the question "How hungry do you feel right now?" The anchors were "not hungry at all" and "extremely hungry." Satiety was evaluated in a similar manner.

Ad Libitum Buffet Lunch

After the final blood draw and appetite evaluations, participants were offered an *ad libitum* lunch to assess *ad libitum* energy intake. To avoid bias in food intake based on a dislike for specific foods, a research dietitian worked with the participant to provide a meal that replicated, to the extent practical/possible, a usual lunch consumed by the participant. The meal was consumed in the CTRC and offered in a "buffet" style with 15% more food than predicted requirements, with the option to get more food as desired. This design should neither restrict intake nor encourage over consumption. Energy intake was determined by "weigh and measure" methods by the dietary staff of the CTRC.

Laboratory Analyses

An intravenous catheter was placed for blood sampling. Blood samples were collected into EDTA-containing tubes, centrifuged, aliquoted, and stored at −80°C until the time of analysis. Assays were run on individual participants after the completion of all three study phases. Leptin (fasting only), ghrelin, PYY, and GLP-1 were analyzed. For analysis of GLP-1, 30 μL of dipeptidyl peptidase IV inhibitor was added to the 4-mL EDTA tube before collection. The GLP-1 assays were performed using the Alpco Diagnostic ELISA (43-GPTHU-E01). Serum leptin, PYY, and total ghrelin were each measured by radioimmunoassay (Millipore) with a Perkin Elmer Wallac Gamma counter using Maciel RIA-AID data reduction software.

Statistical Analyses

Data were analyzed using SPSS version 24 (IBM Corp., Armonk, NY). Results are reported as mean ± SE, unless otherwise indicated. Differences in change over time between groups were analyzed using a two-way repeated-measures ANOVA. Two-tailed *t*-tests were used to examine differences between groups on individual study day visits. The area under the curve (AUC) was calculated using the trapezoid method for appetite ratings and hormones (GLP-1, PYY, and ghrelin). The study was powered to detect differences in the hormonal response to a meal with a sample size of 16 participants. Significance was set at $\alpha < 0.05$.

Ethics Statement

This pilot study was conducted according to the principles expressed in the Declaration of Helsinki. The study was approved by the Colorado Multiple Institutional Review Board. All participants were provided written informed consent for all study procedures.

RESULTS

Baseline and Post–Weight Loss

A total of 13 women (46 ± 12 yr) completed all study phases and were included in the analysis. Baseline characteristics are included in Table 1; there were no significant between-group differences at baseline (data not shown). As intended, during the weight loss period, participants lost 8.4 ± 1.1 kg of body weight (9.1% ± 1.1%),

TABLE 1.
Baseline and Post–Weight Loss Body Composition, Appetite, and Hormone Measures.

	Baseline	Post–Weight Loss
Body weight (kg)	93.6 ± 3.5	85.0 ± 3.5*
BMI ($kg \cdot m^{-2}$)	34.3 ± 0.7	31.0 ± 0.9*
Lean body mass (kg)	47.4 ± 1.7	45.4 ± 1.9*
Fat mass (kg)	41.5 ± 2.0	35.8 ± 2.0*
Body fat (%)	45.4 ± 1.0	42.7 ± 1.3*
Ad libitum intake (kcal)[a]	754 ± 54.6	662 ± 91.5
TFEQ		
Disinhibition	8.8 ± 0.9	5.9 ± 0.9*
Restraint	10.9 ± 1.5	15.6 ± 1.0*
Perceived hunger	4.6 ± 0.7	2.9 ± 0.5*
VAS appetite ratings[b]		
Hunger AUC ($mm \cdot 180\ min^{-1}$)	5078 ± 2471	6674 ± 3046
Satiety AUC ($mm \cdot 180\ min^{-1}$)	4810 ± 2789	5758 ± 2504
Hedonic image ratings		
Desire	64.0 ± 4.8	61.1 ± 4.0
Appeal	67.1 ± 3.0	66.3 ± 3.2
Food cravings	39.5 ± 2.6	35.2 ± 2.7
Hormones (AUC)[b]		
Ghrelin AUC ($pg \cdot mL^{-1} \cdot 180\ min^{-1}$)	160,413 ± 41,226	173,838 ± 56,778
GLP-1 AUC ($pmol \cdot L^{-1} \cdot 180\ min^{-1}$)	862 ± 402	996 ± 574
PYY AUC ($pg \cdot mL^{-1} \cdot 180\ min^{-1}$)	21,683 ± 11,141	23,370 ± 11,480
Fasting leptin ($ng \cdot mL^{-1}$.)	45.3 ± 5.3	33.9 ± 4.5*

Values are presented as mean ± SE.
[a] Intake during *ad libitum* lunch buffet.
[b] Response to a standardized breakfast meal.
* $P < 0.05$ main effect of time.
BMI, body mass index; TFEQ, Three Factor Eating Questionnaire; VAS, visual analog scale.

5.8 ± 0.7 kg fat mass (2.7% ± 0.5%), and 2.0 ± 0.5 kg lean mass (Fig. 3 and Table 1). Weight loss was associated with decreased disinhibition, increased cognitive restraint, and decreased perceived hunger ($P < 0.01$) (Table 1). Ratings of desire or appeal for high hedonic foods as well as ratings of hunger and satiety (AUC) did not change with weight loss. Weight loss resulted in decreased fasting leptin concentrations ($P < 0.01$); however, there was no difference in ghrelin, GLP-1, or PYY AUC in response to the standardized meal or in *ad libitum* energy intake (Table 1). There were no differences between the WLM-D and the WLM-Ex groups post–weight loss (data not shown).

WLM

Weight loss, fat mass, and lean mass were similarly maintained in both WLM intervention groups from the post–weight loss period to the post-WLM period (Fig. 3 and Table 2). On average, exercisers completed 3.6 ± 0.2 exercise bouts per week (range, 2.8 to 4.5 bouts per week) with an average duration of 47.0 ± 0.2 min at an average intensity of 5.8 ± 0.4 METs. During the WLM phase of the study, attendance of the WLM-D group at biweekly meetings with study personnel (71.7% attendance) and the WLM-Ex group at exercise sessions (72.0% attendance) was similar.

Eating-related behaviors, appetite ratings, and appetite-related hormones after the WLM interventions are presented in Table 2 and Figure 4. No significant between-group differences were detected in these measures, although there was a trend ($P = 0.07$) for the perceived hunger subscale of the Three Factor Eating Questionnaire to be higher in WLM-Ex as compared with WLM-D. There was also no difference detected in ratings of hedonic food pictures or food cravings (Table 2). No differences were seen in hunger or

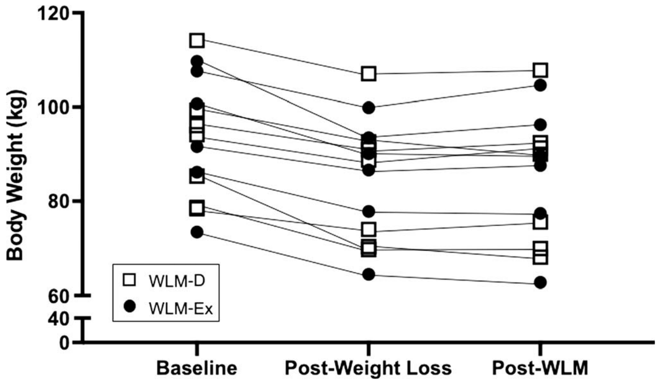

Figure 3: Individual body weights at each study phase. Body weight at baseline, post–weight loss, and post-WLM for women randomized to WLM-D or WLM-Ex interventions.

satiety AUC between the two conditions (Fig. 4). Furthermore, fasting leptin did not differ between the two groups nor did ghrelin, PYY, or GLP-1 AUC (Table 2 and Fig. 4). Energy intake during the *ad libitum* lunch meal did not differ between the groups either (WLM-D = 646 ± 168 kcal vs WLM-Ex = 836 ± 120 kcal).

DISCUSSION

This pilot study was conducted to examine the effects of exercise, as compared with diet, during WLM and its association with hormonal and behavioral indices of appetite regulation. The results of this study suggest that both continued dietary support or exercise interventions can lead to short-term WLM in weight-reduced women with obesity. In line with these findings, no significant differences were seen in measures of appetite regulation between the two WLM strategies. Taken together, these results demonstrate that both the WLM-D and the WLM-Ex interventions were effective during this short-term WLM contrary to observational studies, suggesting an important role of exercise in long-term WLM.

The exercise intervention in this study targeted an increase in energy expenditure of 2000 kcal·wk^{-1} above resting levels. This amount of physical activity falls within the American College of Sports Medicine's recommendation for WLM of 200–300 min

TABLE 2.
Post-WLM Body Composition, Appetite, and Hormone Measures.

	WLM-D (*n* = 7)	WLM-Ex (*n* = 6)
Body weight (kg)	85.0 ± 5.4	86.4 ± 6.0
Fat mass (kg)	35.4 ± 3.3	35.9 ± 3.8
Lean mass (kg)	46.1 ± 2.9	46.4 ± 2.4
Body fat (%)	42.0 ± 2.5	41.9 ± 2.2
TFEQ		
Disinhibition	5.8 ± 1.2	7.2 ± 1.4
Cog restraint	15.0 ± 1.8	15.0 ± 1.7
Perceived hunger	2.2 ± 0.8	4.6 ± 0.8
VAS appetite ratings[a]		
Hunger AUC (mm·180 min^{-1})	5383 ± 1239	5366 ± 1047
Satiety AUC (mm·180 min^{-1})	5448 ± 1375	4679 ± 753
Hedonic image ratings		
Desire	57.5 ± 6.8	46.9 ± 9.2
Appeal	61.7 ± 5.1	58.2 ± 4.8
Food cravings	35.6 ± 3.5	42.3 ± 4.9
Hormones (AUC)[a]		
Ghrelin AUC (pg·mL^{-1}·180 min^{-1})	155,713 ± 23,559	191,570 ± 20,647
PYY AUC (pg·mL^{-1}·180 min^{-1})	21,425 ± 4990	20,913 ± 2368
GLP-1 AUC (pmol·L^{-1}·180 min^{-1})	824 ± 146	828 ± 145
Fasting leptin (ng·mL^{-1})	35.1 ± 7.9	40.6 ± 10.9

Values are presented as mean ± SE.
[a] Response to standardized breakfast meal.
BMI, body mass index; TFEQ, Three Factor Eating Questionnaire; VAS, visual analog scale.

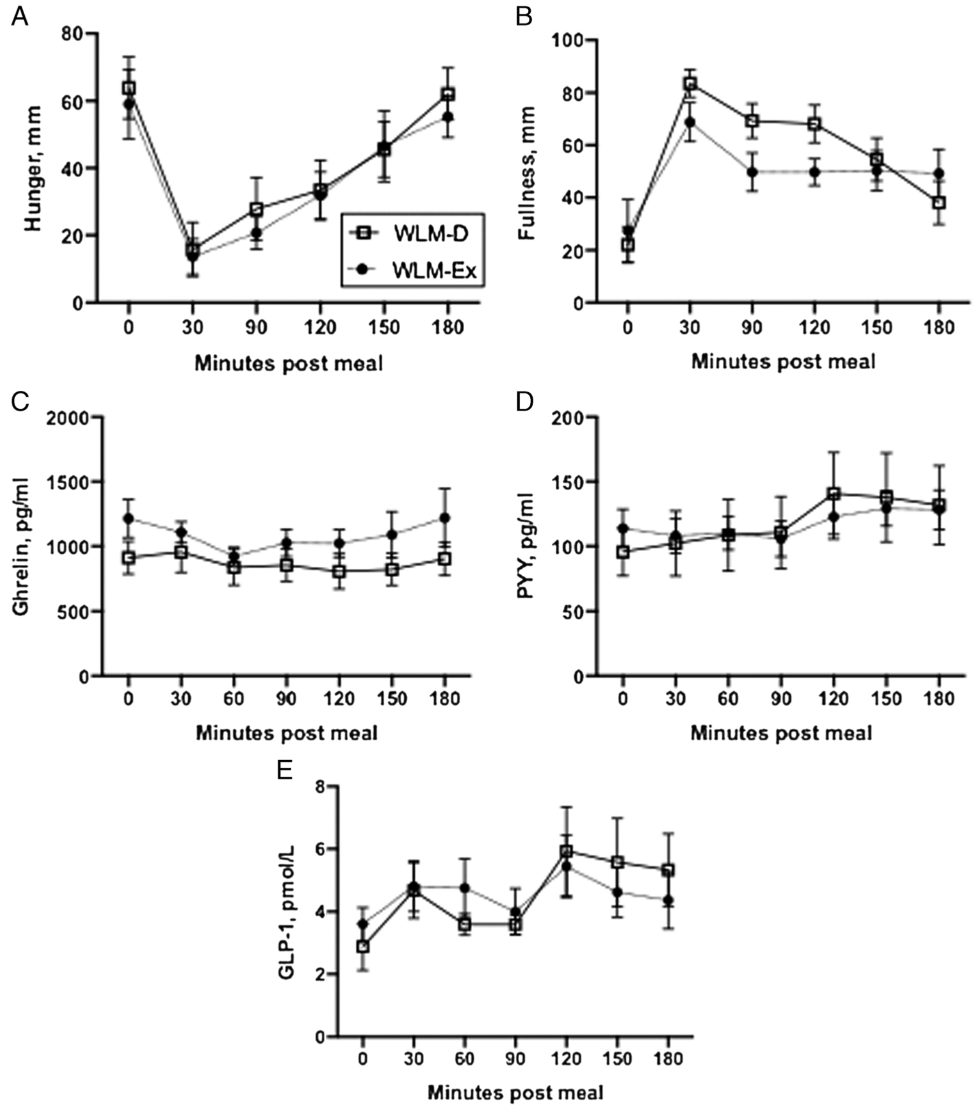

Figure 4: Appetite ratings and appetite-related hormones in response to a standardized breakfast meal. Subjective hunger (A) and fullness (B), and ghrelin (C), PYY (D), and GLP-1 (E) after an overnight fast and for 3 h after a standardized breakfast meal after WLM interventions for women randomized to WLM-D or WLM-Ex groups.

of moderate-intensity physical activity per week (21). We found, like many others (22–29), that this level of activity supported short-term WLM. We used supervised exercise in our study but still found variability in the average number of exercise bouts completed each week ranging from 2.82 to 4.5 sessions per week. Because this was a pilot study, the study was not powered to determine whether differences in the number of exercise bouts affected WLM success; however, others have found exercise to improve WLM in a dose-dependent manner (24,30). We only examined a 12-wk WLM period; as such, it is possible that longer follow-up periods during which motivation wanes and small differences in intake and expenditure accumulate over time would be required to detect differences between WLM-D and WLM-Ex groups.

In contrast to the WLM-Ex group, the WLM-D group in the current study received ongoing dietary support during the WLM period. Providing dietary support to the WLM-D group may have led to improvements in WLM success beyond what would be expected had they not received continued care. In addition, the structured weight loss program used in the current study used liquid meal replacements, and participants were given the option to continue to use the liquid meal replacements as part of a WLM strategy. The use of liquid meal replacements has been shown to improve WLM success compared with a food-based diet program and may have improved WLM in both WLM groups (31–34). Research has shown that even as few as one contact with study personnel per month, either in person or via telephone, can improve WLM compared with no contact groups (35). The WLM-D group maintained a similar weight loss as the WLM-Ex group despite having fewer contacts with study personnel during the WLM phase. These results could indicate that despite receiving fewer contacts, the WLM-D group received sufficient contact with study personnel to receive this benefit.

This current study was designed to investigate the hormone and appetite response to a standardized meal in response to either a diet (WLM-D) or an exercise (WLM-Ex) intervention during WLM. In the present study, both WLM-D and WLM-Ex groups responded similarly to the standardized breakfast meal. To our knowledge, no other studies have looked at the hormone and appetite responses to a meal with exercise during WLM; however, several studies have been conducted in non–weight-reduced women. In women without obesity, exercise increased fasting total ghrelin concentrations when participants were in an energy deficit, but consistent with the findings of the current study, fasting ghrelin concentrations did not change in women that were weight stable (36). In a study conducted in women with obesity, Hagobian et al. (37) found that 4 d of aerobic exercise induced increases in total and acylated ghrelin after a standardized meal compared with a nonexercise condition. Despite this increase in ghrelin, the investigators found no difference in reported hunger or satiety (37). In healthy females, an acute bout of exercise (30% of total daily energy expenditure) did not change hormone (PYY, acylated ghrelin, and insulin) or subjective appetite compared with rest (38). Largely in line with these results, the current study found no difference between the WLM-D and the WLM-Ex groups in appetite-regulating hormones or measures of hunger and satiety over the course of the study day. Variability in results between studies can likely be attributed to variation in the type, intensity, duration of exercise, acute versus chronic exercise, amount of time since the last exercise bout, variation in participant characteristics (sex, age, obesity status, weight loss magnitude, and duration in a weight-reduced state), and differences between run-in meals, standardized meal macronutrient composition, timing, calorie content, and duration of peptide/hormone measurements (39). Future work is needed to understand how each of these variables influence the appetite-regulating hormones and aspects of hunger and satiety.

Preclinical studies of weight loss and WLM find that exercising females regain lost weight at a similar rate to sedentary females. Specifically, female rats compensate for the cost of the exercise bout by increasing their food intake, which results in a similar weight regain to sedentary females (5). The results of the current study suggest that the findings in the animal literature may translate to humans. Despite an increased energy expenditure brought about by the exercise bout, the exercising women maintained a similar weight loss to the WLM-D group. Although we were unable to capture the compensation, this suggests that the exercising participants compensated for the cost of the exercise bout by increasing energy intake, decreasing nonexercise energy expenditure, or a combination of both.

There are a number of strengths to this study: 1) there was good adherence to the exercise intervention, 2) we controlled the participants' diet for 3 d leading into each of the study days to maintain energy balance and provided all meals during each study day, and 3) we used a comprehensive evaluation of behavioral and hormonal indices of appetite regulation. Despite these strengths, we acknowledge the following limitations. This study did not measure nonexercise physical activity or sedentary time, so we cannot determine whether compensation occurred from changes in diet, nonexercise physical activity, or both. The sample size of this pilot study was modest and may have limited our ability to detect differences between the groups. We measured total ghrelin and acknowledge that measuring acylated ghrelin may have provided additional insights. The duration of the WLM intervention was only 12 wk, and therefore participants in both groups were likely still motivated to adhere to their assigned interventions. It is possible that a longer duration of WLM follow-up could have produced differences in WLM success between the exercise and the diet groups. Hormonal and peptide measurements in response to the standardized breakfast meal were obtained 24 h after the last exercise bout. This may have limited our ability to detect differences in appetite and appetite-related hormone concentrations between groups, which may have been evident acutely after the exercise bout as has been shown by others (40). Although there were no significant differences seen in *ad libitum* intake at the in-laboratory lunch meal between diet and exercise groups, we may have missed capturing habitual compensatory behaviors occurring across multiple days or meals.

CONCLUSION

In conclusion, we found that both a diet or an exercise intervention after weight loss was equally successful in maintaining a body weight in women over 12 wk. Furthermore, there was no difference in measures of hunger, satiety, or appetite-related hormones in response to a standardized meal between the intervention groups. Although this pilot work warrants further investigation in a larger sample size and over a longer duration, these results suggest that women may compensate for the cost of the exercise by either increasing food intake or decreasing daily energy expenditure, thus experiencing short-term WLM success similar to that of women that did not exercise.

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The authors report no conflicts of interest. The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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