Published in final edited form as:

J Nutr Health Aging. 2014 December ; 18(10): 888–893. doi:10.1007/s12603-014-0481-9.

DIETARY PRESCRIPTION ADHERENCE AND NON-STRUCTURED PHYSICAL ACTIVITY FOLLOWING WEIGHT LOSS WITH AND WITHOUT AEROBIC EXERCISE

M.C. SERRA¹, M.S. TREUTH², and A.S. RYAN¹

¹ GRECC, Baltimore VA Medical Center & Division of Gerontology and Geriatric Medicine, University of Maryland School of Medicine

² Department of Exercise Science, University of Maryland Eastern Shore.

Abstract

Objectives—To compare the effects of weight loss with and without exercise on 1) dietary prescription adherence and 2) non-structured activity in postmenopausal women.

Design—Longitudinal study.

Setting—Clinical research setting with facility based exercise and nutrition education.

Participants—Overweight and obese women, 45–76 years old.

Intervention—6 months of weight loss alone (WL; N=38) or with aerobic exercise (AEX+WL; N=41).

Measurements—Cardiorespiratory fitness (VO₂max), resting metabolic rate (RMR), seven day food intake, and physical activity (by Actical accelerometers worn in a subset subgroup: WL: N=10; AEX+WL: N=15) were assessed before and after the interventions.

Results—Both interventions resulted in similar weight loss (~9%) and no significant changes in RMR, while only the AEX+WL group improved VO₂max (~10%). At baseline, the AEX+WL group consumed slightly more protein than the WL group (P<0.01). Macronutrient intake did not change following AEX+WL, but the WL group decreased their fat intake and increased their carbohydrates and protein intakes (Ps<0.05), which resulted in similar macronutrient intakes between groups post-intervention. Weekday total activity counts decreased 22% (P<0.05) following WL. This change tended (P=0.07) to be different than the lack of change in non-structured activity observed following AEX+WL.

Conclusion—Although similar dietary adherence was observed, these data suggest that postmenopausal women undergoing weight loss may benefit from the addition of exercise to prevent the decline in non-structured activity observed following weight loss alone.

Corresponding author: Monica C. Serra, Baltimore VA Medical Center, 10 N. Greene St, GRECC (BT/18/GR), Baltimore, MD 21201, Phone: (410) 605 7000 × 4199, Fax: (410) 605 7913, mserra@grecc.umaryland.edu.

Ethical Standards: The experiments in this study comply with the current laws of the country in which they were performed.

Conflict of interest: Dr. Serra has nothing to disclose. Dr. Treuth has nothing to disclose. Dr. Ryan reports grants from NIH and VA, during the conduct of the study.

Keywords

Physical activity; weight loss; aerobic exercise; postmenopausal women

Introduction

Poor dietary intake and reduced total daily energy expenditure (TDEE) appear to be at the root of obesity development. Hormonal changes associated with the menopausal transition, as well as factors related to aging (lower metabolic rate and more sedentary lifestyle), result in weight gain (1). This places postmenopausal women at increased risk for the development of chronic diseases (2). Decreasing caloric intake, modifying macronutrient intake, and increasing physical activity (PA) remain the first line of treatment defense to induce weight loss (3).

Weight loss interventions typically follow a similar regimen with energy deficit goals of 500–1,000 kcals/d (~0.5-1 kg/week) and total dietary fat equal to <30% of total kcals/d. Within 6 months, these diets, on average, only produce a weight loss of 5 to 8.5 kg (4) rather than the predicted 11-22 kg, indicating a discrepancy between dietary prescription and adherence. Further, Del Corral et al. (5) found that the greater the severity of caloric restriction, the less the dietary adherence, suggesting that a more liberal approach to weight loss may be beneficial. Self-reported adherence to caloric restriction recommendations are associated with greater weight loss (6). Interestingly, the addition of PA to weight loss interventions enhances dietary adherence and leads to greater fat loss compared with weight loss only interventions in obese premenopausal women (7, 8).

TDEE can be elevated by increasing resting metabolic rate (RMR), structured exercise, or activities outside of structured exercise (non-structured PA). While older, aerobically trained, chronic exercisers have greater TDEE and activity related energy expenditure than sedentary older adults [9,10], short-term (<12 months), prescribed aerobic exercise results in a decrease (11, 12) or no change (13-15) in non-structured PA in older adults. While it is well known that structured exercise results in beneficial health improvements, high amounts of non-structured PA, even if at a light intensity, are correlated with better physical health and well-being in older adults (16), emphasizing the importance of non-structured PA. In obese adolescents, weight loss improves non-structured PA (17). To the best of our knowledge, there are no studies available examining the effects of weight loss alone and only one study with the combination of weight loss and aerobic exercise on non-structured PA in overweight, older women. Wang et al. (18) found that overweight, postmenopausal women undergoing five months of weight loss with prescribed aerobic exercise expend more energy on non-structured PA on days that they do not perform structured exercise, especially if the prescribed exercise is of a higher intensity (vigorous vs. moderate intensity). Further, these data indicate that outside influences (e.g. structured exercise, work) affect non-structured PA in postmenopausal women and may influence non-structured activity patterns during the week differently than the weekend.

Thus, we proposed to compare the effects of six months of weight loss with and without prescribed aerobic exercise on 1) dietary prescription adherence and 2) non-structured PA in

overweight and obese, postmenopausal women. We hypothesized that the addition of aerobic exercise to weight loss will result in greater dietary prescription adherence, but reductions in non-structured PA in postmenopausal women compared to women undergoing weight loss alone. Further, we will examine how the changes in non-structure PA differ on weekend days versus weekdays to determine whether differences in daily activities affect non-structured PA. These results may have important implications for clinical practice and the development of future strategies for health promotion in older, overweight women.

Materials and methods

Subjects

Generally healthy, nonsmoking, sedentary (no exercise >20 min, 2 days per week), overweight and obese, postmenopausal (45-80 year old) women (n=174) were recruited from the Baltimore, Maryland area (19). Research methods and procedures were approved by the Institutional Review Board of the University of Maryland School of Medicine, and each participant provided written consent prior to participation in the study. Women were screened by a medical history questionnaire, physical exam, fasting blood profile, and a graded exercise treadmill test in an attempt to exclude those with unstable medical conditions. Specifically, exclusion criteria included evidence of hypertension, hypertriglyceridemia, heart disease, cancer, liver, renal or hematological disease, orthopedic limitations, and/or medical conditions deemed to impact participation.

Interventions

Of 96 women who finished the interventions (body composition and VO_2max data previously published (19)), a subset of women with complete pre- and post-intervention food records (n=79) are included in the current study analyses. Women who were initially recruited were not different from the women who completed the study (with or without complete food records) with regard to age, BMI, % body fat, and race. Thirty-eight women who completed the weight loss intervention only (WL) and 41 women who also performed aerobic exercise three times per week for six months (AEX+WL) are included. All women underwent six weeks of “heart healthy” dietary modifications (consuming <30% of total calories as total fat, 10% as saturated fat, 300 mg of cholesterol, and 2,400 mg of sodium per day) with weight maintenance, followed by six months of weekly weight loss classes instructed by a Registered Dietitian (RD). Weight loss instructions included following the “heart healthy” dietary modification guidelines plus beginning a 250-350 kcal/d hypocaloric diet with a goal ~5-10% weight loss over the study duration. Aerobic exercise prescriptions for the AEX+WL group incorporated a progressive treadmill training exercise plan where intensity began at ~50-60% of heart rate reserve for 30 min and progressed to >85% for 50 minutes. Women continued to exercise throughout post-testing. For this particular study analysis, intervention adherence was assessed by the proportion of dietary and exercise sessions completed vs. sessions scheduled and the ability to lose at least 5% of body weight and, by food record analysis, achieve a weekly average caloric deficit of at least 250 kcal/d with <30% of total calories contributed by fat.

VO₂ max and Body Composition

VO₂max was measured using a maximal treadmill test before and after both interventions as previously described (19). Participants had their body weight and height measured to determine BMI (kg/m²). Percent body fat and fat-free mass (FFM) were determined by dual-energy X-ray absorptiometry (Prodigy, LUNAR Radiation Corp., Madison, WI). The data of intervention changes in VO₂max and body composition have been previously published (19).

Dietary Intake and Energy Expenditure

Instruction on completing food records was provided by a RD. Seven-day food records were collected at baseline (prior to beginning the heart healthy diet) and during the final week of WL and AEX+WL. Records were analyzed by the RD using Nutritionist Pro (Axxya Systems, Stafford, TX) to determine average total daily energy intake, as well as the % of calories consumed from energy producing nutrients and g/kg/d of protein intake.

Subjects consumed two days of an isocaloric diet (55-60% carbohydrates, 15-20% protein, and <30% fat) provided by the RD. They reported to our laboratory after a 12-hour fast. RMR was measured by indirect calorimetry (COSMED; Rome, Italy), while subjects rested quietly in the supine position for 30 minutes. Energy expenditure was calculated by the Weir equation [20] and expressed per 24 hours before and after WL and AEX+WL.

Activity logs (subjects reported brief descriptions of activities that were completed each hour) were collected and biaxial accelerometers (Actiwatch AW16; Mini Mitter; Bend, OR) were worn for five consecutive days (three week and two weekend days) during the first week of beginning the interventions and during the last week of completing the interventions. The unit was secured over the subject's hip with an elasticized belt to maintain a normal pattern of PA and only removed for bathing. Most subjects wore the accelerometer from a Friday morning through a Wednesday morning. Women in the AEX+WL group typically put the accelerometer on after a Friday morning exercise session and returned the accelerometer prior to initiating the exercise session Wednesday morning, thus wearing the accelerometers during their center-based Monday morning treadmill training session. To test whether the amount of activity accomplished during a structured exercise session increased in the AEX+WL group, the activity during the exercise session was compared pre and post intervention. Additionally, this structured exercise was removed to compare the average remaining "non-structured" activity achieved pre and post intervention, as well as between interventions. There were 15 women in the AEX+WL and 10 women in the WL group who had activity count data available from days with and without center based exercise pre and post-intervention, respectively. Data were collected in one-minute epochs (sampling times) and analyzed using Actiware Version 2.1 software. Data were summarized as total non-structured activity counts and sleep time for both interventions and structured exercise for the AEX+WL group. Non-structured activity counts excluded activity counts achieved during sleep time and the structured exercise session for the AEX+WL group. Sleep time was designated as the number of minutes that the accelerometer read "0" for at least 20 consecutive minutes and the participant reported sleeping on their activity log). Data were averaged over five days (weekend + weekday), as well as by weekend and weekdays. Total

activity counts were broken into tertiles to determine low, middle, and high levels of physical activity. The data was examined to determine whether an individual shifted into a different activity tertiles post-intervention.

Statistical Analysis

Independent t-tests were used to determine differences between groups at baseline and after the weight loss interventions. Repeated measures ANOVAs were used to assess changes over time between the groups and to control for baseline differences. Paired t-tests were used to determine intervention changes within each group. Pearson chi-square tests were used to determine whether distributions of categorical variables differed from one another between groups. Pearson correlations were used to assess relationships between key variables. All statistical tests were two-tailed. Data are expressed as means $\pm$ SEM, and significance was set at the 0.05 level. All analyses were performed utilizing PASW Statistics (Version 18, Chicago, IL).

Results

Effects of WL and AEX+WL Interventions

Baseline—Groups were similar with respect to physical characteristics. Age, weight, BMI, % body fat, FFM, and RMR did not differ between the two groups (Table 1). All women had poor cardiorespiratory fitness ($VO_2\max$), but women in the AEX+WL had a slightly higher fitness level (WL vs. AEX+WL: 18 ± 1 vs. 21 ± 1 ml/kg/min; $P<0.01$) at baseline. Working status did not differ by intervention, with 14% of women working part-time, 61% full time, and 25% retired. Compared to the WL group, baseline dietary protein intake was greater in the AEX+WL group ($P<0.05$). Because alcohol intake was minimal for both groups (60% of subjects consumed <1 g alcohol/d), it was eliminated from further analyses.

At baseline, weekend, weekday, and average week (weekend + weekday) PA was similar between groups (Figure 1). Sleep patterns (Table 2) also were similar between groups at baseline. Sleep was greater on the weekends (averaging 9.0 hrs/night) than during the week (averaging 7.5 hours/night) ($P<0.01$). Neither baseline activity counts nor sleep time were related to baseline cardiorespiratory fitness.

Post Interventions—As published previously (19), the WL and AEX+WL interventions led to significant loss of body weight, BMI, body fat, and FFM. The losses were similar between interventions (Table 1). Based on food record analyses, both groups had a ~11% mean reduction in total calories following the interventions ($P_s<0.01$). The average caloric reduction in each group did not reach the prescribed caloric reduction of at least 250 kcals/d. Further, ~67% of subjects in each group cut their caloric intake by at least 250 kcals/d. There were no changes in the macronutrient dietary intake composition in AEX+WL; however, the WL group decreased the % of calories consumed from fat and increased intake of carbohydrates and protein ($P_s<0.05$) (Table 2). While these changes were different between groups ($P_s<0.05$), they resulted in macronutrient intakes that were similar between groups following the intervention. Attendance to the dietary classes was not different between groups, with an average attendance of $89\pm2\%$ (previously published [19]).

Attendance to the dietary sessions was not correlated with changes in body composition or dietary intake. Changes in caloric and macronutrient intakes were not related to changes in weight, body fat, or activity counts.

The AEX+WL group attended $90\pm 2\%$ of exercise sessions (previously published (19)). The change in absolute VO_2max (before and after controlling for baseline VO_2max differences) was different by intervention ($P<0.01$), with no significant change after WL and a 10% increase after AEX+WL ($P<0.01$). Activity counts achieved during the individual treadmill training session increased 105% from baseline to post intervention (pre vs. post: $26,046\pm 3,922$ vs. $53,302\pm 5,860$ activity counts; $P<0.05$). Weekday total activity counts decreased 23% following WL ($P<0.05$), with a trend for a 26% decrease in the average weekend + weekday total activity counts ($P=0.07$), but activity counts did not change following AEX+WL. There was a trend for a significant difference in the change in weekday and weekend + weekday total activity counts by intervention ($P=0.07$), which resulted in intervention differences in weekday and weekend + weekday total activity counts post intervention ($P<0.05$) (Figure 1). Thirty-six percent of women in the AEX+WL group shifted upward one category towards a higher activity tertile, compared to none in the WL group. Additionally, only 29% of women in the AEX+WL group shifted downward to a lower activity tertile, compared to 42% in the WL group. The change in total activity counts was not associated with the changes in weight and body fat. Additionally, the change in VO_2max did not correlate with the change in the activity counts accumulated during the treadmill exercise training session.

Discussion

The focus of this study was to assess how each intervention affected dietary prescription adherence and structured and non-structured PA. This information is needed to determine how best to promote a “heart healthy” dietary modification and improve TDEE while undergoing weight loss.

Dietary Prescription Adherence

The finding that both groups lost an average of eight kg of body weight indicates that women achieve a deficit of ~ 350 kcals/d, thus achieving the upper range of prescribed weight loss goals ($\sim 9\%$). Food record analyses also support similar mean caloric restriction between groups. These data contradict previous reports (7, 8), which suggested greater adherence to caloric restriction regimens when PA is added to weight loss. However, these previous studies enrolled premenopausal women, prescribed more severe caloric restrictions, and were of short duration (8-12 weeks), suggesting that older women undergoing weight loss may find greater success with weight loss when moderate caloric deficit is promoted over a longer duration.

According to the Institute of Medicine's Food and Nutrition Board, acceptable macronutrient distribution ranges for adults range from 45-65% for carbohydrates, 10-35% for protein, and 20-35% for fat (21). However, a fat intake of $<30\%$ is recommended to reduce the risk of chronic diseases, such as heart disease and certain cancers (21). A recent study examined trends in dietary intake patterns found that older adults consume $\sim 47\%$ of calories from

carbohydrate, ~18% from protein, and ~30% from fat (22). This is similar to the macronutrient profiles of women in the current study. The baseline fat intake was slightly above the 30% recommendation in the WL group. The WL group decrease the proportion of calories consumed from fat and increase carbohydrate and protein intakes to a greater extent than the AEX+WL group. This resulted in similar macronutrient proportions between interventions post-intervention. Combined with a high attendance rate to dietary classes, which was not different by intervention, these data suggest that WL and AEX+WL result in similar dietary adherence to a weight loss intervention.

Energy Expenditure and Physical Activity

As mentioned previously, energy expenditure can be boosted by increasing RMR, structured exercise, and non-structured PA. Studies examining the effects of weight loss on RMR, both with and without structured aerobic exercise, consistently show a decrease in RMR (23-25). In contrast, RMR did not significantly decrease in either group in the present study. This could be a result of our modest approach to weight loss, which resulted in minimal loss of FFM. The high exercise session attendance rate, improvement in exercise activity counts, and increase in VO_2max indicate that the women in this study were successful at completing the structured exercise portion of the AEX+WL intervention. Further, the addition of structured aerobic exercise to weight loss prevented the ~23% and ~26% decrease in weekday and weekend + weekday non-structured total activity counts observed following weight loss alone, respectively. Thus, these data provide evidence that aerobic exercise should be promoted during periods of weight loss to not only improve structure exercise energy expenditure, but also maintain non-structured PA in older women.

In women undergoing WL only, the decrease in weekday non-structured activity counts suggests that maintaining activity during weight loss may be difficult to achieve during the week, and thus PA may be best incorporated into a daily routine if promoted on the weekend vs. during the week. This is further supported by the greater % of time spent sleeping on the weekend, suggesting that women may have more time to perform PA on the weekend. Similar conclusions have been drawn by Young et al. (26), who found that overweight and obese adults were more likely to complete a combination of moderate and vigorous physical activity (MVPA) during the weekends than during the week. Our study did not show a difference between weekend and weekday activity.

While activity intensity thresholds have been set using the specific model of Actiwatch accelerometers in children and adolescents (27-29), these thresholds have not been validated in older adults. Using these cutoffs, the women in our study spent ~66%, 33%, and <1% of their time performing sedentary, light, and MVPA. Some studies suggest that because older adults spend a higher percentage of their time completing low intensity activities and less time performing high intensity activities [30], the activity thresholds for children and younger adults may not pertain to older adults (31, 32). However, another study found that thresholds are adequate across a wide age range, including older adults (33), even though this study used a different accelerometer model (Actigraph) than that of the current study. Thresholds are defined for older adults using the Actigraph accelerometer (34-36). These values were originally validated in a young (age range 23–30 years old), healthy population

of men and women (37-39). Buman et al. (16) show that women between the ages of 66-69 years of age spend ~61%, ~38%, and ~2% in sedentary, light, and MVPA, respectively. These percentages are remarkably similar to our findings. Troiano et al. (35) report that African Americans and Caucasians who are 60+ years old only spend 5.9 ± 0.8 and 8.8 ± 0.6 minutes/day performing MVPA, respectively. These data reiterate the need to identify ways to promote non-structured PA in postmenopausal women to promote energy balance and prevent obesity. Future studies would benefit from using accelerometers with validated physical activity intensity thresholds to determine whether weight loss with and without exercise also affects intensity of activities in postmenopausal women.

Conclusion

These results should be interpreted in light of a few considerations. Underreporting of food records, common in postmenopausal women (40), may have affected the accuracy of the dietary analysis. To limit this effect, instructions for completing food records were provided by a RD and food records were reviewed by the RD with each study participant. Additionally, the study of dietary and physical activity adherence is complex. Adherence is often measured through analysis of numerous variables (e.g. body composition, energy expenditure and intake, and attendance to dietary and exercise training sessions); thus, it is possible that we did not have adequate power to accurately analyze each adherence variable. However, this is balanced by our extensive subject characterization, which reveals that subjects were similar between groups at baseline, as well as our highly structured weight loss and exercise sessions, which resulted in significant weight loss in postmenopausal women at risk for chronic disease.

Postmenopausal women are successful at achieving weight loss goals if moderate caloric restriction is prescribed over a long duration (i.e. 6 months). Additionally, our data suggest that the addition of structured aerobic exercise to weight loss results in similar dietary prescription adherence to weight loss, and also promotes energy expenditure by increasing exercise PA and preventing a decline in weekday total non-structured activity observed with weight loss alone. Future studies should address whether promoting weekend or weekday structured and non-structured PA results in greater improvements in TDEE and moderate and vigorous physical activity in postmenopausal women.

Acknowledgments

Our appreciation is extended to the women who participated in this study. We are grateful to the expertise of Andrew P. Goldberg, M.D. and the medical team, exercise physiologists, and Registered Dietitians of the Division of Gerontology and Geriatric Medicine and GRECC for their assistance to this project.

Funding Sources: This study was supported by funds from: the Baltimore VA Medical Research Service, VA Research Career Scientist Award, VA Advance Health Postdoctoral Fellowship, Department of Veterans Affairs and Veterans Affairs Medical Center Baltimore Geriatric Research, Education and Clinical Center (GRECC), National Institute on Aging (NIA) grants R01-AG19310, R01-AG20116, Claude D. Pepper Older Americans Independence Center P30-AG028747, 5T32-AG000219-18, NIDDK Mid-Atlantic Nutrition Obesity Research Center (NIH P30-DK072488), and the GCRC of the University of Maryland, Baltimore (5M01RR016500).

References

1. Toth MJ, Tchernof A, Sites CK, Poehlman ET. Menopause-related changes in body fat distribution. *Ann N Y Acad Sci.* 2009; 904:502–506. [PubMed: 10865795]
2. Hsiao PY, Mitchell DC, Coffman DL, Craig Wood G, Hartman TJ, et al. Dietary patterns and relationship to obesity-related health outcomes and mortality in adults 75 years of age or greater. *J Nutr Health Aging.* 2013; 17:566–572. [PubMed: 23732554]
3. Cannon CP, Kumar A. Treatment of overweight and obesity: lifestyle, pharmacologic, and surgical options. *Clin Cornerstone.* 9:55–68. [PubMed: 19789064]
4. Franz MJ, VanWormer JJ, Crain AL, Boucher JL, Histon T, et al. Weight-loss outcomes: a systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *J Am Diet Assoc.* 2007; 107:1755–1767. [PubMed: 17904936]
5. Del Corral P, Chandler-Laney PC, Casazza K, Gower BA, Hunter GR. Effect of dietary adherence with or without exercise on weight loss: a mechanistic approach to a global problem. *J Clin Endocrinol Metab.* 2009; 94:1602–1607. [PubMed: 19258409]
6. Dansinger ML, Gleason JA, Griffith JL, Selker HP, Schaefer EJ. Comparison of the Atkins, Ornish, Weight Watchers, and Zone diets for weight loss and heart disease risk reduction: a randomized trial. *JAMA.* 2005; 293:43–53. [PubMed: 15632335]
7. Kempen KP, Saris WH, Westerterp KR. Energy balance during an 8-wk energy-restricted diet with and without exercise in obese women. *Am J Clin Nutr.* 1995; 62:722–729. [PubMed: 7572699]
8. Racette SB, Schoeller DA, Kushner RF, Neil KM. Exercise enhances dietary compliance during moderate energy restriction in obese women. *Am J Clin Nutr.* 1995; 62:345–349. [PubMed: 7625341]
9. Withers RT, Smith DA, Tucker RC, Brinkman M, Clark DG. Energy metabolism in sedentary and active 49- to 70-yr-old women. *J Appl Physiol.* 1998; 84:1333–1340. [PubMed: 9516201]
10. Brochu M, Starling RD, Ades PA, Poehlman ET. Are aerobically fit older individuals more physically active in their free-living time? A doubly labeled water approach. *J Clin Endocrinol Metab.* 1999; 84:3872–3876. [PubMed: 10566622]
11. Goran MI, Poehlman ET. Endurance training does not enhance total energy expenditure in healthy elderly persons. *Am J Physiol.* 1992; 263:E950–957. [PubMed: 1443128]
12. Meijer EP, Westerterp KR, Verstappen FT. Effect of exercise training on total daily physical activity in elderly humans. *Eur J Appl Physiol Occup Physiol.* 1999; 80:16–21. [PubMed: 10367718]
13. Egan C, Deering BM, Blake C, Fullen BM, McCormack NM, et al. Short term and long term effects of pulmonary rehabilitation on physical activity in COPD. *Respir Med.* 2012; 106:1671–1679. [PubMed: 23063203]
14. Keytel LR, Lambert MI, Johnson J, Noakes TD, Lambert EV. Free living energy expenditure in post menopausal women before and after exercise training. *Int J Sport Nutr Exerc Metab.* 2001; 11:226–237. [PubMed: 11402255]
15. Opdenacker J, Boen F, Coorevits N, Delecluse C. Effectiveness of a lifestyle intervention and a structured exercise intervention in older adults. *Prev Med.* 2008; 46:518–524. [PubMed: 18405960]
16. Buman MP, Hekler EB, Haskell WL, Pruitt L, Conway TL, et al. Objective light-intensity physical activity associations with rated health in older adults. *Am J Epidemiol.* 2010; 172:1155–1165. [PubMed: 20843864]
17. Lazzar S, Boirie Y, Poissonnier C, Petit I, Duche P, et al. Longitudinal changes in activity patterns, physical capacities, energy expenditure, and body composition in severely obese adolescents during a multidisciplinary weight-reduction program. *Int J Obes (Lond).* 2005; 29:37–46. [PubMed: 15534613]
18. Wang X, Nicklas BJ. Acute Impact of Moderate-Intensity and Vigorous-Intensity Exercise Bouts on Daily Physical Activity Energy Expenditure in Postmenopausal Women. *Journal of Obesity.* 2011

19. Ryan AS, Ortmeier HK, Sorkin JD. Exercise with calorie restriction improves insulin sensitivity and glycogen synthase activity in obese postmenopausal women with impaired glucose tolerance. *Am J Physiol Endocrinol Metab.* 2012; 302:E145–152. [PubMed: 22008454]
20. Cunningham JJ. Calculation of energy expenditure from indirect calorimetry: assessment of the Weir equation. *Nutrition.* 1990; 6:222–223. [PubMed: 2136001]
21. Otten, JJ.; Hellwig, JP.; Meyers, LD., editors. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements.* The National Academies Press; Washington, D.C.: 2006. p. 537
22. Vadiveloo M, Scott M, Quatromoni P, Jacques P, Parekh N. Trends in dietary fat and high-fat food intakes from 1991 to 2008 in the Framingham Heart Study participants. *Br J Nutr.* 2013;1–11.
23. Martin CK, Heilbronn LK, de Jonge L, DeLany JP, Volaufova J, et al. Effect of calorie restriction on resting metabolic rate and spontaneous physical activity. *Obesity (Silver Spring).* 2007; 15:2964–2973. [PubMed: 18198305]
24. Martin CK, Das SK, Lindblad L, Racette SB, McCrory MA, et al. Effect of calorie restriction on the free-living physical activity levels of nonobese humans: results of three randomized trials. *J Appl Physiol.* 2011; 110:956–963. [PubMed: 21292847]
25. Elliot DL, Goldberg L, Kuehl KS, Bennett WM. Sustained depression of the resting metabolic rate after massive weight loss. *Am J Clin Nutr.* 1989; 49:93–96. [PubMed: 2912016]
26. Young DR, Jerome GJ, Chen C, Laferriere D, Vollmer WM. Patterns of physical activity among overweight and obese adults. *Prev Chronic Dis.* 2009; 6:A90. [PubMed: 19527591]
27. Puyau MR, Adolph AL, Vohra FA, Butte NF. Validation and calibration of physical activity monitors in children. *Obes Res.* 2002; 10:150–157. [PubMed: 11886937]
28. Treuth MS, Schmitz K, Catellier DJ, McMurray RG, Murray DM, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. *Med Sci Sports Exerc.* 2004; 36:1259–1266. [PubMed: 15235335]
29. Lopez-Alarcon M, Merrifield J, Fields DA, Hilario-Hailey T, Franklin FA, et al. Ability of the actiwatch accelerometer to predict free-living energy expenditure in young children. *Obes Res.* 2004; 12:1859–1865. [PubMed: 15601983]
30. Westerterp KR. Physical activity as determinant of daily energy expenditure. *Physiol Behav.* 2008; 93:1039–1043. [PubMed: 18308349]
31. Copeland JL, Esliger DW. Accelerometer assessment of physical activity in active, healthy older adults. *J Aging Phys Act.* 2009; 17:17–30. [PubMed: 19299836]
32. Pruitt LA, Glynn NW, King AC, Guralnik JM, Aiken EK, et al. Use of accelerometry to measure physical activity in older adults at risk for mobility disability. *J Aging Phys Act.* 2008; 16:416–434. [PubMed: 19033603]
33. Miller NE, Strath SJ, Swartz AM, Cashin SE. Estimating absolute and relative physical activity intensity across age via accelerometry in adults. *J Aging Phys Act.* 2010; 18:158–170. [PubMed: 20440028]
34. Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, et al. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care.* 2008; 31:369–371. [PubMed: 18000181]
35. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, et al. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc.* 2008; 40:181–188. [PubMed: 18091006]
36. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, et al. Amount of time spent in sedentary behaviors in the United States, 2003–2004. *Am J Epidemiol.* 2008; 167:875–881. [PubMed: 18303006]
37. Brage S, Wedderkopp N, Franks PW, Andersen LB, Froberg K. Reexamination of validity and reliability of the CSA monitor in walking and running. *Med Sci Sports Exerc.* 2003; 35:1447–1454. [PubMed: 12900703]
38. Hendelman D, Miller K, Baggett C, Debold E, Freedson P. Validity of accelerometry for the assessment of moderate intensity physical activity in the field. *Med Sci Sports Exerc.* 2000; 32:S442–449. [PubMed: 10993413]
39. Leenders NY, Nelson TE, Sherman WM. Ability of different physical activity monitors to detect movement during treadmill walking. *Int J Sports Med.* 2003; 24:43–50. [PubMed: 12582951]

40. Horner NK, Patterson RE, Neuhouser ML, Lampe JW, Beresford SA, et al. Participant characteristics associated with errors in self-reported energy intake from the Women's Health Initiative food-frequency questionnaire. *Am J Clin Nutr.* 2002; 76:766–773. [PubMed: 12324289]

Figure 1.

Non-structured total activity counts during the average weekend, weekday, and weekend + weekday before and after six months of weight loss with and without aerobic exercise (mean $\pm$ SEM)

Table 1

Baseline and Changes in Body Composition and Fitness

	Baseline WL (N=38)	Baseline AEX+WL (N=41)	Post WL	Post AEX+WL
Race (# AA / C)	12 / 26	15 / 26	-	-
Age (years)	61 ± 1	59 ± 1	-	-
Weight (kg)	89 ± 3	85 ± 2	-8 ± 1 *	-8 ± 1 *
BMI (kg/m ²)	34 ± 1	32 ± 1	-3.3 ± 0.2 *	-3.1 ± 0.2 *
Body fat (%)	48 ± 1	46 ± 1	-3.0 ± 0.6 *	-3.8 ± 0.5 *
FFM (kg)	46 ± 1	45 ± 1	-1.6 ± 0.4 *	-1.1 ± 0.3 *
RMR (kcal/d)	1474 ± 43	1411 ± 38	-66 ± 39	-23 ± 45
VO ₂ max (L/min)	1.55 ± 0.07	1.74 ± 0.07 †	-0.04 ± 0.04	0.17 ± 0.04 * †

Data are means ± SEM. Significant change from baseline:

* P<0.01. Differences vs. WL alone at respective time point:

† P<0.01.

Table 2

Baseline and Changes in Dietary Intake and Activity and Sleep Patterns

	Baseline WL	Baseline AEX+WL	Post WL	Post AEX+WL
Caloric Intake (kcal/d)	1748 ± 68	1774 ± 64	-221 ± 54 [*]	-184 ± 60 [*]
CHO (% of calories)	51 ± 1	53 ± 1	2.2 ± 0.8 [*]	-0.52 ± 0.9 [†]
FAT (% of calories)	31 ± 1	28 ± 1	-3 ± 1 [*]	-1 ± 1 [§]
PRO (% of calories)	16.4 ± 0.4	17.6 ± 0.4	2.1 ± 0.5 [*]	0.3 ± 0.5 [†]
PRO (g/kg/d)	0.82 ± 0.03	0.96 ± 0.04 [§]	0.28 ± 0.09 [*]	0.02 ± 0.11 [‡]
Average Activity (counts/awake minutes)	101 ± 12	126 ± 7	-24 ± 33	17 ± 18
-Weekend	158 ± 54	147 ± 12	-81 ± 8	-3 ± 24
-Weekday [◆]	96 ± 10	115 ± 8	-16 ± 8	28 ± 16
Sleep (minutes/night)	477 ± 26	493 ± 16	78 ± 63	-4 ± 19
-Weekend	598 ± 72	545 ± 34	-101 ± 96	-28 ± 37
-Weekday [¥]	439 ± 20	460 ± 17	49 ± 28	2 ± 25

Data are means ± SEM. Significant change from baseline:

^{*} P<0.01. Differences vs. WL alone at respective time point:[†] P<0.05[§] P<0.01[‡] P=0.07. Differences vs. weekend at baseline:[◆] P<0.05[¥] P<0.01.