Effects of habitual physical activity on the resting metabolic rates and body compositions of women aged 35 to 50 years

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ABSTRACT

Objective To examine the effect habitual physical activity has on resting metabolic rate (RMR) and body composition (fat-free mass[FFM], fat mass, and percent body fat) in active compared to sedentary adult women.
Design RMR was measured (by indirect calorimetry) twice after a 12-hour fast at the same point of the menstrual cycle and 48 hours after exercise. FFM, fat mass and percent body fat were measured using whole body air displacement plethysmography. Energy intake and expenditure were determined using 7-day weighed-food records and activity logs.
Subjects Healthy, weight-stable premenopausal women aged 35 to 50 years classified as either active (approximately 9 hours per week of physical activity for 10 or more years) (n=18) or sedentary (approximately 1 hour per week of physical activity) (n=14).
Statistical analyses Analysis of covariance was used to investigate differences in mean RMR (kcal/day) between the groups adjusted for FFM, and independent *t* tests were used to determine differences in demographic, energy expenditure, and diet variables.
Results Percent body fat and fat mass were lower ($P<.0005$) and RMR (adjusted for FFM) was significantly higher in the active women ($P=.045$) compared with sedentary controls. In the active and sedentary groups respectively, mean adjusted RMR was 1,510 kcal/day and 1,443 kcal/day, body fat was 18.9% and 28.8%, and fat mass was 11.1 kg and 18.8 kg. Groups were similar in body mass, FFM, body mass index, and age. Mean energy balance appeared to be more negative in the active group ($P=.0059$) due to significantly higher mean self-reported energy expenditures ($P=.0001$) and similar mean self-reported energy intakes ($P=.52$) compared with sedentary controls. These data indicate that active women who participate in habitual physical activity can maintain lower body fat and a higher RMR than sedentary controls with similar body mass, FFM, and body mass index.
Applications/Conclusions This research supports and emphasizes the benefits of habitual physical activity in maintaining RMR and lower body fat levels in middle-aged women. *J Am Diet Assoc. 2001;101:1181-1188.*

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As the proportion of older adults in the United States rises, the health care community is increasingly focused on factors that positively affect health and well-being during the later years of life, such as increased physical activity, proper diet, and maintenance of a healthful body weight and composition. Exercise is especially beneficial for women because it helps prevent the loss of fat-free mass (FFM), strength, bone mineral density, and functional ability that usually occur with aging, while helping to maintain lower fat mass and reduce the risk of obesity (1,2).

Exercise affects total daily energy expenditure 2 ways. First, regular physical activity increases the amount of energy expended daily. Second, exercise helps maintain FFM, which in turn helps to maintain a higher resting metabolic rate (RMR).

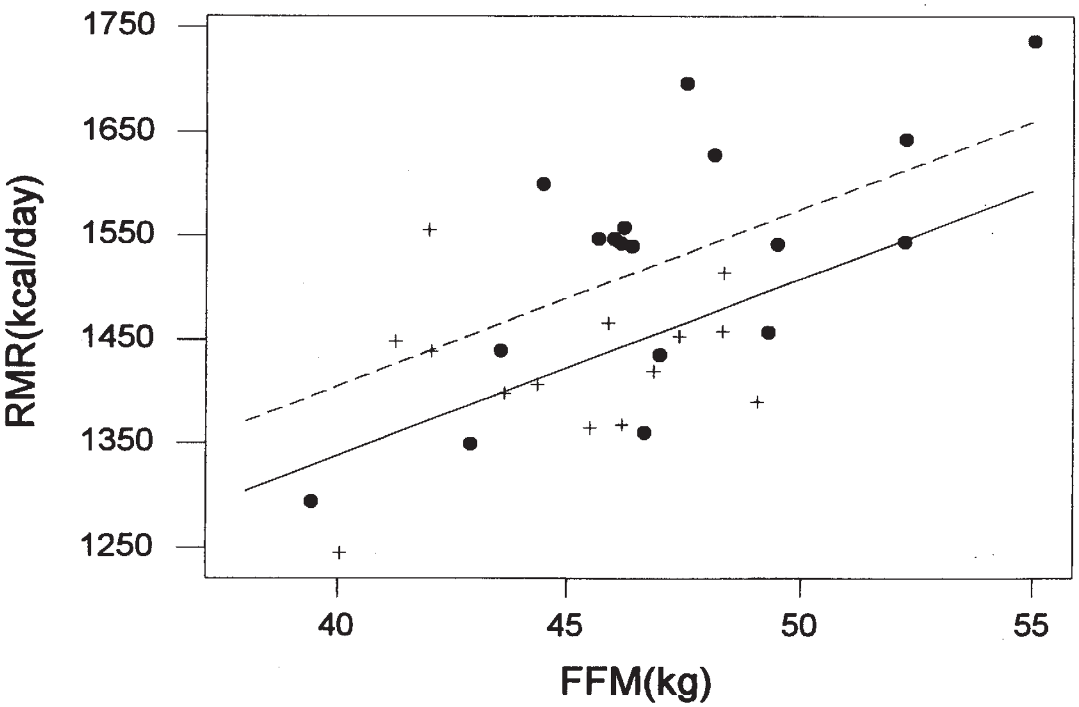

FIG. Relationship between resting metabolic rate (RMR) and fat-free mass (FFM) in active (n=18) and sedentary (n=14), weight-stable women aged 35 to 50 years. Regression lines are significantly different (P=.045) between groups. Dashed line = active; solid line = sedentary; closed circles = active; plus signs = sedentary.

RMR can represent 60% to 75% of total daily energy expenditure for many adults (3), therefore playing a substantial role in maintaining a healthful body weight.

Because FFM is a primary determinant of RMR, factors that influence RMR often do so through their affect on FFM. For example, aging is associated with a 1% to 2% decrease in RMR per decade resulting in part from age-related declines in FFM and concurrent increases in fat mass (4,5). Unfortunately, as people age they tend to become less physically active and experience a decrease in muscle mass (6). Gender also impacts RMR. Women typically have lower FFM and higher fat mass than men and thus, a lower RMR (7-9). Finally, many women engage in weight-loss diets at various points in their lives. Severe energy restriction, which results in a loss of total body weight, FFM, and fat mass, can cause a decrease in RMR (10). If FFM can be maintained into old age by sustaining physical activity and avoiding severe energy restriction, then the age-related declines generally seen in RMR and strength may be minimized or delayed.

Research examining the affects of age and physical activity on RMR generally compare young (<35 years) and older (>50 years) groups, and leave out women aged 35 to 50 years. In addition, studies have focused primarily on men (11-15). Thus, there are limited studies examining changes in RMR in active and sedentary women (16-20), and only 2 we know of have included groups of middle-aged women (16,17). Unfortunately, these studies report conflicting results. Toth and Poehlman (17) found significantly higher RMR in women aged 36 to 50 years trained in both aerobic and resistant exercise compared with sedentary controls. Conversely, Ryan et al (16) examined changes in RMR and FFM in active women aged 18 to 69 years by decade but only had young (aged 18 to 29 years) and middle-age (aged 40 to 50 years) sedentary controls. They found no significant loss of FFM across the life cycle in the active subjects, although RMR decreased significantly with age. In addition, they found no significant differences in RMR or FFM between athletes aged 40 to 49 years (n=10) and their controls aged 40 to 50 years (n=6). However, Ryan et al (16) did not control for menstrual function nor for phase of the menstrual cycle. Toth and Poehlman (17) controlled for phase of the menstrual cycle but included pre-, peri-, and postmenopausal women within each group. RMR fluctuates over the phases of the menstrual cycle (21-23), whereas those without regular menses or with no menses do not experience these changes (24). Thus, when measuring RMR in women, point of the menstrual cycle and regularity of the cycle need to be considered.

Currently, there is little information available on the affect chronic physical activity has on the body composition (FFM, fat mass, percent body fat) and RMR of middle-age premenopausal women compared to sedentary controls. Therefore, the purpose of this study was to compare differences in RMR and body composition in healthy, weight-stable premenopausal women aged 35 to 50 years classified as either active or sedentary, while controlling for phase of the menstrual cycle and menstrual regularity, and body mass index (BMI, measured as kg/m^2).

METHODS

Subject Selection and Classification

Habitually active (n=18) and sedentary (n=14) healthy white women aged 35 to 50 years were recruited. To be classified as habitually active, a woman had to exercise for a minimum of 6 hours per week (eg, distance running, swimming, cycling, tennis, weight training, aerobics, or triathlons) and have maintained this level of activity for a minimum of 5 years. To be classified as sedentary, a woman had to exercise <2 hours per week and have maintained a sedentary lifestyle for at least 5 years.

All subjects were premenopausal and self-reported having regular menstrual periods (approximately 28-day cycles, 12 cycles per year), had BMIs <27, were weight stable (no unexplained weight fluctuations >2.3 kg) for the previous 6 months, were nonsmokers, and reported no major health problems. Subjects were not eliminated if they used vitamin/mineral supplements or oral contraceptives.

Subjects were initially screened using a telephone interview. Healthy premenopausal women who met the age, body size, and activity criteria were asked to visit the nutrition laboratory for further screening. Eligible subjects signed an informed consent; completed health history, medication, and supplement questionnaires; and were instructed on completing 7-day food and activity records. A fasting blood sample was taken for the assessment of iron and thyroid status; any subject with poor status would have been eliminated because these factors can affect RMR and/or the ability to exercise. All procedures were approved by the Arizona State University Institutional Review Board for Human Subjects Research. Of the 25 active and 20 sedentary women recruited, 2 women were excluded because their 7-day mean self-reported energy intakes were lower than their measured RMR, 10 were excluded because RMR measurements were not reproducible due to equipment problems, and 1 subject was excluded because of self-reported alcoholism. The final analysis included 18 active and 14 sedentary subjects.

Diet and Activity Records

Subjects completed consecutive 7-day food and activity records. Calibrated food scales were provided and subjects were instructed to be as precise as possible when measuring, weighing, and recording all foods and beverages. Food labels, recipes, or other product information were also provided to the researchers. Subjects received 24-hour logs, divided into 30-minute time blocks, on which to record all activity for each 24-hour period. Careful attention was given to instructing subjects on how to record programmed physical activity such as running, swimming, or cycling. Subjects were asked to record duration (time), intensity (heart rate), speed (mi/hour; m/hour) for each programmed activity they engaged in during the day. If subjects were also engaged in strength training, their specific routine was recorded (amount of weight lifted, types of exercises completed, time to complete the routine). Records were reviewed for accuracy and clarity then analyzed using the Food Processor (version 7.12, 1997, ESHA Research, Salem, Ore) nutrient and activity analysis program. To calculate total energy expenditure, the program uses 6% for the thermic effect of food and the WHO equation to estimate RMR. In this study, the estimated RMR was replaced with the actual RMR measurement. Energy balance was determined by subtracting 7-day mean energy expenditure (kcal/day) from 7-day mean energy intake (kcal/day).

Resting Metabolic Rate and Body Composition

RMR was determined in the morning, after a 12-hour fast, within 5 to 7 days of the onset of the menstrual cycle. All participants reported normal menstrual cycles with no premenopausal symptoms. Active subjects refrained from strenuous exercise for 48 hours before testing, and all subjects were instructed to maintain usual dietary habits for 3 days before their RMR measurement. RMR was measured twice using a MAX-1 metabolic cart (Fitness Instrument Technologies Corporation, Quoque, NY) that was calibrated before each measurement period using known gases. Participants came to the laboratory between 4 AM and 10 AM for height and body mass measurements. RMR was measured using a facemask in a dimly lit, temperature-controlled room with subjects in a semirecumbent position. After a 15-minute habituation period, ventilation, oxygen consumption, and respiratory exchange ratio were monitored continuously for 30 minutes, with periods of movement or fidgeting eliminated, leaving approximately 20 to 25 minutes of RMR data. After a 10 to 20 minute break, a second RMR measurement was taken using the same protocol. If the measurements were not reproducible (<5% difference), the subject returned on another morning for a third test. Mean values of oxygen and carbon dioxide from each collection period were used in determining RMR (kcal/minute) using the Weir equation (3.941 [VO_2 (L/min)] + 1.106 [VCO_2 (L/min)] = kcal/min) (25). The coefficient of variation of this procedure has been previously determined to be 3.08% in our laboratory.

Body composition was determined after an overnight fast by whole body air displacement plethysmography using a BodPod machine (Life Measurement Instruments, Concord, Calif). Weight (in swimsuit) was measured on a calibrated scale to the nearest 0.25 kg, and body density was determined. Two body composition assessments were done while the subject was in the chamber, and the mean body density values used to calculate percent body fat using an equation specific for women (percent body fat = [5.01/density - 4.57] x 100) (26). If the 2 body density measurements were inconsistent, a third test was conducted.

Biochemical Assessments

A fasting blood sample was taken for a general biochemical screen, including iron and thyroid (triiodothyronine resin uptake, total thyroxine index, free thyroxine, and thyroid-stimulating hormone third generation) status. The samples were cold centrifuged and sent to a certified external lab for analysis. Mean group values for each biochemical parameter were within normal ranges. Classification of an abnormally low thyroid status required low concentrations of triiodothyronine resin uptake, total thyroxine index, free thyroxine, and thyroid-stimulating hormone third generation concentration. Using these criteria, no subject had abnormal thyroid status. One subject had low iron status; however, she did not report feeling ill or tired and exercised 565 minutes per week.

Statistical Analysis

Differences between groups for demographic variables (age, height, body mass, BMI, percent body fat, fat mass, FFM), energy expenditure variables (energy expenditure, energy balance) and diet variables (total energy intake, macronutrients) were determined using independent *t* tests. Significance was set at P=.05 for all statistical tests. When conducting multiple hypothesis tests (eg, the independent *t* tests),

Table 1
Demographic and energy balance data of active and sedentary women aged 35 to 50 years

Characteristic	Active women (n=18)	Sedentary women (n=14)	P value
	← mean±standard deviation →		
Age (y)	42±3	42±4	.98
Height (cm)	164.6±7.2	167.4±4.8	.19
Body mass (kg)	58.3±4.7	63.9±7.2	.02
Body mass index (kg/m²)	21.6±1.6	22.8±2.4	.12
Body fat mass (kg)[a]	11.1±3.5	18.8±6.1	.0005*
Body fat (%)[a]	18.9±4.9	28.8±6.8	.0001*
Fat free mass (kg)[a]	47.1±3.7	45.1±2.9	.085
Estimated energy			
Energy intake (kcal/d)[b]	2,186±560	2,069±457	.52
Energy expenditure (kcal/d)[c]	2,865±357	2,189±177	.0001*
Energy balance (kcal/d)	−679±593	−120±471	.0059*
Exercise (min/wk)	544±258	60±47	—

[a]Values obtained using plethysmography (BodPod, Life Measurement Instruments, Concord, Calif).
[b]Mean energy intake determined from 7-day food records.
[c]Energy expenditure determined using resting metabolic rate values from MAX-1 metabolic cart (Fitness Instrument Technologies Corporation, Quoque, NY) and activities and thermic effect of food (6%) from the 7-day activity records.
[d]Minutes per week of programmed exercise was tabulated from the 7-day activity records.
*Significantly different (using independent *t* test) at $P<.01$.

Table 2
Self-reported mean 7-day energy and nutrient data for active (n=18) and sedentary (n=14) women aged 35 to 50 years

Nutrient	Active women	Sedentary women	P
	← mean±standard deviation →		
Energy (kcal/d)	2,186±560	2,069±457	.52
Protein (g/d)	81.7±22.4	78.0±18.0	—
g/kg body mass	1.4±0.3	1.2±0.3	—
% total kcal	15.3±4.3	15.3±2.6	.96
Carbohydrate (g/d)	316.8±95.7	276.6±80.6	—
g/kg body mass	5.5±1.7	4.4±1.3	—
% total kcal	57.9±9.8	52.9±6.6	.097
Fat (g/d)	62.4±28.4	75.0±15.8	—
g/kg body mass	1.1±0.4	1.2±0.3	—
% total kcal	25.4±7.9	33.1±4.9	.0022*
Alcohol (g/d)	11.7±15.6	2.6±4.9	—
% total kcal	3.7±4.7	0.9±1.6	.031
Caffeine (mg/d)	155±113	137±137	—
Fiber (g/d)	24.5±11.4	21.5±7.5	—

*Significantly different (using independent *t* test) at $P<.01$.

familywise significance was P=.05 and the Bonferroni method was applied to reduce the type I error rate; the resulting individual test significance level was P=.01 (27). Analysis of covariance was used to investigate differences in mean RMR (kcal/day) for the 2 groups adjusted for FFM (kg). We applied the regression formulation of analysis of covariance with RMR the dependent variable and FFM the independent variable. We first tested the hypothesis to determine if the slopes of the 2 regression models were identical. When this hypothesis was accepted, we conducted a hypothesis test to determine if there was any difference in the average RMR values of the 2 groups for fixed FFM. The Mann-Whitney U test was used to determine if there were significant differences in the average frequency of multivitamin/mineral supplement use and sports food use between the active and sedentary groups. A 2-proportion hypothesis test was also conducted to determine if there were significant differences in the groups for the proportion of subjects within each group who used supplements and/or sport foods. Data were analyzed using the Minitab Statistical Package for Windows (version 12.1, 1998, Minitab Inc, State College, Pa).

RESULTS

This study examined the differences in RMR and body composition in healthy, middle-age weight-stable women, classified as either sedentary (approximately 1 hour per week of physical activity) or habitually active (approximately 9 hours per week of physical activity during the past 10 years). Using analysis of covariance, RMR was found to be significantly higher (P=.045) in the active compared with the sedentary group (see the Figure). Mean adjusted RMR was 1,510 kcal/day for the active and 1,443 kcal/day for the sedentary women. There were no differences in respiratory exchange ratio taken at rest (active = 0.835; sedentary = 0.862). Table 1 gives the demographic characteristics of the subjects and their self-reported energy intakes and expenditures. Subjects were recruited into each group based on activity level (sedentary vs activity), age (40 to 50 years) and body size (BMI <27); thus, by design the activity levels were higher in the active group, while there were no differences in age and body size between the groups. Although not matched for FFM, there were no significant differences between the groups; however, the active women had significantly lower body fat levels (approximately 19% vs 29%, P=.0001) and total fat mass (approximately 11 kg vs 19 kg, P=0.0005) than the sedentary women. Finally, although body weight was not statistically different between the groups, the sedentary group weighed 5.6 kg (about 12 lb) more than the active group. These data indicate that middle-age women who exercise regularly can maintain lower body fat levels and higher RMR relative to FFM than their sedentary counterparts who have similar body mass, FFM, and BMI.

Even though the active women exercised more (544 minutes per week) and had greater total energy expenditures (2,865 kcal/day) than the sedentary women (60 minutes of exercise per week, expending 2,189 kcal/day), there were no significant differences in self-reported mean energy intakes (Table 1). Thus, mean calculated energy balance (mean energy intake - mean energy expenditure) was more negative in the active than the sedentary group (P=.0059). However, all women in this group reported weight stability before and during the study; thus, we assumed that subjects were either underreporting energy intake and/or overreporting energy expenditure. The sedentary group appeared to be in energy balance based on their self-reported data, as their calculated energy balance value was close to zero and within the standard error of the method. Self-reported mean energy and macronutrient intakes are presented in Table 2. As indicated, there were no differences between the groups for total energy intake; however, the sedentary women had significantly higher fat intakes (approximately 33% of total energy) than the active women (approximately 25% of total energy). There were no other notable differences in macronutrient intakes between the groups. Mean protein intake for each group exceeded the Recommended Dietary Allowance for protein intake (0.8 g/kg) (28). In addition, absolute caffeine and fiber intakes were similar.

Because active persons are reported to use supplements more frequently than sedentary persons (29,30), we examined the use of these products within each group (Table 3). In addition, we examined the use of sports foods, many of which are highly fortified with vitamins and minerals, within each group. Use of multivitamin/mineral supplements and sports foods were tabulated based on self-report questionnaires and 7-day diet records, and expressed as number of subjects in each group reporting use and the frequency of use for each of these persons. Both groups reported similar supplement use, but the active group had a significantly higher frequency of use per week. Subjects in the active group reported using sports foods (eg, sports drinks, energy bars, protein powders) nearly twice as often as subjects in the sedentary group and with 3.5 times the frequency.

DISCUSSION

Only 2 cross-sectional studies, besides ours, have examined the differences in adjusted RMR and body composition in healthy, middle-age women classified as either physically active or sedentary (16,17). In our study, the active women reported exercising approximately 9 hours per week for the past 10 years, and thus represent a group of habitual exercisers, whereas the sedentary control group exercised approximately 1 hour per week and had been sedentary for most of their lives. Using analysis of covariance, adjusted RMR was significantly higher in active compared with sedentary women. Although groups were similar for body mass, FFM, and BMI, the sedentary group had significantly higher percent body fat and absolute fat mass. It should be also be noted that although body mass was not statistically different between the groups, the sedentary group weighed 5.6 kg (about 12 lb) more than the active group.

RMR, FFM, and Exercise

FFM is a strong predictor of RMR. We found significant differences between the groups in adjusted RMR while controlling for FFM using regression analysis. This statistical approach is more reliable and valid than the ratio method (comparing RMR to FFM using independent *t* tests) because the regression-based approach does not assume a zero y intercept and adjusts individual and group RMR data according to the linear relationship between RMR and FFM (17). In addition, we measured RMR at least 48 hours after the last exercise bout to eliminate any possible residual effects of exercise on RMR, because exercise can increase RMR up to 39 hours postexercise (31)

We found a significantly higher adjusted RMR in the active group compared with their sedentary counterparts, although FFM was similar between the groups. These results are in agreement with Toth and Poehlman (32) who also found a significantly higher adjusted RMR in aerobically and resistant trained women compared to controls. Conversely, Ryan et al (16) found no differences in adjusted RMR in active and sedentary women; however, they did not match groups for BMI or FFM and did not measure RMR in their subjects at the same point in the menstrual cycle. They also found that RMR declined with age in their athletes aged 18 to 69 years, whereas Van Pelt et al (18), while examining women aged 21 to 35 years and aged 50 to 72 years, found that with age, adjusted RMR significantly decreased in healthy sedentary women, but not in active women who exercised regularly. Thus, it appears that exercise can maintain RMR across the life span in women aged 21 to 35 years and 50 to 72 years (18) and in women aged 35 to 50 years as we observed in this study and as reported by Toth and Poehlman (17).

We found significantly higher adjusted RMR and lower body fat levels in active middle-age women compared to sedentary women with similar body mass, body mass index, and FFM

Data from our study, and that collected by Ryan et al (16) and Toth and Poehlman (17), are all cross-sectional, examining the effects of exercise in 2 independent groups of persons (physically active vs sedentary) at 1 point in time. Currently, no longitudinal study has examined RMR over time in sedentary and active women to determine if these cross-sectional data are supported.

Body Composition and Exercise

Few studies have examined the affect of habitual exercise on body composition in active middle-age women compared to controls. We found that absolute levels of FFM were similar between groups, whereas percent body fat was approximately 10% higher (P=.0001) and fat mass was approximately 8 kg higher in the sedentary group (P=.0005). These results are similar to Toth and Poehlman (17), who found no differences in FFM between active and sedentary women, but sedentary women had significantly higher mean body fat than the active

Table 3
Percentage and frequency of multivitamin/mineral supplement and sports food use in active (n=18) and sedentary (n=14) women aged 35 to 50 years

Supplement	Active women	Sedentary women	P^d
Multivitamin/mineral use (%)[a]	61	57	.82
Frequency (d/wk)[b]	6.5±1.2	4.3±2.1	.01*
Sports food use (%)[c]	83	43	.01*
Frequency (times/wk)[b]	5.3±4.4	1.5±0.8	.04*

[a]Values calculated from the medication and dietary supplement questionnaires and the 7-day diet records.
[b]Mean±standard deviation.
[c]Values calculated from 7-day food records. Sports foods included PowerBars (PowerBar, Berkeley, Calif), Balance Bars (Balance Bar Co, Rye Brook, NY), Clif Energy Bars (Clif Bar Inc, Berkeley, Calif), and Gatorate Sports Drink (Quaker Oats Company, Chicago, Ill).
[d]Groups were significantly different if $P<.05$.

women. Conversely, Ryan et al (16) found that although body mass, percent body fat, and BMI were significantly higher in sedentary women compared to active controls, FFM was similar. Additionally, Van Pelt et al (18) compared active and sedentary premenopausal women aged 21 to 35 years and postmenopausal women aged 50 to 72 years with similar FFM. The results showed that sedentary postmenopausal women had approximately 12% more body fat than premenopausal sedentary women, yet active postmenopausal women had approximately 10% more body fat than active premenopausal women. When comparing active and sedentary premenopausal women, body fat was approximately 12% lower in the active group, and comparing active and sedentary postmenopausal women, body fat was approximately 14% lower in the active group (18). These data suggest that exercise can decrease the accumulation of body fat in young and older persons compared to their sedentary counterparts. However, the study also suggests that exercise cannot prevent or eliminate an increase in body fat from the pre- to postmenopausal years.

Energy Balance

Although all subjects reported being weight stable and not dieting for weight loss, the active group had a mean negative energy balance (- 679 kcal/day), whereas the sedentary group was in approximate balance (-100 kcal/day is within the standard error of the method). Only 5 of the active subjects reported negative energy balance, yet the measured RMR values in these subjects were similar to predicted values using the Harris-Benedict equation (33). The most likely explanation for the discrepancies in energy intake and energy expenditure is inaccuracies in self-reported energy intake and physical activity records, which made the active women appear to be in negative energy balance. The validity of the self-reporting of energy intake and daily activities has been criticized in the literature (34,35). Because the women self-reported being weight stable, it is assumed that our subjects were not in negative energy balance, and the discrepancies are attributed to errors associated with the method.

Another suggested explanation for the negative energy balance without weight loss frequently reported in active persons is increased energy efficiency (36,37). Similar to our study, Mulligan and Butterfield (38) found that women who had maintained high levels of activity for at least 6 months had increased energy intake vs the nonexercisers; however, they did not have energy intakes that matched their energy expenditure to maintain energy balance. The subjects did, however, remain weight stable. These researchers concluded that the body might adapt to the exercise through maintaining body weight without significantly increasing energy intake (38). Other researchers have reported increased energy efficiency in male triathletes self-reporting negative energy balance compared to controls self-reporting energy balance who were matched for activity levels and body composition and mass. This increased energy efficiency was confirmed using a metabolic chamber and controlled eating conditions. In that study, athletes self-reporting negative energy balance actually maintained body weight by having significantly reduced 24-hour energy expenditure, RMR, sleep metabolic rate, and spontaneous physical activity compared to matched controls (36). To date, there are no metabolic chamber data documenting energy efficiency in activewomen.

Dietary Intakes

There is no ideal method of assessing dietary intake in free-living people; thus, there are inherent errors associated with collecting food records and determining the number of days to collect (39,40). We used 7-day weighed diet records because most active persons have a weekly training routine that can influence the timing of meals and/or the amount of food consumed at a meal. This approach also gave us an opportunity to get a better picture of typical activity and dietary patterns during a week. To help improve accuracy of recording, we provided each person with detailed instructions, measuring utensils, and a calibrated scale for weighing food. In addition, subjects provided food labels and recipes, along with specific brand names of foods consumed and restaurants where meals were purchased. Finally, we also measured total energy expenditure (activity records and measured RMR), which gave us an additional way of checking accuracy of total energy intake. Weight-stable persons should be close to energy balance; only 5 of our active subjects did not self-report energy balance. Although every effort was made to get the most accurate food records possible, the energy and nutrient intakes reported here need to be considered within the context of dietary method used and its associated errors (39).

The influence of the menstrual cycle on energy intake has been documented in the literature. Some researchers show higher energy intakes during the luteal phase of the menstrual cycle (41,42), yet other researchers report no differences in energy intake across the menstrual cycle (43,44). In our study, women were able to record their 7-day food records anytime following their initial screening visit, and thus the influence of the menstrual cycle on energy intake was not controlled. However, RMR for all subjects was taken during the follicular phase of the cycle.

The current recommendation for protein is 0.8 g per kilogram body mass (28); however, it is thought that endurance athletes and weight-trained athletes may have an increased protein requirement (1.2 g and 1.7 g/kg, respectively) (45-47). The active women in this study were consuming a mean intake of 1.4 g/kg body mass and sedentary women were consuming a mean of 1.2 g/kg body mass.

It has been suggested that female athletes need a minimum carbohydrate intake of 5 g/kg body mass to sustain glycogen stores for moderate physical activity (48), and needs increase to 6 g to 8 g/kg body mass when exercise duration, intensity, and frequency are high (47,49). In our study, active women consumed a mean of 5.5 g carbohydrate per kilogram body mass.

The recommendation for total fat intake is <30% of total energy (50). The active group consumed significantly less fat (P=.022) (25% of total energy) than the sedentary group (33% of total energy). This difference in fat intake may be related to differences in lifestyle between the 2 groups, with the active group being more health conscious (ie, exercising, regulating fat intake) than the sedentary group.

Supplement and Sports Foods

In addition to macronutrients and energy intake, we tabulated the percentage and frequency of the use of multivitamin/mineral supplements and sports foods in active and sedentary women. Supplement use is frequently associated with a more healthful lifestyle (29,30). Kirk et al (29) compared 8,409 supplement users to 5,413 nonusers, including all-female subjects across all age groups. A healthful lifestyle was defined as having a diet high in vegetables and fruits and low in alcohol intake, refraining from smoking, and maintaining a physically active lifestyle. We found that approximately two-thirds of our subjects consumed a multivitamin/mineral supplement, with no differences between the groups. Thus, our data do not support Kirk et al, who hypothesized that those who supplement have a more healthful lifestyle. However, the frequency of supplement use was significantly higher in the active group (ie, they took their supplements more regularly during the week). We also tabulated sports food use in each group and found that the active women used sports foods approximately twice as often and with more than 3 times the frequency of the sedentary group.

APPLICATIONS/CONCLUSIONS

The relationship between RMR, body composition, and nutrient status of healthy, active, middle-age women is limited and equivocal (16,17), and we found significantly higher adjusted RMR and lower body fat levels in active middle-age women compared to sedentary women with similar body mass, body mass index, and FFM. Thus, habitual exercise appears to help maintain RMR and reduce body fat in women aged 35-50 years. Dietitians and other health professionals should encourage lifelong physical activity for women of all ages.

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PRACTICE POINTS

Positive influences of exercise in middle-aged women: More research needed

For many women, maintaining a healthy body weight and composition, especially during their later years in life, can be a daunting and seemingly impossible task. Focusing on the factors that positively affect health and well-being can also be cumbersome, unfortunately research in this area is limited and incomplete. According to Katherine Beals, PhD, RD, and an assistant professor of nutrition at Ball State University in Muncie, Indiana, "Research needs to be done in this area. The prevalence of obesity in this country is skyrocketing. Obesity is associated with a myriad of health problems and chronic diseases. If there were something that could potentially prevent the typical weight gain seen with increasing age, as well as decrease the risk of developing chronic diseases, I would think we would want to find out what that was and promote it. If physical activity might just be that thing then we should research it." Not only is there little research, as Beals notes, but the authors of this study also point out that no other study of this kind has included the "point of menstrual cycle and regularity of the cycle."

"Controlling for the menstrual cycle is imperative when conducting research examining energy balance and/or substrate utilization because energy intake and expenditure as well as substrate utilization has been shown to vary with the different phases of the menstrual cycle," explains Beals. "Dietitians could alert their patients to the changes in energy expenditure that occur with the menstrual cycle and to adjust energy intake accordingly." She also suggests extending the research further, to include "a study done using a variety of physical activity levels (ranging from sedentary to very active) so that an amount of exercise necessary to bring about the resting metabolic rate and body composition benefits can be established."

Until this area of research is expanded, dietitians can prescribe a less rigorous exercise program. Dietitians should foster the importance of exercise on their patients health and, as Beals believes, "general well-being (ie psychological and emotional health). New dietitians should encourage regular or lifelong physical activity. I think there are enough good (and scientifically sound) reasons for maintaining a regular exercise program to convince individuals of the importance of exercise. The American College of Sports Medicine, as well as the Guidelines for Americans, recommend that individuals accumulate at least 30 minutes of exercise on most days of the week. Nonetheless, something is better than nothing at all."

Supporting and emphasizing the benefits of habitual physical activity in maintaining a healthy weight and body composition in middle-aged women is an area of research that needs to continue to be examined in future studies. For now, dietetics professionals have the opportunity to guide their patients through promoting exercise and its advantages to attain and sustain optimal physical health.

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