Relationship between Accumulated Walking and Body Composition in Middle-Aged Women

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ABSTRACT

THOMPSON, D. L., J. RAKOW, and S. M. PERDUE. Relationship between Accumulated Walking and Body Composition in Middle-Aged Women. *Med. Sci. Sports Exerc.*, Vol. 36, No. 5, pp. 911–914, 2004. **Purpose:** The purpose of this study was to examine the relationship between objectively determined physical activity (pedometer counted steps per day) and body composition variables in middle-aged women. **Methods:** Height, weight, body fat percentage (%BF), waist circumference, and hip circumference were measured on eighty women (50.3 ± 6.8 yr). For 7 d after testing, each subject wore a pedometer throughout the day while following her normal daily routine. Each morning the pedometer was reset to zero, and each evening the subject recorded the steps accumulated during the day. Pearson product moment correlations were used to examine the relationship between average steps per day and body composition variables. Subjects were placed in groups to reflect different levels of physical activity: inactive (<6000 steps·d^{-1}), somewhat active (6000–9999 steps·d^{-1}), and regularly active (≥10,000 steps·d^{-1}). ANOVA was utilized to determine whether body composition variables varied across activity groups. Significance was set at $P < 0.05$ for all tests. **Results:** A significant correlation was found between average steps per day and %BF (−0.713, $P < 0.0001$); body mass index (BMI) (−0.417, $P < 0.0001$); waist circumference (−0.616; $P < 0.0001$); hip circumference (−0.278; $P = 0.013$); and waist-to-hip ratio (−0.652; $P < 0.0001$). There was a significant difference in body composition variables among activity groups, with higher values found in the less active groups. **Conclusion:** This is the first study to specifically examine the relationship between steps per day and body composition in middle-aged women. Although the cross-sectional nature of this study does not allow causal relationships to be determined, women who walked more had lower %BF. Additionally, the average BMI of women who accumulated 10,000+ steps·d^{-1} was in the normal range. **Key Words:** PEDOMETER, BODY FAT, BMI, EXERCISE, AMBULATION

Obesity is a major health issue worldwide. In the United States, overweight and obesity prevalence rates are 64.5% and 30.5%, respectively (6). Cross-sectional data using questionnaire-generated estimates of physical activity (PA) suggest an association between regular PA and body composition variables (2,8), but methodological issues make examination of this relationship complex (5). Studies in which pedometers were used to document PA report that approximately 10% of the variation in body mass index (BMI) can be explained by ambulatory activity (4,23,24). Investigations using doubly labeled water have shown a weak or no relationship between PA energy expenditure corrected for basal metabolic rate (BMR) and body fat percentage in cross-sectional studies (5,28). The weak associations between quantified PA and body composition variables may be due to methodological issues such as combining sexes and various ages in the analyses. Longitudinal studies provide stronger evidence for the importance of PA in weight regulation. In observational studies (9,30) and in interventions (7,18), individuals who exercise regularly accumulate less body fat over time.

Obesity prevalence is increasing across all ages (6), but women are particularly vulnerable to weight gain in the years surrounding menopause (13,22). The role of exercise in prevention of weight gain in women around the time of menopause is an area receiving much attention. Research indicates that women who remain physically active throughout life have less total fat (10,17,26) and less abdominal fat (17,26) compared with sedentary women. Attenuation of fat accumulation is one avenue through which PA may reduce the impact of the menopause on the health risk profile of aging women.

Pedometers have become increasingly popular devices for public use and for researchers. These devices are relatively inexpensive, are unobtrusive and provide immediate feedback to the wearer, have demonstrated validity and reliability, and daily steps are fairly reflective of overall energy expenditure in ambulatory individuals (1,25). When a wide age range is used or when men and women are examined together, steps per day explain about 10% of the variation in body composition variables (4,23,24). DiPietro et al. (3) showed that, whereas survey-determined walking for leisure had no impact on the weight of younger individuals, walking was significantly linked with lower body weights among those 40 yr or older. However, there is a lack of research examining the association between quantified PA and body composition variables in middle-aged women. Based on the facts that the prevalence of activities such as cycling and running decrease with age (3) and the

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highest prevalence of walking for leisure-time PA is seen in the 45–54 age range for women (19), we hypothesized that pedometer-measured daily walking would be strongly associated with body composition variables in middle-aged women. Therefore, the purposes of this study were to: 1) examine the relationship between objectively determined physical activity (pedometer counted steps per day) and various body composition variables in women in their middle years and 2) determine whether women who accumulated 10,000 or more steps per day had a more favorable body composition profile compared with women who walk less.

METHODS

Eighty women (50.3 ± 6.8 yr) between the ages of 40 and 66 yr made one laboratory visit for the measurement of height, weight, body fat percentage (%BF), waist circumference, and hip circumference. Before any measurements, subjects provided written informed consent to participate in this study. The University of Tennessee Institutional Review Board approved this experimental protocol and the informed consent document. Weight was measured and %BF estimated using air displacement plethysmography with the BOD POD Body Composition System (Life Measurement Inc., Concord, CA) using standard procedures (14). Body density was converted to %BF using the Siri equation (20). Height was measured using a wall-mounted stadiometer (Seca Corporation, Columbia, MD). Standing waist and hip circumferences were measured in duplicate using a Gulick fiberglass measuring tape with a tension handle (Creative Health Products, Inc., Plymouth, MI), and mean values were used in calculations. The waist measurement was taken at the narrowest part of the torso between the rib cage and the iliac crest, after a normal expiration. Hip circumference was measured at the greatest gluteal protuberance while the subject stood with the feet together. Body mass index was calculated by dividing weight (kilograms) by height squared (meters square).

After body composition testing, subjects were instructed in the use of a pedometer. For 7 d after the laboratory testing, each subject wore a Digi-Walker pedometer model SW-200 (New Lifestyles Inc., Lees Summit, MO) throughout the day, except for sleeping and bathing. The pedometers were positioned on the waist, in-line with the right mid-thigh. Each morning the pedometer was reset to zero, and each evening the subject recorded the steps accumulated during the day. Subjects were asked to follow their typical work and leisure routines during the week of investigation.

TABLE 1. Descriptive characteristics (N = 80).

Variable	Mean	SD	Minimum	Maximum
Age (yr)	50.3	6.8	40.0	66.0
Height (m)	1.641	0.060	1.496	1.756
Weight (kg)	70.2	15.5	44.6	153.9
BMI (kg·m^{-2})	26.0	5.1	18.3	53.3
Waist (cm)	82.7	12.4	62.0	117.4
Hip (cm)	103.0	12.6	75.9	159.5
WHR	0.80	0.07	0.65	1.00
Body fat (%)	34.9	9.4	14.3	61.9
Steps·d^{-1}	8354	3249	3407	16,729

BMI, body mass index; Waist, waist circumference; Hip, hip circumference; WHR, waist-to-hip ratio; Body fat, body fat percentage; Steps·d^{-1}, average steps accumulated per day.

TABLE 2. Pearson correlations and partial correlations (controlling for age) between average steps per day and body composition variables (N = 80).

Variable	Correlation	P	Partial Correlation	P
BMI	−0.417	<0.0001	−0.421	<0.0001
Body fat	−0.713	<0.0001	−0.712	<0.0001
Waist	−0.616	<0.0001	−0.610	<0.0001
Hip	−0.278	0.013	−0.285	0.011
WHR	−0.652	<0.0001	−0.643	<0.0001

BMI, body mass index; Body fat, body fat percentage; Waist, waist circumference; Hip, hip circumference; WHR, waist-to-hip ratio.

Pearson product moment correlations were used to examine the relationship between average steps per day and the body composition variables. Partial correlation coefficients were calculated between steps per day and body composition variables while controlling for age. *A priori*, activity groups were chosen to indicate inactive (<6000 steps·d^{-1}), somewhat active (6000–9999 steps·d^{-1}), and regularly active (≥10,000 steps·d^{-1}) women. ANOVA was utilized to determine whether body composition variables varied across activity groups. Significance was set at $P < 0.05$ for all tests. All statistical tests were conducted using SPSS version 11 for Macintosh operating system X (SPSS Inc, Chicago, IL).

RESULTS

The subject characteristics are shown in Table 1. There was wide variation in body composition variables and steps per day among these subjects. A significant inverse correlation was found between average steps per day and %BF ($r = -0.713$, $P < 0.0001$); BMI ($r = -0.417$, $P < 0.0001$); waist circumference ($r = -0.616$; $P < 0.0001$); hip circumference ($r = -0.278$; $P = 0.013$); and waist-to-hip ratio ($r = -0.652$; $P < 0.0001$) (Table 2). There was no significant correlation found between age and steps per day ($r = -0.141$; $P = 0.213$). There was no significant association between age and any body composition variable [r values ranging from $r = -0.032$ ($P = 0.778$) to $r = 0.214$ ($P = 0.057$), data not shown]. When partial correlation was used to factor out the impact of age on the relationship between steps per day and body composition variables, all relationships remained significant (Table 2). When examined by activity group, there was a significant difference in the %BF among all groups, with higher fat percentages found in the less active groups (Table 3). Similarly, the highest values for all measured body composition variables were seen in the least active group (Table 3).

DISCUSSION

This is the first study to specifically examine the relationship between average accumulated steps per day and body composition variables in women who are in their middle years. Although the cross-sectional nature of this study does not allow causal relationships to be determined,

TABLE 3. Comparison of body composition variables across activity groups.

Group (steps·d^{-1})	BMI (kg·m^{-2})	Body Fat (%)	Waist (cm)	Hip (cm)	WHR
<6000 (N = 22)	29.3 (1.0)^{a}	44.2 (1.4)^{a}	94.6 (2.0)^{a}	109.1 (2.6)^{a}	0.87 (0.01)^{a}
6000–9999 (N = 33)	25.6 (0.8)^{b}	35.1 (1.1)^{b}	81.5 (1.7)^{b}	102.0 (2.1)^{a,b}	0.80 (0.01)^{b}
≥10,000 (N = 25)	23.6 (0.9)^{b}	26.4 (1.3)^{c}	73.8 (1.9)^{c}	98.9 (2.4)^{b}	0.75 (0.01)^{c}

Values represent means and standard errors [mean (SE)].
Means with different letter superscripts are significantly different, $P < 0.05$.
BMI, body mass index; Body fat, body fat percentage; Waist, waist circumference; Hip, hip circumference; WHR, waist-to-hip ratio.

we found that those women who walked more had lower %BF as well as a smaller waist circumference, hip circumference, and waist-to-hip ratio. In fact, approximately 50% of the variance in %BF was explained by differences in daily steps (Table 2). Additionally, the average BMI (23.6 ± 0.9 kg·m^{-2}) of women who accumulated 10,000 or more steps per day was in the recommended range (Table 3, Fig. 1). Women classified as inactive (<6000 steps·d^{-1}) or somewhat active (6000–9999 steps·d^{-1}) had a less favorable body composition profile than those who averaged 10,000 or more steps each day (Table 3). Those who walked less had more total fat and more centrally located fat (Table 3). The health implications (e.g., increased risk of cardiovascular disease and Type 2 diabetes) of excess adiposity, particularly visceral fat, make this finding important. If subsequent studies support these findings, it may be possible to establish a volume of walking with demonstrated protection against obesity.

Current PA recommendations encourage all adults to accumulate at least 30 min of moderate PA on most, preferably all, days of the week (16). Simpson and colleagues (19), using data from the Behavioral Risk Factor Surveillance System, found that only 21.1% of men and 19.6% of women met this recommendation. However, among women who met the recommendation, 45.6% reported only walking, while an additional 22.2% reported walking in combination with other activities (19). When examined by sex and age, the highest prevalence for walking was reported by women between the ages of 45 and 54 yr (19). Clearly, walking is an important means for American adults, and particularly women in their middle and older years, to meet PA recommendations.

An alternative to the current approach of recommending PA (i.e., ≥ 30 min of moderate PA on most days of the week) is to prescribe a targeted number of daily steps and monitor this goal with the use of a pedometer. This approach has been used in Japan for a number of years (12) and is gaining popularity in other countries (1). The 10,000 steps·d^{-1} recommendation is the most popular pedometer-driven approach for increasing PA (1,11,12). Although the 10,000 steps·d^{-1} approach is not the strict equivalent to the current PA recommendation, there is some agreement between approaches. Wilde et al. (29) found that, when given instructions to take a 30-min walk, sedentary women increased their daily steps from 7,220 to 10,030. Additionally, Welk et al. (27) found that exceeding 10,000 steps·d^{-1} was generally linked with meeting the current PA recommendation of accumulating 30 min of moderate activity. Cross-sectional data indicate that accumulating 10,000 steps·d^{-1} is linked with lower blood pressure and skinfold thickness (11). In interventions, increasing walking to approximately 10,000 steps·d^{-1} in previously inactive women has been shown to lower blood pressure (15,21), decrease body mass (15), and improve glucose tolerance (21). In a recent examination of steps per day and body composition, Tudor-Locke et al. (24) reported a correlation of r = −0.27 between steps per day and %BF. This lower association, compared with that seen in the current study, is likely due to the inclusion of both men and women, Caucasians and African-Americans, and a wider age range of subjects (24). Collectively, the results of interventions (15,21) and this study suggest that, for women in their middle years, accumulating 10,000 steps·d^{-1} is an approach that yields health-related benefits and helps protect against obesity.

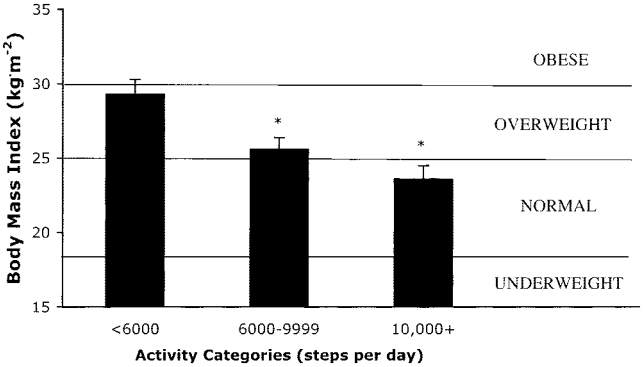

FIGURE 1—Body mass index of the activity groups; * significantly different (P < 0.05) from the group averaging less than 6000 steps·d^{-1}.

There are limitations to this study. Because our purpose was to investigate the relationship between daily, quantified PA and body composition variables in women during their middle years, these results cannot be used to draw conclusions for men or for women in different age categories. Additionally, all subjects in this study were Caucasian, and therefore, results may not be consistent across races. The subjects in this study were not randomly chosen from the population. They were a convenience sample recruited through public service announcements, posting recruitment flyers, and using "word of mouth." However, the wide variation seen in both steps per day and body composition variables suggests that we examined a diverse sample. To fully answer questions related to these issues, large-scale, randomized sampling is needed.

Our findings demonstrate a clear inverse association between body composition variables and daily accumulated steps in middle-aged women. The women in this study who averaged 10,000 steps·d^{-1} had a BMI in the recommended range and a significantly lower %BF, waist circumference,

hip circumference, and waist-to-hip ratio compared with inactive women. The high rate of physical inactivity and the rising obesity prevalence are major public health threats in the United States. Finding public health messages that resonate with the public and also result in health benefits is critical. Considering that middle-aged and older women are more likely to choose walking for leisure (19), the results of recent interventions (15,21) and the findings of this study suggest that the 10,000 steps·d^{-1} recommendation is suitable for promoting health in women ages 40–66 yr.

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