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Increasing daily walking lowers blood pressure in postmenopausal women

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ABSTRACT

MOREAU, K. L., R. DEGARMO, J. LANGLEY, C. MCMAHON, E. T. HOWLEY, D. R. BASSETT, JR., and D. L. THOMPSON. Increasing daily walking lowers blood pressure in postmenopausal women. *Med. Sci. Sports Exerc.*, Vol. 33, No. 11, 2001, pp. 1825–1831. **Purpose:** The American College of Sports Medicine and the Centers for Disease Control and Prevention (ACSM-CDC) recommend 30 min of daily moderate-intensity physical activity for health; however, the effectiveness of this recommendation in lowering blood pressure (BP) in hypertensives is unclear. The present study tested the hypothesis that walking activity following the ACSM-CDC physical activity recommendation would lower BP in postmenopausal women with high BP. **Methods:** Resting BP was measured in 24 postmenopausal women with borderline to stage 1 hypertension at baseline, 12 wk, and 24 wk. Fifteen women in the exercise (EX) group walked 3 $km \cdot d^{-1}$ above their daily lifestyle walking, whereas 9 women in the control (CON) group did not change their activity. Walking activity was self-measured with a pedometer in both groups. **Results:** Resting systolic BP was reduced in the EX group after 12 wk by 6 mm Hg ($P < 0.005$) and was further reduced by 5 mm Hg at the end of 24 wk ($P < 0.005$). There was no change in diastolic BP with walking. The CON group experienced no change in BP at either 12 or 24 wk. Body mass was modestly reduced by 1.3 kg in the EX group after 24 wk ($P < 0.05$); however, it was not correlated with the change in BP. There were no changes in selected variables known to impact BP including percent body fat, fasting plasma insulin, or dietary intake. **Conclusion:** In conclusion, a 24-wk walking program meeting the ACSM-CDC physical activity recommendation is effective in lowering systolic BP in postmenopausal women with borderline to stage 1 hypertension. **Key Words:** ESSENTIAL HYPERTENSION, PHYSICAL ACTIVITY, EXERCISE, INSULIN, GLUCOSE

An estimated 43 million U.S. adults are hypertensive, with the highest prevalence rates occurring in men and postmenopausal women (7). Hypertension is difficult to treat because of its complex etiology. "The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure" (JNC-VI) encourages lifestyle modification, including regular physical activity in the treatment of high blood pressure (BP) as well as adjunctive therapy for hypertensive patients on pharmacological therapy (2). Exercise programs including walking, running, cycling, and swimming have demonstrated significant BP lowering effects in hypertensive individuals (8,11,18,19,23,31,34). However, persuading adults to participate regularly in aerobic exercise is a challenge.

The American College of Sports Medicine and the Centers for Disease Control and Prevention (ACSM-CDC) developed a physical activity recommendation geared toward getting more people active. This guideline recommends that every U.S. adult should accumulate at least 30 min of moderate-intensity physical activity on most, and preferably all, days of the week (26). The activity can be intermittent or continuous and can include occupational and nonoccupational activities such as brisk walking 3 $km \cdot d^{-1}$. This recommendation is derived in part from epidemiological data demonstrating a dose-response relation between self-reported physical activity (derived from questionnaires) and health outcomes (20,25). Physical activity questionnaires have been shown to underestimate daily walking activity by 2–4 km (3,6). Thus, if the respondents on questionnaire data used to derive the ACSM-CDC physical activity recommendation also underestimated their daily walking distance, then the minimum amount of physical activity necessary to confer cardiovascular health benefits may be greater than the 3 $km \cdot d^{-1}$ recommendation.

The effectiveness of the ACSM-CDC recommendation in lowering BP in healthy sedentary adults is equivocal (9,24,27). Reasons for the discrepancies could be because of a compensatory decline in subjects' daily lifestyle activity upon initiation of an exercise program or because the populations studied were normotensive (24,27). To our knowledge, the effectiveness of this recommendation in lowering BP in hypertensive postmenopausal women has not been investigated. Accordingly, the present study tested the hypothesis that a daily walking regimen meeting the ACSM-CDC physical activity recommendation would be effective in lowering resting BP in postmenopausal women with borderline to high BP. To determine this, we assessed resting BP, body composition, diet, and fasting insulin levels at baseline and after 12 and 24 wk of walking activity meeting the ACSM-CDC recommendation in a group of postmenopausal women with borderline to stage 1 hypertension. In

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order to prevent the decline in daily lifestyle walking activity and to monitor the amount of walking performed, a pedometer was used to measure baseline daily walking, and a step prescription equivalent to a distance of 3 $km \cdot d^{-1}$ was added onto this baseline value.

METHODS

Subjects. Twenty-four postmenopausal women (age, 54 ± 1 yr) with borderline to stage 1 hypertension (systolic BP of 130–159 mm Hg and/or diastolic BP of 85–99 mm Hg), determined on the basis of repeated seated BP recordings at rest on two separate days, were studied. Fifteen women were randomized to the exercise (EX) group and 9 to a nonexercising control (CON) group. The women had cessation of menses for at least 1 yr and were not participating in regular physical activity (<2 $d \cdot wk^{-1}$) within the past year. They were nonsmokers, had no orthopedic limitations to walking, and were absent of known cardiovascular disease (CVD) as assessed with a health history questionnaire. Ten women (eight in the EX group, two in the CON group) were taking antihypertensive medications: four were taking ACE inhibitors, one was taking a diuretic, one was taking a beta blocker, two were taking a combination calcium channel blocker/ACE inhibitor drug, one was taking an angiotensin II receptor antagonist, and one was taking an alpha blocker. Sixteen women (12 in the EX group, four in the CON group) were on stable hormone replacement therapy (HRT) for at least a year. Antihypertensive medications and hormone supplements were maintained (no change in medication type or dosage) throughout the course of the study in each of these women, and all medications were taken at the same time of day when testing was performed. All subjects read and signed a consent form approved by the University of Tennessee Institutional Review Board.

Walking program. Subjects were given a Yamax SW-200 pedometer (Yamax, Inc., Tokyo, Japan) to wear throughout the day for a 1- to 2-wk period before beginning the 24-wk walking program in order to document preintervention daily lifestyle walking activity. Previous work conducted in our laboratory has shown a similar Yamax electronic pedometer (DW-500) to measure walking distances with an accuracy of ±10% between speeds of 2.5 and 4.0 mph (5). Instructions on how to position and wear the pedometer have been discussed previously (5,6). Briefly, the subjects put the pedometer on their belt or waistband as soon as they woke up each morning, removed it before going to bed each night, and recorded the number of steps they accumulated each day. An average daily value was computed and served as the baseline value. Stride length was measured in each subject and walking distance was calculated.

Women in the EX group were provided with a target number of steps that would lead to a 3-km increase in daily walking (the amount that ACSM-CDC recommends). The target steps were added onto their baseline step value in order to prevent a decline in their current daily lifestyle activity. Initially, all women were prescribed a distance of 1.4 $km \cdot d^{-1}$ above their baseline walking during week 1. The distance was then increased by 0.5 $km \cdot d^{-1}$ until the desired walking distance was achieved by the third week. The women were instructed to walk at a self-selected, comfortable pace, and were allowed to accumulate their steps in whatever pattern best fit their lifestyle. Walking steps were recorded on daily log sheets along with any additional physical activities and were collected on a biweekly basis. Other than walking, subjects were asked not to make any changes in their current lifestyle activities. Women in the CON group were asked not to change daily activity and subsequently wore a pedometer 1 wk each month to document their walking.

Measurements. Testing procedures were performed at baseline, 12 wk, and 24 wk. Subjects reported to the laboratory after fasting and abstaining from caffeine for at least 10 h. All testing procedures were conducted in the morning between 6:00 a.m. and 10:00 a.m. and at approximately the same time for each subject.

Resting blood pressure. Blood pressure and heart rate were measured at rest in triplicate by the same trained observer who was blinded to the group assignment as previously described (34). Briefly, subjects rested quietly in a seated position for at least 5 min before measurement. Heart rate was calculated from a 15-s radial pulse rate. The BP measurements were taken according to the guidelines established by the American Society of Hypertension (1). Blood pressure was measured in the left arm by brachial artery sphygmomanometer with at least 3 min separating each measurement. Systolic BP and diastolic BP were recorded at the first and fifth Korotkoff sounds, respectively. Mean arterial BP was calculated using the following equation: Mean BP = diastolic BP + ⅓(systolic BP − diastolic BP). The two closest heart rate and BP readings were averaged and served as the resting values.

Fasting insulin and glucose. Blood samples from an antecubital vein were collected into tubes containing EDTA and were used for subsequent determination of plasma glucose and insulin concentrations. Plasma insulin was determined in duplicate using a commercially available radioimmunoassay kit (ICN Biomedicals, Inc., Costa Mesa, CA). Plasma glucose was analyzed in duplicate using the hexokinase (HK) enzymatic method (Procedure No. 16-UV, Sigma Diagnostics, St. Louis, MO). All samples from each subject were analyzed within the same assay. The homeostasis model (fasting glucose × fasting insulin/22.5) was used to calculate the insulin sensitivity index (10).

Body composition. Body mass was measured to the nearest 0.01 kg using a calibrated scale and height was measured to the nearest 0.1 cm. Body mass index (BMI) was calculated from the ratio of weight (kg) to height (m^2). Abdominal circumference was measured at the umbilicus, and hip circumference was measured at the maximal circumference of the buttocks; measurements were made with a plastic tape fitted with a tension-handle. Sagittal diameter was measured with an anthropometer at the level of the umbilicus (measured front to back) with the subjects standing with arms across their chests. Anthropometric measurements were performed in duplicate by the same technician at

TABLE 1. Physical characteristics of the women in the CON and EX groups at baseline, 12 wk, and 24 wk.

Variable	CON Group ($N = 9$)			EX Group ($N = 15$)		
	Baseline	12 Wk	24 Wk	Baseline	12 Wk	24 Wk
Age (yr)	55 ± 1			53 ± 2		
Height (cm)	165.3 ± 1.3			165.8 ± 1.8		
Body mass (kg)	79.1 ± 7.4	79.3 ± 7.4	79.7 ± 7.5	81.1 ± 5.9	80.1 ± 5.8*	79.8 ± 5.8**
Body fat (%)	43.4 ± 2.0	43.9 ± 1.8	43.3 ± 2.1	42.1 ± 2.2	42.4 ± 2.0	42.0 ± 2.1
Resting HR (beats·min^{-1})	77 ± 3	73 ± 3	76 ± 3	77 ± 3	72 ± 2	75 ± 2
Insulin (μIU·mL^{-1})	15.3 ± 1.6	18.5 ± 3.3*	18.2 ± 3.3*	13.0 ± 1.5	11.9 ± 1.8	10.4 ± 1.8
Glucose (mmol·L^{-1})	5.7 ± 0.4	5.5 ± 0.2	5.7 ± 0.3	5.6 ± 0.3	5.5 ± 0.2	5.5 ± 0.2
HOMA	3.7 ± 0.4	4.6 ± 0.8	4.6 ± 0.9	3.3 ± 0.4	2.9 ± 0.3	2.6 ± 0.2

HR, heart rate; HOMA, insulin sensitivity index.
Values expressed as means ± SE. * $P < 0.05$, vs baseline; ** $P < 0.005$, vs baseline.

each testing period. Body composition was assessed by air displacement plethysmography using the BOD POD system (LMI, Inc., Concord, CA). The subjects sat inside a sealed chamber wearing either a Lycra swimsuit or undergarments and uncorrected body volume was measured. Body volume was corrected for thoracic gas volume using a predicted equation derived from gender, age, and height. Thoracic gas volume was predicted instead of measured to maintain consistency between measurement periods (22). Body density was determined from the ratio of body weight to corrected body volume. Percent body fat was calculated from body density using the Siri equation (32).

Dietary records. Subjects were asked to maintain their current dietary habits for the duration of the study. To document dietary food intake, subjects completed a 3-d dietary food record at baseline and at 12 and 24 wk of the study. The food records were analyzed for dietary composition using a computerized dietary analysis program (Nutritionist III, N-Squared Computing, Silverton, OR).

Statistical analysis. A two-way analysis of variance with repeated measures was used to determine the effects of the walking program and time on resting BP and heart rate, body composition, glucose, insulin, and dietary variables. A Newman-Keuls *post hoc* analysis was used to clarify all significant interactions. Univariate correlations were used to examine the relation between the change in resting BP with variables of interest. Statistical significance for all tests was established at $P < 0.05$. Data are presented as mean ± SE.

RESULTS

Walking activity. At baseline (within their daily lifestyle activity), women in the EX and CON groups walked an average of 5400 ± 500 and 7200 ± 700 steps·d^{-1}, respectively, equivalent to walking 3.4 ± 0.3 and 4.7 ± 0.4 km·d^{-1} (significantly different between EX and CON groups, $P < 0.05$). Women in the EX group increased their daily walking by 4300 steps (2.9 ± 0.2 km·d^{-1}; significantly different from baseline and from the CON group, $P < 0.05$) and averaged a total of 9700 ± 400 steps·d^{-1} (including baseline steps) across the 24-wk walking program (significantly different vs the CON group). The women in the CON group did not change their walking activity over 24 wk (−0.3 ± 0.3 km·d^{-1}).

Subject characteristics. There were no significant differences between the EX and CON groups in baseline levels of body composition, resting heart rate, and fasting insulin and glucose levels (Table 1). Body mass was reduced by 0.9 ± 0.3 kg after 12 wk ($P < 0.05$; Table 1) and was reduced by an additional 0.3 kg at 24 wk of walking in the EX group ($P < 0.005$; Table 1), but remained constant in the CON group. There were no significant changes in percent body fat, abdominal and hip circumferences, or sagittal diameter over 24 wk in either the EX or CON group. Fasting insulin and glucose levels and the insulin/glucose index were not significantly changed with walking in the EX group. However, in the CON group fasting insulin was elevated by 23% after 12 wk in comparison with baseline and remained elevated at 24 wk ($P < 0.05$; Table 1). No significant changes were observed in fasting glucose levels in either group. Baseline caloric intake was not different between the EX and CON groups (1826 ± 140 kcal vs 1855 ± 338 kcal) and did not change across the course of the study. There also was no difference in baseline intake of carbohydrates (58 ± 2% vs 56 ± 3%), fat (28 ± 2% vs 29 ± 3%), protein (14 ± 1% vs 16 ± 2%), or sodium (2717 ± 211 mg vs 2500 ± 295 mg), nor did these dietary variables change across the course of the study.

Resting blood pressure. Systolic BP and mean arterial BP measured at rest were reduced after 12 wk in the EX group (systolic BP, 142 ± 3 to 136 ± 2 mm Hg, $P < 0.05$, Fig. 1; mean arterial BP, 103 ± 1 to 98 ± 2 mm Hg, $P < 0.001$). Systolic BP was further reduced by 5 mm Hg after 24 wk ($P < 0.005$), whereas mean arterial BP remained unchanged from 12 wk to 24 wk. Systolic BP and mean arterial BP remained constant in the CON group throughout the 24 wk (systolic BP, 142 ± 3 vs 144 ± 3 vs 143 ± 3 mm Hg, Fig. 1; mean arterial BP, 104 ± 2 vs 104 ± 2 vs 106 ± 2 mm Hg). There was no significant change in diastolic BP measured at rest in either group across 24 wk (EX group, 84 ± 1 vs 79 ± 2 vs 81 ± 1 mm Hg; CON group, 86 ± 2 vs 85 ± 3 vs 87 ± 3 mm Hg; Fig. 1). The individual reductions in BP in the EX group are presented in Figure 2. By the end of the study, six women in the EX group normalized their BP (systolic BP < 130 and diastolic BP < 85 mm Hg), four of whom were stage 1 hypertensives. Additionally, three stage 1 hypertensive women in the EX group lowered their BP into the borderline high category. Eleven out of the 15 women in the EX group lowered their systolic BP by 5 mm Hg or more, and 9 of these women lowered their systolic BP by at least 10 mm Hg.

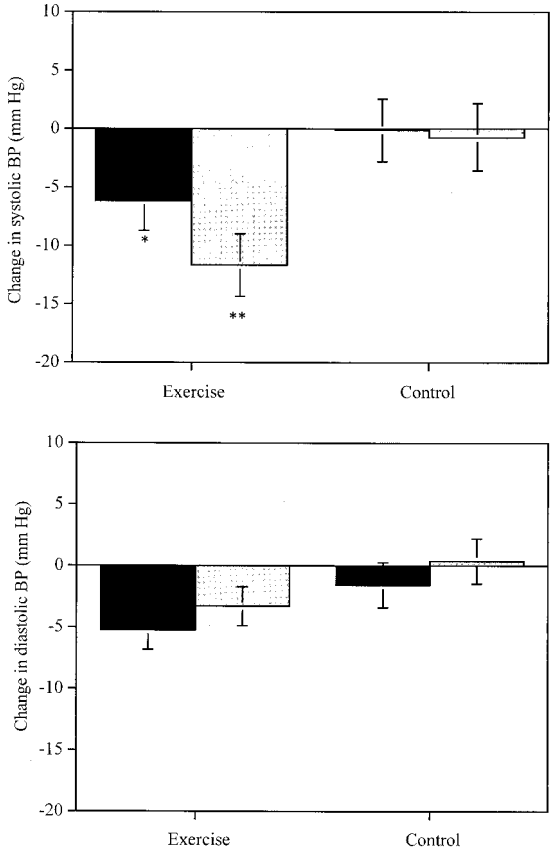

FIGURE 1—The change in systolic and diastolic blood pressures from baseline after 12 (*solid bars*) and 24 (*shaded bars*) wk in the EX and CON groups. *$P < 0.05$, from baseline; **$P < 0.005$, from baseline.

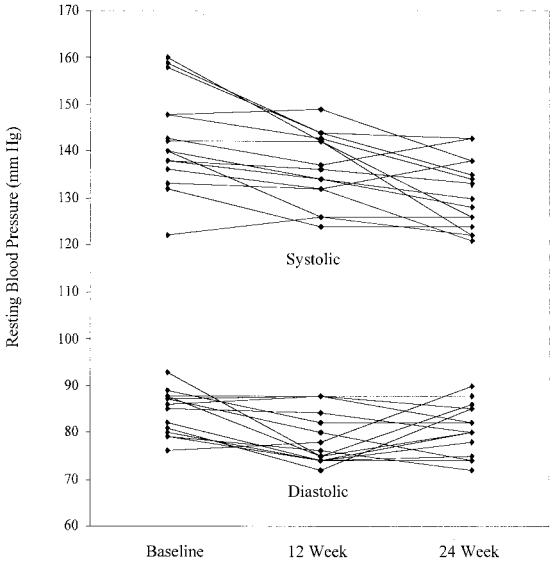

FIGURE 2—Individual changes in resting systolic BP and diastolic BP from baseline after 12 and 24 wk in women in the EX group.

Correlational analyses demonstrated that the reductions in systolic BP and mean arterial BP after 24 wk of walking in the EX group were strongly related to their initial BP ($r = -0.75$, $P < 0.001$ for both). There were no relations between the change in systolic BP and mean arterial BP and the changes in body mass, percent body fat, baseline or change in walking activity (steps·d^{-1} or km·d^{-1}), diet, fasting insulin and glucose, or insulin sensitivity index.

Figure 3 demonstrates the reduction in systolic and diastolic BP at rest after 12 and 24 wk in women in the EX group who were taking antihypertensive medications and those who were not taking antihypertensive medications. At 24 wk, neither the medicated nor nonmedicated walkers realized a change in diastolic BP (medicated, 84 ± 2 vs 80 ± 2 vs 81 ± 2 mm Hg; nonmedicated, 84 ± 2 vs 78 ± 2 vs 81 ± 2 mm Hg, $P > 0.05$); however, both groups of exercisers demonstrated a fall in systolic BP (medicated, 145 ± 4 vs 139 ± 2 vs 132 ± 3 mm Hg; nonmedicated, 140 ± 4 vs 133 ± 3 vs 129 ± 3 mm Hg, $P < 0.005$). The decrease in systolic BP was similar for medicated and nonmedicated walkers, 13 and 11 mm Hg, respectively. Women who were not taking antihypertensive medications lowered their body mass by 1.3 kg at 24 wk ($P < 0.5$, Table 2), whereas there were no significant changes in body mass in women taking antihypertensive medications. The change in body mass in women not taking antihypertensives was not related to the reduction in BP. There were no significant changes in body fat, diet (data not shown), fasting insulin and glucose, or the insulin sensitivity index in either group across 24 wk (Table 2). Hormone replacement status also did not influence the BP lowering effect, as the mean reduction in systolic BP (10 mm Hg) remained the same after removing the three nonusers of HRT from the analyses. Type of HRT also did not influence the findings, nor were there differences in subject characteristics between HRT users and nonusers of HRT (data not shown).

DISCUSSION

The major findings from the present investigation are as follows. First, 12 wk of walking activity meeting the ACSM-CDC minimum physical activity recommendation of walking 3 km·d^{-1} was effective in lowering systolic BP and mean arterial BP in postmenopausal women with borderline to stage 1 hypertension. Systolic BP was further reduced with an additional 12 wk of walking activity. The magnitude of BP reduction was not influenced by antihypertensive medications or HRT. Second, the reduction in systolic BP with walking was unrelated to changes in body mass, adiposity, diet, or fasting insulin level.

The present investigation demonstrates the efficacy of the ACSM-CDC physical activity recommendations in producing health benefits in hypertensive postmenopausal women. Systolic BP was reduced by an average of 11 mm Hg after 24 wk of walking, which is similar to the magnitude that has been reported for traditional exercise programs in hypertensives (4,12,16,31). Eleven women in the EX group reduced their systolic BP and 8 women reduced their diastolic BP by at least 5 mm Hg. Eight women had substantial systolic BP drops of 12 mm Hg or more, which has been reported to be associated with a 21% reduction in coronary heart disease (CHD) risk, 37% decrease in stroke risk, 28% reduction in CVD mortality, and a 13% reduction in all-cause mortality

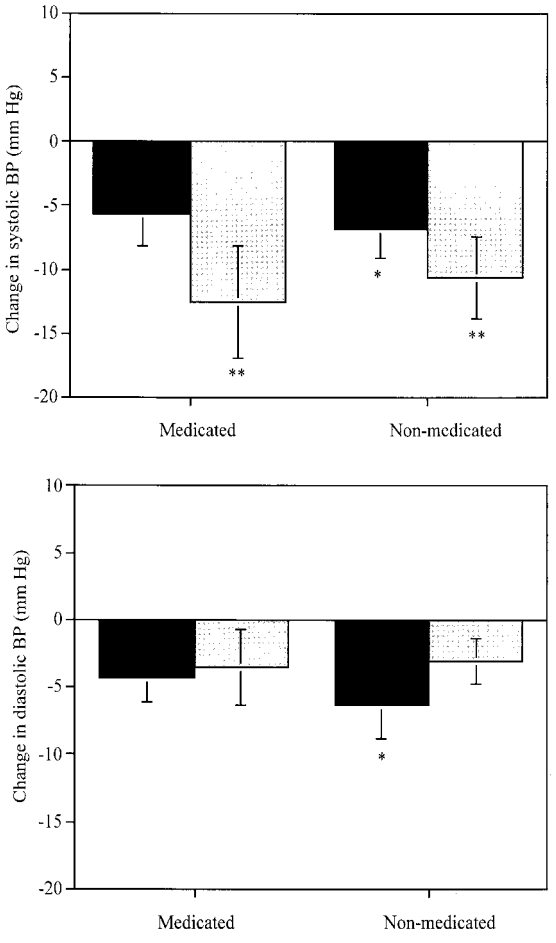

FIGURE 3—The change in systolic and diastolic blood pressures from baseline after 12 (*solid bars*) and 24 (*shaded bars*) wk in women in the EX group taking antihypertensive medications and women not taking antihypertensive medications. *$P < 0.05$, from baseline; **$P < 0.005$, from baseline.

(14). Also, six women, four of whom were stage 1 hypertensives, normalized their BP by the end of the study. These findings have important implications for physicians and other health care professionals who are looking for effective strategies to lower high BP. The JNC-VI guidelines recommend lifestyle modification as the first line of defense in treating borderline to stage 1 hypertensives (2), and the present findings provide evidence for the efficacy of prescribing activities that the ACSM-CDC recommends for attaining their 30-min·d^{-1} recommendation (i.e., walking 2–3 km·d^{-1}) to lower BP in postmenopausal women with borderline to stage 1 hypertension.

Since the adoption of the ACSM-CDC physical activity recommendation, several studies have investigated the effectiveness of this recommendation in lowering BP (9,24,27). In contrast to the present findings, Murphy and Hardman (24) and Ready et al. (27) reported nonsignificant reductions in systolic BP of 5 and 3 mm Hg with walking activity. Ready et al. (27) hypothesized that the lack of a BP lowering effect could be attributed to a decline in other daily activities. To avoid this potential problem in the present study, baseline walking levels were recorded with pedometers, additional walking was added to this baseline, and distance walked daily was recorded with pedometers. Using this approach, the present study was able to document increases in walking activity above the women's baseline walking activity. Another explanation for the differences in findings between the present study and the previous studies (24,27) can partially be attributed to the differences in subject populations. The subjects in the previous studies (24,27) were normotensive, and therefore were less likely to see significant reductions in BP. Walking programs have demonstrated significant BP lowering effects in hypertensive individuals (23,31,35). In the present study, the reduction in BP in the EX group was related to baseline BP. Specifically, the women who had higher baseline resting BP experienced the greatest reduction in BP with walking, a common finding in the literature (4,23,31).

In contrast to the previous findings (24,27), Dunn et al. (9) reported significant reductions in systolic BP and diastolic BP of 4 and 5 mm Hg, respectively, in normotensive men and women who participated in a 2-yr lifestyle activity program following the ACSM-CDC recommendation. However, the magnitudes of the reductions in BP are comparable to the nonsignificant reductions reported in the previous studies (24,27), and comparable to the nonsignificant reduction in diastolic BP in the present study. The significant reductions in BP are attributable in part to their large sample size ($N = 121$). Also, they did not use a nonexercising control group for comparisons, and therefore these small reductions in BP must be interpreted with caution (30). The nonexercising control groups in the previous studies (24,27) both showed small decreases in BP, precluding the possibility of a significant BP lowering effect with the walking. The control group in the present study allowed us to compare women who began to exercise with those who remained inactive. The reduction in BP among the EX group could therefore be attributed to the change in activity pattern.

The depressor effect of exercise has been attributed to factors known to influence BP such as body composition, insulin levels, and diet (17,28,29). In the present study, adiposity, dietary intake and composition, fasting insulin and glucose, and the HOMA insulin sensitivity index were not significantly changed over 24 wk in the EX group; however, fasting insulin was elevated in the CON group after 12 and 24 wk of the study. It is not clear as to why fasting insulin increased in the CON group, since diet, body mass, and adiposity did not change over the 24-wk period. However, fasting insulin in the CON group was still in the desirable range. Body mass was significantly reduced, albeit modestly, by 1.3 kg in the EX group at the end of the walking program but was not related to the reduction in systolic BP. This is not an uncommon finding, as other studies have also shown exercise to lower BP in hypertensives independent of body mass changes (8,11,18,19,23,31,34). Also, a recent review by Hagberg et al. (12) reported a nonsignificant correlation of 0.11 between the reduction in systolic BP and the reduction in body mass in 61 studies that reported body weight changes in hypertensives with exercise training. The authors concluded that the exercise training–induced

TABLE 2. Physical characteristics of the women taking antihypertensive medications and those not taking antihypertensive medications in the exercise groups at baseline, 12 wk, and 24 wk.

Variable	Medicated Walkers ($N = 8$)			Nonmedicated Walkers ($N = 7$)		
	Baseline	12 Wk	24 Wk	Baseline	12 Wk	24 Wk
Age (yr)	52 ± 1			55 ± 3		
Height (cm)	164.9 ± 2.2			166.8 ± 3.2		
Body mass (kg)	86.2 ± 10.3	84.9 ± 9.8	85.1 ± 9.9	75.2 ± 5.9	74.7 ± 6.5	73.9 ± 6.2*
Body fat (%)	44.4 ± 3.3	43.9 ± 3.3	42.7 ± 3.4	40.9 ± 3.7	42.1 ± 3.4	41.3 ± 3.5
Resting HR (beats·min^{-1})	77 ± 4	70 ± 3	77 ± 3	76 ± 4	75 ± 2	74 ± 3
Insulin (μIU·mL^{-1})	11.6 ± 1.0	11.4 ± 0.8	10.0 ± 1.0	14.5 ± 3.0	12.4 ± 2.5	10.8 ± 1.4
Glucose (mmol·L^{-1})	5.7 ± 0.3	5.4 ± 0.3	5.6 ± 0.3	5.4 ± 0.3	5.5 ± 0.2	5.4 ± 0.2
HOMA	3.0 ± 0.4	2.8 ± 0.3	2.5 ± 0.3	3.6 ± 0.9	3.0 ± 0.6	2.6 ± 0.4

HR, heart rate; HOMA, insulin sensitivity index.
Values expressed as means ± SE. * $P < 0.05$, vs baseline.

reductions in systolic BP and diastolic BP do not appear to be the result of body mass changes with exercise. The potential mechanism for the exercise-induced reduction in systolic BP in the present study could be because of changes in large artery and/or left ventricular function and possibly structure (35,36).

The present study has two potential confounding factors. First, we included women who were taking antihypertensive medications (three in the CON group and eight in the EX group) and HRT (four in the CON group and 12 in the EX group). The rationale for including women taking antihypertensive medications comes from the work of Cade et al. (8), who reported similar reductions in BP in those taking antihypertensive medications in comparison with those who were not taking medications. Also, Motoyama et al. (23) demonstrated an additional antihypertensive effect with a 3-month walking program in patients receiving antihypertensive medications. Women using HRT were included because previous cross-sectional studies have shown no differences in BP between users and nonusers of HRT (15,21,33). To control for any medication effect, the women in the present study took their medications at the same time of day at each testing period. Additionally, medications remained stable throughout the 24-wk intervention. In the present study, systolic BP responses of the antihypertensive-medicated subjects were similar to the nonmedicated subjects (reductions of 13 and 11 mm Hg, respectively), and removing the three nonusers of HRT from the analyses did not change the mean reduction in BP. Body mass was lowered after 24 wk in the nonmedicated subjects only; however, the reduction in body mass was not related to the change in BP. Also, there was no difference in BP response between those using HRT and those not using HRT.

A second potentially confounding factor is the difference in baseline levels of daily lifestyle walking activity between the EX and CON groups. This issue is overshadowed by the following factors. First, correlational analysis demonstrated no relation between baseline level of walking activity and the reduction in systolic BP. Second, there was no difference in baseline systolic BP at rest between the EX and CON groups (142 vs 142 mm Hg, respectively) even though baseline levels of daily lifestyle walking were different. Third, intervention studies usually do not account for daily lifestyle walking activity when initiating a walking program, at least not measured with motion sensors such as a pedometer. In the present study, pedometers were used to help the women achieve their walking prescription and so that we could document that women were increasing walking activity from their usual daily lifestyle walking.

The ACSM-CDC physical activity recommendation is aimed at those individuals who are sedentary or who do not participate in regular physical activity. The ACSM-CDC summary statement contends that health benefits can be accrued by accumulating physical activity throughout the day, and one way that the recommendation can be met is by briskly walking 3 km·d^{-1}. In the present study, 20 out of 24 of the women walked this amount within their daily lifestyle routine before beginning the study. On average, the women walked ~5000 steps·d^{-1} (3.4 km·d^{-1}), a level of daily lifestyle walking that has been reported previously (6,13). Since walking speed was not determined, we were unable to determine whether the amount of daily walking that the women performed was of "moderate" intensity. However, none of the women reported routine exercise, so it is unlikely that their baseline walking would be classified as "moderate" intensity. With the walking program, the women were each given a pedometer to wear along with a step prescription that equaled the physical activity recommendation of walking 3 km·d^{-1}. It must be noted, however, that the women were free to accumulate those steps in whatever way fit their lifestyle, and no intensity recommendation was given. The women increased their walking activity by an average of 5000 steps·d^{-1} and were walking an estimated 10,000 steps·d^{-1} (including their baseline walking level). In Japan, walking 10,000 steps·d^{-1} is promoted for the attainment of cardiovascular health benefits (13,37). Thus, the present investigation provides support for the 10,000 step·d^{-1} recommendation and also demonstrates the utility of using a pedometer and a step prescription to incorporate lifestyle physical activity.

In conclusion, the present study found that 24 wk of walking activity meeting the ACSM-CDC minimum physical activity recommendation of 3 km·d^{-1} (above normal daily routine activities) is effective in lowering systolic BP in postmenopausal women with borderline to mild hypertension. Women who were taking antihypertensive medications demonstrated a blood pressure lowering effect similar to women who were not taking medications. The reduction in BP was independent of changes in diet, body composition, or insulin level. The magnitude of systolic BP reduction observed with the walking program is clinically impor-

tant in that it translates into lower risks for cardiovascular disease and stroke. Finally, using a pedometer can be a useful tool for incorporating walking into daily activity.

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