Relation Between Leisure-Time Physical Activity and Blood Pressure in Older Women*

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Although there is some evidence that physical activity may decrease blood pressure in young and middle-aged women, the physical activity–blood pressure association in older women has rarely been studied. As part of an ongoing community-based study of chronic disease, 641 Caucasian women between the ages of 50 and 89 years had blood pressure measured following the Hypertension Detection and Follow-up Program protocol. They also answered selected Health Interview Survey questions about their leisure-time activity and were classified into categories of light (58%), moderate (24%), heavy (6%), or no physical activity (12%) by the estimated metabolic rate required for each activity. Women who engaged in any physical activity were significantly younger and thinner than sedentary women and had lower fasting and 2-hour postchallenge insulin levels. They did not differ in alcohol consumption, cigarette use, or prevalence of coronary heart disease or diabetes. Rates of systolic and diastolic hypertension were significantly lower in women participating in light, moderate, or heavy physical activity compared with sedentary women. Blood pressure levels decreased with each increase in reported activity intensity (p<0.005 for trend), with systolic blood pressure approximately 20 mm Hg lower in the heaviest activity group compared with systolic blood pressure in sedentary women. Intergroup differences remained statistically significant after adjustment for age and body mass index. Although physical activity was associated with lower fasting and 2-hour postchallenge insulin levels (p<0.01 for trend), adjustment for insulin levels did not alter blood pressure differences among activity groups. We conclude that habitual physical activity in older women is associated with clinically important lower systolic and diastolic blood pressures and that this benefit is independent of physical activity–related changes in obesity and plasma insulin. (Circulation 1991;83:559–565)

There is good evidence that physical activity at work or during leisure time may reduce rates of cardiovascular disease.1–6 In addition to the benefits of physical activity to lipid and lipoprotein levels,7,8 physical activity may protect against these diseases in part through effects on blood pressure.9–13 Studies have often compared blood pressure before with that after short-term physical activity training regimens in normotensive or hypertensive men.9,10,12,13 Although these studies generally show that strenuous physical activity training can modestly reduce systolic and diastolic blood pressures, these results are not directly applicable to most North Americans who do not regularly perform such strenuous physical activity. Importantly, most studies have not evaluated the benefits of physical activity on blood pressure in older populations, who are those most at risk for cardiovascular disease, nor do they control for other variables, such as obesity, alcohol ingestion, and medication use, that are known to affect blood pressure levels. Furthermore, only limited data are available on the physical activity–blood pressure association in women. Although rates of cardiovascular disease are lower in women than in men, coronary heart disease and strokes are common causes of morbidity and mortality in middle-aged and older women.14–17 Elevated blood pressure has been implicated as an important risk factor in both of these disease processes.9,18–20 The possibility of modifying this risk factor in older women through physical activity and providing a safe way to decrease cardiovascular disease risk merits further study. The present cross-sectional population-based study investigates the effect of reported leisure-time...
activity on blood pressure levels and rates of hypertension in older women.

Methods

From 1972 through 1974, 82% of women in a predominantly white, upper-middle-class community in southern California participated in a risk-factor screening survey as part of a Lipid Research Clinics Prevalence Study.21 From 1984 through 1987, 84% of the surviving women from the earlier study participated in an ongoing population-based study designed to examine life-styles and chronic disease incidence in older adults. The study was approved by the University of California San Diego Human Subjects Committee. Participants came to the clinic between 8:00 and 11:00 AM after a 12-hour fast. Weight and height were measured with the subject in light clothing and without shoes. The body mass index, computed as weight divided by height squared (kg/m²), was used to estimate obesity. Twelve-lead electrocardiograms were performed on participants using a Hewlett-Packard Pagewriter model 4750-A cardiograph. Resting heart rate was determined by taking the average of three normal QRS complexes. After a 12-hour fast, insulin levels were measured by a double-antibody radioimmunoassay method before and 2 hours after a standard 75-g glucose tolerance test. The coefficient of variation for measurement of insulin levels was 8.5%. Trained personnel using the Hypertension Detection and Follow-up Program protocol measured blood pressure twice in the seated position after 5 minutes of rest.22 The average of two blood pressure measurements was used in this study.

All participants were interviewed by trained personnel about their medical history and current use of cigarettes, alcoholic beverages, and medications; these variables as well as measurements of obesity, fat distribution, and physical activity were part of the chronic disease assessment. All subjects evaluated after May 1985 completed a questionnaire that assessed participation in 17 leisure-time activities during the 2-week period preceding their visit. This questionnaire, which was adapted from the 1985 Health Interview Survey23 and has been described previously,24 is presented in the “Appendix.” For analysis, activities were classified on the basis of relative intensity, using the activity intensity codes (ICs) established and validated by the Minnesota Heart Survey.25 The IC represents the ratio of metabolic rate during work to the basal metabolic rate.26 Light activities (IC >1–4.5) included walking, gardening, dancing, calisthenics, golfing, bowling, and horseback riding; moderate activities (IC ≥4.5–7.5) included hiking, tennis, biking, water exercises, and swimming; and heavy activities (IC ≥7.5) included jogging or running, handball, racquetball, squash, and aerobic exercise classes. Light, moderate, and heavy exercisers were those who reported participating in at least one activity at that estimated intensity level during the previous 2 weeks. Duration or frequency of activities was not considered in the classification of activity intensity to keep physical activity assessments as objective and free of bias as possible. Participants reporting physical activity in more than one intensity level during this period were classified by the estimated IC of their most strenuous physical activity.

Alcohol consumption in the week preceding the visit was calculated by summing the total number of milliliters of alcohol consumed in beer, wine, mixed drinks, and liqueurs according to the following formula: ml alcohol=(n beers×15.98 ml alcohol/12-oz beer)+(n glasses of wine×10.83 ml alcohol/3-oz glass of wine)+(n mixed drinks×19.09 ml alcohol/1.5-oz mixed drink)+(n liqueurs×8.88 ml alcohol/1-oz liqueur).27

Current smokers were those who reported smoking one or more cigarettes per day. Current estrogen use was defined as any use of estrogen in the 2 weeks before evaluation. Estrogen and antihypertensive medication use was confirmed by examination of prescriptions or medicine containers brought to the clinic for that purpose.

Systolic hypertension was defined as systolic blood pressure equal to or more than 160 mm Hg, and diastolic hypertension was defined as diastolic blood pressure equal to or more than 90 mm Hg. Overall hypertension represents either systolic or diastolic hypertension.

Data are presented for the 641 women who were seen consecutively after July 1985 (when the physical activity intensity questionnaire was initiated) and who were 50–89 years old at the time of the visit. Those without blood pressure measurements or verification of medication use were excluded from these analyses (n = 2). Women using antihypertensive medications were included in all analyses except where specifically stated as otherwise.

Age-adjusted mean blood pressure levels, insulin levels, and relevant population characteristics were computed for each physical activity group using analysis of covariance for continuous variables and by the direct method for categorical variables. To assess whether the association of physical activity intensity to blood pressure was mediated through reductions in body mass index or insulin, each of these variables was entered into a multiple linear regression model with age, alcohol, and smoking statistics. Statistical significance for linear trends was calculated using analysis of covariance with a linear contrast between activity intensity categories.

Results

In the portion of the population queried about specific types of physical activity, approximately 12% were classified as sedentary, 58% as light exercisers, 24% as moderate exercisers, and 6% as engaging in at least one form of heavy physical activity during the previous 2 weeks. The prevalence rates of known coronary heart disease and diabetes in this population of older adults were relatively low (<11%), and there were no significant differences in their preva-
In Table 1, mean age-adjusted population characteristics by exercise category in women aged 50–89 years, Rancho Bernardo, Calif., 1984–1987, are presented. The data show differences in age, heart rate, body mass index (kg/m²), alcohol consumption (ml/wk), smoking (cigarettes/day), and fasting insulin levels across exercise intensity groups.

Table 2 presents unadjusted mean (SD) blood pressure by exercise category in women by 10-year age groups, Rancho Bernardo, Calif., 1984–1987. The trend for systolic blood pressure was significant (p<0.05) across physical activity categories compared to the sedentary group.

Table 3 shows mean systolic and diastolic blood pressures by exercise category in women aged 50–89 years, Rancho Bernardo, Calif., 1984–1987. Systolic blood pressure was lower in the light to moderate physical activity category, while diastolic blood pressure was higher in the heavy intensity group.

The trend across physical activity categories was significant for both systolic and diastolic blood pressures, with systolic pressure decreasing and diastolic pressure increasing with increased physical activity intensity.

<table>
<thead>
<tr>
<th>Exercise intensity</th>
<th>None</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
<th>p for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic (mm Hg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>49</td>
<td>269</td>
<td>124</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>137.7</td>
<td>132.1</td>
<td>127.5</td>
<td>120.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>138.1</td>
<td>130.2</td>
<td>130.0</td>
<td>127.2</td>
<td>0.014</td>
</tr>
<tr>
<td>Age and BMI</td>
<td>136.9</td>
<td>130.5</td>
<td>129.1</td>
<td>127.9</td>
<td>0.031</td>
</tr>
<tr>
<td>Age, BMI, alcohol, estrogen</td>
<td>136.7</td>
<td>130.5</td>
<td>129.2</td>
<td>128.2</td>
<td>0.042</td>
</tr>
<tr>
<td>Age, BMI, fasting insulin</td>
<td>136.6</td>
<td>130.5</td>
<td>128.9</td>
<td>127.9</td>
<td>0.035</td>
</tr>
<tr>
<td>Age, BMI, 2-hr insulin</td>
<td>136.5</td>
<td>130.2</td>
<td>127.9</td>
<td>128.1</td>
<td>0.037</td>
</tr>
<tr>
<td><strong>Diastolic (mm Hg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>75.9</td>
<td>73.2</td>
<td>73.9</td>
<td>72.1</td>
<td>0.095</td>
</tr>
<tr>
<td>Adjusted</td>
<td>75.9</td>
<td>73.4</td>
<td>73.6</td>
<td>71.4</td>
<td>0.044</td>
</tr>
<tr>
<td>Age</td>
<td>75.0</td>
<td>73.7</td>
<td>73.2</td>
<td>71.9</td>
<td>0.130</td>
</tr>
<tr>
<td>Age and BMI</td>
<td>74.9</td>
<td>73.7</td>
<td>73.3</td>
<td>72.0</td>
<td>0.160</td>
</tr>
<tr>
<td>Age, BMI, alcohol, estrogen</td>
<td>75.1</td>
<td>73.7</td>
<td>73.1</td>
<td>71.9</td>
<td>0.115</td>
</tr>
<tr>
<td>Age, BMI, fasting insulin</td>
<td>75.1</td>
<td>73.7</td>
<td>73.1</td>
<td>71.9</td>
<td>0.112</td>
</tr>
</tbody>
</table>

BMI, body mass index.

Discussion

In this older population of women, significantly lower systolic and diastolic blood pressures were seen with light-intensity leisure-time physical activity, and further reductions were present with heavier physical activity. In addition, significantly lower rates of systolic and diastolic hypertension were present in all physically active women compared with sedentary women. As classification of physical activity intensity was based on the highest intensity activity reported, even if it was performed only once during the 2-week period, it likely overestimates the true physical activity intensity of this population. Therefore, the results represent a conservative estimate of the association between physical activity and blood pressure in older women and offer support for the benefit of even light-intensity physical activity.

The results of the present study confirm the large differences in blood pressure between sedentary and active subjects reported in the few studies.
evaluating physical activity training effects on blood pressure in older populations.\textsuperscript{28–32} Results very similar to ours were reported by Hagberg et al\textsuperscript{32} from a study of 60–69-year-old men and women who underwent exercise training. Both systolic and diastolic blood pressures were markedly lower, even with low-intensity physical activity. Together, these studies suggest that physical activity of light-to-moderate intensity may be a particularly effective and simple nonpharmacological method of lowering blood pressure in older adults.

Despite lower body mass indexes in exercising women, blood pressure differences remained clinically and statistically significant between physical activity intensity categories after adjusting for body mass index differences. This suggests that physical activity in older women may have effects on blood pressure beyond its role in weight control. The inverse association between physical activity and blood pressure was independent of age, alcohol consumption, and estrogen use, attributes known to have important effects on blood pressure.\textsuperscript{9,33} In addition, blood pressure levels were lower in each physical activity category regardless of whether participants used antihypertensive medications. This suggests that benefits of physical activity may exist for those with recognized hypertension as well as for those with normal blood pressure. Studies in younger adults have also demonstrated physical activity to be modestly effective in lowering blood pressure in normotensive and hypertensive subjects.\textsuperscript{10,12,34}

As in any cross-sectional study, we cannot exclude the possibility that health differences between active and sedentary participants explain the inverse association between physical activity and blood pressure. This is unlikely, however, for two reasons. First, all participants were ambulatory and relatively healthy. All acutely ill participants were rescheduled for visits when in their usual health. Second, the prevalences of both coronary heart disease and diabetes (diseases that could limit physical activity and influence blood pressure) were relatively low and were similar in physically active and sedentary participants. Finally, the exclusion of participants with either or both of these diseases did not alter the inverse association between physical activity and blood pressure.

Self-reported physical activity assessments have well-known limitations.\textsuperscript{35} These result primarily from problems in questionnaire bias or recall bias and contribute to subject misclassification, which may diminish the strength of the physical activity–blood pressure association. This fact along with our decision to classify subjects by their most strenuous physical activity regardless of the frequency or duration of that activity makes it likely that we have underestimated the relation between leisure-time physical activity and blood pressure in this cohort. Eliminating the duration or frequency of reported activities precludes a truly accurate estimate of the relation between energy expenditure and blood pressure. However, it does eliminate much of the recall bias that may occur with self-reported physical activity. A specific limitation of any brief assessment of usual physical activity is the necessary exclusion of some specific activities from the questionnaire. In this cohort, less than 10\% of the women reported participating in physical activities that were not listed on the exercise questionnaire.\textsuperscript{24} It is unlikely that the omission of these activities from the 14-day physical activity recall altered the results of the study as the number of subjects affected was small and most were classified through their participation in other listed activities. Seasonal variation in activity and activity reporting, a common problem in cross-sectional studies of exercise, was minimal,\textsuperscript{24} probably a benefit of the year-round temperate climate in southern California. The ability of self-report physical activity assessments to measure “true” fitness or physical activity patterns is always difficult to assess in population studies. The validity of this physical activity scale was indirectly supported by other measures of fitness such as resting heart rate and body mass index,\textsuperscript{36} which were significantly lower in physically active women. Importantly, these estimates of physical fitness reflected the reported physical activity in a graded, dose–response fashion. This simple physical activity questionnaire appears to provide a relatively objective and valid estimate of activity in this older cohort.

The mechanism by which physical activity may lower blood pressure is not known. Many studies have demonstrated decreased insulin levels with physical activity,\textsuperscript{37,38} and recent studies have shown lower catecholamine levels with physical activity.\textsuperscript{32} It has been suggested that insulin may increase blood pressure by increasing sodium reabsorption and/or catecholamine secretion\textsuperscript{39–42} and that reductions in insulin levels with physical activity may reverse this process.\textsuperscript{37} Although insulin levels were inversely related to intensity of reported physical activity in this study, which is consistent with the possibility that physical activity–induced changes in insulin modulate blood pressure, adjustment for insulin levels did not reduce blood pressure differences among physical activity categories. This suggests that insulin may not be the final or most important mediator in physical activity–induced changes in blood pressure in older women. However, this study does not address insulin’s role in nonphysical activity–related blood pressure modulation.

The results of this study demonstrate that physical activity routinely performed by older women is associated with lower blood pressure and a lower prevalence of hypertension. Importantly, it appears that even light or moderately intense physical activity may be sufficient to obtain these benefits. If similar results are found in prospective studies, the public health implications would be very important. Several population studies have shown that systolic and diastolic
Appendix

In the past 14 days, have you done any of the following exercises, sports, or physically active hobbies?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>On the average, how many times in the past 14 days did you play/go/do:</th>
<th>About how many minutes did you actually spend on each occasion?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Walking for exercise?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>2) Jogging or running?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>3) Hiking?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>4) Gardening or yard work?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>5) Aerobics or aerobic dancing?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>6) Other dancing?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>7) Calisthenics or general exercise?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>8) Golf?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>9) Tennis?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>10) Bowling?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>11) Bicycle riding?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>12) Swimming or water exercises?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>13) Horseback riding?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>14) Handball, racquetball, or squash?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>15) Have you done any other exercises, sports, or physically active hobbies in the past 2 weeks other than the ones listed above?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
<tr>
<td>If yes, what were they?</td>
<td>☐</td>
<td>☐</td>
<td>___ times</td>
</tr>
</tbody>
</table>

blood pressures are important predictors of coronary heart disease at all ages.20,43,44 Systolic hypertension may be a particularly important determinant of cerebrovascular disease in older populations.44–46 Leisure-time physical activity may therefore prove to be an effective and safe way to reduce cardiovascular disease risk in older women.

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References


43. The Pooling Project Research Group: Relationship of blood pressure, serum cholesterol, smoking habit, relative weight and ECG abnormalities to incidence of major coronary events. Am J Epidemiol 1984;120:759–767


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