Walking to Work and the Risk for Hypertension in Men: The Osaka Health Survey

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Background: It is not known whether physical activity is effective in reducing the risk for hypertension.

Objective: To investigate the association of the duration of the walk to work and leisure-time physical activity with the risk for hypertension.

Design: Prospective cohort study.

Setting: Work site in Osaka, Japan.

Participants: 6017 Japanese men 35 to 60 years of age with systolic blood pressure less than 140 mm Hg, diastolic blood pressure less than 90 mm Hg, normal glucose intolerance, and no history of hypertension or diabetes at baseline.

Measurements: Data on physical activity were obtained by using questionnaires. Blood pressure was measured by using a standard technique; a value of at least 160/95 mm Hg was used to diagnose hypertension.

Results: During 59 784 person-years of follow-up, 626 cases of hypertension were confirmed. The duration of the walk to work was associated with a reduction in the risk for incident hypertension; multivariate-adjusted relative risks were 1.00 for a walk of 10 minutes or less (reference category), 0.88 (95% CI, 0.75 to 1.04) for an 11- to 20-minute walk, and 0.71 (CI, 0.52 to 0.97) for a walk of 21 minutes or more (P for trend = 0.02). For every 26.3 men who walk more than 20 minutes to work, one case of hypertension will be prevented.

Conclusions: Walking to work and other types of physical activity decreased the risk for hypertension in Japanese men. Regular exercise can prevent hypertension.

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There is good evidence that physical activity reduces the risk for cardiovascular disease (1–6), possibly in part by lowering blood pressure (7). Although mild or moderate physical activity, such as brisk walking, is a recommended part of the treatment protocol for persons with hypertension (8, 9), it is not known whether mild physical activity, especially walking, reduces the risk for hypertension.

With few exceptions, epidemiologic studies of physical activity and hypertension have been cross-sectional rather than prospective. Physical activity was inversely related to blood pressure in cross-sectional and controlled studies (7), and in two prospective studies (10, 11), vigorous exercise was inversely related to the subsequent risk for hypertension. Physicians in Japan usually advise their patients to walk to work as often as they can, and indeed, for middle-aged working Japanese men, the journey to and from work seems to be the main source of exercise.

We prospectively examined the relation of mild physical activity, especially walking to work, and leisure-time physical activity to the risk for hypertension during 6 to 16 years of observation.

Methods

The Osaka Health Survey

The Osaka Health Survey is an ongoing cohort study of risk factors for chronic diseases, including hypertension and diabetes. Study participants are male employees of a gas company in Osaka, Japan. Japanese law requires all employers to conduct annual health screenings for all employees. For the purposes of the Osaka Health Survey, in addition to these annual screenings, all employees 35 years of age or older undergo more detailed biennial clinical examinations and complete questionnaires on health-related behaviors, including exercise.

Study Sample

Between 1981 and 1990, 7979 Japanese men 35 to 63 years of age at entry who had sedentary occupations were enrolled in the study. We excluded 1875 men because they had physician-diagnosed hypertension, borderline hypertension (systolic blood pressure ≥ 140 and < 160 mm Hg,

Table 1. Baseline Characteristics According to Duration of the Walk to Work*

Characteristics	All Participants (n = 6017)	Duration of the Walk to Work†		
		0–10 Minutes (n = 3066)	11–20 Minutes (n = 2373)	≥21 Minutes (n = 578)
Age, *y*	41.7 ± 6.5	41.3 ± 6.3	42.1 ± 6.6	42.3 ± 6.7
Body weight, *kg*	62.9 ± 8.3	63.1	62.7	62.3
Body mass index, kg/m^2	22.6 ± 2.6	22.7	22.5	22.4
Regular physical exercise at least once weekly, %	31.5	30.3	32.6	33.3
Alcohol drinkers, %	82.0	81.7	82.4	81.2
Alcohol intake, *mL/d*	36.9 ± 25.8	37.4	36.1	37.3
Smokers, %	61.8	63.4	60.3	56.9
Cigarettes smoked per day, *n*	24.4 ± 9.9	24.6	24.1	23.6
Systolic blood pressure, *mm Hg*	121.6 ± 10.6	121.6	121.4	121.6
Diastolic blood pressure, *mm Hg*	67.4 ± 10.1	67.3	67.4	67.4
Heart rate, *beats/min*	71.7 ± 10.9	71.7	71.7	71.2
Fasting plasma glucose level, *mg/dL*‡	90.2 ± 8.5	90.0	90.3	90.9

* Values are the mean or the mean ± SD, except for regular physical exercise at least once weekly, alcohol drinkers, and smokers.
† All variables (except for age) across the duration of the walk to work were adjusted for age.
‡ To convert to mmol/L, multiply by 0.05551.

diastolic blood pressure ≥ 90 and < 95 mm Hg, or both in men without a history of hypertension), diabetes, or impaired glucose tolerance (fasting plasma glucose level ≥ 6.1 mmol/L [≥110 mg/dL] and < 7.8 mmol/L [<140 mg/dL] in men with no history of diabetes) at entry. The study sample ultimately consisted of 6104 men.

Data Collection and Measurements

The biennial clinical examination consisted of a medical history; a physical examination; blood pressure measurement; anthropometric measurements; measurement of the fasting plasma glucose level; and surveys of health-related behaviors, such as physical activity, smoking, and daily alcohol consumption. Trained nurses took all measurements. Participants were asked to fast for 12 hours and to avoid smoking and heavy physical activity for more than 2 hours before the examination. After a 5-minute rest in a quiet room, a standard mercury sphygmomanometer was used to measure systolic and diastolic blood pressures in the right arm while the participant was seated. Pressure was measured twice, at an interval of a few minutes. Anthropometric measurements included height and body weight, which were measured while the participant was wearing light clothing without shoes. Body mass index was calculated as the weight in kilograms divided by the height in meters squared.

The questionnaire completed by each participant elicited information on leisure-time physical activity, the duration of the walk to work, the nature of the participant's occupation, and the level of activity involved. Leisure-time physical activity was defined as physical activity unrelated to the participant's work. Questions about leisure-time physical activity were as follows: "Do you engage in any regular physical exercise, such as jogging, bicycling, swimming, and tennis, long enough to 'work up a sweat' (lasting 30 minutes or more)? If yes, how many times per week? What exercise is this?" The questions about regular physical exercise have been validated as a measure of physical exercise (12–15). In the analysis, participants were classified as engaging in regular physical exercise at least once per week or less than once per week. They were also classified into one of three categories of exercise frequency: 0 (less than once per week), once per week, or two or more times per week. The question about the duration of the walk to work was "How long does it take you to walk to this office?" Occupational activity was scored as 1 if the participant's work was mostly sedentary and 2 if he worked outside or if the job required a lot of lifting and walking. In the present study, we excluded all participants who reported a score of 2 for their occupational activities.

Questions about alcohol intake included items about the type of alcoholic beverage, the weekly frequency of alcohol consumption, and the usual amount consumed daily. Alcohol intake was converted to total alcohol consumption (in milliliters of ethanol per day) by using standard Japanese tables. Current and past smoking habits were classified according to the type and quantity of cigarettes smoked daily. Participants were classified as current smokers, past smokers, or nonsmokers.

Hypertension was also diagnosed during the biennial study clinical examinations. All participants underwent medical screening by a physician at least once annually, and hypertension was also diagnosed by the physicians. Hypertension was defined by using World Health Organization criteria as physician-diagnosed hypertension (systolic blood pressure ≥ 160 mm Hg, diastolic blood pressure ≥ 95 mm Hg, or both) or use of antihypertensive medication (16).

Statistical Analysis

Age-adjusted mean values and relevant population characteristics were computed for the duration of the walk to work by using analysis of covariance for continuous variables and the direct method for categorical variables.

For each participant, person-years of follow-up were counted from the date at study entry to the date of diagnosis of hypertension or 1 April 1997, whichever came first. The rate of follow-up was 94% of the total potential person-years of follow-up. Multivariate Cox proportional hazards regression models were used to evaluate the simultaneous effects of the duration of the walk to work, the frequency of leisure-time physical activity, age, body mass index, daily alcohol consumption, smoking status, and fasting plasma glucose level. Baseline systolic and diastolic blood pressure were not included in our primary analyses because they could presumably be in the causal pathway between the exposures (such as physical activity, age, body mass index, and alcohol consumption) and risk for hypertension. However, we included systolic and diastolic blood pressure in further models to assess the effect of physical activity on the risk for hypertension independent of their effects on systolic and diastolic blood pressure. The linear trends in risks were evaluated by entering indicators for each categorical level of exposure or by using the median value for each category. As a reference category, we used men with the lowest level of physical activity.

To address the potential misclassification of leisure-time physical activity over time, additional analyses were performed on the basis of the data at both study entry (1981 to 1990) and the examination done 4 years after (1985 to 1994) each participant was enrolled. We also performed analyses that excluded participants who developed hypertension between study entry (1981 to 1990) and the third examination done 4 years later (1985 to 1994).

We calculated the 95% CI for each relative risk (17), and all *P* values are two-tailed. Statistical analyses were performed by using the SPSS 7.5J software package (SPSS, Inc., Chicago, Illinois).

We estimated the "number needed to walk," a value analogous to the "number needed to treat." The number needed to treat for a given therapy is the reciprocal of the absolute risk reduction for that treatment (18). A 95% CI for the number needed to treat is obtained simply by taking reciprocals of the values defining the 95% CI of the absolute risk reduction (19). In our study, the number needed to walk was defined as the number of men who would have to adopt walking to avoid a single case of hypertension. The number needed to treat must always be based on an outcome for a specific period of time (20); thus, in estimating the number needed to walk, we chose an observation period of 10 years between study entry (1981 to 1986) and the examination done 10 years after (1991 to 1996) each participant was enrolled.

Role of the Funding Source

The funding agencies did not participate in the collection, analysis, or interpretation of data presented in this report or in the decision to submit the manuscript for publication.

Results

Of the 6104 men eligible for this study between 1981 and 1990, we excluded 87 men who did not undergo medical check-ups during the follow-up period. The study sample for analysis consisted of 6017 men. During the 59 784 person-years of follow-up between 1981 and 1997, 626 men developed hypertension. As the duration of the walk to work increased, body weight and the body mass index decreased (*P* for trend = 0.037 and 0.035, respectively) (**Table 1**). We identified no significant relation between the duration of the walk to work and the levels of leisure-time physical activity (*P* for trend = 0.062).

Table 2. Relative Risk for Hypertension According to Duration of the Walk to Work

Variable	Person-Years of Follow-up	Cases of Hypertension, *n*	Multivariate Relative Risk (95% CI)*	Further Multivariate Relative Risk (95% CI)†
Walk to work‡				
0–10 minutes	30 796	337	1.00 (reference)	1.00 (reference)
11–20 minutes	23 266	242	0.91 (0.77–1.08)	0.88 (0.75–1.04)
≥21 minutes	5722	47	0.70 (0.59–0.95)	0.71 (0.52–0.97)
Walk to work as a continuous variable (per 10 minutes)			0.88 (0.78–0.98)	0.88 (0.79–0.98)

* Adjusted for age, body mass index, alcohol consumption, leisure-time physical activity (regular physical exercise at least once weekly or less than once weekly), smoking status (current smoker, past smoker, or nonsmoker), and fasting plasma glucose level.
† Adjusted for age, body mass index, alcohol consumption, leisure-time physical activity (regular physical exercise at least once weekly or less than once weekly), smoking status (current smoker, past smoker, or nonsmoker), fasting plasma glucose level, systolic blood pressure, and diastolic blood pressure.
‡ *P* for trend = 0.02 for multivariate relative risk and further multivariate relative risk.

Table 3. Relative Risk for Hypertension According to Leisure-Time Physical Activity

Regular Physical Exercise	Person-Years of Follow-up	Cases of Hypertension, *n*	Multivariate Relative Risk (95% CI)*	Further Multivariate Relative Risk (95% CI)†
At least once weekly				
At study entry (1981–1990)‡				
No	40 644	461	1.00 (reference)	1.00 (reference)
Yes	19 140	165	0.70 (0.59–0.84)	0.70 (0.59–0.84)
From study entry (1981–1990) to the third examination (1985–1994)§				
No at both time points	29 934	262	1.00 (reference)	1.00 (reference)
Yes at both time points	10 734	68	0.64 (0.49–0.84)	0.61 (0.47–0.80)
Frequency (times per week)‡‖				
0	40 644	461	1.00 (reference)	1.00 (reference)
1	6058	42	0.62 (0.45–0.85)	0.65 (0.47–0.90)
≥2	13 082	123	0.74 (0.60–0.90)	0.72 (0.59–0.88)

* Adjusted for age, body mass index, alcohol consumption, duration of walk to work (as a continuous variable), smoking status (current smoker, past smoker, or nonsmoker), and fasting plasma glucose level.

† Adjusted for age, body mass index, alcohol consumption, duration of walk to work (as a continuous variable), smoking status (current smoker, past smoker or nonsmoker), fasting plasma glucose level, systolic blood pressure, and diastolic blood pressure.

‡ Based on data of leisure-time physical activity from the study entry and including cases of hypertension from 1981 through 1997.

§ Based on data of leisure-time physical activity from the study entry (1981 to 1990) and the third examination four years later (1985 to 1994) since each participant was enrolled and excluding cases of hypertension during the first 4-year follow-up period since each participant was enrolled.

‖ *P* for trend < 0.001 for multivariate relative risk and for further multivariate relative risk.

Duration of the Walk to Work

The duration of the walk to work was associated with a decreased risk for incident hypertension (**Table 2**). After adjustment for age, body mass index, daily alcohol consumption, smoking status, frequency of leisure-time physical activity, systolic blood pressure, diastolic blood pressure, and fasting plasma glucose level, the relative risk for hypertension was 0.71 (95% CI, 0.52 to 0.97) in men whose walk to work lasted 21 minutes or more compared with those whose walk to work lasted 10 minutes or less.

To further quantify the effect of the duration of the walk to work on hypertension, we modeled this duration as a continuous variable. The results suggested that the multivariate-adjusted risk for hypertension was reduced by 12% when the duration of the walk to work was increased by 10 minutes (relative risk, 0.88 [CI, 0.79 to 0.98]). Adjustments for other factors, including systolic blood pressure and diastolic blood pressure, did not influence our estimates of the relative risk.

Leisure-Time Physical Activity

Compared with men who engage in regular physical exercise less than once weekly, the multivariate-adjusted relative risk for hypertension in men who engaged in regular physical activity at least once weekly was 0.70 (CI, 0.59 to 0.84) (**Table 3**). Further adjustments for other factors changed the risk estimate only slightly. When we examined the data obtained at study entry (1981 to 1990) and at the third examination 4 years after each participant was enrolled (1985 to 1994), excluding cases of hypertension identified during the first 4-year follow-up period, we found that the multivariate-adjusted relative risk for hypertension was 0.64 (CI, 0.49 to 0.84) among men who engaged in regular physical exercise at least once weekly at both time points compared with those who reported regular physical exercise less than once weekly at both time points. Adjustments for other factors did not influence our estimates of the relative risk.

We also analyzed the association between the frequency of regular physical exercise and the risk for hypertension. The risk for hypertension was decreased even in men who engaged in regular physical exercise only once weekly. The multivariate-adjusted relative risk for hypertension decreased from 1.00 for exercise less than once weekly (reference category) to 0.62 for once-weekly exercise (CI, 0.45 to 0.85) and to 0.74 for exercise two or more times weekly (CI, 0.60 to 0.90). Adjustments for other factors did not influence our estimates of the relative risk.

Number Needed To Walk

Between 1981 and 1986, we enrolled 4410 normotensive men 35 to 60 years of age with normal glucose intolerance and no history of hypertension or diabetes at baseline. During 10 years of follow-up, 375 men developed hypertension. For men whose walk to work lasted 21 minutes or more compared with men whose walk to work lasted 10 minutes or less, the absolute risk reduction was 0.038 (CI, 0.0377 to 0.0383) and the number needed to walk was 26.3 (CI, 26.1 to 26.5). For men who reported an 11- to 20-minute walk to work, the absolute risk reduction was 0.009 (CI, 0.0088 to 0.0092) and the number needed to walk was 111.1 (CI, 108.7 to 113.6) compared with men whose walk to work was 10 minutes or less (**Table 4**).

Discussion

Our prospective data show that the duration of the walk to work was associated with a decreased risk for incident hypertension, even after adjustment for age, body mass index, alcohol consumption, leisure-time physical activity (regular physical exercise at least once weekly or less than once weekly), smoking status (current smoker, past smoker, or nonsmoker), systolic and diastolic blood pressure at baseline, and fasting plasma glucose level. Multivariate analysis also showed that regular physical exercise at least once weekly was inversely related to the risk for incident hypertension.

Previous studies have shown an inverse association between physical activity and the incidence of hypertension. Vigorous exercise was inversely associated with the risk for hypertension in a cohort of Harvard University alumni followed for 16 to 50 years and in a cohort of University of Pennsylvania alumni followed for 15 years, but no significant relation between walking and the incidence of hypertension was seen in either study (10, 11). In those studies, the analysis was adjusted only for age and body mass index and questions on walking were not limited to walking to work. In our study, the duration of the walk to work was associated with a decreased risk for hypertension. In Japan, an employee often stays at the same job until retirement, and there are few opportunities for transfer in the company from which our study participants were recruited. Thus, the duration of a man's to walk to work may be a consistent and reliable indicator of mild physical activity status throughout his adult life.

We did not identify the reason why the duration of the walk to work reduced the risk for hypertension. Controlled studies have showed that even mild exercise, especially walking, reduces blood pressure in hypertensive (21, 22) and normotensive (23) persons. In a population-based study of elderly persons, light-intensity physical activity, including walking, significantly decreased systolic and diastolic blood pressures (24). The intensity of exercise does not seem to be related to the magnitude of the decrease in blood pressure (25). In our study, walking seemed to have a positive effect in reducing the risk for hypertension. The explanatory mechanisms are probably multifactorial.

We considered the possibility that participants with a longer walk to work might have had more active lifestyles. However, only 33.3% of participants who belonged to the group with the longest walk to work engaged in vigorous activity at least once a week. Therefore, there did not appear to be any association between the duration of the walk to work and a more active lifestyle. When we examined the relation between the duration of the walk to work and the risk for hypertension, we adjusted the data for leisure-time physical activity in addition to other cofounders. Therefore, the relation between the duration of the walk to work and the risk for hypertension was independent of leisure-time physical activity.

Our study has some potential limitations. First, all participants were registered employees of the same company. Thus, our results may not be representative of the general population; however, these relations are thought to apply to many men who work outside the home. The relative homogeneity of the cohort may actually enhance the study's internal validity. Because of the relatively uniform education background and socioeconomic status of the men in our cohort, these variables were unlikely to represent confounding factors. Second, all our study participants were men. It remains to be determined whether our results also apply to women. Finally, we could not include several confounding variables, such as diet and family history. It is well known that family history and consumption of salt are associated with hypertension (26, 27). A recent study showed that a diet rich in fruits, vegetables, and low-fat dairy foods that includes reduced saturated and total fats significantly lowers blood pressure (28). Therefore, the history of food intake and fam-

Table 4. Number Needed To Walk To Avoid One Case of Hypertension during 10 Years of Follow-up*

Walk to Work	All Participants	Cases of Hypertension	Absolute Risk Reduction (95% CI)	Number Needed To Walk (95% CI)
	n	*n (%)*		
Model 1				
0–10 minutes	2240	207 (9.2)		
11–20 minutes	1766	146 (8.3)	0.009 (0.0088–0.0092)†	111.1 (108.7–113.6)‡
Model 2				
0–10 minutes	2240	207 (9.2)		
≥21 minutes	404	22 (5.4)	0.038 (0.0377–0.0383)§	26.3 (26.1–26.5)‡

* The number needed to walk is the number of men needed to walk to work in order to prevent one incident case of hypertension.
† Absolute risk reduction = case rates of hypertension (0 to 10 minutes of walking) − case rates of hypertension (11 to 20 minutes of walking).
‡ Number needed to walk = 1/absolute risk reduction.
§ Absolute risk reduction = case rates of hypertension (0 to 10 minutes of walking) − case rates of hypertension (≥21 minutes of walking).

ily history of hypertension should be included in future studies.

In conclusion, our results provide evidence that the duration of the walk to work has an independent effect on the risk for hypertension. Even persons who drive to work or use public transportation may benefit from parking or leaving their transportation more than a 20-minute walk from the office. We believe that physicians should recommend walking to work as an adjunct to proper weight control, reduction of alcohol consumption, and leisure-time physical activity.

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