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REGULAR ARTICLE

No association between the frequency of forest walking and blood pressure levels or the prevalence of hypertension in a cross-sectional study of a Japanese population

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Abstract
Objective To study the non-temporary effects of successive walks in forested areas (*shinrin-yoku*) on hypertension prevalence and blood pressure levels.
Methods Data for the analysis were derived from the baseline survey of the Japan Multi-Institutional Collaborative Cohort (J-MICC) study in the Shizuoka area. Eligible participants were individuals aged 35–69 years who attended a health check-up center during 2006 and 2007. Of the 5,040 individuals who participated in the J-MICC study, Shizuoka, 4,666 were included in this analysis [3,174 men and 1,492 women; age (mean ± standard deviation) 52.1 ± 8.7 years]. The frequency of forest walking was estimated by a self-administrated questionnaire. Hypertension was defined as a systolic blood pressure ≥140 mmHg, a diastolic blood pressure ≥90 mmHg or, based on information provided in the questionnaire, the use of medication for hypertension.
Results After adjusting for age, body mass index (BMI), smoking status, alcohol consumption, and habitual exercise, the odds ratios of hypertension associated with forest walking once a week or more frequently, relative to less than once a month were 0.98 in men [95% confidence interval (CI) 0.68–1.42] and 1.48 (95% CI 0.80–2.71) in women. There was no significant trend between adjusted blood pressure levels and the frequency of forest walking.
Conclusion The results of our cross-sectional study in a Japanese population show no association between either blood pressure levels or the prevalence of hypertension and the frequency of forest walking.

Keywords Forest walking · *Shinrin-yoku* · Hypertension · Cross-sectional study · Japanese population

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Introduction

It is empirically accepted that some natural environments contribute to improvements in health. Health resort medicine is included in the medical system in some European countries, with the majority of such health resorts tending to be located in natural environments. Experts in health resort medicine believe that the natural environment of health resorts is a factor that influences the functioning and health of visitors [1]. In this context, the effects of 'green environments' have been reported. In one study, the amount of walkable green space, such as parks and tree-lined streets, around the homes of senior citizens was found to be associated with longevity [2]. An observational study in the UK showed that health inequalities related to income deprivation in all-cause mortality and mortality from circulatory diseases were lower in the greenest areas; in this study, green areas mean green space, including parks, other open spaces, and agricultural land but excluding domestic gardens [3].

Among the activities using green environments that have been promoted as being beneficial to health

promotion, forest walking, or "*shinrin-yoku*," is a common leisure activity in Japan. According to a public opinion poll conducted in 2007 by the Cabinet Office of the Government of Japan, 36.2% of respondents had participated in *shinrin-yoku* within the preceding year for recreational purposes and mental and physical benefits [4]. However, the effects of forest walking have not been fully elucidated. The temporary acute effects of forest environments have been reported in a number of recent studies. Morita et al. [5] found that hostility and depression scores decreased and liveliness score increased, as measured by the Multiple Mood Scale [6], during a day spent in a forested area compared to that spent in non-forested areas. Natural killer cell activity and immunoglobulin levels have been shown to increase [7] and cortisol and noradrenalin levels to decrease in healthy individuals after a one-off walk in forested areas [8]. A study that evaluated interventions for treating diabetes showed that one-off forest walking was more effective for decreasing blood glucose levels than other forms of exercise, such as cycle ergometer, treadmill, or underwater exercise examined in other studies [9]. In terms of blood pressure, some studies do show that one-off walking in forested areas is significantly effective for temporarily reducing blood pressure compared with walking in non-forested areas [8, 10], although other studies report that there is no significant difference [7, 8, 11, 12].

However, temporary acute effects do not always contribute to improved human health in general. Healthy lifestyles, such as abstinence from smoking, habitual exercise, and non-consumption of alcohol, contribute to the prevention of disease and the maintenance of good health [13–21]. In terms of forest walking, the authors of a cross-sectional study reported that the frequency of forest walking was associated with self-rated good general health by the forest walkers [22], suggesting that frequent forest walking may contribute to the maintenance of good health. Based on the reports of positive temporary acute effects of forest environments on reducing blood pressure, frequent forest walking may contribute to the prevention of hypertension. However, there are few studies that have evaluated the non-temporary effects of successive forest walking on blood pressure.

The aim of the study reported here was to investigate the association of the frequency of forest walking with blood pressure levels and the prevalence of hypertension in a Japanese population.

Methods

Data was derived from the baseline survey of the Japan Multi-Institutional Collaborative Cohort (J-MICC) Study [23] in the Shizuoka area [24]. This was a long-term cohort study to identify interactions between genetics and lifestyle for the prevention of cancer and lifestyle-related diseases [23]. Individuals presenting for health check-ups to the Seirei Preventive Health Care Center in Hamamatsu City, Shizuoka Prefecture, Japan between January 2006 and December 2007 were eligible for enrolment [24]. Criteria for inclusion in the cohort study were an age of between 35 and 69 years and residence in the west-central area of Shizuoka Prefecture, Japan [23, 24]. In total, 13,740 individuals presented for the health check-up who matched the eligibility criteria. Of these, 5,040 (36.7%) participated in the study [24]. A total of 4,666 participants {3,174 men and 1,492 women; age [mean ± standard deviation (SD)] 52.1 ± 8.7 years} who responded to a question about their frequency of forest walking were included in this analysis.

The participants were requested to complete a self-administrated questionnaire that included questions on the frequency of forest walking (6 categories: 1, once a week or more; 2, two or three times per month; 3, once a month; 4, several times a year; 5, once a year; and 6, rare) and lifestyle [for example, smoking status, alcohol consumption, and leisure-time activities (intensity, frequency, and duration of exercise]. Participants also on reported whether they had used medication for hypertension, diabetes, high serum cholesterol, or constipation during the preceding month and on their use (if any) of analgesics, sleeping drugs, or other medications.

The blood pressure of each participant was measured once, with the participant in a seated position, using a standard mercury sphygmomanometer with a cuff appropriate for arm size by a nurse during a health check-up. A specific resting time before measurement was not arranged for. Hypertension was defined as a systolic blood pressure (SBP) ≥140 mmHg, a diastolic blood pressure (DBP) ≥90 mmHg or, based on information provided in the questionnaire, the use of medication for hypertension. Optimal blood pressure was defined as SBP <120 mmHg and DBP <80 mmHg. Normal blood pressure was defined as SBP <130 mmHg and DBP <85 mmHg, but excluding optimal blood pressure. A high-normal blood pressure was defined as SBP ≥130 mmHg or DBP ≥85 mmHg, and non-hypertension.

Six categories for the frequency of forest walking were summarized into four categories by placing the three less frequent categories (several times a year, once a year, and rare) into one category defined as "less than once a month". Body mass index (BMI) was calculated based on the weight and height of the individual measured at the check-up.

Alcohol consumption was classified into two categories: 1, once a week or more; 2, other responses, including "used to drink" and "never drink". Habitual exercise was defined as participating in ≥30 min of a leisure time activity at

least once a week; the intensity of exercise was not considered.

The associations between ordinal variables were analyzed by the Mantel–Haenszel chi-squared test. The trends in the continuous variables by ordinal categories were tested using a linear regression model. Age-adjusted prevalence of hypertension by frequency of forest walking was calculated by the direct method, and the trend was tested by the Mantel-extension test. Age was categorized into four groups (35–39, 40–49, 50–59, and 60–69 years).

Since the effects of forest walking may be minimal, the age-adjusted association between the frequency of forest walking and blood pressure (4 groups; optimal blood pressure, normal blood pressure, high-normal blood pressure, and hypertension) was also examined. The significance was tested using correlation statistics in the generalized Cochran–Mantel–Haenszel tests.

In logistic regression analysis in Model 1, the dependent variable was hypertension (yes/no); the independent variables were age (continuous variable), frequency of forest walking (4 categories), smoking status (current smokers/other responses), alcohol consumption (once a week or more/other responses), and BMI ($\geq$25.0/<25.0). In Model 2, the dependent variable was also hypertension, and the independent variables were the same as in Model 1 plus habitual exercise (yes/no).

The mean values of SBP and DBP by frequency of forest walking were tested using a general liner model (GLM). The following variables were adjusted: (1) age (continuous variable), or (2) age, smoking status (current smokers/other responses), alcohol consumption (once a week or greater/other responses) and BMI ($\geq$25.0/<25.0). The significance level was set at 5%. PASW Statistics 18 (SPSS, Chicago, IL) and SAS 9.1 (SAS Institute, Cary, NC) were used for the statistical analysis.

The study was approved by the ethics committee of Nagoya University School of Medicine (approval number 288), and written informed consent was obtained from all participants.

Results

The characteristics of participants by frequency of forest walking are presented in Table 1. The percentages of each gender in each forest walking frequency group were significantly different (chi-squared test, $p = 0.013$), with the higher forest walking-frequency groups having a larger percentage of men. A significant trend in mean age was observed in each frequency group among both men (trend $p < 0.001$) and women (trend $p < 0.001$), with the higher forest walking-frequency groups associated with a higher mean age. A significant trend was observed between habitual exercise and frequency of forest walking (men: trend $p < 0.001$, women: trend $p < 0.001$), with a higher frequency of forest walking being associated with a greater percentage of participants who engaged in habitual exercise. The percentages of alcohol consumption once a week or more and current smoking in each forest-walking frequency group reached significance in men (alcohol consumption: trend $p < 0.001$, current smokers: trend $p = 0.002$), but not in women (alcohol consumption: trend $p = 0.76$, current smokers: trend $p = 0.59$). The percentages of BMI $\geq$25.0 by frequency of forest walking were not significant.

The association between the frequency of forest walking and prevalence of hypertension is presented in Fig. 1. A significant trend was observed between the frequency of forest walking and the crude prevalence of hypertension among both men (trend $p < 0.001$) and women (trend $p = 0.004$). However, the higher walking-frequency groups had a higher percentage of individuals with hypertension. Since age was also associated with the frequency of forest walking, with the higher frequency groups having a higher mean age, age-adjusted prevalence was calculated. No significant trend was found between the age-adjusted prevalence of hypertension and the frequency of forest walking in either men (Mantel-extension test $p = 0.25$) or women ($p = 0.23$).

The association between frequency of forest walking and blood pressure level group by each age subgroup is presented in Table 2. A significant trend was not observed in women (correlation statistics, $p = 0.18$). A statistical trend was significant in men ($p = 0.01$). However, an obvious trend cannot be identified in Table 2.

The results of the logistic regression analysis are shown in Table 3. After adjusting for age, BMI, smoking status, and alcohol consumption in Model 1, the frequency of forest walking was not significantly associated with the prevalence of hypertension. The adjusted odds ratios of forest walking once a week or more compared with less than once a month were 0.97 [95% confidence interval (CI) 0.67–1.40] for men and 1.51 (95% CI 0.82–2.78) for women. The results show that the frequency of forest walking, including the contribution of habitual exercise, was not associated with the prevalence of hypertension.

In Model 2, when habitual exercise was considered, the frequency of forest walking was again not significantly associated with the prevalence of hypertension. The adjusted odds ratios of the once a week or more groups compared to the less than once a month group were 0.98 (95% CI 0.68–1.43) for men and 1.43 (95% CI 0.77–2.65) for women. The results show that the frequency of forest walking, when adjusted for habitual exercise, was not associated with the prevalence of hypertension.

Table 1 Characteristics of participants by frequency of forest walking

Frequency of forest walking	Once a week or more		Two or three times per month		Once a month		Less than once a month		Total	*p* value
	n	%	*n*	%	*n*	%	*n*	%	*n*	
Total	235	5.0	274	5.9	394	8.4	3,763	80.6	4,666	
Sex										
Men	164	5.2	210	6.6	270	8.5	2,530	79.7	3,174	$p = 0.013^{*}$
Women	71	4.8	64	4.3	124	8.3	1,233	82.6	1,492	
Age (mean ± SD)										
Men	57.3 ± 7.8		56.8 ± 8.1		54.7 ± 8.4		51.7 ± 8.6		52.6 ± 8.7	Trend $p < 0.001^{\dagger}$
Women	55.5 ± 7.4		53.7 ± 8.4		53.7 ± 8.9		50.4 ± 8.5		51.0 ± 8.6	Trend $p < 0.001^{\dagger}$
BMI[a] ≥ 25.0										
Men	39	23.8	52	24.8	62	23.0	662	26.2		Trend $p = 0.31^{\ddagger}$
Women	8	11.3	13	20.3	18	14.5	202	16.4		Trend $p = 0.51^{\ddagger}$
Alcohol consumption[b]										
Men	126	77.3	158	76.0	179	66.8	1,666	66.2		Trend $p < 0.001^{\ddagger}$
Women	18	26.1	16	25.0	42	34.1	325	26.5		Trend $p = 0.76^{\ddagger}$
Current smokers[c]										
Men	35	21.3	33	15.7	47	17.5	631	25.0		Trend $p = 0.002^{\ddagger}$
Women	2	2.8	2	3.1	7	5.7	54	4.4		Trend $p = 0.59^{\ddagger}$
Habitual exercise[d]										
Men	129	79.1	144	68.6	167	62.1	1,207	48.1		Trend $p < 0.001^{\ddagger}$
Women	54	77.1	45	75.0	80	66.1	530	43.5		Trend $p < 0.001^{\ddagger}$

* Chi-squared test; † linear regression model; ‡ Mantel–Haenszel chi-squared test

[a] Body mass index; number of available responses was 4,665 (men: $n = 3,173$, women: $n = 1,492$)

[b] Once a week or more; number of available responses was 4,636 (men: $n = 3,155$, women: $n = 1,481$)

[c] Number of available responses was 4,657 (men: $n = 3,170$, women: $n = 1,487$)

[d] Leisure time activity (≥30 min exercise at least once a week); Number of available responses was 4,618 (men: $n = 3,149$, women: $n = 1,469$)

Since blood pressure levels are affected by hypertension medications, blood pressure levels by frequency of forest walking were stratified for medication use (see Table 4). A significant trend in the crude blood pressure levels by frequency of forest walking was partially observed, with the higher forest walking-frequency groups having higher mean blood pressure values. However, these trends disappeared when the data were adjusted for age, alcohol consumption, smoking status, and habitual exercise.

Discussion

This study revealed that the frequency of forest walking was not associated with either blood pressure levels or the prevalence of hypertension. Furthermore, there were no observed associations between the frequency of forest walking and blood pressure levels with respect to obesity (BMI ≥25.0/<25.0), and diabetes (positive or negative) after adjustment for age, smoking status, alcohol consumption, habitual exercise, and medication for hypertension using GLM (data not shown). However, in the subgroup of women without dyslipidemia, the association of SBP with frequency of forest walking was significant after adjustment for the above-mentioned factors (data not shown). In the subgroups of men with dyslipidemia and women without dyslipidemia, the associations of DBP with frequency of forest walking were also significant (data not shown). Nevertheless, neither a trend of crude SDP by frequency of forest walking in the subgroup of women without dyslipidemia nor trends of crude DBP by frequency of forest walking in subgroups of men with dyslipidemia and women without dyslipidemia were observed using linear regression models for the trend test (data not shown). Although the beneficial temporary acute effects of one-off forest walking on reducing blood pressure have been previously reported [8, 10], our results suggest that frequent forest walking does not have any non-temporary effects on blood pressure.

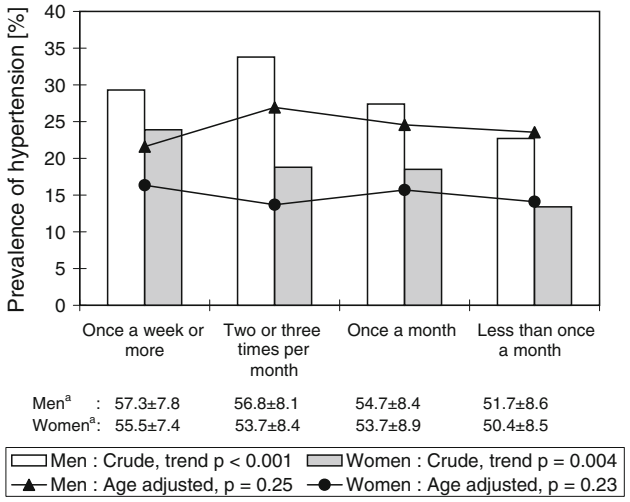

Fig. 1 Crude and age-adjusted prevalence of hypertension by each forest walking-frequency group. Age-adjusted prevalence was calculated by the direct method. Age was categorized into four groups (35–39, 40–49, 50–59, and 60–69 years). Trend was tested by the Mantel–Haenszel chi-squared test in crude. The age-adjusted trend was calculated by the Mantel-extension test. [a]Mean age ± standard deviation (SD)

It should be noted that some studies have reported that the mean values of SBP and DSP after forest walking were not significantly different from those after walking in city areas [11] or from those among healthy students in an indoor setting [7]. Another study reported that the mean reduction in DBP was not significantly different between individuals walking in a forested area and those walking in a non-forested area [8].

These results show an inconsistency in the temporary acute effects of one-off forest walking on decreasing blood pressure, suggesting that the acute beneficial effects of forest walking in terms of decreasing blood pressure are weak or absent. Although some studies have reported that blood pressure decreased significantly by walking in forested areas compared with non-forested areas, the difference in the mean values of blood pressure reported was less than 3–16.5 mmHg [8, 10]. This difference may be within the normal range of daily fluctuations in blood pressure. As a consequence, the non-temporary effects may not be shown.

The other possible explanation for the lack of an association between the frequency of forest walking with either blood pressure levels or the prevalence of hypertension is that more frequent forest walking may be required to improve hypertension or to maintain optimal/normal blood pressure. The category for frequency of forest walking with the most responses in our study was once a week or more. This level of "once a week or more" may not have reached

Table 2 The association between frequency of forest walking and blood pressure level group by each age subgroup

Blood pressure	Once a week or more		Two or three times per month		Once a month		Less than once a month	
	n	%	*n*	%	*n*	%	*n*	%
Men								
30–39 (years)								
Optimal	3	100.0	5	62.5	7	53.8	137	60.1
Normal	0	0.0	2	25.0	5	38.5	55	24.1
High-normal	0	0.0	1	12.5	0	0.0	23	10.1
Hypertension	0	0.0	0	0.0	1	7.7	13	5.7
40–49 (years)								
Optimal	19	63.3	17	53.1	27	43.5	408	50.2
Normal	4	13.3	5	15.6	10	16.1	168	20.7
High-normal	4	13.3	6	18.8	18	29.0	106	13.0
Hypertension	3	10.0	4	12.5	7	11.3	131	16.1
50–59 (years)								
Optimal	16	27.1	27	31.4	41	36.0	383	38.8
Normal	17	28.8	13	15.1	24	21.1	201	20.4
High-normal	14	23.7	20	23.3	20	17.5	153	15.5
Hypertension	12	20.3	26	30.2	29	25.4	250	25.3
60–69 (years)								
Optimal	18	25.0	11	13.1	15	18.5	142	28.3
Normal	9	12.5	14	16.7	10	12.3	102	20.3
High-normal	12	16.7	18	21.4	19	23.5	77	15.3
Hypertension	33	45.8	41	48.8	37	45.7	181	36.1

Table 2 continued

Blood pressure	Once a week or more		Two or three times per month		Once a month		Less than once a month	
	n	%	*n*	%	*n*	%	*n*	%
Women								
30–39 (years)								
Optimal	1	100.0	6	66.7	10	90.9	144	86.2
Normal	0	0.0	2	22.2	1	9.1	14	8.4
High-normal	0	0.0	1	11.1	0	0.0	5	3.0
Hypertension	0	0.0	0	0.0	0	0.0	4	2.4
40–49 (years)								
Optimal	9	69.2	3	60.0	22	75.9	298	72.9
Normal	0	0.0	1	20.0	2	6.9	53	13.0
High-normal	4	30.8	1	20.0	1	3.4	30	7.3
Hypertension	0	0.0	0	0.0	4	13.8	28	6.8
50–59 (years)								
Optimal	20	54.1	19	54.3	25	56.8	259	54.6
Normal	6	16.2	5	14.3	7	15.9	78	16.5
High-normal	3	8.1	4	11.4	5	11.4	58	12.2
Hypertension	8	21.6	7	20.0	7	15.9	79	16.7
60–69 (years)								
Optimal	4	20.0	5	33.3	18	45.0	71	38.8
Normal	4	20.0	2	13.3	8	20.0	30	16.4
High-normal	3	15.0	3	20.0	2	5.0	28	15.3
Hypertension	9	45.0	5	33.3	12	30.0	54	29.5

Correlation statistics in the generalized Cochran–Mantel–Haenszel tests (for men) $p = 0.01$; correlation statistics in the generalized Cochran–Mantel–Haenszel tests (for women) $p = 0.18$

Table 3 The adjusted odds ratio for prevalence of hypertension

Model	Men		Women	
	aOR	95% CI	aOR	95% CI
Model 1[a]				
Frequency of forest walking				
Less than once a month	1		1	
Once a month	1.07	0.79–1.44	1.02	0.60–1.71
Two or three times per month	1.19	0.86–1.64	1.07	0.54–2.12
Once a week or more	0.97	0.67–1.40	1.51	0.82–2.78
Model 2[b]				
Frequency of forest walking				
Less than once a month	1		1	
Once a month	1.08	0.80–1.47	1.04	0.61–1.75
Two or three times per month	1.21	0.87–1.67	0.88	0.42–1.84
Once a week or more	0.98	0.68–1.43	1.43	0.77–2.65

aOR, Adjusted odds ratio; CI, confidence interval

[a] Adjusted by age(continuous valuable), BMI (≥25.0/<25.0), smoking status (current smokers/other responses), and alcohol consumption (once a week or more/other responses)

[b] Adjusted by age (continuous valuable), BMI (≥25.0/<25.0), smoking status (current smokers/other responses), alcohol consumption (once a week or more/other responses), and habitual exercise (leisure time activity: ≥30 min exercise at least once a week)

Table 4 Blood pressure levels by frequency of forest walking

Frequency of forest walking	Once a week or more		Two or three times per month		Once a month		Less than once a month		Trend $p^{\dagger}$	Adjusted[a] $p^{\ddagger}$	Adjusted[b] $p^{\ddagger}$
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD			
Systolic blood pressure											
Men											
Medication for hypertension											
−	139	122.5 ± 16.5	165	122.9 ± 16.0	220	121.0 ± 14.5	2211	118.4 ± 14.5	<0.001	0.03	0.69
+	25	133.3 ± 12.0	45	129.3 ± 13.6	50	134.7 ± 12.7	319	131.2 ± 13.1	0.72	0.19	0.50
Women											
Medication for hypertension											
−	60	117.3 ± 14.8	55	114.6 ± 13.1	111	112.3 ± 15.6	1121	112.0 ± 14.7	0.005	0.28	0.17
+	11	136.5 ± 18.0	9	132.2 ± 17.8	13	130.6 ± 16.0	112	131.2 ± 14.2	0.32	0.73	0.78
Diastolic blood pressure											
Men											
Medication for hypertension											
−	139	75.8 ± 10.2	165	76.9 ± 10.7	220	75.4 ± 10.5	2211	75.3 ± 10.3	0.13	0.65	0.62
+	25	78.7 ± 8.8	45	80.0 ± 8.0	50	82.4 ± 7.2	319	82.1 ± 9.7	0.04	0.75	0.49
Women											
Medication for hypertension											
−	60	72.3 ± 8.2	55	70.0 ± 10.2	111	68.2 ± 9.6	1121	68.6 ± 9.8	0.008	0.10	0.36
+	11	81.8 ± 15.8	9	78.9 ± 9.5	13	80.5 ± 11.9	112	78.9 ± 9.7	0.42	0.65	0.87

† Linear regression model; ‡ General linear model

[a] Adjusted by age(continuous variable)

[b] Adjusted by age(continuous valuable), body mass index (BMI) (≥25.0/<25.0), smoking status (current smokers/other responses), alcohol consumption (once a week or more/other responses), and habitual exercise (leisure time activity: once a week for at least 30 min or more/other responses)

the threshold required for the improvement of blood pressure or maintenance of optimal/normal blood pressure.

There are a number of limitations associated with our study. (1) This was a cross-sectional study and as such could not identify a causal relationship. This lack of an association between the frequency of forest walking and blood pressure levels/hypertension prevalence may be caused by those forest walkers with hypertension who had just begun forest walking to improve their hypertension. Cohort studies or intervention studies will be required to confirm this lack of association. (2) The study participants may not represent the general population in Japan because they attended private health check-ups that involved high expenses; these participants may be more interested in health promotion activities than the general population. The percentage of current smokers in the study cohort was 23.3% for men and 4.4% for women [24]. These percentages are lower than for the general population in Japan [25]. (3) We evaluated the non-temporary effects of successive forest walking based solely on the frequency of forest walking. Duration may contribute to the non-temporary effects of successive forest walking on blood pressure, although acute psychological effects have been reported not to depend on the duration of forest waking [6]. (4) Blood pressure measurements were conducted only once.

In conclusion, the results of our current cross-sectional study in a Japanese population showed no association between either blood pressure levels or the prevalence of hypertension and the frequency of forest walking.

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