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Frequency of forest walking is not associated with prevalence of hypertension based on cross-sectional studies of a general Japanese population: a reconfirmation by the J-MICC Daiko Study

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ABSTRACT

Forest walking or *Shinrin-yoku* is a health promotion activity in Japan. Although some studies have reported the acute effects of walking a few hours in forested areas in reducing blood pressure level compared to other environments, studies investigating whether successive walking has long-term effects in lowering blood pressure levels or lowering prevalence of hypertension are rare. This study aimed to reconfirm the presence or absence of an association between the frequency of forest walking and prevalence of hypertension in a Japanese population. This J-MICC Daiko Study was conducted targeting residents in Nagoya City. A total of 5,109 participants (1,452 men and 3,657 women; age, mean ± standard deviation: 52.5 ± 10.3 years) were included in the analysis. Age-adjusted blood pressure level by frequency of forest walking was not significant. After adjusting for age and lifestyle, the adjusted odds ratios (aORs) of the most frequent group (n=88, 1.7%; once a week or more group) relative to the less than once a month group (n=4,558, 89.2%) for prevalence of hypertension were not also significant [0.80 (95% CI: 0.40–1.62) for men and 1.48 (95% CI: 0.73–3.00) for women]. This study reconfirmed that either lowering blood pressure level or lowering the prevalence of hypertension is not associated with frequency of forest walking, similar to the results of our previous J-MICC Shizuoka Study. Given that these two studies were cross-sectional studies, cohort studies investigating the causal relationship are required to evaluate the effect of frequent forest walking on the prevention of hypertension.

Keywords: forest walking, *Shinrin-yoku*, hypertension, cross-sectional study, Japanese general population

Abbreviations:
aOR: adjusted odds ratio
SBP: systolic blood pressure
DBP: diastolic blood pressure
BMI: body mass index
CI: confidence interval

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INTRODUCTION

It has been recognized that some natural environments contribute to improving and/or maintaining health. Health resort medicine is a relevant field of the health systems in several European countries.[1] Most of health resorts are located in natural environments. Experts in health resort medicine considered that the natural environment, green space, and forested areas of health resorts are relevant factors influencing the functioning and health of visitors.[2]

Regarding the advantage of green space for health in epidemiological studies, a study in England on the relation between health inequalities and green space involving 40,000,000 study participants showed that health inequalities related to income deprivation in all-cause mortality and mortality from circulatory diseases were lower in the greenest areas. Green areas in the study meant green spaces that included parks, other open spaces, and agricultural land, but excluding domestic gardens[3] because forested areas in the United Kingdom is only 12%.[4]

In Japan, forested areas account for 69% of the land, which is among the highest proportions of forested areas in the world; the average percentage of forested area in the world is only 31%.[4] In Japan, forest walking or *Shinrin-yoku* (walking and/or staying in forested areas) has been well known as one of the activities for health promotion using forest environments. According to a public opinion poll conducted in 2011 by the Cabinet Office of the Government of Japan, 37.2% of respondents had participated in *Shinrin-yoku* within the preceding year to refresh mental and physical conditions.[5] However, the concept of *Shinrin-yoku* is not well known worldwide because the origin of the concept of *Shinrin-yoku* was only introduced in the 1980s in Japan, where there are rich forest environments.[6] Therefore, the knowledge concerning the effects of forest walking or *Shinrin-yoku* based on studies has been still limited, and the expected effects of forest walking or *Shinrin-yoku* have not been fully elucidated.

Many studies have evaluated the temporary acute effects, including benefits to psychological well-being, better sleep, reducing stress-related hormones such as cortisol, and lowering blood pressure or blood glucose levels, of one-off forest walking.[7-10] Regarding the temporary acute effect of decreasing blood pressure of forest walking or *Shinrin-yok*u, a recent meta-analysis showed that both systolic blood pressure (SBP) and diastolic blood pressure (DBP) levels were significantly lower in participants walking or sitting in a forest environment than in those walking or sitting in a non-forested environment.[11]

However, there are only a few epidemiological studies that have evaluated the long-term effects of successive walking as part of a healthy lifestyle.[12,13] Given that forest environments had temporary acute effects in reducing blood pressure levels, as previously reported, frequent forest walking may contribute to the prevention of hypertension. Therefore, in our J-MICC Shizuoka Study, we previously evaluated the association of the frequency of forest walking with blood pressure levels and the prevalence of hypertension in a Japanese general population, specifically targeting individuals who visited a private center for health check-up.[13] The cross-sectional study showed no association between either blood pressure levels or the prevalence of hypertension, and the frequency of forest walking. However, results of different targeted populations in epidemiological studies are often inconsistent. The effects generally should be confirmed not only in one population but also in other populations.

The aim of this study was to reconfirm the results of the J-MICC Shizuoka Study on whether the frequency of forest walking is associated with the prevalence of hypertension and blood pressure levels in another Japanese general population.

METHODS

Data Collection

This present Daiko Study is a member of the Japan Multi-Institutional Collaborative Cohort (J-MICC) Study; thus, the data collection process was similar to the study protocol in our previous J-MICC Shizuoka Study.[14] J-MICC Study is a long-term cohort study that investigated the interactions among genetic factors and lifestyle and lifestyle-related diseases, especially cancer.[15] The team at the Department of Preventive Medicine, Nagoya University Graduate School of Medicine has the following two enrollment fields: west-central areas of Shizuoka Prefecture launched in 2006 and Nagoya City launched in 2008. The former is called J-MICC Shizuoka Study where we previously evaluated the association of the frequency of forest walking with the prevalence of hypertension and blood pressure levels. The latter is also known as the Daiko Study, which was named after its enrollment place, Daiko Medical Center of Nagoya University.[14] These two studies were conducted under common protocol in terms of age and questionnaires used.

The baseline survey of the Daiko Study was conducted between June 2008 and May 2010.[14] Criteria for inclusion in the cohort study were individuals aged between 35 and 69 years and residents of Nagoya City located in the central area of the Main Island in Japan.[14,15] The detailed study protocols, including methods of recruitments, data collection, measurements, and characteristics of participants, of the J-MICC Daiko study have been described previously.[14] The study was approved by the ethics committee of Nagoya University Graduate School of Medicine (approval number 2008-0618-4), and written informed consent was obtained from all participants.

Participants

In this study, data were derived from the baseline survey in all participants in the Daiko Study. In the Daiko Study, 5,172 individuals participated in the baseline survey.[14] Among them, 4 participants withdrew their consent to participate in the study, and 59 participants were excluded because they did not meet the study criteria (e.g. lack of data for frequency of forest walking or lifestyle, no resident registration). Finally, a total of 5,109 participants (1,452 men and 3,657 women; age, mean ± standard deviation (SD): 52.5 ± 10.3 years) who responded to our questionnaire about their frequency of forest walking and lifestyle, have not withdrawn their participation, and did not meet the exclusion criteria (typically out of range for age or unregistered resident in the area), were included in the analysis.

Blood Pressure and Hypertension

Participants' blood pressure level was measured twice, in a seated position using a standard automated blood pressure measurement monitor (HEM-1000, Omron, Japan). Participants were given a 5-minute rest before the first measurement and another two-minute rest before the second measurement.[14] Mean blood pressure level of the two obtained values was used for analysis.

Participants were considered hypertensive if SBP ≥ 140 mmHg, DBP ≥ 90 mmHg, or if they are taking hypertensive medications, as identified by their responses in the questionnaire, similarly to Shizuoka Study.[13]

Questionnaire

The participants were requested to complete a self-administrated questionnaire with most questions commonly found in J-MICC Shizuoka Study's questionnaire,[13] which are as follows: frequency of forest walking as exposure of forest environment (*"How about frequency of forest walking, including hiking, nature observation, mountain-walking, working or camping in forested areas, but excluding visits in city parks?"*, 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); lifestyle, for example: smoking status, alcohol consumption; and leisure-time activities (intensity, frequency, and duration of exercise). Participants also reported the use of hypertensive medications or other medications.

Statistical Analysis

Statistical analysis was conducted mostly in a similar manner as our previous study.[13] For a more suitable analysis, alcohol consumption and body mass index (BMI) were divided into three categories in the Daiko Study, which differed from the two categories in the Shizuoka Study.

The six categories of the frequency of forest walking of the Shizuoka Study were modified into only four categories in this study by combining the three less frequent categories (several times a year, once a year, and rare) into one category, which was termed "less than once a month". BMI was calculated based on the measured weight and height and classified into three categories (≥25.0, 18.5–24.99, <18.5 kg/m^2). Alcohol consumption was classified into the following three categories: 1: five times a week or more, 2: one to four times a week, and 3: other responses, including 'used to drink' and 'never drink'. Habitual exercise was defined as ≥30 minutes of leisure time activity at least once a week; the intensity of exercise was not considered.[13]

The percentage difference of the frequency of forest walking by sex was calculated using the chi-squared test. The associations between the ordinal variables were analyzed using the Mantel-Haenszel test for trend. 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 using the direct method, and the trend was tested using the Mantel-extension test. Age was categorized into the following 4 groups: 30s, 40s, 50s, and 60s. The mean values of SBP and DSP by frequency of forest walking were tested using a general liner model (GLM) adjusted for age.

On the logistic regression analysis in Model 1, the dependent variable was hypertension (yes/no), whereas the independent variables were age (continuous variable), frequency of forest walking (4 categories), smoking status (current smokers/other responses), alcohol consumption (3 categories), and BMI (3 categories). In Model 2, the dependent variable was also hypertension, whereas the independent variables were the same as in Model 1 plus habitual exercise (yes/no).

The significance level was set at 5%. IBM SPSS Statistics version 23 for Windows (IBM, Armonk, NY, USA) and SAS version 9.1 (SAS Institute, Cary, NC, USA) were used for the statistical analysis.

RESULTS

The characteristics of participants by frequency of forest walking are presented in Table 1. The number of participants in each frequency of forest walking were as follows: once a week or more (n=40, 2.8%), two or three times per month (n=79, 5.4%), once a month (n=101, 7.0%), and less than once a month (n=1,232, 84.8%) in men, and once a week or more (n=48, 1.3%), two or three times per month (n=100, 2.7%), once a month (n=183, 5.0%), and less than once a month (n=3,326, 90.9%) in women. The percentages of each sex in each forest walking frequency group were significantly different (Chi-squared test: *p*<0.001); the higher forest walking frequency groups had a larger percentage of men. Significant trends by frequency of forest walking were observed on age (men: trend *p*<0.001, women: trend *p*<0.001) and habitual exercise (men: trend *p*<0.001, women: trend *p*<0.001) both in men and women; the higher forest walking groups were older and had a higher percentage of habitual exercise. Significant trends by frequency

of forest walking were observed on BMI (3 groups) in men (trend p=0.03) but not in women (trend p=0.09); the higher forest walking groups had a lower percentage of BMI ≥25.0 in men. Significant trends by frequency of forest walking were not observed on percentages of alcohol consumption ≥ once a week and current smokers in men and women.

The prevalence of hypertension was 35.0% (n=508/1,452) in men and 15.6% (n=571/3,657) in women. The prevalence of hypertension by frequency of forest walking is presented in Fig. 1. A significant trend was observed between the frequency of forest walking and the crude prevalence of hypertension in both men (trend p=0.03) and women (trend p<0.001); the higher forest walking frequency groups had a higher prevalence of hypertension. The higher forest walking frequency groups had a higher mean age. Given that age is one of the strong factors of hypertension, age-adjusted prevalence was calculated. After adjusting for age, the significant trend disappeared between the age-adjusted prevalence of hypertension and the frequency of forest walking in either men (Mantel-extension test: p=0.76) or women (p=0.09).

The results of the logistic regression analysis are shown in Table 2. 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 (aORs) of the most frequent group (once a week or more) relative to less than once a month group were 0.84 (95% confidence interval (CI): 0.42–1.68) for men and 1.41 (95% CI: 0.70–2.85) for women.

In Model 2, when considering habitual exercise in addition to Model 1, the frequency of forest walking was not also significantly associated with the prevalence of hypertension. The aORs of the most frequent group (once a week or more group; smallest number of participants: men, n=40; women, n=48) relative to the less than once a month group were 0.80 (95% CI: 0.40–1.62) for men and 1.48 (95% CI: 0.73–3.00) for women. Although the tendency on adjusted odds ratios of the once a week or more groups between men and women was different, adjusted odds ratios were not significant in both men and women with a large range of 95% CI owing to the small number of participants. The results showed that the frequency of forest walking, adjusted for habitual exercise, was not associated with the prevalence of hypertension.

However, aOR for habitual exercise was not significant in men (1.14, 95% CI (0.89–1.47)), but was significant in women (0.81, 95%CI (0.66–0.995)). These results show that habitual exercise but not frequency of forest walking was associated with the low prevalence of hypertension in women.

When ≥50 years was used as the susceptible age for hypertension, the aOR for frequency of forest walking was not also significant both in men [less than once a month (reference), once a month (0.95; 95%CI: 0.57–1.59), two or three times per month (1.33; 0.78–2.27), once a week or more (0.72; 0.35–1.52)] and in women [less than once a month (reference), once a month (0.89; 95% CI: 0.59–1.34), two or three times per month (1.60; 0.98–2.63), once a week or more (1.48; 0.70–3.11)] in Model 2. The aOR for habitual exercise was not also significant in men (1.24; 95%CI: 0.93–1.65) but was significant in women (0.75; 0.60–0.93).

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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		*p* value
	n	**%**	**n**	**%**	**n**	**%**	n	**%**	
Total, n=5,109	88	(1.7)	179	(3.5)	284	(5.6)	4,558	(89.2)	
Sex									
Male, n=1,452	40	(2.8)	79	(5.4)	101	(7.0)	1,232	(84.8)	*p*<0.001[c]
Female, n=3,657	48	(1.3)	100	(2.7)	183	(5.0)	3,326	(90.9)	
Age: mean ± SD[a]									
Men, 53.6 ± 10.3	59.4 ± 9.2		59.4 ± 8.9		56.0 ± 10.6		52.8 ± 10.2		Trend *p*<0.001[d]
Women, 52.1 ± 10.3	56.7 ± 10.1		57.6 ± 9.7		57.7 ± 10.4		51.5 ± 10.2		Trend *p*<0.001[d]
BMI									
Men									Trend *p*=0.03[e]
≥25.0	6	(15.0)	16	(20.3)	23	(22.8)	310	(25.2)	
18.5–24.99	32	(80.0)	56	(70.9)	74	(73.3)	877	(71.2)	
<18.5	2	(5.0)	7	(8.9)	4	(4.0)	45	(3.7)	
Women									Trend *p*=0.09[e]
≥25.0	7	(14.6)	11	(11.0)	16	(8.7)	306	(9.2)	
18.5–24.99	32	(66.7)	77	(77.0)	145	(79.2)	2,444	(73.5)	
<18.5	9	(18.8)	12	(12.0)	22	(12.0)	576	(17.3)	
Alcohol consumption									
Men									Trend *p*=0.05[e]
Five times a week or more	20	(50.0)	34	(43.0)	53	(52.5)	502	(40.7)	
One to four times a week	8	(20.0)	19	(24.1)	29	(28.7)	292	(23.7)	
Other responses	12	(30.0)	26	(32.9)	19	(18.8)	438	(35.6)	
Women									Trend *p*=0.76[e]
Five times a week or more	5	(10.4)	21	(21.0)	21	(11.5)	460	(13.8)	
One to four times a week	7	(14.6)	17	(17.0)	39	(21.3)	611	(18.4)	
Other responses	36	(75.0)	62	(62.0)	123	(67.2)	2,255	(67.8)	
Current smokers									
Men	15	(37.5)	15	(19.0)	24	(23.8)	298	(24.2)	Trend *p*=0.52[e]
Women	2	(4.2)	7	(7.0)	9	(4.9)	235	(7.1)	Trend *p*=0.34[e]
Habitual exercise[b]									
Men	34	(85.0)	68	(86.1)	62	(61.4)	611	(49.6)	Trend *p*<0.001[e]
Women	41	(85.4)	75	(75.0)	134	(73.2)	1,661	(49.9)	Trend *p*<0.001[e]

[a]Standard deviation

[b]Leisure time activity (once a week for 30 minutes or more)

[c]Chi-squared test

[d]Linear regression model

[e]Mantel-Haenszel test for trend
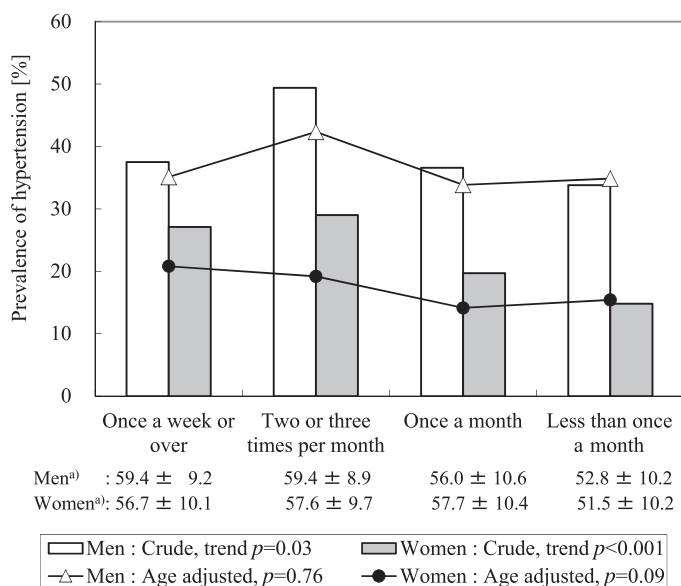
Abbreviation: BMI, body mass index

Fig. 1 Crude and age-adjusted prevalence of hypertension by each forest walking frequency group
Age-adjusted prevalence was calculated using the direct methods. Age was categorized into 4 groups (30s, 40s, 50s, and 60s). Trend was tested using the Mantel-Haenszel test for trend in crude. Age-adjusted trend was calculated using the Mantel-extension test.
a) Mean age ± standard deviation.

Table 2 Adjusted odds ratios (aOR) for the prevalence of hypertension

Frequency of forest walking	n	Hypertension n (%)	Model 1[c] aOR[a]	95% CI[b]	Model 2[d] aOR	95% CI
Men						
Less than once a month	1,232	417 (33.8%)	1		1	
Once a month	101	37 (36.6%)	0.87	(0.55–1.38)	0.86	(0.54–1.37)
Two or three times per month	79	39 (49.4%)	1.41	(0.86–2.33)	1.36	(0.82–2.26)
Once a week or more	40	15 (37.5%)	0.84	(0.42–1.68)	0.80	(0.40–1.62)
Women						
Less than once a month	3,326	493 (14.8%)	1		1	
Once a month	183	36 (19.7%)	0.78	(0.52–1.17)	0.81	(0.54–1.21)
Two or three times per month	100	29 (29.0%)	1.46	(0.91–2.35)	1.51	(0.94–2.45)
Once a week or more	48	13 (27.1%)	1.41	(0.70–2.85)	1.48	(0.73–3.00)

[a] Adjusted odds ratio

[b] Confidence interval

[c] Adjusted by age (continuous variable), body mass index (≥25.0, 18.5–24.99, <18.5), smoking status (current smokers/other responses), and alcohol consumption (five times and more, one to four times a week, other responses)

[d] Adjusted by age (continuous variable), body mass index (≥25.0, 18.5–24.99, <18.5), smoking status (current smokers/other responses), alcohol consumption (five times and more, once to four times a week, other responses), and habitual exercise (leisure time activity: once a week for at least 30 minutes or more/other responses)

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Given that blood pressure levels are affected by anti-hypertensive medications, blood pressure levels stratified for medication use by frequency of forest walking were presented in Table 3. 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 age and higher mean blood pressure values. However, these trends disappeared when adjusted for age.

Table 3 Blood pressure levels by frequency of forest walking: analysis stratified by sex and hypertension medication

	Once a week or more		Two or three times per month		Once a month		Less than once a month		Trend $p^{b)}$	Age-adjusted $P^{c)}$
	n	Mean ± SD[a]	**n**	Mean ± SD	**n**	Mean ± SD	**n**	Mean ± SD		
Systolic blood pressure										
Men										
Medication for hypertension										
(−)	34	128.4 ± 19.2	61	129.6 ± 17.3	83	127.9 ± 19.6	1,035	124.0 ± 18.0	0.004	0.59
(+)	6	143.3 ± 15.9	18	136.2 ± 19.8	18	138.6 ± 18.2	197	136.7 ± 18.3	0.57	0.90
Women										
Medication for hypertension										
(−)	39	118.3 ± 17.7	90	118.6 ± 20.2	165	116.0 ± 17.8	3,078	112.2 ± 17.4	<0.001	0.31
(+)	9	146.3 ± 18.4	10	137.0 ± 9.4	18	140.9 ± 17.6	248	133.5 ± 19.5	0.02	0.14
Diastolic blood pressure										
Men										
Medication for hypertension										
(−)	34	77.9 ± 11.5	61	81.0 ± 12.9	83	81.3 ± 12.2	1,035	77.6 ± 12.3	0.04	0.07
(+)	6	83.9 ± 5.1	18	80.4 ± 12.4	18	85.7 ± 11.6	197	82.7 ± 11.6	0.91	0.50
Women										
Medication for hypertension										
(−)	39	71.2 ± 11.7	90	70.5 ± 11.8	165	69.3 ± 10.2	3,078	68.6 ± 11.0	0.03	0.59
(+)	9	82.7 ± 10.5	10	80.7 ± 11.0	18	80.9 ± 13.0	248	78.7 ± 11.2	0.19	0.38

[a] Standard deviation
[b] Linear regression model
[c] General linear model

DISCUSSION

This study reconfirmed that the frequency of forest walking was not associated with either blood pressure levels or prevalence of hypertension in another population in Nagoya City, which is a large city. Although the beneficial temporary acute effects of one-off forest walking on reducing blood pressure have been previously reported in a meta-analysis,[11] our results suggest that frequent forest walking does not have any non-temporary effects on blood pressure in the two general populations not only in our previous study (J-MICC Shizuoka Study)[13] but also in this study.

Frequency of forest walking in both Daiko Study and Shizuoka Study previously had been reported in detail.[16,17] Frequency of forest walking in the Shizuoka Study was higher than that in the Daiko Study, with once a week or more being 1.7% in the Daiko Study and 5.0% in the Shizuoka Study. Given that the percentage of forested area was lower in Nagoya City than in the Shizuoka Prefecture, a higher frequency of forest walking might be obtained by the Shizuoka Study, which was conducted in the Shizuoka Prefecture. However, the frequency of walking was higher in urban areas than in rural areas, although the rural area had a high percentage of forested area.[16,18] This might be due to the low enjoyment level of forest walking in individuals living in the rural area.[16,18] Another possible difference in the frequency of forest walking between the Daiko Study and the Shizuoka Study is that the characteristics of the participants might be different. Shizuoka Study involved individuals who visited a private center for health check-up, whereas Daiko Study involved local residents who are considered to represent the general population. Nevertheless, these two studies showed similar results regarding the absence of an association between frequency of forest walking and blood pressure levels or prevalence of hypertension.

Despite the fact that a meta-analysis has reported that blood pressure was significantly lower in individuals in a forest environment than those in a non-forest environment, it should be noted that the acute beneficial effects of the forest environment relative to the non-forest environment on blood pressure are weak.[11] The SBP of 732 participants of the 20 trials had a mean difference (MD) of −3.15 mmHg (95% CI: −4.12 to −2.18), and the DBP of the 705 participants of the 17 trials was MD −1.75 mmHg (95% CI −2.38 to −1.13). In a subgroup analysis, middle-aged or older female individuals had the largest MD of SBP [MD −7.16 mmHg; 95%CI −10.88 to −3.45: 84 participants; 4 trials]. However, these differences may be within the normal range of daily fluctuations in blood pressure. As a consequence, the successive forest walking may not contribute to the reduction of either blood pressure levels or the prevalence of hypertension.

Another possible explanation for the lack of an association between the frequency of forest walking and 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 as mentioned in a previous study.[13] 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 the threshold required for the improvement of blood pressure or maintenance of optimal/normal blood pressure. Furthermore, the study did not mention the strength of exercise intensity during forest walking. *Shinrin-yoku* or forest walking in Japan does not require a specific exercise intensity. Walking slowly in forested areas is permitted. For the prevention of hypertension or maintenance of optimal blood pressure, a specific intensity during forest walking as an exercise therapy, similar to a terrain cure conducted on health resorts in Germany, might be required.[6]

In addition, the number of participants who responded once a week or more, which was the group with the most frequent times of forest walking and with a higher possibility of improving

or maintaining optimal blood pressure, was not enough. Only 88 participants (1.7%) responded to perform forest walking once a week or more, although majority of the participants performed forest walking less than once a month (n=4,558, 89.2%). In the power analysis (setup: ratio of once a week or more/less than once a month; 0.02, statistical power; 0.8, significant level; 0.05, prevalence of hypertension on once a week or more group; 15%, prevalence of hypertension on less than once a month: 20% based on the prevalence 21.1% on the study), the required sample size was 480 in the once a week or more group and over 23,000 in the less than once a month group. Given that not only the once a week or more group and less than once a month group are included but also the two or three time per month group and the once a month group exist, the required total sample size should be more than 23,480.

Moreover, it is difficult to recommend once a week or more on forest walking for health promotion to residents in urban areas who live far from forested areas, even if the preferable effects for once a week or more of forest walking are observed in epidemiological studies. In fact, only 1.7% of the participants performed forest walking once a week or more. It is realistic to recommend habitual exercise instead, which was observed to be statistically significant in the logistic regression analysis in women in this study.

This study had some limitations similar to our previous study[13] because the methods were similar. First, the research work is an epidemiological study with some biases common in such studies. For example, blood pressure measurements were conducted only once. The established risk factors of hypertension were not also fully incorporated in this study (e.g. genetic factors, salt intake). We evaluated the non-temporary effects of successive forest walking by only frequency of forest walking, and the frequency of forest walking was evaluated based on self-assessment. Duration and/or methods of forest walking may contribute to the non-temporary effects of successive forest walking on blood pressure. Although exercise intensity might be relevant for reducing blood pressure, we did not investigate exercise intensity during forest walking. Therefore, we cannot conclude that there was a definite association between forest walking and hypertension. The mentioned limitations would remain even if we used a prospective cohort study design as opposed to the cross-sectional design employed for this study. Second, because this was a cross-sectional study, a causal relationship between hypertension and forest walking cannot be determined. This was evaluated only to determine whether there was an association between the frequency of forest walking and the prevalence of hypertension. Thus, we cannot conclude that *Shinrin-yoku* or forest walking had no effect in preventing hypertension based on the findings of our cross-sectional study. Cohort studies will be required to investigate whether there is a causal relationship between frequent *Shinrin-yoku* or forest walking and prevention of hypertension. These studies require follow-up of the participants to identify the incidence of hypertension among participants without hypertension at baseline. However, the aforementioned limitations might remain in epidemiological studies due to biases common in such studies. Further well-designed interventional studies with a specific exercise intensity are warranted to evaluate the efficacy of *Shinrin-yoku* or forest walking for the prevention or management of hypertension. However, the strength of the study was that it involved a large number of participants that may lead us to obtain robust results in case of using this method.

In conclusion, this study reconfirmed that either lowering blood pressure level or lowering the prevalence of hypertension is not associated with frequency of forest walking, similar to the results of our previous J-MICC Shizuoka Study. Our current two cross-sectional studies in a Japanese general population with more than 10,000 participants from Shizuoka Prefecture (previous study) and from Nagoya City (this study) showed no association between either blood pressure levels or the prevalence of hypertension and the frequency of forest walking.

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DISCLOSURE STATEMENT

The authors declare that they have no conflicts of interest.

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