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Original article

Sustained effects of a forest therapy program on the blood pressure of office workers

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ABSTRACT

We examined the sustained effects of a forest therapy program on the blood pressure of office workers. Twenty-six office workers (mean age ± standard deviation, 35.7 ± 11.1 years) participated in a 1-day forest therapy program. Systolic and diastolic blood pressure and pulse rate were used as measurement indices. The evaluations were performed three times before breakfast, lunch, and dinner 3 days before, during, and 3 and 5 days after the forest therapy program. Systolic and diastolic blood pressure significantly decreased during the forest therapy program relative to the value from 3 days before the program, and this decrease was maintained 3 and 5 days after the forest therapy program. There were no significant differences in pulse rate. We then specifically focused on nine participants whose systolic blood pressure was above 120 mmHg. For the measurement before dinner, the systolic blood pressure significantly decreased (from 133.8 to 116.6 mmHg) during the forest therapy program, and this decrease was maintained at 3 and 5 days after the program (126.4 and 124.0 mmHg, respectively). A significant decrease in diastolic blood pressure (from 88.6 to 77.1 mmHg) was observed during the forest therapy program. In conclusion, systolic and diastolic blood pressure decreased during the forest therapy program and these decreases were maintained for 5 days.

1. Introduction

There are serious social concerns over health problems caused by job stress. Job stress is defined as harmful physical and emotional responses that occur when the requirements of a job do not match the capabilities, resources, or needs of the worker (National Institute for Occupational Safety and Health, 1999). Over the past few decades, more and more research has documented that job stress is associated with a moderately elevated risk of adverse health outcomes, especially cardiovascular-related adverse effects (Kang et al., 2005; Kivimäki and Kawachi, 2015; Siegrist and Li, 2016).

According to a survey conducted in Japan (Ministry of Health, Labour and Welfare, 2012), 60.9% of Japanese workers feel stress in their jobs. This high stress state of workers has become an important social issue and, therefore, the Japanese government launched a new occupational health policy called the Stress Check Program to monitor and screen for workers experiencing high psychological stress in the workplace (Kawakami and Tsutsumi, 2016). It has become increasingly important to seek solutions for people to cope with workplace stress in Japan.

In recent years, there has been considerable and increasing attention on the use of forest environments as a setting for health promotion. Numerous studies have demonstrated that forest environments mitigate stress states and induce physiological relaxation (Tsunetsugu et al., 2007; Park et al., 2007; Lee et al., 2009; Park et al., 2009; Park et al., 2010; Lee et al., 2011; Tsunetsugu et al., 2013; Lee et al., 2014). It is well known that spending time in forest settings improves immune function and that these effects last for about 1 month (Li et al., 2007; Li et al., 2008a, 2008b). From the psychological aspect, the restorative effects of forest environments related to psychological stressors or mental fatigue and improved mood states and cognitive function have been reported (Morita et al., 2007; Shin et al., 2010; Park et al., 2011; Shin et al., 2011).

The idea of “forest therapy” has been proposed in accordance with the results of the above studies. The aim of evidence-based “forest bathing (shinrin-yoku)” is to induce preventive medical effects to improve weakened immune function and prevent diseases by achieving a state of physiological relaxation through exposure to forest-origin stimuli (Song et al., 2016). Forest therapy is now increasingly recognized as an effective relaxation and stress management tool that has been

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure

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demonstrated to be an effective preventive or alternative therapy (Frumkin, 2001; Lee et al., 2012), and its effects have been studied in elderly individuals and adults at risk of stress- and lifestyle-related diseases such as high blood pressure, diabetes, and depression (Ohtsuka et al., 1998; Mao et al., 2012; Shin et al., 2012; Sung et al., 2012; Lee and Lee, 2014; Kim et al., 2015; López-Pousa et al., 2015; Ochiai et al., 2015; Song et al., 2015a; Chun et al., 2017; Song et al., 2017).

The preventive medical effects induced by forest environments are increasingly being recognized; however, there is a lack of research on how long these effects last. The aim of the present study was to clarify the sustained effects of a forest therapy program on the blood pressure of office workers. We specifically focus on participants whose systolic blood pressure (SBP) was above 120 mmHg because recent research indicates that lowering SBP to less than 120 mmHg can significantly reduce the rates of major cardiovascular events and death from any case (The SPRINT Research Group, 2015).

2. Materials and methods

2.1. Participants

2.1.1. All participants (N = 26)

The participants were employees from a company that aims for regional creation with information technology from Tottori Prefecture. Twenty-six office workers aged 19–56 years (male: 14, female: 12, mean age ± standard deviation: 35.7 ± 11.1 years; Table 1) participated in this study.

With respect to recruitment, we posted study information on an office bulletin board. Those who wished to participate in the study applied via e-mail. All participants were thoroughly informed regarding the aims and procedures of the study. After receiving a description of the experiment, they signed an agreement to participate in the study. During the study period, the consumption of alcohol, caffeine, and tobacco was prohibited. Participants were asked to perform normal life activities on the days before and after participating in the forest therapy program. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Center for Environment, Health and Field Sciences, Chiba University, Japan (Project identification code number: 5).

2.1.2. Higher than 120 mmHg group (N = 9)

Of the 26 participants, we focused on 9 participants (male: 8, female: 1, mean age ± standard deviation: 37.4 ± 10.0 years) whose SBP was above 120 mmHg, as measured before dinner, at the office and 3 days before participating in the forest therapy program. We named this group as the “higher than 120 mmHg group.”

2.2. Experimental sites

The forest therapy programs were conducted in Chizu, Tottori Prefecture, which is located in the Chūgoku region in Japan. More than 90% of the total area of this region is covered by forests and forestry and timber processing are its main industries. The experimental site of the present study (hereafter referred to as the forest area) was certified as a forest therapy base in 2010 and it is a mixed forest mostly composed of cedar and hardwood. Annually, around 1400 forest therapy tourists visit this town (as of April 2015).

It was sunny on the days on which the forest therapy program was run and the mean temperature, humidity, and intensity of illumination in the forest area were 18.7 ± 3.3 °C, 65.3 ± 9.8%, and 2097 ± 1910 lx, respectively.

Table 1
Participant demographics.

Parameter	Mean ± standard deviation		
	All participants	Males	Females
Total sample number	26	14	12
Age (years)	35.7 ± 11.1	35.3 ± 10.6	36.2 ± 12.2
Height (cm)	164.7 ± 8.6	170.1 ± 6.2	158.4 ± 6.4
Weight (kg)	60.7 ± 10.7	66.9 ± 10.8	53.4 ± 3.8
BMI (kg/m^2)	22.3 ± 3.1	23.1 ± 3.5	21.4 ± 2.4

BMI: Body mass index.

2.3. Measurement

SBP, diastolic blood pressure (DBP), and pulse rate were used as physiological measurement indices. A digital blood pressure monitor using oscillometric methods (HEM1020; Omron, Kyoto, Japan) was used to measure the blood pressure and pulse rate in the right upper arm. Participants rested in a seated position for 5 min and then measured their blood pressure and pulse rate twice, with their arm placed on top of a desk. Desks and chairs of the same size were used in all measurements. In the case of discrepancies in SBP exceeding 10 mmHg and/or DBP exceeding 6 mmHg between two measurements, an additional measurement was taken. The mean of two or three measurements was used in the analysis.

2.4. Experimental design

Before joining the forest therapy program, the 26 office workers attended an orientation in the meeting room of their office on September 3, 2014. The participants were randomly assigned to three groups of eight, ten, and eight individuals, and these three groups participated in the forest therapy program on September 13, and October 11 and 18, 2014, respectively.

To investigate the changes in the physiological response of the participants to the forest therapy program over time, the physiological measurements were taken 3 days before, during, and 3 and 5 days after the program (Fig. 1). The measurements were taken three times before breakfast, lunch, and dinner on each assessment day. The measurement time was based on the timing of the forest therapy program; the participants' blood pressure (SBP and DBP) and pulse rate were measured before breakfast (about 7:00, before participation in the program), before lunch (12:30), and at the end of the program (about 15:00). These measurements were also taken at the same time of day 3 days prior to the forest therapy program and 3 and 5 days after the program in their home and/or office using desks and chairs of the same size.

On the morning of the forest therapy program, the participants gathered at the parking area near the entrance of the “forest therapy road” at 8:50 and joined in the forest therapy program as a group with a guide. The program consisted of multiple timed activities over about 6 h, 12 min, with a walking distance of 4265 m, and included time for lunch and the physiological measurements. Table 2 shows the details of the forest therapy program on September 13. The programs were conducted following the same procedure at approximately the same times for all three groups.

The program and altitude map of the course showing the various activities in the forest therapy program are shown in Figs. 2 and 3, respectively. This data was obtained using an offline map-caching GPS application (Geographica, Japan).

2.5. Data analysis

The data were summarized in terms of the mean value before breakfast, lunch, and dinner 3 days before, during, and 3 and 5 days after the forest therapy program. Furthermore, average daily measures were also examined.

SPSS software (V20.0; IBM Corp., Armonk, NY, USA) was used for all statistical analyses. For all comparisons, $p < 0.05$ was considered statistically significant. A paired *t*-test with Holm correction was used to

Fig. 1. Experimental schedule.

Table 2
Schedule of the various activities in the forest therapy program.

Time	Event	Number in Figs. 2 and 3
09:18–09:20	Brief explanation about the program	–
09:21–09:26	Preparation stretches	–
09:27–09:48	Walking to the forest area	–
09:49–09:51	Blind walking	1
09:52–09:54	Stroll in the forest	–
09:55–10:02	Deep breathing	2
10:03–10:06	Stroll in the forest	–
10:07–10:26	Viewing scenery & lecture	3
10:27–10:37	Stroll in the forest	–
10:38–10:47	Flow stress to waterfall	4
10:48–10:54	Stroll in the forest	–
10:55–11:22	Sitting & lying down in the forest	5
11:23–11:33	Stroll in the forest	–
11:34–11:48	Back walk	6
11:49–12:01	Stroll in the forest	–
12:02–12:35	Rest & measurements before lunch	7
12:36–13:16	Lunch & rest	8
13:17–13:52	Stroll in the forest	–
13:53–14:09	Meditation	9
14:10–14:25	Stroll in the forest	–
14:26–14:37	Hammock	10
14:38–14:54	Stroll in the forest	–
14:55–14:58	Deep breathing	11
14:59–15:10	Stroll in the forest	–
15:11–15:30	Rest & measurements after program	12

compare the physiological measurements obtained during and 3 and 5 days after the forest therapy program with those taken 3 days before the program (baseline); therefore, Holm correction was applied three times. Regarding the smallest p value, the adjustment is the same as the Bonferroni correction for the three outcome measures being analyzed, resulting in a corrected significance level that was set at a p value of 0.017 (=0.05/3). If the smallest p value is > 0.017, the process stops, but if it is smaller, the next smallest p value is divided by 2 (p = 0.025). The process continues in a similar manner if that p value is significant, with the next smallest value being divided by 1 (p = 0.050).

One-sided tests were used because of the hypothesis that the participants would be physiologically relaxed by the forest therapy program.

3. Results

The participants showed significantly lower blood pressure during and following the 1-day forest therapy program than in their everyday life (3 days before participating in the program), and these decreases lasted for at least 5 days.

3.1. All participants (N = 26)

The overall results are summarized in Table 3. Regarding SBP measured before breakfast, compared with the mean value from 3 days before (baseline: 114.2 ± 2.3 mmHg), the mean value significantly decreased on the day of the forest therapy program (110.1 ± 2.2 mmHg, $p < 0.05$), 3 days after (107.7 ± 2.7 mmHg, $p < 0.05$), and 5 days after (107.9 ± 2.5 mmHg, $p < 0.05$). In terms of the SBP measurements taken before dinner, compared with the mean measurements taken 3 days before (baseline: 115.5 ± 3.1 mmHg), the mean value also significantly decreased on the day of forest therapy

Fig. 2. Schematic with images showing the various activities in the forest therapy program.

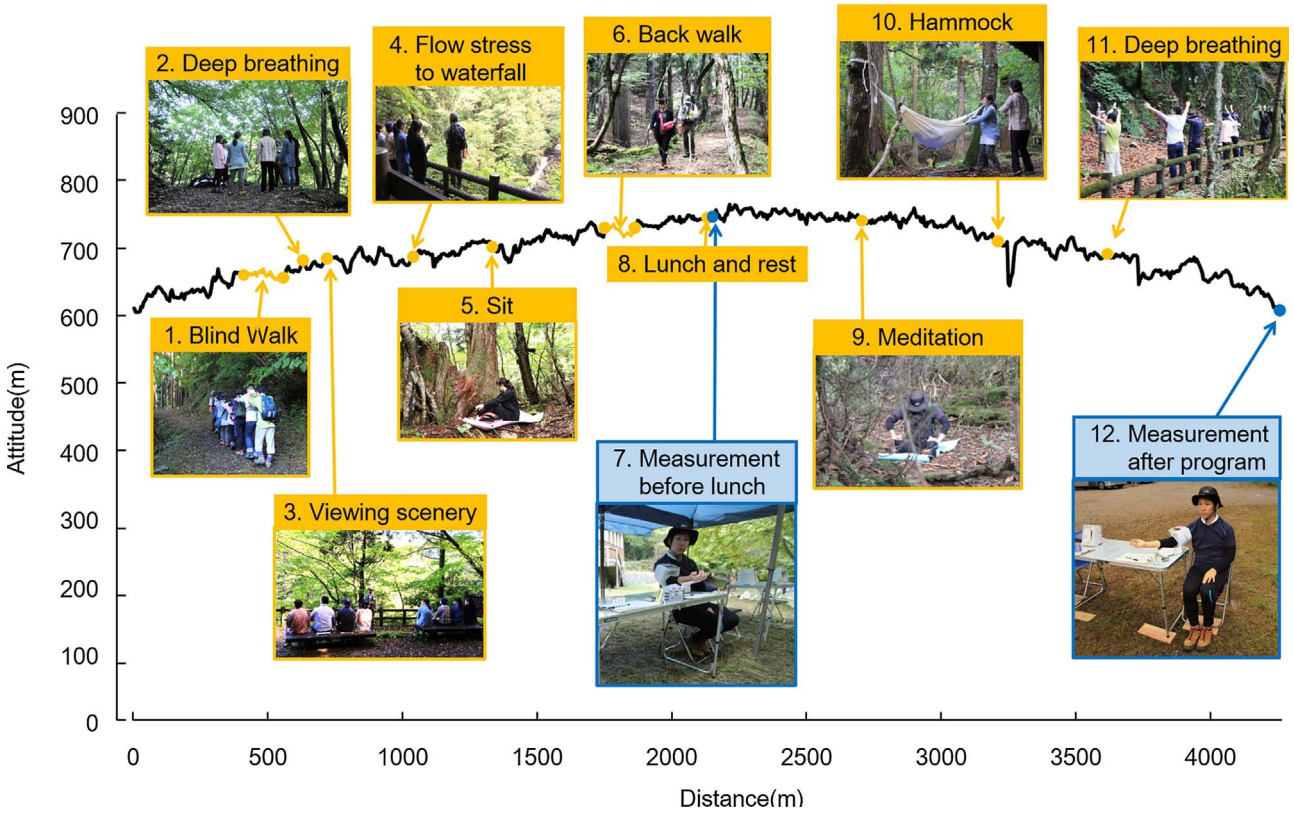

Fig. 3. Altitude map with images showing the various activities in the forest therapy program.

(106.5 ± 2.4 mmHg, $p < 0.05$). No significant difference was observed for the measurements taken before lunch. For the average daily measures, compared with the mean value from 3 days before (baseline: 114.8 ± 2.7 mmHg), the mean value significantly decreased on the day of the forest therapy program (109.1 ± 2.2 mmHg, $p < 0.05$), 3 days after (111.5 ± 2.6 mmHg, $p < 0.05$), and 5 days after (110.7 ± 2.6 mmHg, $p < 0.05$).

For DBP measured before breakfast, compared with the mean value from 3 days before (baseline: 75.6 ± 2.1 mmHg), a significant decrease was found 3 days (70.5 ± 2.0 mmHg, $p < 0.05$) and 5 days after the forest therapy program (72.4 ± 1.9 mmHg, $p < 0.05$). The mean value on the day of forest therapy (73.3 ± 2.0 mmHg) appeared to be lower than the baseline value; however, no significant difference was observed. For the DBP measurements taken before dinner, compared with 3 days before (baseline: 73.5 ± 2.8 mmHg), the mean value also significantly decreased on the day of forest therapy (68.3 ± 2.1 mmHg, $p < 0.05$). No significant difference was observed for the DBP measurements taken before lunch. For the average

Table 3
Systolic blood pressure, diastolic blood pressure, and pulse rate measurements taken at different measurement times.

Measurement time		SBP (mmHg)		DBP (mmHg)		Pulse rate (bpm)	
		Mean ± SE	p value	Mean ± SE	p value	Mean ± SE	p value
Before breakfast	3 days before	114.2 ± 2.3	–	75.6 ± 2.1	–	71.0 ± 2.2	–
	Forest therapy day	110.1 ± 2.2	0.025*	73.3 ± 2.0	0.103	70.6 ± 1.8	0.735
	3 days after	107.7 ± 2.7	0.001*	70.5 ± 2.0	0.000*	69.4 ± 2.0	0.199
	5 days after	107.9 ± 2.5	0.000*	72.4 ± 1.9	0.003*	71.0 ± 1.8	0.988
Before lunch	3 days before	114.5 ± 3.4	–	75.8 ± 2.6	–	70.4 ± 2.0	–
	Forest therapy day	110.7 ± 2.8	0.025	73.5 ± 2.2	0.062	71.3 ± 2.2	0.560
	3 days after	112.6 ± 2.7	0.388	73.8 ± 2.2	0.164	73.3 ± 2.0	0.025
	5 days after	112.0 ± 3.0	0.199	72.5 ± 2.6	0.033	72.5 ± 1.6	0.171
Before dinner	3 days before	115.5 ± 3.1	–	73.5 ± 2.8	–	75.0 ± 2.3	–
	Forest therapy day	106.5 ± 2.4	0.001*	68.3 ± 2.1	0.010*	76.5 ± 2.4	0.311
	3 days after	114.3 ± 3.2	0.519	72.4 ± 2.7	0.524	77.7 ± 2.5	0.024
	5 days after	112.2 ± 2.8	0.062	73.8 ± 2.3	0.854	74.8 ± 2.1	0.926
Mean	3 days before	114.8 ± 2.7	–	75.0 ± 2.3	–	72.1 ± 2.0	–
	Forest therapy day	109.1 ± 2.2	0.000*	71.7 ± 1.9	0.003*	72.8 ± 2.0	0.555
	3 days after	111.5 ± 2.6	0.009*	72.2 ± 2.1	0.011*	73.5 ± 2.0	0.083
	5 days after	110.7 ± 2.6	0.001*	72.9 ± 2.1	0.044*	72.8 ± 1.6	0.548

SBP: systolic blood pressure, DBP: diastolic blood pressure, SE: Standard error.
N = 26, mean ± SE.
* $p < 0.05$ by paired *t*-test (one-sided) with Holm correction.

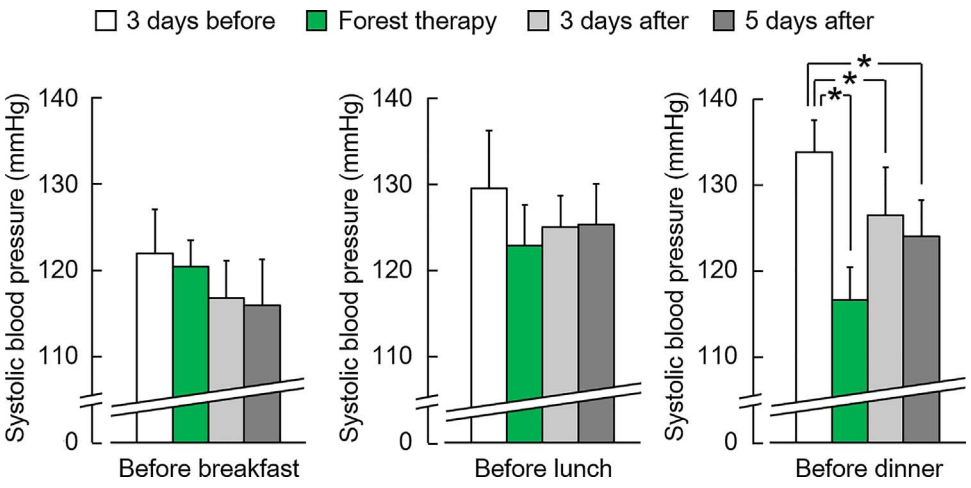

Fig. 4. Systolic blood pressure measurements taken before breakfast, lunch, and dinner in the "higher than 120 mmHg group.".
N = 9, mean ± SE, *p < 0.05 by paired *t*-test (one-sided) with Holm correction.

daily measures, compared with the mean value from 3 days before (baseline: 75.0 ± 2.3 mmHg), the mean value significantly decreased on the day of the forest therapy program (71.7 ± 1.9 mmHg, $p < 0.05$), 3 days after (72.2 ± 2.1 mmHg, $p < 0.05$), and 5 days after (72.9 ± 2.1 mmHg, $p < 0.05$).

Further, no significant differences were found in the pulse rate for any of the measurements.

3.2. Higher than 120 mmHg group (N = 9)

Similar results were obtained in the "higher than 120 mmHg group." The SBP results are shown in Fig. 4. For the results before dinner, compared with the mean value from 3 days before (baseline: 133.8 ± 3.7 mmHg), the mean values significantly decreased on the day of forest therapy (116.6 ± 3.8 mmHg, $p < 0.05$), 3 days after (126.4 ± 5.5 mmHg, $p < 0.05$), and 5 days after (124.0 ± 4.2 mmHg, $p < 0.05$). No significant difference was observed for the measurement before breakfast (3 days before: 122.0 ± 5.1 mmHg; on the day of forest therapy: 120.4 ± 3.1 mmHg; 3 days after: 116.8 ± 4.3 mmHg; 5 days after: 115.9 ± 5.4 mmHg, $p > 0.05$) or before lunch (3 days before: 129.6 ± 6.7 mmHg; on the day of forest therapy: 122.9 ± 4.7 mmHg; 3 days after: 125.1 ± 3.7 mmHg; 5 days after: 125.4 ± 4.2 mmHg, $p > 0.05$). For the average daily measures, compared with the mean value from 3 days before (baseline: 128.4 ± 4.9 mmHg), the mean value significantly decreased on the day of the forest therapy program (120.0 ± 3.3 mmHg, $p < 0.05$), 3 days after (122.8 ± 4.2 mmHg, $p < 0.05$), and 5 days after (121.8 ± 4.6 mmHg, $p < 0.05$).

Fig. 5 shows the DBP results for the "higher than 120 mmHg group." For the results before lunch, compared with 3 days before (baseline: 89.4 ± 3.6 mmHg), the mean value also significantly decreased on the day of forest therapy (83.3 ± 3.6 mmHg, $p < 0.05$). For the measurements taken before dinner, compared with 3 days before (baseline: 88.6 ± 3.4 mmHg), the mean value also significantly decreased on the day of forest therapy (77.1 ± 3.4 mmHg, $p < 0.05$). There were no significant differences for the measurements taken before breakfast (3 days before: 81.9 ± 4.2 mmHg; on the day of forest therapy: 81.7 ± 2.7 mmHg; 3 days after: 76.6 ± 2.9 mmHg; 5 days after: 77.8 ± 3.5 mmHg, $p > 0.05$). For the average daily measures, compared with the mean value from 3 days before (baseline: 86.6 ± 3.4 mmHg), the mean value significantly decreased on the day of the forest therapy program (80.7 ± 2.9 mmHg, $p < 0.05$), 3 days after (81.1 ± 3.2 mmHg, $p < 0.05$), and 5 days after (82.0 ± 3.4 mmHg, $p < 0.05$).

For the pulse rate results, no significant differences were found for any of the measurements.

4. Discussion

In this study, we examined the sustained effects of a forest therapy program on the blood pressure of office workers. The results indicated that blood pressure significantly decreased during the forest therapy program relative to the value measured 3 days before participation in the program, and that this decrease was maintained at 3 and 5 days after the program.

Moreover, we demonstrated the same effect in the "higher than

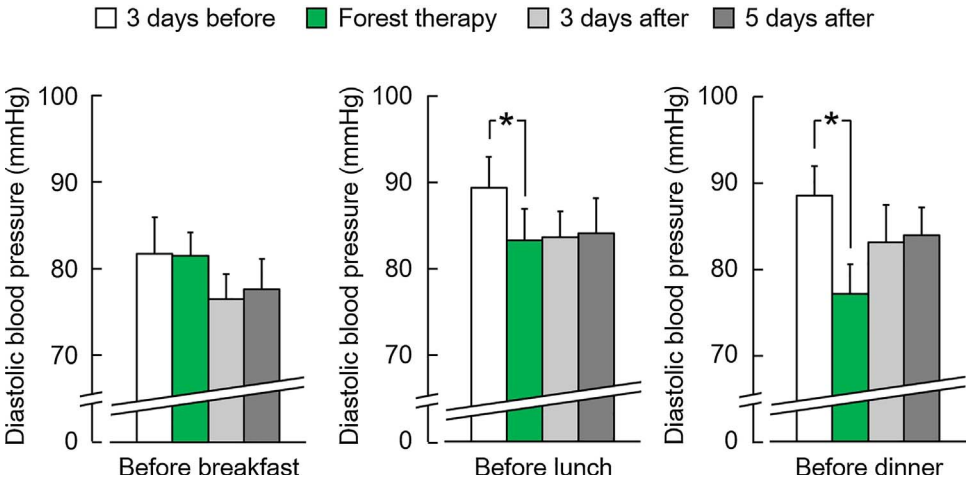

Fig. 5. Diastolic blood pressure measurements taken before breakfast, lunch, and dinner in the "higher than 120 mmHg group.".
N = 9, mean ± SE, *p < 0.05 by paired *t*-test (one-sided) with Holm correction.

120 mmHg group." From the literature, blood pressure levels of ≥140/90 mmHg are regarded as hypertension, 130–139/85–89 mmHg as high normal blood pressure, 120–129/80–85 mmHg as normal blood pressure, and < 120/80 mmHg as optimal blood pressure (Shimamoto et al., 2014). However, the optimal blood pressure remains controversial and recent research has revealed that lowering SBP to a target goal of less than 120 mmHg, as compared with the standard goal of less than 140 mmHg, results in lower rates of major cardiovascular events and death from any case (The SPRINT Research Group, 2015). In the before dinner measurement of the "higher than 120 mmHg group," we detected a dramatic reduction in blood pressure, which was sustained. Compared with the value from 3 days before (baseline: 133.8 ± 3.7 mmHg), SBP significantly decreased by 17.2 mmHg (12.8%) on the day of the forest therapy program by 7.3 mmHg (5.5%) 3 days after and by 9.8 mmHg (7.3%) 5 days after. Further, DBP significantly decreased by 11.5 mmHg (12.9%) on the day of the forest therapy program compared with 3 days before (baseline: 88.6 ± 3.4 mmHg). The mean blood pressure from 3 days before the program, which was assumed to be the same as each participant's average daily blood pressure, was high for both SBP (133.8 mmHg) and DBP (88.6 mmHg). After forest therapy, SBP decreased to 116.6 mmHg and DBP decreased to 77.1 mmHg, indicating a remarkable effect.

On the other hand, a sustained reduction in SBP was observed in the before breakfast measurement in the all participants group, but it was detected in the before dinner measurement in the nine participants with high SBP. Looking at SBP results from 3 days before the forest therapy program, there were no significant differences in the values obtained before breakfast (114.2 mmHg), lunch (114.5 mmHg), and dinner (115.5 mmHg) in all participants. However, when we separate out the nine participants with high SBP, we observed values that gradually increased from before breakfast (122.0 mmHg), to lunch (129.6 mmHg), and dinner (133.8 mmHg). It is possible that work-related stress was reflected in the measures of the high-SBP group. Because the value before dinner was high, it appears that the effect of forest therapy was remarkable. The mechanism that explains different results between the 26 participants and the 9 participants with high SBP are unknown. These would be important topics for examination during future research. In addition, we focused on participants who actively experienced stress. We consequently obtained evening measures of SBP, which is the time when most daily work stressors end. Although we used data that was measured only for 1 day, future studies should examine participants with sustained high blood pressure in the evening.

Some of the results from the present study are consistent with those of previous studies, which showed decreases in blood pressure as a result of various types of contact with forest environments, such as only 15 min walking in and/or viewing forests (Tsunetsugu et al., 2007; Lee et al., 2009; Park et al., 2009; Park et al., 2010) and participation in forest therapy programs for 1 day (Ochiai et al., 2015), 3 days (Sung et al., 2012), and 7 days (Mao et al., 2012). These findings suggest that forest environments can significantly lower blood pressure.

Because job stress is known to be associated with a moderately elevated risk of adverse health outcomes, especially cardiovascular-related outcomes (Kang et al., 2005; Kivimäki and Kawachi, 2015; Siegrist and Li, 2016), proper management and prevention of stress are thought to be important to health. We believe that participation in forest therapy programs can be an effective and beneficial method for stress management and health promotion in office workers. In the future, it will be necessary to study the mechanism and factors in the forest that bring about these effects, as well as how to the forest environment can be used to optimize physiological benefits

Furthermore, recent studies have demonstrated that exposure to urban green spaces, which provide a natural environment that is accessible for most people in modern society, has a positive effect on perceived general health (Takano et al., 2002; Maas et al., 2006) and a brief walk in an urban park can induces parasympathetic nervous activity that is enhanced in relaxed state, suppresses sympathetic nervous activity that is enhanced in stressful state, and decrease the heart rate, regardless of the season (Song et al., 2013, 2014, 2015b). Because the development of urban green spaces is a simple and accessible method of improving health and quality of life, there is a need to clarify the physiological influence and sustainable effects of urban green spaces.

The present study provides evidence of the sustained effects of a forest therapy program on the blood pressure of office workers. However, this study has several limitations. First, it lacks a control group performing similar activities in an urban environment. Second, the only analysis variables were blood pressure and pulse rate; therefore, future studies should determine the effects of the forest environment using other physiological indices. Third, we only measured the blood pressure of the office workers for up to 5 days after participation in the program. Thus, future studies should measure the physiological effects of the program 7–10 days after participation.

5. Conclusions

Regarding the sustained effects of the forest therapy program on the blood pressure of office workers, our study findings revealed the following: (1) blood pressure decreased during the forest therapy program and (2) this decrease continued for 5 days. In conclusion, the forest therapy program reduced the blood pressure of office workers and these effects were sustained for 5 days.

Author contributions

Chorong Song contributed to the experimental design, data acquisition, statistical analysis, interpretation of results, and manuscript preparation. Harumi Ikei contributed to the experimental design, data acquisition, statistical analysis, and interpretation of results. Yoshifumi Miyazaki conceived and designed the study and contributed to the data acquisition, interpretation of results and manuscript preparation. All authors have read and approved the final version submitted for publication.

Conflicts of interest

The authors declare no conflict of interest.

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References

Chun, M.H., Chang, M.C., Lee, S., 2017. The effects of forest therapy on depression and anxiety in patients with chronic stroke. Int. J. Neurosci. 127, 199–203.
Frumkin, H., 2001. Beyond toxicity: human health and the natural environment. Am. J. Prev. Med. 20, 234–240.
Kang, M.G., Koh, S.B., Cha, B.S., Park, J.K., Baik, S.K., Chang, S.J., 2005. Job stress and cardiovascular risk factors in male workers. Prev. Med. 40, 583–588.
Kawakami, N., Tsutsumi, A., 2016. The stress check program: a new national policy for monitoring and screening psychosocial stress in the workplace in Japan. J. Occup. Health 58, 1–6.
Kim, B.J., Jeong, H., Park, S., Lee, S., 2015. Forest adjuvant anti-cancer therapy to enhance natural cytotoxicity in urban women with breast cancer: a preliminary prospective interventional study. Eur. J. Integr. Med. 7, 474–478.
Kivimäki, M., Kawachi, I., 2015. Work stress as a risk factor for cardiovascular disease. Curr. Cardiol. Rep. 17, 74.
López-Pousa, S., Bassets Pagès, G., Monserrat-Vila, S., de Gracia Blanco, M., Hidalgo Colomé, J., Garre-Olmo, J., 2015. Sense of well-being in patients with fibromyalgia: aerobic exercise program in a mature forest–a pilot study. Evid.-Based Complement. Altern. Med. 2015, 614783.
Lee, J.Y., Lee, D.C., 2014. Cardiac and pulmonary benefits of forest walking versus city walking in elderly women: a randomised, controlled, open-label trial. Eur. J. Integr. Med. 6, 5–11.
Lee, J., Park, B.J., Tsunetsugu, Y., Kagawa, T., Miyazaki, Y., 2009. Restorative effects of viewing real forest landscapes, based on a comparison with urban landscapes. Scand. J. For. Res. 24, 227–234.
Lee, J., Park, B.J., Tsunetsugu, Y., Ohira, T., Kagawa, T., Miyazaki, Y., 2011. Effect of

forest bathing on physiological and psychological responses in young Japanese male subjects. Public Health 125, 93–100.
Lee, J., Li, Q., Tyrväinen, L., Tsunetsugu, Y., Park, B.J., Kagawa, T., Miyazaki, Y., 2012. Nature therapy and preventive medicine. In: Maddock, J.R. (Ed.), Public Health-Social and Behavioral Health. InTech, Rijeka, Croatia, pp. 325–350.
Lee, J., Tsunetsugu, Y., Takayama, N., Park, B.J., Li, Q., Song, C., Komatsu, M., Ikei, H., Tyrväinen, L., Kagawa, T., Miyazaki, Y., 2014. Influence of forest therapy on cardiovascular relaxation in young adults. Evid.-Based Complement. Altern. Med. 2014, 834360.
Li, Q., Morimoto, K., Nakadai, A., Inagaki, H., Katsumata, M., Shimizu, T., Hirata, Y., Hirata, K., Suzuki, H., Miyazaki, Y., Kagawa, T., Koyama, Y., Ohira, T., Takayama, N., Krensky, A.M., Kawada, T., 2007. Forest bathing enhances human natural killer activity and expression of anti-cancer proteins. Int. J. Immunopathol. Pharmacol. 20, 3–8.
Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., Hirata, K., Suzuki, H., Li, Y.J., Wakayama, Y., Kawada, T., Park, B.J., Ohira, T., Matsui, N., Kagawa, T., Miyazaki, Y., Krensky, A.M., 2008a. Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins. Int. J. Immunopathol. Pharmacol. 21, 117–127.
Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., Hirata, K., Shimizu, T., Li, Y.J., Wakayama, Y., Kawada, T., Ohira, T., Takayama, N., Kagawa, T., Miyazaki, Y., 2008b. A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects. J. Biol. Regul. Homeost. Agents 22, 45–55.
Maas, J., Verheij, R.A., Groenewegen, P.P., Vries, S.D., Spreeuwenberg, P., 2006. Green space, urbanity, and health: how strong is the relation? J. Epidemiol. Community Health 60, 587–592.
Mao, G.X., Cao, Y.B., Lan, X.G., He, Z.H., Chen, Z.M., Wang, Y.Z., Hu, X.L., Lv, Y.D., Wang, G.F., Yan, J., 2012. Therapeutic effect of forest bathing on human hypertension in the elderly. J. Cardiol. 60, 495–502.
Ministry of Health, Labour and Welfare, 2012. http://www.mhlw.go.jp/toukei/list/h24-46-50.html.
Morita, E., Fukuda, S., Nagano, J., Hamajima, N., Yamamoto, H., Iwai, Y., Nakashima, T., Ohira, H., Shirakawa, T., 2007. Psychological effects of forest environments on healthy adults: Shinrin-Yoku (forest-air bathing, walking) as a possible method of stress reduction. Public Health 121, 54–63.
National Institute for Occupational Safety and Health, 1999. Stress … at Work. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services (Publication no. 99–101, 26 p).
Ochiai, H., Ikei, H., Song, C., Kobayashi, M., Takamatsu, A., Miura, T., Kagawa, T., Li, Q., Kumeda, S., Imai, M., Miyazaki, Y., 2015. Physiological and psychological effects of forest therapy on middle-aged males with high-normal blood pressure. Int. J. Environ. Res. Public Health 12, 2532–2542.
Ohtsuka, Y., Yabunaka, N., Takayama, S., 1998. Shinrin-Yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients. Int. J. Biometeorol. 41, 125–127.
Park, B.J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Sato, M., Miyazaki, Y., 2007. Physiological effects of Shinrin-Yoku (taking in the atmosphere of the forest)–using salivary cortisol and cerebral activity as indicators. J. Physiol. Anthropol. 26, 123–128.
Park, B.J., Tsunetsugu, Y., Kasetani, T., Morikawa, T., Kagawa, T., Miyazaki, Y., 2009. Physiological effects of forest recreation in a young conifer forest in Hinokage Town, Japan. Silva Fennica 43, 291–301.
Park, B.J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., Miyazaki, Y., 2010. The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. Environ. Health Preventative Med. 15, 18–26.
Park, B.J., Furuya, K., Kasetani, T., Takayama, N., Kagawa, T., Miyazaki, Y., 2011. Relationship between psychological responses and physical environments in forest settings. Landscape Urban Plann. 102, 24–32.
Shimamoto, K., Ando, K., Fujita, T., Hasebe, N., Higaki, J., Horiuchi, M., Imai, Y., Imaizumi, T., Ishimitsu, T., Ito, M., et al., 2014. The Japanese Society of Hypertension guidelines for the management of hypertension (JSH 2014). Hypertens. Res. 37, 253–390.
Shin, W.S., Yeoun, P.S., Yoo, R.W., Shin, C.S., 2010. Forest experience and psychological health benefits: the state of the art and future prospect in Korea. Environ. Health Preventative Med. 15, 38–47.
Shin, W.S., Shin, C.S., Yeoun, P.S., Kim, J.J., 2011. The influence of interaction with forest on cognitive function. Scand. J. For. Res. 26, 595–598.
Shin, W.S., Shin, C.S., Yeoun, P.S., 2012. The influence of forest therapy camp on depression in alcoholics. Environ. Health Preventative Med. 17, 73–76.
Siegrist, J., Li, J., 2016. Associations of extrinsic and intrinsic components of work stress with health: a systematic review of evidence on the effort-reward imbalance model. Int. J. Environ. Res. Public Health 13, 432.
Song, C., Joung, D., Ikei, H., Igarashi, M., Aga, M., Park, B.J., Miwa, M., Takagaki, M., Miyazaki, Y., 2013. Physiological and psychological effects of walking on young males in urban parks in winter. J. Physiol. Anthropol. 32, 18.
Song, C., Ikei, H., Igarashi, M., Miwa, M., Takagaki, M., Miyazaki, Y., 2014. Physiological and psychological responses of young males during spring-time walks in urban parks. J. Physiol. Anthropol. 33, 8.
Song, C., Ikei, H., Kobayashi, M., Miura, T., Taue, M., Kagawa, T., Li, Q., Kumeda, S., Imai, M., Miyazaki, Y., 2015a. Effect of forest walking on autonomic nervous system activity in middle-aged hypertensive individuals: a pilot study. Int. J Environ. Res. Public Health 12, 2687–2699.
Song, C., Ikei, H., Igarashi, M., Takagaki, M., Miyazaki, Y., 2015b. Physiological and psychological effects of a walk in urban parks in fall. Int. J Environ. Res. Public Health 12, 14216–14228.
Song, C., Ikei, H., Miyazaki, Y., 2016. Physiological effects of nature therapy: a review of the research in Japan. Int. J. Environ. Res. Public Health 13, 781.
Song, C., Ikei, H., Kobayashi, M., Miura, T., Li, Q., Kagawa, T., Kumeda, S., Imai, M., Miyazaki, Y., 2017. Effect of viewing forest landscape on middle-aged hypertensive men. Urban For. Urban Green. 21, 247–252.
Sung, J., Woo, J.M., Kim, W., Lim, S.K., Chung, E.J., 2012. The effect of cognitive behavior therapy-based Forest Therapy program on blood pressure, salivary cortisol level, and quality of life in elderly hypertensive patients. Clin. Exp. Hypertens. 34, 1–7.
Takano, T., Nakamura, K., Watanabe, M., 2002. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. J. Epidemiol. Community Health 56, 913–918.
The SPRINT Research Group, 2015. A randomized trial of intensive versus standard blood-pressure control. N. Engl. J. Med. 373, 2103–2116.
Tsunetsugu, Y., Park, B.J., Ishii, H., Hirano, H., Kagawa, T., Miyazaki, Y., 2007. Physiological effects of Shinrin-Yoku (taking in the atmosphere of the forest) in an oldgrowth broadleaf forest in Yamagata Prefecture, Japan. J. Physiol. Anthropol. 26, 135–142.
Tsunetsugu, Y., Lee, J., Park, B.J., Tyrväinen, L., Kagawa, T., Miyazaki, Y., 2013. Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. Landscape Urban Plann. 113, 90–93.