Influence of Forest Walking on Blood Pressure, Profile of Mood States and Stress Markers from the Viewpoint of Aging

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Abstract: This study investigated the influence of forest walking on blood pressure (BP), profile of mood states (POMS) and salivary cortisol in both young and aged people. Twenty-three young people (Men=11, Women=12) with a mean age of 22 yrs and twenty-five aged people (M=10, W=15) with a mean age of 59 yrs participated in this study voluntarily. Each participant walked about three hours in the forest according to their comfortable walking pace. After forest walking, systolic BP (SBP) and mean BP (MAP) had significantly decreased in aged people (-10±3 mmHg in SBP, and -5±2 mmHg in MBP, $P<0.05$, respectively) while remained unchanged in young people. The scores for the "tension-anxiety" and "confusion" subscales of POMS were significantly improved in both young and aged people; moreover, the score for the "anger–hostility" subscale in aged people was also improved significantly. Salivary cortisol significantly decreased in young people (-0.22±0.03μg/dl, $P<0.05$) and had a tendency to decrease in aged people (-0.05±0.03μg/dl, $P=0.099$). BP variables at baseline were associated with the changes in BP variables ($r=0.575$ in systolic BP, $r=0.581$ in diastolic BP, $r=0.582$ in MAP, and $r=0.582$ in pulse pressure), respectively. Furthermore, the baseline salivary cortisol was also related to the forest walking-induced changes in that value ($r=0.882$). Thus, people with higher BP and higher stress markers may show greater effects from forest walking. Collectively, these results suggested that forest walking may have the possibility to reduce resting BP, mental stress and stress markers in both young and aged people; moreover, significant deceases in BP of aged people indicate that forest walking can be an important and novel exercise therapy if undertaken at a comfortable pace.

Keywords: Cardiovascular responses, salivary cortisol, Type A, young and elderly.

INTRODUCTION

Progression to an aging society, defined as 14-21% of the population aged over 65 years, is occurring in most advanced countries [1]. Japan is known as one of the fastest aging countries in the world, in terms of the average life expectancy, the number of aged people, and the speed of progression to an aging society [2]. Indeed, Japan became an aging society in 1994 and in 2007 became an extremely aging society; that is, one in which people over 65 years comprise more than 21% of the total population [3]. Under these conditions, keeping healthy both physically and mentally is now becoming an important issue.

Nature therapy has been introduced as a novel health intervention [4, 5] as modern city life has resulted in a novel risk factor, dubbed 'technostress' [6]. Indeed, it has been reported that a 50-min walk in a natural environment increases positive emotions whereas positive emotions decrease in urban environments [7]. In epidemiological studies, "green space", or an open area with growing plants, is associated with a subjective sense of well-being [8] and the longevity of urban residents [9].

Given these results, the traditional practice of forest bathing and/or walking, so called, "Shinrin-yoku" in Japan, has received renewed attention as a novel health intervention. Thus, numerous studies have examined the effects of forest environments on both psychological factors such as emotions and moods [10-13] and physiological factors such as cerebral activity [11], heart rate variability [12-14], pulse rate and blood pressure [12-15], salivary amylase activity [16], salivary cortisol concentrations [11-15], natural killer cell activity [17-19], and urine adrenaline and nor-adrenaline [18, 19]. These studies have suggested that forest environments may have a positive effect on both types of factors. Although these studies were conducted on essentially healthy people, another study has reported that forest walking reduced blood glucose levels in diabetic patients [20].

However, there seems not to be enough evidence on how forest environments affect human health. Surprisingly few studies have been carried out on aged people except for the aforementioned study on diabetes [20] and one that examined aged and elderly subjects without comparison to younger subjects [21].

The purpose of the present study, therefore, was to investigate the influences of forest walking on physiological and psychological factors in both young and aged people, and to compare those results.

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Table 1: Physical Characteristics in Young and Elderly

	Young	Old	P-value
Men/Women	11/12	10/15	0.772
Age (yrs)	21.5 ± 2.8	59.2 ± 6.2	<0.001
Height (cm)	166.6 ± 7.7	159.7 ± 7.6	0.004
Body mass (kg)	59.4 ± 9.4	55.7 ± 6.8	0.139
BMI (kg/m^2)	21.3 ± 2.3	21.9 ± 2.9	0.464
Type A (n / %)	7(30.4%)	3(13.7%)	0.297

METHODS

Participants

In total, twenty-three healthy young subjects and twenty-five aged subjects participated in this study. Subject characteristics in the two groups are shown in Table **1**. After a detailed description and explanation of all study procedures, and the possible risks and benefits of participation, each subject signed an informed consent form. Subjects were requested to abstain from caffeinated beverages for 12 hr and from strenuous exercise and alcohol for a minimum of 24 hr before any experimental sessions. All procedures in the present study were approved by the ethical committee of Yamanashi Institute of Environmental Sciences and were performed in accordance with the guidelines of the Declaration of Helsinki.

Procedure

The participants drove themselves to the starting point in the forest in the morning, and sat in comfortable chairs more than half an hour before baseline measurements. After these measurements, all participants were divided into several groups to avoid a time lag in the measurement after forest walking. Participants were asked not to run and not to compete with each other during the forest walking. Walking speeds were left to their own choice, but a comfortable pace at which they could talk each other was recommended. The total distance was about 6 km and the time spent walking was about three hours, with several breaks. Participants were not restricted in their choice of beverage, with the exception of drinks containing caffeine and alcohol, which were prohibited as they would influence physiological factors such as blood pressure.

Measurements

Systolic and diastolic blood pressure (SBP and DBP) and pulse rate were measured before and after forest walking by a digital blood pressure monitor (HEM-7011, OMRON, Japan) using an oscillometric method on the upper arm. Saliva for analysis of cortisol was collected using a Salivette device (No. 51.1534; Sarstedt, Numbrecht, Germany), for a 5-min period. After collection, saliva samples were frozen and subsequently analyzed for Mitsubishi Chemical Medicine, Co. Ltd.

A short Japanese version of profile of mood states (POMS) based on the original text [22] was used to evaluate mood in each participant [23]. The POMS scale consists of six sub-scales: T–A (tension and anxiety), D (depression and dejection), A–H (anger and hostility), V (vigor), F (fatigue), and C (confusion) with 0-4 scales. The total mood disturbance (TMD) score is calculated by subtracting the V score from the sum of scores for the other dimensions.

These physiological and psychological measurements were conducted before and after forest walking. At the baseline ("before") measurements, each participant sat upright in a chair and filled out the POMS questionnaire; then saliva was collected and blood pressure and pulse rate were measured. After walking a similar procedure was carried out; however, to separate the physiological effects, blood pressure was measured after the pulse rate had recovered to the baseline value.

In addition to these measurements, the Type A behavior pattern (Type A) was assessed by a triple choice questionnaire in Japanese [24] because links between Type A and stress-related diseases have been found [25]. This questionnaire was modified based on a previous study [26] and consisted of 12 questions related to aggression, hostility, hard-driving life style, time-urgency, speed, and power of action, with 0-2 scales.

Data Analysis

Mean arterial pressure (MAP) was calculated as [(2*diastolic pressure) +systolic pressure]/3. Pulse pressure was calculated as the difference between SBP and DBP. The score of total mood of disturbance (TMD) were calculated by summing the scores of all subscales except the score of vigor.

Statistical Analysis

Data are expressed as means ± standard errors (S.E.M.). Unpaired t-tests were conducted for comparison of physical characteristics between young and aged participants. Chi-square tests were carried out to compare the ratio of gender differences and type A pattern between young and aged participants. Two-way repeated measure analysis of variance (ANOVA) was used for physiological and psychological comparisons (Sigma Stat ver. 3.5, Hulinks, USA). For two-way ANOVA, the Tukey post-hoc test was employed when interactions were significant. To estimate the relationship between baseline values and changes in physiological variables, a Pearson correlation coefficient was conducted. P-values > 0.05 were considered to indicate statistical significance.

RESULTS

The ratio of type A pattern was slightly higher in young participants compared to aged participants, but the difference was not statistically significant (Table **1**).

There were no significant differences between young and aged participants in either baseline or post-forest-walking values of SBP, DBP, MAP and PP. However, in -aged participants SBP (pre 138.1±4.6, post; 127.7±3.6mmHg), MAP (pre; 98.6±3.4, post; 93.5±2.7mmHg) and PP (pre; 59.2±2.6,post; 51.3±2.1mmHg) showed a significant decrease from baseline after forest walking (Figure **1**).

Regarding salivary cortisol, several samples from aged participants could not be analyzed due to technical problems, e.g., not enough saliva, so that the total number of samples was 24 in young subjects and only 18 in aged. At baseline, salivary cortisol was significantly higher in young participants than in aged participants (young; 0.33±0.03, aged; 0.19±0.02μg/dl, $p<0.05$), whereas no significant difference was observed after forest walking participants (young; 0.12±0.01, aged; 0.13±0.02μg/dl,). In young participants, salivary cortisol decreased significantly from baseline after forest walking ($p<0.001$); in -aged participants, the decrease was only a trend ($p=0.09$) (Figure **2**).

Table **2** shows the changes in subscales and TMD scores of the POMS in young and aged participants. The T-A and C subscales, and TMD scores in both

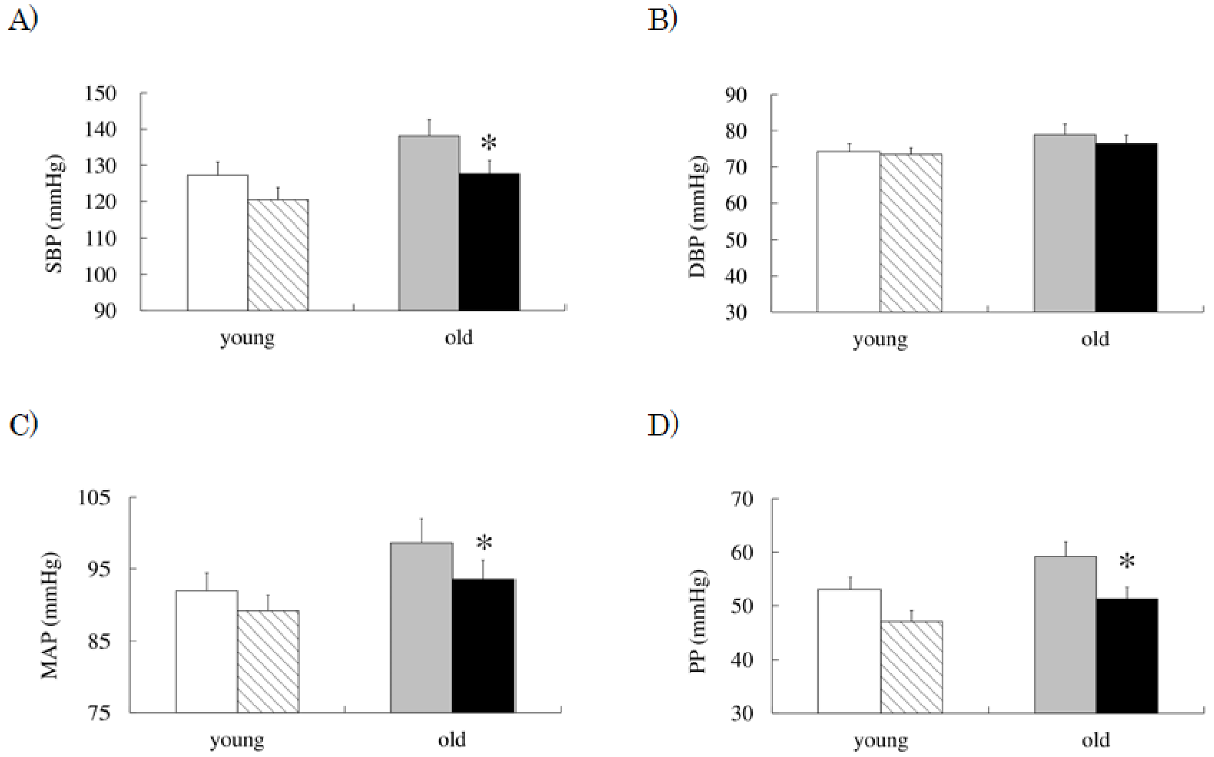

Figure 1: Changes from baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and pulse pressure (PP) after forest walking in young and -aged participants. White bar indicates young subjects at baseline, the diagonally striped bar shows young subjects after walking, gray bar is older subjects at baseline, and black bar is older subjects after walking. *; $p<0.05$ between baseline and post-forest-walking levels.

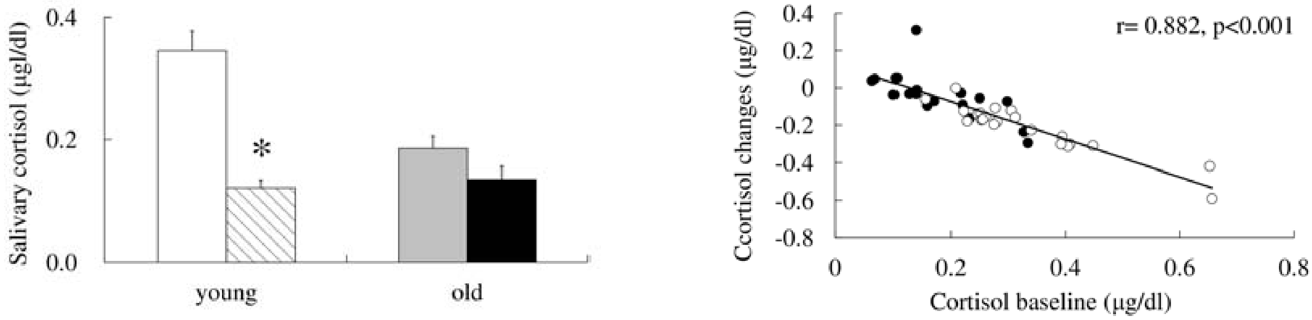

Figure 2: Salivary cortisol changes from baseline after forest walking in young and aged participants (Left panel) and relationships between baseline value of salivary cortisol concentration and forest walking-induced changes of cortisol (Right panel). Classification of bars is the same as in Figure **1**. *; p<0.05 between baseline and post-forest-walking levels.

Table 2: Forest Walking-Induced Changes in Profile of Mood States Between Young and Old Participants

	Young		Old	
	pre	**Post**	**pre**	**post**
Trait-Anxiety	3.6 ± 0.8	1.2 ± 0.5*	3.4 ± 0.5	1.9 ± 0.4*
Depression-Dejection	1.3 ± 0.4	0.5 ± 0.3	1.5 ± 0.4	1.2 ± 0.3
Anger-Hostility	0.6 ± 0.2	0 ± 0	1.9 ± 0.5	1.1 ± 0.3*
Vigor	7.0 ± 0.9	7.7 ± 1.1	8.8 ± 0.8	8.5 ± 1.0
Fatigue	3.0 ± 0.6	4.7 ± 0.7	2.3 ± 0.5	2.5 ± 0.4
Confusion	4.2 ± 0.4	3.3 ± 0.3*	4.3 ± 0.4	3.4 ± 0.3.*
TMD	12.7 ± 1.5	9.6 ± 1.2*	13.3 ± 1.9	10.0 ± 1.2*

Values are means±SE. TMD, total mood of disturbance, *, p<0.05 between pre and post.

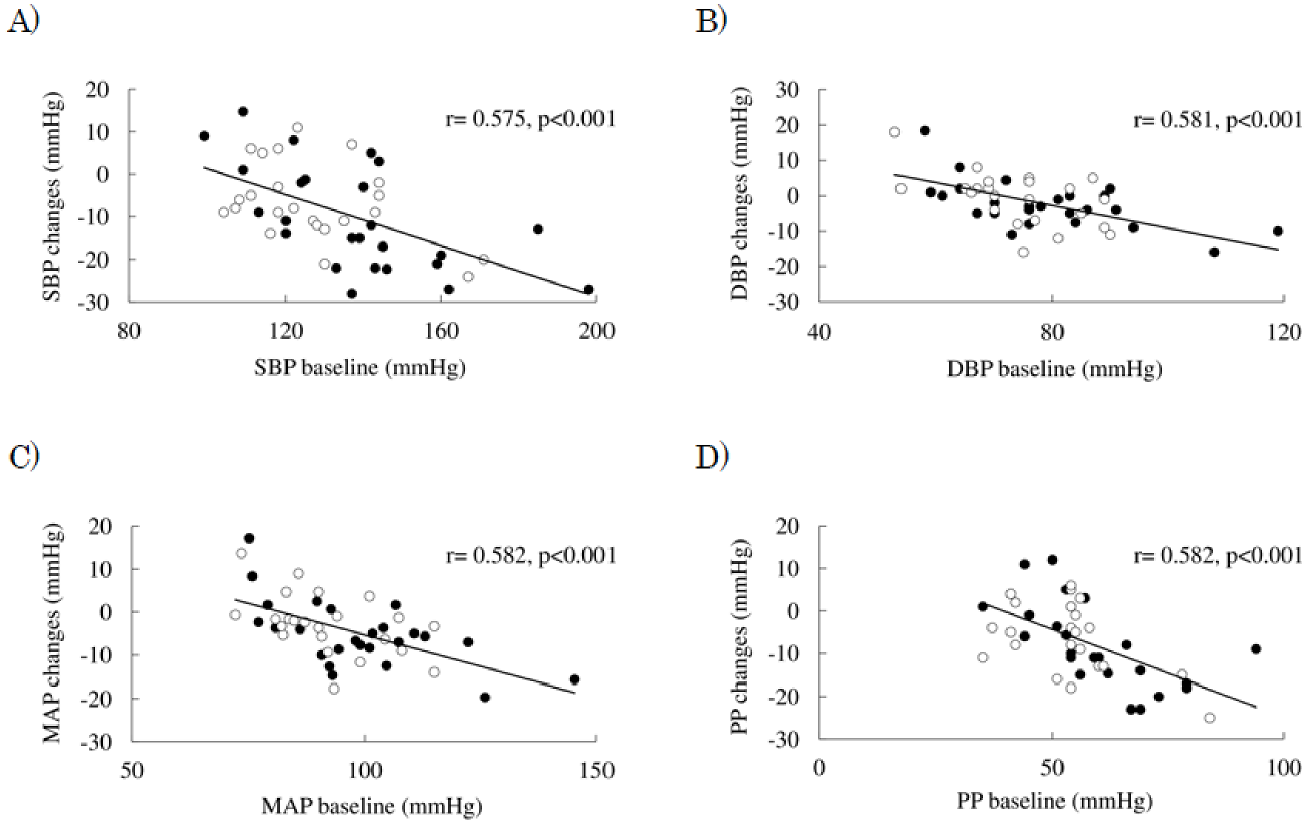

Figure 3: Relationships between baseline value of each BP variables and forest walking-induced changes of BP valuables. **A**) SBP, **B**), DBP, **C**) MAP, and **D**) PP. White circles and black circles indicate young and aged participants, respectively.

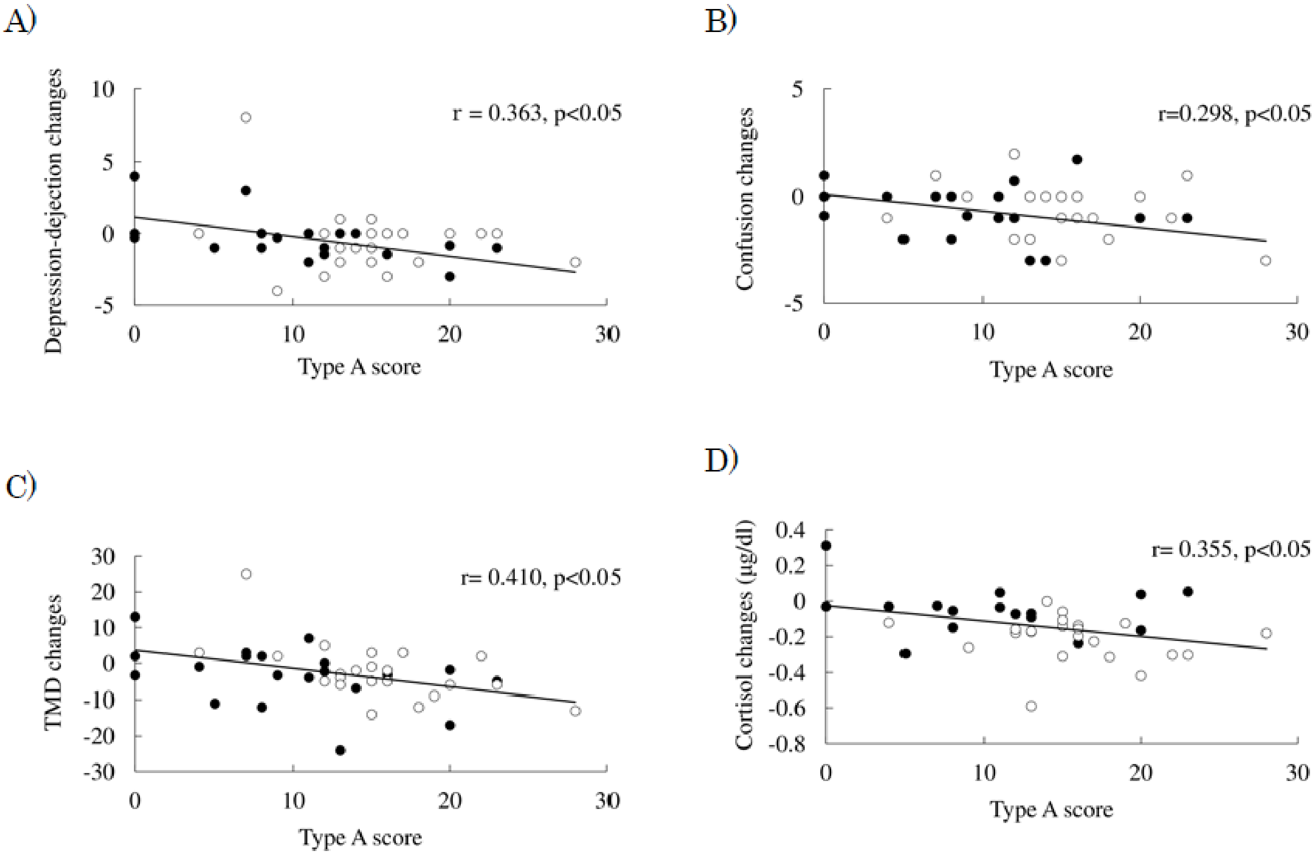

Figure 4: Relationships between Type A behavior and forest walking-induced changes of subscale scores in **A**) 'Depression-Dejection', **B**) 'Confusion', **C**) 'Total Mood of Disturbance' in the POMS and **D**) salivary cortisol concentrations. White circles and black circles indicate young and aged participants, respectively.

young and aged participants significantly decreased after forest walking. The A-H subscale decreased only in aged participants.

Interestingly, the baseline values of SBP, DBP, MBP, PP, and salivary cortisol were closely associated with changes in these respective variables, indicating that forest walking may be more effective for people who have higher BPs and stress markers (Figures **2** and **3**).

Moreover, participants with higher type A test score showed a greater reduction in the D and C subscales and TMD of POMS. Similarly, participants with higher type A test score showed a greater reduction in the salivary cortisol concentrations (Figure **4**).

DISCUSSION

The major findings in the present study were that forest walking had different benefits on the different populations. In -aged participants BP showed a significant decrease from baseline after forest walking, whereas no significant change was observed in young participants. On the other hand, salivary cortisol as a stress marker showed a more significant decrease in young participants. Moreover, several subscales of POMS were improved by forest walking. Different levels of physiological change could be partly explained by baseline values and individual personality (Type A vs. B), indicating those with more severe conditions responded more to the therapy.

Blood Pressure

Previous studies have demonstrated that BP in a forest environment was significantly lower compared than that in an urban area [12,13,15]; however, these studies did not indicate whether forest bathing and/or walking per se reduced BP. Tsunetsugu *et al*. (2007) [13] reported that forest walking reduced DBP, but not SBP. It was also reported that the decrease in both SBP and DBP caused by walking was significantly greater in a forest than in an urban setting [21]. Another study showed no change in SBP and DBP from forest walking [14]. These studies are partly in agreement with our results.

In general, BP is typically reduced 5-10 mmHg following a single bout of moderate-intensity dynamic exercise for 30-60 min. Several factors including but not limited to decreased stroke volume, cardiac output, total peripheral resistance, and sympathetic nerve discharge have all been shown to potentially contribute to the reduction in BP after dynamic exercise [27, 28]. However, there is not enough evidence about post-exercise hypotension in older people. Two previous studies, which recruited people with mean ages of 68 [29] and 64 yrs, [30] respectively, have suggested that reduction in BP after a single bout of moderate-intensity exercise may be attributed to a decrease in stroke volume mediated by a transient reduction in left ventricular function.

One important finding in this study was that PP in -aged participants significantly decreased after forest walking as well as SBP and MAP. Since it is known that increased PP is closely associated with impaired endothelium-dependent vasodilation [31], and that PP is also a good predictor of cardiovascular disease risk [32] and mortality in hypertensive patients [33], this finding may suggest an important benefit of forest walking in a clinical setting. As BP is decided by multiplying cardiac output, i.e., stroke volume by heart rate by total vascular resistance, a reduction in BP implies a decrease in stroke volume or heart rate or vascular resistance. In this study, BP was measured after the recovery in pulse rate; thus, the BP decreases in our aged participants may be attributed to a reduction in either stroke volume or vascular resistance or both. However, since these parameters were not measured in this study, the precise mechanism is still unclear. Another possible explanation is that higher baseline values of BP affect the magnitude of BP changes induced by forest walking. In this study, a significantly negative and linear relationship between baseline BP values and forest-walking-induced changes in BP was observed. Previous studies demonstrated that the magnitude of the reduction in BP in normotensive subjects was less compared to that in hypertensive patients during recovery form exercise [34-36]. Similarly, people with higher resting BP values may show greater hypotension after exercise [37]. Therefore, significant decreases in BP in aged participants in this study can be partly accounted for by the differential in baseline BP values.

Salivary Cortisol

In this study, we analyzed levels of cortisol, a stress hormone, in saliva to evaluate subjects' stress responses to forest walking. It is well known that cortisol is released by the hypothalamic–pituitary–adrenal (HPA) axis in response to stress [38] and is a reliable indicator of endocrine stress responses [39]. Its salivary release in response to stress is immediate and is highly associated with the free cortisol fraction in the blood [40, 41]; thus, salivary cortisol concentration is a useful indicator to assess stress responses. Previous studies have reported that salivary cortisol concentrations were significantly lower in forest environments than in urban areas after viewing a landscape, though these studies did not provide evidence that forest environments reduced salivary cortisol concentration from baseline levels [11, 14, 15]. Tsunetsugu *et al*. (2007) [13] reported that salivary cortisol concentrations were significantly lower in forested areas compared to the city areas, both before and after walking; they also found that walking reduced cortisol levels in the city area but not in the forest area. Thus, changes in salivary cortisol concentrations may have been affected by both the forest environment and the exercise, i.e., walking. Our results showed that salivary cortisol concentrations in young participants significantly decreased after forest walking, and showed a similar but lesser tendency in aged participants. Although whether these changes were induced by the forest environment or the walking is unclear, it is likely that walking in the forest was a relaxing stimulation to reduce stress. It is still unclear why there were no significant changes in salivary cortisol concentrations in aged participants. One possibility is the age-related difference in salivary cortisol responses to various stimuli. Several previous studies reported that HPA axis sensitivity diminished in old subjects compared to younger subjects [42], resulting in decreased cortisol release in older subjects [43, 44]. Another explanation is that, for the same reason as the BP changes, the baseline value may be the cause of differential changes in salivary cortisol concentrations. The baseline value of salivary cortisol was significantly lower in aged than in young participants, such that greater forest walking-induced change in salivary cortisol concentrations was possible for the younger group.

POMS

The changes in POMS in this study showed a similar tendency for young and -aged participants, suggesting that aging had less influence on this measure. POMS has been widely used to assess changes in mood in a variety of fields because of its responsiveness [22]. Several studies have reported the effect of forest environments on the scores of POMS [12, 14] and other questionnaires [10, 11, 13, 15]. It was reported that all POMS subscales were improved by forest viewing and walking [12, 14]. Similar results—for example, improvement of hostility, depression, boredom, friendliness, wellbeing, comfort, calmness, liveliness and refreshed feelings—were observed in previous studies [10, 11, 13, 15].

In contrast, several studies have found no effect on POMS scores of moderate-intensity exercise [45-47]. Although the exercise intensity of forest walking in the present study may be possibly lower than the moderate-intensity exercise in these previous studies, their findings suggest that it was the forest, *per se,* rather than the walking, that had the positive impact on emotion and mood in our human subjects.

Relationship between Individual Personality and Related Factors

As it was supposed that difference would exist in individuals' response to both physiological and psychological changes, we tried to investigate whether differences in personality could explain these individual variances. As it turned out, however, the ratio of type A participants in this study was relatively small, i.e., only 21% compared to 79% of Type B; thus, we could not divide participants into Type A and B groups. Instead, Pearsons correlation coefficient was used to assess the relation between Type A personality and related factors. Our results showed that participants with higher Type A scores were significantly more likely to improve D, C, and TMD scores of subscales in POMS by forest walking. Moreover, changes in salivary cortisol concentration as a stress marker was also related to the Type A score. A recent study demonstrated that after Tai Chi exercise, the scores for D, A–H, F, C and TMD decreased significantly for the type A behavior-pattern subjects, whereas no significant changes were observed in the type B group [48]. Moreover, saliva cortisol release has been associated with the Type A behavior [49] and other personalities [50] although it has been difficult to reach consensus on that matter. Nevertheless, our findings may involve an important issue in reducing mental stress irrespective of age differences. In general, Type A behavior is associated with relatively enhanced sympathetic nerve activity [51-54], and links have been identified between chronic psychosocial stress, markers of excessive sympathetic activation and elevated blood pressure [55]. Moreover, psychosocial stress has been implicated in the pathogenesis of essential hypertension [56], and elevated stress has also been associated with increased risk of atherosclerosis [57] and acute cardiovascular events [58]. While the mechanisms underlying these links are complex, our results may indicate that forest walking may be more effective for Type A personalities, suggesting its potential for clinical intervention in individuals at increased risk of cardiovascular disease.

Technical Considerations

Several limitations must be considered when interpreting the findings from the present study. First, we did not collect data in an urban area; hence, it is possible that our results may involve the effects of exercise *per se* rather than the effect of exercise in a forest environment. Similarly, we did not investigate the effect of forest environments *per se*, that is, influence without walking. However, the major purpose of this study was to compare the influence of forest walking in young and aged people, and our results clearly demonstrated age-related differences in the impact of forest walking. Second, the sample size in this study was relatively small, so it is still uncertain whether the results are generalizable and/or applicable to different populations such as hypertensives. Third, the precise mechanisms underlying the influence of forest environments could not be completely clarified in this study due to the technical difficulties of experimental manipulation in a forest environment.

In summary, the current results suggest that forest walking may have an important role in reducing BP in aged participants. Moreover, there is a possibility that this exercise therapy may be useful for people with higher psychological stress. Thus, despite the several limitations mentioned above, this is clearly an area worthy of further investigation in an era of aging populations.

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REFERENCES

[1] Okamoto Y. Health care for the elderly in Japan: medicine and welfare in an aging society facing a crisis in long term care. BMJ 1992; 305: 403-405. http://dx.doi.org/10.1136/bmj.305.6850.403

[2] Oksuzyan A, Crimmins E, Saito Y, O'Rand A, Vaupel JW, Christensen K. Cross-national comparison of sex differences in health and mortality in Denmark, Japan and the US. Eur J Epidemiol 2010; 25: 471-80. http://dx.doi.org/10.1007/s10654-010-9460-6

[3] Japan Statistical Association, 2011. Statistical Handbook of Japan, Chapter 2, Available from: http://www.stat.go.jp/english/data/handbook/c02cont.htm

[4] Maller C, Townsend M, Pryor A, Brown P, St Leger L. Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. Health Promot Int 2006; 21(1): 45-54. http://dx.doi.org/10.1093/heapro/dai032

[5] St Leger L. Health and nature-new challenges for health promotion. Health Promot Int 2003; 18(3): 173-75. http://dx.doi.org/10.1093/heapro/dag012

[6] Brod C. Technostress: The human cost of the computer revolution. MA: Addison-Wesley, ISBN 0-201-11211-6, 1984.

[7] Hartig T, Evans GW, Jammer LD, Davis DS, Garling T. Tracking restoration in natural and urban field settings. J Environ Psychol 2003; 23: 109-123. http://dx.doi.org/10.1016/S0272-4944(02)00109-3

[8] Mass J, Verheiji RA, Gronenwegen PP, deViers S, Spreeuwemberg P. Green space, urbanity, and health; how strong is the relation? J Epidemiol Community Health 2006; 60: 587-92. http://dx.doi.org/10.1136/jech.2005.043125

[9] Takano T, Nakamura K, Watanabe M. Urban residential environments and senior citizens 'longevity in megacity areas: the importance of walkable green spaces. J Epidemiol Community Health 2002; 56: 913-18. http://dx.doi.org/10.1136/jech.56.12.913

[10] Morita E, Fukuda S, Nagano J, Hamajima N, Yamamoto H, Iwai Y, *et al*. Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. Public Health 2007; 121(1): 54-63. http://dx.doi.org/10.1016/j.puhe.2006.05.024

[11] Park BJ, Tsunetsugu Y, Kasetani T, Hirano H, Kagawa T, Sato M, *et al*. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest)--using salivary cortisol and cerebral activity as indicators. J Physiol Anthropol 2007; 26(2): 123-28. http://dx.doi.org/10.2114/jpa2.26.123

[12] Park BJ, Tsunetsugu Y, Kasetani T, Kagawa T, Miyazaki Y. 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 Prev Med 2010; 15(1): 18-26. http://dx.doi.org/10.1007/s12199-009-0086-9

[13] Tsunetsugu Y, Park BJ, Ishii H, Hirano H, Kagawa T, Miyazaki Y. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata Prefecture, Japan. J Physiol Anthropol 2007; 26(2): 135-42. http://dx.doi.org/10.2114/jpa2.26.135

[14] Lee J, Park BJ, Tsunetsugu Y, Ohira T, Kagawa T, Miyazaki Y. Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. Public Health 2011; 125(2): 93-100. http://dx.doi.org/10.1016/j.puhe.2010.09.005

[15] Lee J, Park BJ, Tsunetsugu Y, kagawa T, Miyazaki Y. The restorative effects of viewing real forest landscapes: Based on a comparison with urban landscapes. Scan J Forest Res 2009; 24: 227-34. http://dx.doi.org/10.1080/02827580902903341

[16] Yamaguchi M, Deguchi M, Miyazaki Y. The effects of exercise in forest and urban environments on sympathetic nervous activity of normal young adults. J Int Med Res 2006; 34(2): 152-59. http://dx.doi.org/10.1177/147323000603400204

[17] Li Q, Morimoto K, Nakadai A, Inagaki H, Katsumata M, Shimizu T, *et al*. Forest bathing enhances human natural killer activity and expression of anti-cancer proteins. Int J Immunopathol Pharmacol 2007; 20(2 Suppl 2): 3-8.

[18] Li Q, Morimoto K, Kobayashi M, Inagaki H, Katsumata M, Hirata Y, *et al*. Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins. Int J Immunopathol Pharmacol 2008; 21(1): 117-27.

[19] Li Q, Morimoto K, Kobayashi M, Inagaki H, Katsumata M, Hirata Y, *et al*. A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects. J Biol Regul Homeost Agents 2008; 22(1): 45-55.

[20] Ohtsuka Y, Yabunaka N, Takayama S. Shinrin-yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients. Int J Biometeorol 1998; 41: 125-27. http://dx.doi.org/10.1007/s004840050064

[21] Li Q, Otsuka T, Kobayashi M, Wakayama Y, Inagaki H, Latsumata M *et al*. Acute effects of walking in forest environments on cardiovascular and metabolic parameters. Eur J Appl Physiol 2011; 111(11): 2845-53. http://dx.doi.org/10.1007/s00421-011-1918-z

[22] McNair DM, Lorr M, Droppleman LF. Profile of Mood States. San Diego Educational and Industrial Testing Service 1992

[23] Yokoyama A, Araki S, Kawakami N, Takeshita T. Production of the Japanese edition of profile of mood states (POMS): assessment of reliability and validity (in Japanese). Jpn J Public Health 1990; 37(11): 913-18.

[24] Maeda S. A study on behavior pattern of patients with coronary heart diseases: Application of brief questionnaire-Jpn J Psychosomatic Med 1985; 25: 297-306.

[25] Contrada RJ, Krantz DS. Stress, reactivity, and Type A behavior: Current status and future directions. Ann Behav Med 1988; 10: 64-70. http://dx.doi.org/10.1207/s15324796abm1002_4

[26] Friedman M, Rosenman RH. Association of specific overt behavior pattern with blood and cardiovascular findings. JAMA 1959; 169: 1286-96. http://dx.doi.org/10.1001/jama.1959.03000290012005

[27] Hallwill JR. Mechanisms and clinical implications of post-exercise hypotension in humans. Exerc Sports Sci Rev 2001; 29(2): 65-70. http://dx.doi.org/10.1097/00003677-200104000-00005

[28] MacDonald JR. Potential causes, mechanisms, and implications of post exercise hypotension. J Human Hypertension 2002; 16: 225-36. http://dx.doi.org/10.1038/sj.jhh.1001377

[29] Rondon BMU, Alves MJ, Braga AM, Teixeira OT, Baretto AC, *et al*. Postexercise blood pressure reduction in elderly hypertensive patients. J Am Coll Cardiol 2002; 39(4): 676-82. http://dx.doi.org/10.1016/S0735-1097(01)01789-2

[30] Hagberg JM, Montain SJ, Martin WH 3rd. Blood pressure and hemodynamic responses after exercise in older hypertensives. J Appl Physiol 1987; 63(1): 270-76.

[31] Chamoit-Clerc P, Renaud JF, Safar ME. Pulse pressure, aortic reactivity, and endothelium dysfunction in old hypertensive rats. Hypertension 2001; 37: 313-21. http://dx.doi.org/10.1161/01.HYP.37.2.313

[32] Safar ME, London GM. Therapeutic studies and arterial stiffness in hypertension: recommendations of the European Society of Hypertension. The Clinical Committee of Arterial Structure and Function. Working Group on Vascular Structure and Function of the European Society of Hypertension. J Hypertens 2000; 18: 1527-35. http://dx.doi.org/10.1097/00004872-200018110-00001

[33] Gasowski J, Fagard RH, Staessen JA, Grodzicki T, Pocock S, Boutitie F, *et al*; INDANA Project Collaborators. Pulsatile blood pressure component as predictor of mortality in hypertension: a meta-analysis of clinical trial control groups. J Hypertens 2002; 20: 145-51. http://dx.doi.org/10.1097/00004872-200201000-00021

[34] Bennett T, Wilcox RG, Macdonald IA. Post-exercise reduction of blood pressure in hypertensive men is not due to acute impairment of baroreflex function. Clin Sci (Lond) 1984; 67(1): 97-103.

[35] Hannum SM, Seals DR. Acute postexercise blood pressure response to hypertensive and normotensive men. Scan J Sports Sci 1981; 3: 11-15.

[36] Wilcox RG, Bennett T, Brown AM, Macdonald IA. Is exercise good for high blood pressure? Br Med J (Clin Res Ed) 1982; 285(6344): 767-69. http://dx.doi.org/10.1136/bmj.285.6344.767

[37] Forjaz CL, Tinucci T, Ortega KC, Santaella DF, Mion D Jr, Negrão CE. Factors affecting post-exercise hypotension in normotensive and hypertensive humans. Blood Press Monit 2000; 5(5-6): 255-62. http://dx.doi.org/10.1097/00126097-200010000-00002

[38] Seplaki CL, Goldman N, Weinstein M, Lin YH. How are biomarkers related to physical and mental well-being? J Gerontol A Biol Sci Med Sci 2004; 59: 201-201. http://dx.doi.org/10.1093/gerona/59.3.B201

[39] Kirschbaum C, Hellhammer DH. Salivary cortisol in psychobiological research: an overview. Neuropsychobiology 1989; 22(3): 150-69. http://dx.doi.org/10.1159/000118611

[40] Kirschbaum C, Hellhammer DH. Salivary cortisol in psychoneuroendocrine research: recent developments and applications. Psychoneuroendocrinology 1994; 19: 313-33. http://dx.doi.org/10.1016/0306-4530(94)90013-2

[41] Pruessner JC, Hellhammer DH, Kirschbaum C. Burnout, perceived stress, and cortisol responses to awakening. Psychosom Med 1999; 61: 197-204.

[42] Hatzinger M, Brand S, Herzig N, Holsboer-Trachsler E. In healthy young and elderly adults, hypothalamic-pituitary-adrenocortical axis reactivity (HPA AR) varies with increasing pharmacological challenge and with age, but not with gender. J Psychiatr Res 2011; 45(10): 1373-80. http://dx.doi.org/10.1016/j.jpsychires.2011.05.006

[43] Kukolja J, Thiel CM, Wolf OT, Fink GR. Increased cortisol levels in cognitively challenging situations are beneficial in young but not older subjects. Psychopharmacology (Berl) 2008; 201(2): 293-304. http://dx.doi.org/10.1007/s00213-008-1275-8

[44] Traustadóttir T, Bosch PR, Matt KS. The HPA axis response to stress in women: effects of aging and fitness. Psychoneuroendocrinology 2005; 30(4): 392-402. http://dx.doi.org/10.1016/j.psyneuen.2004.11.002

[45] Cramer SR, Nieman DC, Lee JW. The effects of moderate exercise training on psychological well-being and mood state in women. J Psychosom Res 1991; 35: 437-49. http://dx.doi.org/10.1016/0022-3999(91)90039-Q

[46] Nieman DC, Custer WF, Butterworth DE, Utter AC, Henson DA. Psychological response to exercise training and/or energy restriction in obese women. J Psychosom Res 2000; 48: 23-29. http://dx.doi.org/10.1016/S0022-3999(99)00066-5

[47] Stanton JM, Arroll B. The effect of moderate exercise on mood in mildly hypertensive volunteers: a randomized controlled trial. J Psychosom Res 1996; 40: 637-42. http://dx.doi.org/10.1016/0022-3999(95)00643-5

[48] Toda M, Den R, Hasegawa-Ohira M, Morimoto K. Influence of personal patterns of behavior on the effects of Tai Chi: a pilot study. Environ Health Prev Med 2011; 16(1): 61-63. http://dx.doi.org/10.1007/s12199-010-0159-9

[49] Vermunt R, Peeters Y, Berggren K. How fair treatment affects saliva cortisol release in stressed low and high type-A behavior individuals. Scand J Psychol 2007; 48(6): 547-55. http://dx.doi.org/10.1111/j.1467-9450.2007.00593.x

[50] Oswald LM, Zandi P, Nestadt G, Potash JB, Kalaydjian AE, Wand GS. Relationship between cortisol responses to stress and personality. Neuropsychopharmacology 2006; 31(7): 1583-91. http://dx.doi.org/10.1038/sj.npp.1301012

[51] Anderson SF, Lawler KA. The anger recall interview and cardiovascular reactivity in women: An examination of context and experience. J Psychosom Res 1995; 39: 335-43. http://dx.doi.org/10.1016/0022-3999(94)00140-Z

[52] Oishi K, Kamimura M, Nigorikawa T, Nakamiya T, Williams RE, Horvath SM. Individual differences in physiological responses and Type A behavior pattern. Appl uman Sci 1999; 18(3): 101-108.

[53] Ward MM, Chesney MA, Swan GE, Black GW, Parker SD, Rosenman RH. Cardiovascular responses in Type A and Type B men to a series of stressors. J Behav 1986; 9(1): 43-49. http://dx.doi.org/10.1007/BF00844643

[54] Williams RB Jr, Lane JD, Kuhn, CM, Melosh W, White AD, Schanberg SM. Type A behavior and elevated physiological and neuroendocrine responses to cognitive tasks. Science 1982; 218(4571): 483-85. http://dx.doi.org/10.1126/science.7123248

[55] Lucini D, Di Fede G, Parati G & Pagani M. Impact of chronic psychosocial stress on autonomic cardiovascular regulation in otherwise healthy subjects. Hypertension 2005; 46: 1201-206. http://dx.doi.org/10.1161/01.HYP.0000185147.32385.4b

[56] Esler M, Eikelis N, Schlaich M, Lambert G, Alvarenga M, Dawood T, *et al*. Chronic mental stress is a cause of essential hypertension: presence of biological markers of stress. Clin Exp Pharmacol Physiol 2008; 35: 498-502. http://dx.doi.org/10.1111/j.1440-1681.2008.04904.x

[57] Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation 1999; 99: 2192-17. http://dx.doi.org/10.1161/01.CIR.99.16.2192

[58] Rosengren A, Hawken S, Ounpuu S, Sliwa K, Zubaid M, Almahmeed WA, *et al*. Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study. Lancet 2004; 364: 953-62. http://dx.doi.org/10.1016/S0140-6736(04)17019-0

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