

Original paper

Assessment of psychophysiological effects of forest and urban walking on young people

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Abstract: Our study aimed to evaluate how psychological mood states as well as blood pressure, pulse rate, and the levels of salivary stress biomarkers change between before and after forest or urban walking. In 2016-2018, 33 young people participated in both forest and urban walking, for two hours each. Salivary amylase, blood pressure, and pulse rate were measured before and the next day after walking. Psychological mood states of the participants were also checked using a short form of the Profile of Mood States questionnaire. As the results, the levels of salivary amylase showed decrease in 19 participants (63%) after forest walking, and in 15 participants (45.5%) after urban walking. However, the mean level of salivary amylase did not show significant differences between before and after walking either in forest or urban environments. On the psychological dimension of the participants, the scores of tension-anxiety ($p < 0.01$), depression-dejection ($p < 0.01$), anger-hostility ($p < 0.01$), fatigue ($p < 0.05$), and confusion ($p < 0.01$) significantly decreased after forest walking but not after urban walking. Our findings suggest that immersing the body in forest environment even for a short time would improve negative mood and reduce stress.

I. Introduction

A residential area near natural green space has demonstrated some potential population health benefits to mental health, reduction of mortality risk of cardio-metabolic diseases and hyperlipidemia (Beyer et al. 2014, Kardan et al. 2015, Kim et al. 2016). In recent years, the effects of forest bathing (spending a few hours in forest environment) has attracted particular attention in the fields of preventive medicine and public health (Hansen 2017). Research evidences reported from various countries showed that forest bathing had some psychological and physiological effects. For example, Li & Kawada (2011) reported increase in human natural killer cell activity and in anticancer protein expression. In Japan, Park et al. (2007) and Morita et al. (2011) reported reduction of salivary cortisol level and pulse rate, as well as improvement of sleep quality. In Korea, Han et al. (2016) and Chun et al. (2017) reported beneficial effects on chronic stroke patients for treating depression and anxiety symptoms, reduction of pain, negative emotion, and elevation of health related quality of life. In China, Mao et al. (2012) reported reduction in blood pressure by inducing inhibition of the renin-angiotensin system and inflammation in the elderly. In USA, McCaffrey et al. (2010) reported decreased symptoms of depression in elderly after garden

walk. However, information is limited regarding whether exposure to forest environment has any psychological and physiological effects different from exposure to urban environment. The present study aimed to evaluate (1) how psychological mood states change, and (2) how blood pressure, pulse rate, and the levels of salivary stress biomarkers change on young people after forest or urban walking.

II. Methods

In 2016-2018, 33 senior university students (24 males and 9 females) aged 21-22 years volunteered to participate in the walking sessions of the present study. The forest walking was made in a forest of Okayama Prefecture, and the urban walking was made in Okayama City downtown (Fig. 1), each for two hours in slow walking with gait velocity less than 60 m/min (Waters et al. 1988). The study was a crossover design, and all the participants in each year attended both forest and urban walking in one group, except three absentees from the forest walking. The “washout” period between the forest and urban walking in each year was about four to six weeks (Fig. 2). Two to three days before forest or urban walking, and the next day after walking, salivary amylase, blood pressure, and pulse rate were measured. Salivary amylase was measured

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Fig. 1. Pictures of forest walking (A) and urban walking (B).

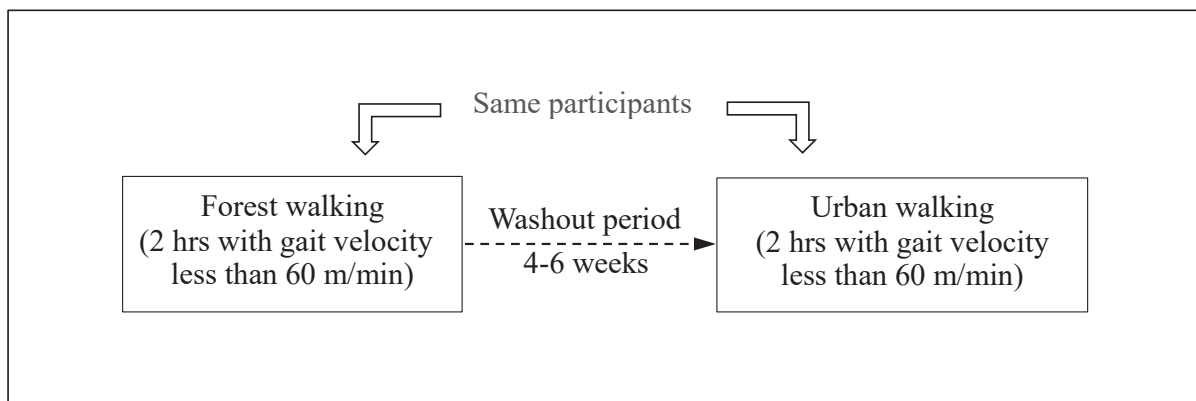


Fig. 2. Washout period between forest walking and urban walking.

by NIPRO salivary amylase monitor (NIPRO, Osaka, Japan). Blood pressure was measured as systolic blood pressure (SBP) and diastolic blood pressure (DBP) in a sitting position after resting for at least 10 min, using an automatic blood pressure monitor (OMRON, Kyoto, Japan). All participants were asked not to drink coffee, tea or alcohol and not to smoke on the measurement day. The psychological mood states of the participants were also investigated using a short form of the Profile of Mood States questionnaire, Japan version (POMS) with 30 questions to measure current mood states by six mood subscale factors (tension-anxiety, depression-dejection, anger-hostility, vigor, fatigue, and confusion) (McNair & Lorr 1964, McNair et al. 1971, Yokoyama et al. 1990). All the data were expressed as the mean \pm standard error of the mean (SEM). The difference of continuous variables was compared using a paired t-test (before vs. after walking), and a value of $p < 0.05$ was considered statistically

significant.

The study design was approved by the Ethics Committee of Okayama University of Science (No. 27-4, No. 30-2). All participants signed the informed consents.

III. Results and Discussion

In the subjects' psychological dimension analyzed by POMS, the scores of tension-anxiety ($p < 0.01$), depression-dejection ($p < 0.01$), anger-hostility ($p < 0.01$), fatigue ($p < 0.05$), and confusion ($p < 0.01$) significantly decreased after forest walking (Fig. 3A). This is consistent with previous researches (Lee et al. 2011, Song et al. 2018). In contrast, none of the mood state subscales showed any significant changes after urban walking (Fig. 3B). In addition, the participants' total mood disturbance (TMD) was significantly improved by forest walking ($p < 0.01$) but not by urban walking. This improved TMD was

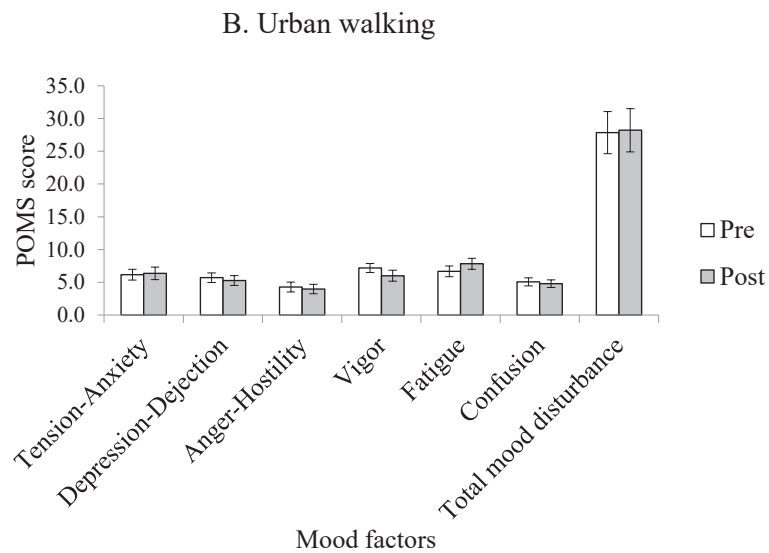
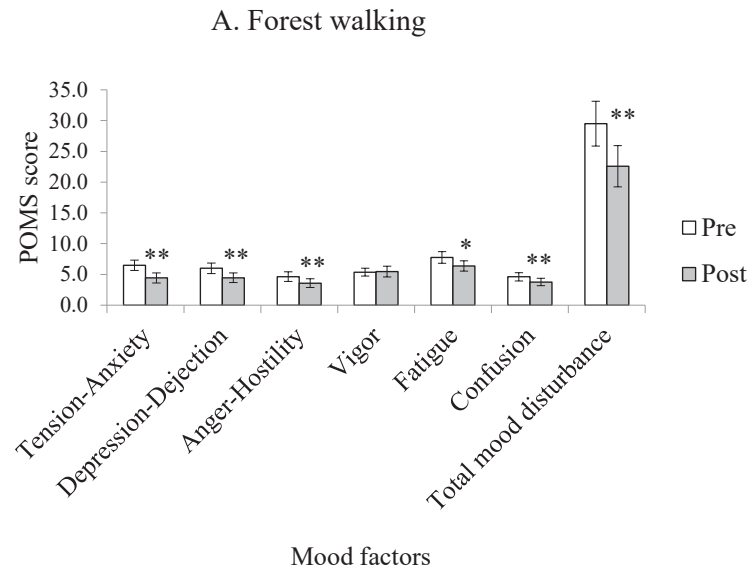


Fig. 3. Mean subscale POMS scores before and after forest (A) or urban walking (B).
Data are expressed as mean \pm standard error of the mean (* $p < 0.05$, ** $p < 0.01$).

Table 1. Salivary amylase, systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate of the participants before (Pre) and after (Post) forest and urban walkings.

	Forest		<i>p</i> value	Urban		<i>p</i> value
	Pre	Post		Pre	Post	
Salivary amylase (KIU/L)	22.3 \pm 2.8	22.8 \pm 3.9	0.273	21.0 \pm 2.2	23.4 \pm 2.9	0.280
SBP (mmHg)	119.6 \pm 2.5	118.0 \pm 2.3	0.172	116.1 \pm 2.7	115.6 \pm 2.5	0.667
DBP (mmHg)	70.6 \pm 1.5	68.9 \pm 1.4	0.066	69.0 \pm 1.4	66.6 \pm 1.4	0.014
Pulse rate (beats/min)	74.7 \pm 1.8	74.8 \pm 1.9	0.956	77.1 \pm 1.7	75.6 \pm 2.0	0.409

Data are expressed as mean \pm standard error of the mean. Log-transformed salivary amylase data were used for the statistical analyses because of their skewed distributions.

derived by summing the scores of five negative subscales (tension-anxiety, depression-dejection, anger-hostility, fatigue, and confusion). Human body is well known to receive sensory information through smell, sight, hearing, touch, and taste. Alleviation of the participants' tension-anxiety, depression-dejection, anger-hostility, fatigue, confusion, and TMD after forest walking implies that temporary immersion in natural green stimuli would provide health with psychological benefits by improving mood and reducing stress.

We also found that the level of salivary amylase decreased in 19 participants (63.3%) after forest walking and in 15 participants (45.5%) after urban walking. However, the mean level of salivary amylase did not significantly differ between before and after walking in either forest or urban environment (Table 1). Salivary amylase is known as one of the physiological biomarkers for immediate response to stress through neuro-endocrine mediated Sympatho-Adreno-Medullary pathway (Beil & Hanes 2013). As salivary amylase was measured the next day after the walking, however, it might not necessarily reflect the immediate response to stress right after the walking.

Our findings revealed no significant changes of systolic blood pressure and pulse rate after walking either in forest or urban environment (Table 1). The diastolic blood pressure tended to decrease after forest walking ($p = 0.066$) and urban walking ($p = 0.014$). However, all the fluctuations were within the normal range. Some researchers reported pulse rate reduction in middle-aged men and women with higher blood pressure after the forest therapy (Li et al. 2016, Ochiai et al. 2015). The different results may be explicable by the influence of the forest environment, which probably helps the body to regulate physiological response homeostatically and promote health.

In our study, the sample was limited to university students, who might responded to the forest or urban walking somewhat differently from the general population. In addition, the small sample size did not represent all young people in Japan. Nevertheless, the current findings contribute to natural greenery literature regarding the difference in psychophysiological effects of forest and urban walking on the young subjects.

In conclusion, the present study suggests that immersing the body in forest environment even for a short period of time, rather than in urban environment, would improve mood and reduce stress.

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- 山田愛・汪達紘・宮永政光：若年層における森林および都市散策の心理学的・生理学的影響の評価
- 要約
- 本研究は、森林または都市の散策後に、唾液ストレスバイオマーカー、血圧、脈拍数、および気分状態のレベルがどのように変動するかを評価することを目的とした。2016-2018年に20代の若者33人を対象として森林散策および都市散策をそれぞれ2時間実施した。森林散策または都市散策の前および翌日に、唾液アミラーゼ、血圧、および脈拍数の測定を行った。参加者の気分状態の調査には、短縮版の気分プロフィール検査(POMS)を用いた。唾液アミラーゼのレベルは、森林散策後では19人(63%)、都市散策後では15人(45.5%)で減少した。また、参加者の気分状態については、緊張-不安($p < 0.01$)、憂うつ-落込み($p < 0.01$)、怒り-敵意($p < 0.01$)、疲労($p < 0.05$)、混乱($p < 0.01$)のスコアが、森林散策後に有意に減少したが、都市散策後では変化が見られなかった。これらの調査結果から、参加者の気分状態は都市散策ではなく森林散策によって改善され、短時間でも森林環境に滞在することでネガティブな気分状態の改善とストレス緩和の一助となることが示唆された。

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