The Restorative Effect of Staying in a Broad-Leaved Forest on Healthy Young Adults in Winter and Spring

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Abstract

Many studies have assessed the impact of broad-leaved trees in the vegetative season on humans' restoration. But it still remains unknown if this positive effect will also be observable in broad-leaved forest during winter, when trees maintain no leaves. To test the hypothesis that broad-leaved trees also produce psychological restoration during winter (in comparison to spring), we designed an experiment, in which the same participants viewed the forest environment during these two seasons, while urban setting was used as a control environment. The participants filled in four psychological questionnaires, which measured different psychological conditions. The results confirmed the hypothesis that broad-leaved trees had the restorative effect in winter, and it was even greater than in spring time. These results suggest that the living woody plants in their natural environment produce a positive, psychological effect on humans, hence visiting broad-leaved forest also during winter can be recommended as a method for stress reduction.

Keywords: environment, forest bathing, seasons, stress reduction, woodland

Introduction

The influence of the forest environment on human organism and possible effectiveness of forest therapy is often measured during short interventions called 'forest bathing', in which participants 'take in the atmosphere of the forest' (Tsunetsugu et al. 2007). Usually, this type of intervention involves 15-30 minutes of walking or sitting and viewing the forest landscape. Many cases of forest bathing and description of their influence on humans have been reported in literature (Bratman et al. 2012, Lee et al. 2017)

Basing on the findings in previous studies, the psychological response of humans to the forest environment might be conceptualized by a single noun 'restoration' (Stigsdotter et al. 2017), which mainly describes the positive, needed effect of decreasing or increasing values of many psychological indicators (or alleviating the negative symptoms). Forest therapy has a restorative effect on humans by reducing the negative physiological and psychological symptoms of stress (Ikei et al. 2014, Jung et al. 2015, Morita et al. 2007, Yu et al. 2016). Literature provides many examples of the positive effects of forest on human health (Jung et al. 2015; Lee et al. 2014, Li et al. 2016, Morita et al. 2007, Ochiai et al. 2015, Park et al. 2014). The positive effects of forest bathing on psychological restoration were scientifically tested; they were observed in both patients and healthy individuals and included both stimulation (vigour, vitality, positive affect) and suppression (depression, tension, anxiety) of the psychological traits (Takayama et al. 2014, Lee et al. 2017).

Many experiments have been conducted to examine the positive influence of forest bathing on human organism in Asian countries (China, Japan, Korea) (Bing et al. 2016, Im et al. 2016, Komori et al. 2017, Ochiai et al. 2015, Song et al. 2013, Takayama et al. 2014), but only few in European countries (Sonntag-Öström et al. 2014, Poulsen et al. 2016, Stigsdotter et al. 2017). However, European societies face also problems caused by living in the urban environment (Lederbogen et al. 2012, Lottrup et al. 2013, Thompson et al. 2012), and the Polish population is not an exception (Buljan et al. 2016, Kiersztyn 2016). But the effect of forest therapy (or forest bathing intervention) in the conditions of the Central Europe is rarely addressed. Only some Danish research (Stigsdotter et al. 2017) shows that the interaction with forest has a positive influence on participants' psychological traits. Thus, the assessment of any European population is valuable for extending scientific knowledge in the field of the forest therapy.

The knowledge about the influence of forests on humans in different seasons is required in regions where different seasons and different conditions occur in forests throughout the year, especially in forests in which trees lose leaves in autumn and maintain no leaves in winter (broad-leaved forests). For this reason, the aim of this study was to determine which season of the year (winter or spring) is better for the forest bathing interventions, and which environment is better for stress symptoms reduction.

The restorative effect on humans may depend of different properties of forest like, e.g., the presence of vegetative leaves. Some previous studies have indicated that the urban park environment had a positive influence on healthy individuals in winter (Song et al. 2013). In the current research we tried to establish the effect of the forest environment in winter or in spring on the psychological traits of healthy young adults. Also, some other research shows that there is no difference between forest bathing results on humans during summer and autumn (Takayama et al. 2017b), and this is why we have decided to compare only two seasons with apparent differences. This is a pioneer study in this research area since we do not know any other research in the area of forest therapy in which winter and spring are compared, thus we have decided to conduct this pilot study in which only two extremely different seasons were compared.

Material and Methods

Research group

To examine the influence of the forest environment on psychological restoration of healthy young adults, 54 academic students (24 women, 30 men) aged 21.35 ± 1.39 years were selected as survey participants. Students were recruited from one study course at the University, and we completely randomly assigned participants for the control group (urban environment) and for the experimental group (forest environment). None of them reported a history of physical or psychiatric disorders; none of the participants suffered from obesity or the metabolic syndrome. They were informed that they took part in a 'forest therapy experiment', and consent for participation in the research was obtained from each of them. All procedures performed in this study were in accordance with the ethical standards of the Polish Committee of Ethics in Science and with the 1964 Helsinki Declaration with its later amendments.

The study sites

The main research site was Kortowo campus of the University of Warmia and Mazury in Olsztyn (north-eastern Poland) with conterminal forest of Kudypy Forest District. A lecture room, which was used as a gathering point, is located at Kortowo campus. The participants walked through the campus to the place of destination: to the city centre in Olsztyn or to the woodland in Kudypy Forest District (to experimental sites). The distance from the lecture room to both destination sites was similar, and the transiting time was about 15 minutes for both groups (Figure 1). Landscape viewing in the city area was not disturbed with any green trees, there were only streets with vehicles and buildings (Figure 2A, C). Landscape viewing in forest was not disturbed with dead wood, shrubs or other obstacles (Figure 2B, D). The forest environment was broad-leaved forest com-

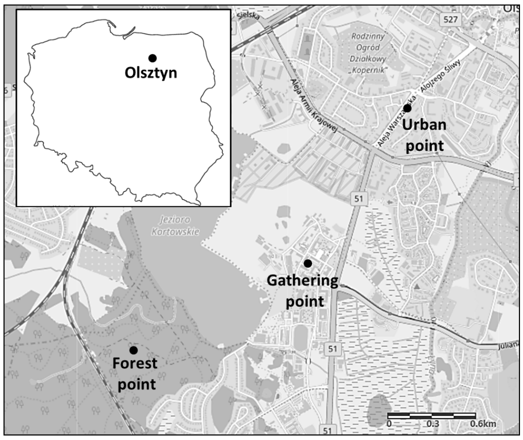

Figure 1. Map of experimental locations

Figure 2. The photographs of examined situations in different settings: A – urban setting in the winter; B – forest setting in the winter; C – urban setting in the spring; D – forest setting in the spring

prising European beech, *Fagus sylvatica* L., pedunculate oak, *Quercus robur* L., and black alder, *Alnus glutinosa* (L.) Gaertn. These trees are common species in Polish forests. To obtain comparable results of the effect of two different seasons (winter and spring), we used the same places for the experiment in the city and in the forest environment and the same lecture room in both seasons.

The sound level in both experimental environments was measured with a smartphone (iPhone 6.0, Apple, USA) using an application 'Sound Level Analyzer Lite (SLA)' (TOON 2018) in both seasons (in winter and in spring). SLA Lite was examined as an excellent application, comparable with a professional laboratory sound analyzing instrument (Murphy and King 2016). During the winter studies, the mean sound level (±SD) in the urban environment measured with this application was 65.53 ± 5.90 dB, meanwhile the mean sound level in the forest was 47.22 ± 2.79. During the spring studies, the respective values were: 65.78 ± 5.82 dB and 45.47 ± 2.49. The meteorological data were collected from Olsztyn-Mazury meteorological station (localization: 53°28'50.0"N, 20°56'10.9"E). During the winter experiment, temperature was 4°C, humidity was 82%, cloudiness was 100% and atmospheric pressure was 999 hPa. The southeast wind speed was 13 km/h. During the spring experiment, temperature was 17°C, humidity was 40%, the sky was clear and atmospheric pressure was 1016 hPa. The north-west wind speed was 17 km/h. No precipitation observed during the experiments in both seasons.

The questionnaires

The restorative effects or stress-induced changes in the psychological traits might be assessed using the POMS, PANAS, ROS, and SVS scales (Ali et al. 2017, Takayama et al. 2014; Tyrväinen et al. 2014).

In this paper, we analyzed the psychological features. An increase in the mean score is perceived as a positive outcome (there are positive features), and a decrease in the event of some of them is also perceived as a positive effect (there are negative features). The positive states are measured with the aid of one subscale of the POMS – vigour subscale, with the aid of PANAS positive subscale and with the aid of the ROS and SVS scales. An increase in the event of this feature is perceived as a positive effect of the environment on the psychological health, whereas a decrease is considered as a negative effect of the environment on the psychological health (Bielinis et al. 2018). The negative states are measured via some subscales of the POMS questionnaires: tension and anxiety (T-A), depression and dejection (D), anger and hostility (A-H), fatigue (F), and confusion (C) were measured via the PANAS negative subscale. A decrease in scores of these scales is perceived as a positive effect on the psychological health, while an increase is perceived as a negative effect (Bielinis et al. 2018).

The Positive and Negative Affect Schedule (PANAS) allows measuring the negative and positive affect with 20 items, where 10 items are for the negative and 10 items are for the positive affect. The original PANAS is compiled in the English language (Watson et al. 1988); we used Polish adaptation of this schedule in our study (Brzozowski 1991). In addition, we used the time frame 'during the present moment'. The total score of positive or negative affect per participant was used for the statistical analysis. The reliability of the PANAS is high (Crawford and Henry 2004) and its use for "forest bathing" assessments was previously described (Takayama et al. 2014).

The Profile of Mood States (POMS) is a reliable and valid measure of psychological distress (McNair and Lorr 1964). This psychometric tool was previously used to determine the influence of forest environment on mood states (Lee et al. 2011). It measures six mood states: tension and anxiety (T-A), depression and dejection (D), anger and hostility (A-H), vigour (V), fatigue (F), and confusion (C). The 65-item Polish version of POMS was used in the current research (Dudek and Koniarek 1987).

The Restorative Outcome Scale (ROS) is a scale originated and developed on the basis of the previous research and observations of restorative phenomena. The scale is reliable and valid (Korpela et al. 2008, Korpela et al. 2010) and was used to assess humans' restoration in the forest environment (Takayama et al. 2014). The ROS scale contains 6 items, each assessed by the participants in a seven-point Likert scale (from "1 – not at all" to "7 – completely"). In this study, we used 6 items of the ROS scale, modified by Takayama et al. (2014). The items were translated into Polish because no research with the ROS scale has ever been reported in this language. The sampled items were: "I feel focused and alert" or "My thoughts are clear". The total score of these six items was used for the statistical analysis.

The Subjective Vitality Scale (SVS) (Ryan and Frederick 1997) was used as a scale for vitality investigation. We used the version adapted to research in the forest environment with 4 items (e.g. "I feel alive and vital" or "I look forward to each new day") (Takayama et al. 2014). These items were assessed by participants in a seven-point Likert scale (ranging from "1 – not at all" to "7 – completely"), one negative item was inversely scored. These four items were translated into the Polish language. The total score of the four items was used for the statistical analysis.

The validity and reliability of the Polish-language versions of the POMS, PANAS, ROS and SVS scales have been analyzed in earlier investigations (Dudek and Koniarek 1987, Brzozowski 1995, Bielinis et al. 2018).

Experimental design

In each of these two seasons the participants were grouped at the gathering point at the University of Warmia and Mazury at 9 a.m. The same group participated in the research during the winter and spring. The participants were divided into two groups, and each of them filled four questionnaires (the POMS, PANAS, ROS and SVS) in lecture room conditions. Afterwards, one group walked to the destination point in the city and the second group walked to the destination point in the forest. Both in the forest and city environments, the participants were asked to stand and view the landscape for 15 minutes. After this time, they received and filled in the questionnaires.

In fact, there were eight experimental interventions: 1. Room winter (city) – group which filled questionnaires in room conditions in the winter and then walked towards the urban environment; 2. Room spring (city) – the same group of students as in level 1, but who filled in the questionnaire in the lecture room in the spring; 3. Room winter (forest) – the second group of students who filled in questionnaires in room conditions in the winter and walked to the forest environment; 4. Room spring (forest) – the same group of students as in level 3, but who filled the questionnaire in the lecture room in the spring; 5. City winter – the same group of students as in level 1 and 2, but surveyed for the effect of the urban environment in the winter on their psychological traits; 6. City spring – the same group of students as in level 1, 2 and 5, but surveyed for the effect of the urban environment in the spring on their psychological traits; 7. Forest winter – the same group of students as in level 3 and 4, but surveyed for the effect of the forest environment in the winter on their psychological traits; 8. Forest spring - the same group of students as in level 3, 4 and 7, but surveyed for the effect of the forest environment on their psychological traits in the spring.

Statistical analysis

Differences among groups for each variable were homogenous and distribution of variables complied with normal distribution, thus the one-way ANOVA approach was used: the different experimental interventions were treated as experimental levels (from 1 to 8). Thus, the differences between experimental levels were tested in the analysis of variance procedure, whereas a *post hoc* least significance test (LSD) was used to determine differences between mean values.

Results

Internal consistency of scales

The results of internal consistency verification were provided for the winter (Table 1) and for the spring (Table 2). In both seasons, the internal consistency of measures was satisfying, only in the event of the Confusion subscale of POMS the internal consistency was moderate in both seasons (but still valid).

Table 1. Verification of internal consistency (winter)

Scales and Subscales		Cronbach's α
POMS	T-A	0.886
	D	0.924
	A-H	0.875
	F	0.822
	C	0.749
	V	0.859
PANAS	Positive	0.874
	Negative	0.880
ROS		0.928
SVS		0.842

Table 2. Verification of internal consistency (spring)

Scales and Subscales		Cronbach's α (Sub)scales
POMS	T-A	0.786
	D	0.936
	A-H	0.862
	F	0.839
	C	0.718
	V	0.843
PANAS	Positive	0.872
	Negative	0.837
ROS		0.922
SVS		0.862

The POMS scale

The Tension and Anxiety subscale (T-A). There were significant differences between mean values of T-A (F_7 = 7.47, $p < 0.001$). The highest values of these traits were observed in the city environment in the spring, and the lowest ones in the forest in the winter (Figure 3). The T-A of the city group in room conditions in the spring (1) was higher than in the city group in room conditions in the winter (2), but the difference was not significant. The forest group in room conditions in the winter (3) had lower values of T-A than in the spring (4), and the difference was significant. The values of T-A in the city (5, 6) were higher than in other conditions, especially in the spring time. There was a difference between reaction of the respondents in the forest in the winter (7) and in the spring (8); in the winter time the values of T-A were significantly lower.

The Depression and Dejection subscale (D-D). There was a significant effect of experimental interventions on D-D (F_7 = 5.49, $p < 0.001$). The same pattern of differences and similarities as in the event of T-A was found for the variable D-D (Figure 4).

Anger and Hostility subscale (A-H). The influence of experimental interventions was also observable in the event of the anger and hostility subscale (A-H) (F = 4.25,

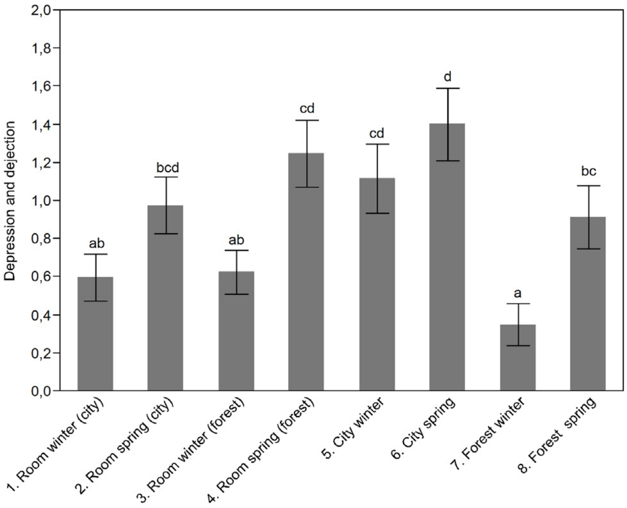

Figure 3. Mean score of POMS depression and dejection subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, *N* = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

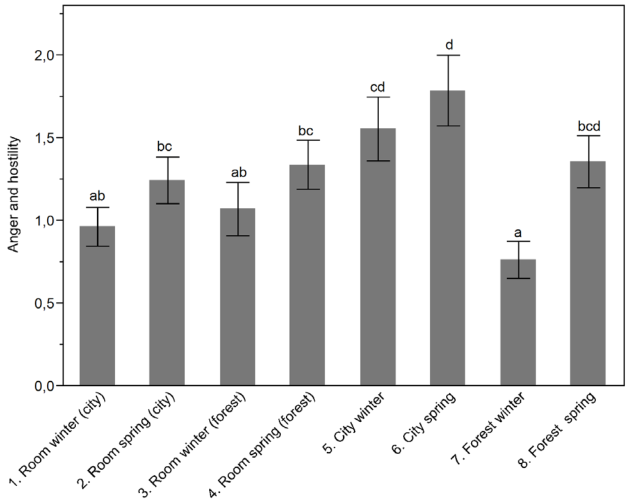

Figure 5. Mean score of POMS anger and hostility subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

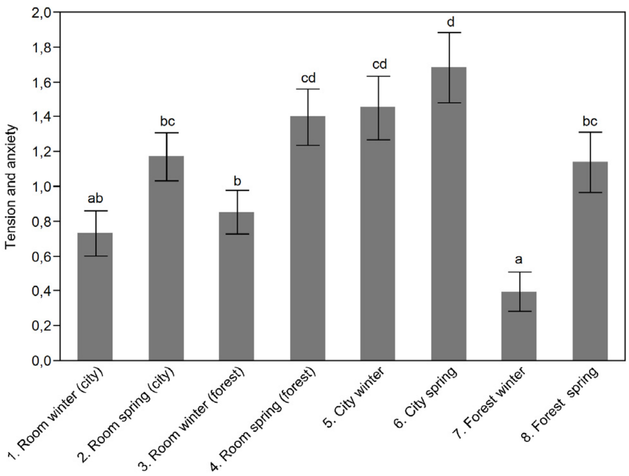

Figure 4. Means score of POMS tension and anxiety subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

$p < 0.001$); the differences between anger and hostility in all four groups filling questionnaires in room conditions (1-4) were not significant. The city and forest environments had the same influence on A-H of study participants as on their T-A and D-D, the same pattern of differences and similarities was found (Figure 5).

The Fatigue subscale (F). There was also a significant impact of experimental interventions on F ($F = 4.79$, $p < 0.001$). There was no difference between each four (1-4) room conditions (Figure 6). The highest values of participants' F were observed in the city spring conditions (6) (which was significantly different from the room city condition during both seasons) and the lowest ones in the forest winter and forest spring interventions (these two, 7 and 8, had significantly lower mean values).

The Confusion subscale (C). The values of C differed significantly among experimental interventions ($F = 5.18$, $p < 0.001$); the lowest value of F was observed in the forest during the winter (7), whereas the highest one in the city during the spring (6) (Figure 7). Each reaction of respondents in the forest conditions (7, 8) did not differ significantly with the compared room condition (3, 4) but differed significantly with the city conditions (5, 6), respectively. However, there were significant differences between reactions in the forest group in room during the spring (4) and in reaction of participants in the forest in the winter (7).

Vigour subscale (V). In the event of V, there were differences between mean values ($F = 4.96$, $p < 0.001$). Differences between mean values of V in all room conditions (1-4) and between the city conditions (5, 6) were not significant (Figure 8). In the forest environment during the winter (7), the V values were significantly higher than in the room or city conditions (1-6). In the forest environment during the spring (8), there were signifi-

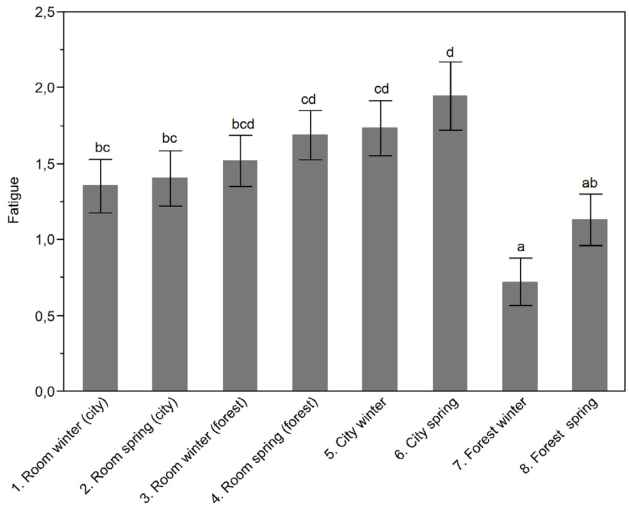

Figure 6. Mean score of POMS fatigue subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

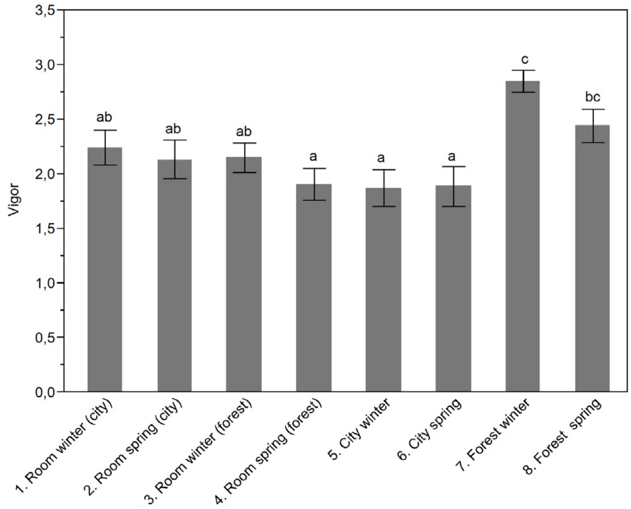

Figure 8. Mean score of POMS vigour subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

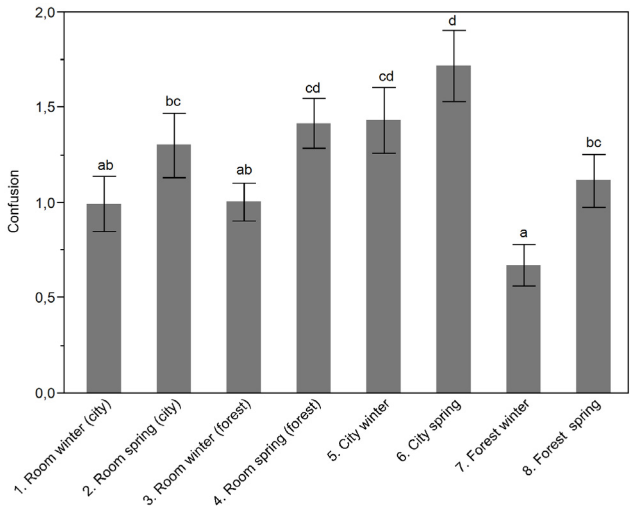

Figure 7. Means score of POMS confusion subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE,* N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

cantly higher values than in room during the spring (forest group), city winter and city spring (4, 5 and 6).

The PANAS scale

The PANAS positive subscale. There was a significant difference between mean values of the PANAS positive subscale ($F = 4.34$, $p < 0.001$). Values of PANAS positive were not significantly different between room (1-4) and city conditions (5, 6) during both seasons (Figure 9). PANAS positive was significantly higher in the forest environment during both seasons (7, 8).

The PANAS negative subscale. The difference between mean values of PANAS negative was significant ($F = 4.76$, $p < 0.001$). Those who stayed in the city environment (5, 6) had the strongest influence on participant's response; the mean values of PANAS negative were significantly higher than in the respective room conditions (Figure 10). The forest environment had no influence on the values of PANAS negative in both seasons (7, 8) in comparison to the room conditions (3, 4).

The ROS scale

There were differences between mean values in the event of the ROS scale ($F = 6.31$, $p < 0.001$). The highest values of the ROS scale were observed in the forest during the winter (7) and during the spring (8), but during the winter they were significantly higher than during the spring (Figure 11). The values of ROS in the forest during winter (7) were significantly higher than in the room conditions (3, 4) or in the city (5, 6). Forest spring (8) was differed significantly with: 4, 5, 6 and 7. There was no significant difference between room spring (2) and city spring (6), but a difference was noticed between room winter (1) and city winter (5) values of the ROS scale; the values of the ROS scale were lower in the city during the winter.

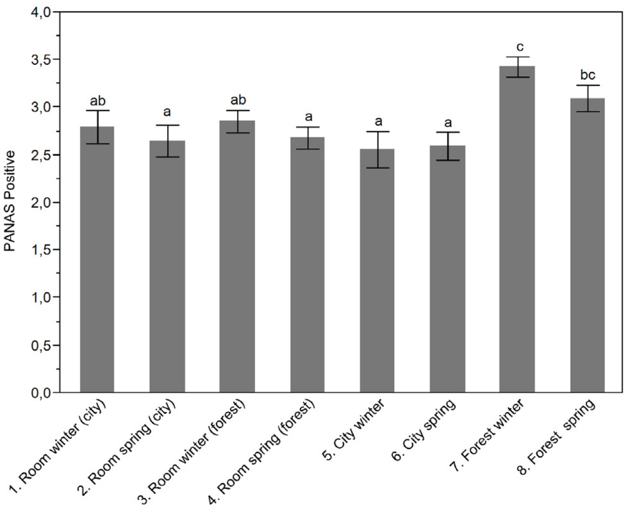

Figure 9. Mean score of PANAS positive subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

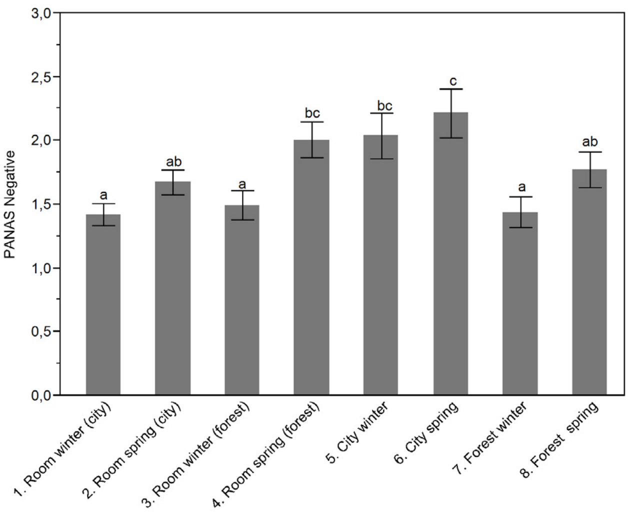

Figure 10. Mean score of PANAS negative subscale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

The SVS scale

There was a significant difference between mean values of the SVS scale ($F = 5.37$, $p < 0.001$). There was no statistically significant difference between mean values obtained in the room conditions (1-4) and city conditions (5, 6) (Figure 12). The forest environment affected the SVS values, which in the forest during the winter were significantly higher than during the spring (8) or in the room (1-4) or the city conditions (5, 6). Higher values of traits from the SVS scale were also achieved in the forest

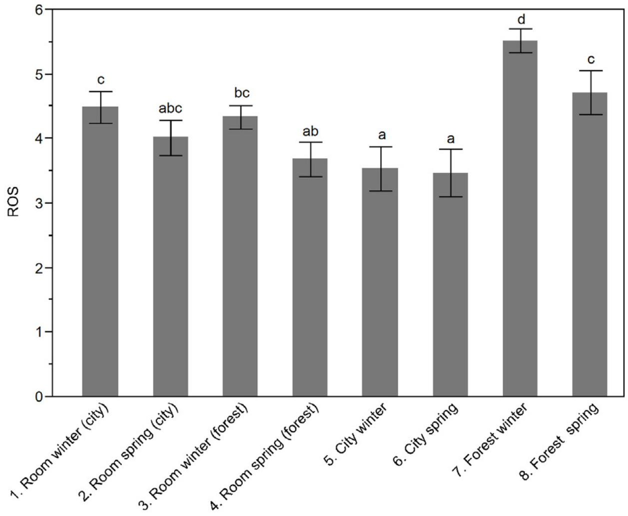

Figure 11. Mean score of ROS scale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

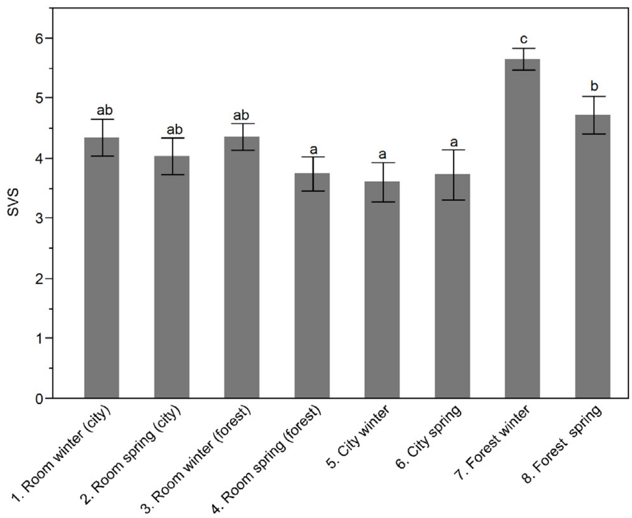

Figure 12. Mean score of SVS scale results showing the differences between room, forest and urban environments in two different seasons: winter and spring. Mean ± *SE*, N = 54. Mean values with the same small letter of alphabet are not significantly different at $\alpha = 0.05$ in LSD post-ANOVA comparisons, mean values with different letters are significantly different

during the spring (8) in comparison to the city (5, 6) or in comparison to the respective room conditions (4).

Discussion

The mean values of traits usually did not differ statistically between room conditions in the winter and spring groups, but it is worth noticing that the mean values were usually lower in the negative scales during the winter (in comparison to spring) and higher in the positive scales during the winter (in comparison to spring). It is difficult to explain why the same participants responded in this way in the same room conditions after four months. The spring measurements coincided in time with the exam time at the University, thus respondents might be stressed up with this occasion and that might influence their mood and restoration (Robotham and Julian 2006).

The participants reported the higher values of negative emotions in the urban environment, especially during the spring. This is a common situation when respondents notice negative emotions in the urban environment in comparison to the room conditions (Ochiai et al. 2015). The positive emotions and restorative effect (vigour, PANAS positive, ROS and SVS) in the urban environment were not higher or sometimes even lower than in the room conditions, especially during the spring. During the spring time, the participants stood in the urban environment in a sunny place and this could influence their restorative experience. But on the other hand, the urban environment without trees might be an extreme environment with high temperature and be perceived as an uncomfortable place (Heaviside et al. 2017).

The forest environment affected participant's response. Its effect was positive as it caused a decrease in negative emotions, an increase in positive emotions, and an increase in restoration level. Differences among two different seasons in the forest environment have not been previously examined, but there is some research investigated the impact of the garden and park environments on humans in winter (Lee 2017, Song et al. 2013). In the event of some of the analyzed traits, the positive impact of forest bathing was higher during the winter than in the spring. One of possible explanations of this unexpected observation is the presence of mosquitoes in the research forest area during the spring time. The participants reported the impact of mosquitoes after research in the forest; these insects might influence their comfort and be a cause of incomplete restoration. In other study, the period when mosquitoes appeared was omitted in analyses (Sonntag-Öström et al. 2014). It is worth to emphasize that forest without leaves during the winter could have a more restorative potential than the forest with vegetative leaves. A clear conclusion cannot be, however, drawn in this event because of mosquito occurrence, and this is the limitation of this study. However, as indicated in the current research, the forest bathing in the spring also had a restorative effect, but not as strong as in the winter.

These findings can provide much useful information for forest therapy specialists and forest managers, to help design control, select and use the forest areas with their best abilities for stress reduction (Stoltz et al. 2016). The usefulness of different seasons in the forest therapy was signalized in literature but not discussed or investigated (Stoltz et al. 2016, Takayama et al. 2017a).

Noteworthy is that the same respondents, namely the same persons participated in our study in both seasons, thus the effect of forest therapy might be clearly evaluated for both seasons. However, the response of people might be dependent of life events, thus their mood may vary over time. In further studies, it would be advisable to assess different seasons in the same time (e.g. in different parts of the Earth, in the northern and southern hemispheres or under controlled conditions, like in a special tent for forest therapy used by Takayama et al. (2017a). The participant's response may also be affected by temperature, humidity, cloudiness, and even time of the day.

The present study demonstrated that a 15-minute "forest bathing", compared to the urban environment as a control: (1) significantly improved mood, (2) significantly improved positive affect, (3) induced the feeling of significant subjective restoration, (4) and induced the feeling of significant subjective vitality. This influence was observed in both seasons but was stronger in the winter than in the spring, which might be caused by the presence of mosquitoes in the spring, but elucidation of this problem needs further research in the period, in which foliage occurs and there are no mosquitoes.

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