






## Article

# Physiological and Psychological Effects of Nature Experiences in Different Forests on Young People

Qiaohui Liu <sup>1</sup>, Xiaoping Wang <sup>1</sup>, Jinglan Liu <sup>2,\*</sup>, Congying An <sup>2</sup>, Yuqi Liu <sup>2</sup>, Xiaoli Fan <sup>2</sup> and Yishen Hu <sup>2</sup>

<sup>1</sup> College of Forestry, Beijing Forestry University, Beijing 100083, China; liuqiaohui202109@163.com (Q.L.); wangxp@bdfic.com (X.W.)

<sup>2</sup> School of Ecology and Nature Conservation, Beijing Forestry University, Beijing 100083, China; acy19961219@163.com (C.A.); rachelyuqi@gmail.com (Y.L.); fanxiao0802@163.com (X.F.); hys16637102261@163.com (Y.H.)

\* Correspondence: liujl66@bjfu.edu.cn; Tel.: +86-010-6233-6716

**Abstract:** Many studies have proved that having nature experiences in forests is conducive to human physiological and psychological health. However, currently there is little research focusing on the effects of forest characteristics and the experiential characteristics of nature experiences on changes in health. In the study, three types of forest (mixed forest; deciduous forest; coniferous forest) and an urban site were used to measure the effects of these environments on participants' physiological and psychological restoration after nature experience activities (sitting and walking activities). The study participants were 30 young adult students from Beijing Forestry University. Restorative effects were measured by physiological indicators (blood pressure and heart rate) and four psychological questionnaires (Profile of Mood States (POMS); Restorative Outcome Scale (ROS); Subjective Vitality Scale (SVS); Warwick-Edinburgh Mental Well-being Scale (WEMWBS)). Results demonstrated that all types of forest were beneficial to lower blood pressure and heart rate as well as to reduce negative feelings while boosting positive emotions. The mixed forest was more effective in lowering blood pressure and heart rate as well as increasing vitality. The levels of restoration and positive mental health increased significantly, while all subscales of the POMS (with the exception of vigor) decreased greatly in the coniferous forest. Relative to the sitting activity, obvious decreases in blood pressure and negative emotions were observed, while significant increases in restoration, vitality and positive mental health were observed after the walking activity. In conclusion, the impact on subjects' health restoration varied with different forest characteristics, and the experiential characteristics of exposure may be helpful for creating supportive interventions and lifting the benefits of forest therapy as people interact with the forest.



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## 1. Introduction

Urbanization has promoted social and economic development while causing negative effects on nature's ecosystem. Urban living represents convenient transportation, better medical and education services, more opportunities for employment and higher incomes [1]. Meanwhile, rapid urbanization is usually associated with environmental pollution, high population density, and the loss of chances to experience nature [2] as well as exposure to chronic, noncommunicable and mental health-exacerbated conditions [3,4]. A natural environment is likely to provide a distinctive intervention to help people with solving many of these health problems. Furthermore, an increasing number of studies have confirmed the restorative effects between nature and physiological and psychological well-being [5,6], including the prevention of cardiovascular and respiratory diseases [7,8], reduction of stress levels [9], lifting of mood condition [10–12] as well as the restoration and sustainment of vitality [13–15]. Restorative effects refer to the restoration and replenishment, or updating

effects of restorative environments on people's depleted physical, psychological or social resources and abilities that are constantly consumed under stress conditions; that is, the effect of the reduction in stress and the decrease of various negative emotions as well as the promotion of psychological and physical health [16,17].

Forests are, as an important part of nature, considered as a basic health resource that may play a key role in human health improvement [18]. Forests restore the physical and psychological health of the human body through a "five senses experience" (vision (landscape), hearing, smell, touch and taste) when people are exposed to a forest environment [19]. Public preferences for the structural attributes of forests are an important factor that are responsible for the perceived response in forests. The degree of public preference for tree species is affected by public culture, the geographic area and subjective expectations [20]. Moreover, factors such as visibility distance, light, number of canopy layers in the forest stand and public viewing habits [21] largely determine people's preference for tree species. Mixed forests are the most popular type of forest followed by broad-leaved forests and coniferous forests [22]. Trees with a large size generally dominate the visual aesthetics of forests and exert their positive influence through their diameter at breast height, forest density and height [20]. In addition, the density of the ground vegetation in a forest is beneficial for increasing public preference, but too high a density of shrubs and grass may make people feel that "the landscape looks too desolate" and there is "poor accessibility in the forest" [23]. When the visibility distance of the forest is about 40–50 m, the landscape reaches the highest value [24]. However, in addition to all of that, factors in the forest environment that may provide beneficial health effects [25] include a special interior forest climate with reduced air temperature, high air purity and humidity, special light conditions and negative oxygen ions concentrations. The influence of a forest on these factors mainly depends on the plant species and size, stand density, growth status and canopy closure [26]. In addition, it has been identified that the effect of biogenic volatile organic compounds (BVOCs) emitted by trees and plants, such as terpenes (usually called phytoncides), would be potential factors for positive health effects in terms of their anti-inflammatory, antioxidant, or neuroprotective activities [27,28]. Studies have found that the composition of trees can significantly influence the concentration of phytoncides, and that coniferous plants such as pine and cypress have higher emission values [29].

Widespread attention has focused on people's physiological and psychological relaxation with forest exposure, and forests are bound up with great performance in terms of positive health restoration outcomes [30–33]. Moreover, short-term forest exposure could significantly improve the cardiovascular and psychological health of people, including lowering blood pressure and lifting mood [34,35]. Although the use of forests has been considered as a novel approach to promoting human health and well-being, the restorative effects of forests for human health are not the same [36,37]. This is because the promotion effects of forests on subjects' health might depend on the different characteristics of forests that have shaped the forest landscapes and environment [38]. It was found that a forest stand's age affected its restorative qualities, an old-growth forest was more restorative compared to a mature forest or a young forest [39]. In addition, the forest's structure, tree species and forest cover are considered to be influential factors for forest relaxation and restoration [21,40]. There is evidence that forest vegetation density is related to stress recovery, and high vegetation density in a forest leads to better attentional functioning than medium density [41]. The beneficial physiological effects relating to decreased levels of blood pressure and saliva cortisol have been associated with different types of forest management; managed forests lead to a better response than unmanaged forests after a stress stimulus [42]. Researchers have also explored the psychological responses to different forest environments through virtual reality experiments, and the results have shown that different types of forest led to uneven responses to stress, reaching a consistent conclusion that coniferous forests and evergreen trees are more conducive to stress relief [43,44]. In particular, the results of studies indicate that a large body of papers have focused on

the topic of forests' restoration effects, but there still needs to be a focus on integrating descriptions of forests' characteristics and how they are related to human health.

Furthermore, recent studies have paid less attention to the effects of the experiential characteristics of nature exposure, termed nature experience, on individuals' mental and physical well-being. Nature experience has been proposed as a method to classify nature exposure, which is an important component of the health outcomes of subjects [45]. The health benefits of nature experience varied according to the ways of interacting with nature and the response of different sensory forms [46,47]. A study of human's nature experience [48] confirmed that specific types of experience in which people interact with nature may throw light on differential impacts of exposure on health. The types of activity were consistent in most studies; for example, walking acted as an active exposure, while sitting or viewing was taken as a passive exposure [48]. Research also showed that specific types of nature experience activity in a green environment have different impacts on human health restoration [49]. For example, one study confirmed that vigor is more enhanced by walking than viewing in a forest environment [50], while another concluded that viewing had better physiological restoration than walking [51].

To our knowledge, studies on the relationship between and the importance of forests and human health restoration have increased quickly, but fewer studies have investigated how restorative effects vary in different types of forest. In this respect, research on forest types and nature experience associated with health restoration is scarcer and fragmented. Therefore, it is not entirely clear whether different types of forest have different restorative effects or which patterns of nature experience activity stimulate a restoration effect the most. The main objective of this study was to investigate the restorative effects of different types of forest (mixed forest, deciduous forest and coniferous forest) and nature experience activities (sitting and walking). Based on the previous studies, we assumed that different types of forest and experience activity would have uneven impacts on people's health promotion. The hypotheses were that: (I) all three types of forest would have impacts on subjects' physiological and psychological restoration and relaxation; (II) there would be differences in the restorative effects among the mixed forest, deciduous forest and coniferous forest; (III) both sitting and walking activities would have unequal restorative effects.

## 2. Materials and Methods

### 2.1. Participants

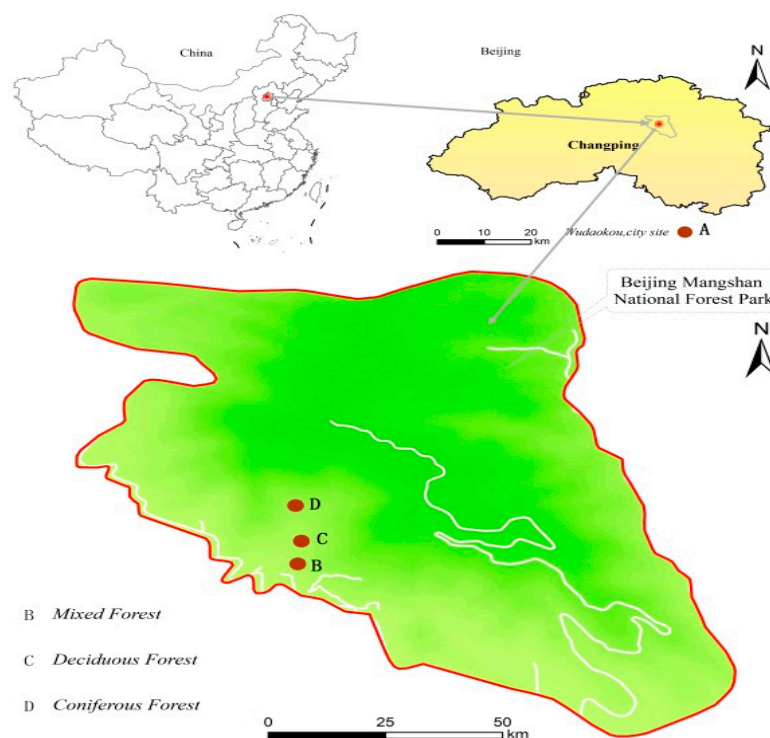
In the highly competitive atmosphere of modern society, university students are faced with various pressures from study, social interaction and employment. These pressures have a profound impact on university students' physiology, psychology and behavior [52]. In most countries, more than 50% of colleges and university students live with different degrees of stress, anxiety or depression [53]. In addition, university students are commonly used as test groups in the study of the relationship between humans and the natural environment. Young adults at university, who at a group level can be assumed not yet to be overly affected by various diseases, are similar in age, have a higher level of knowledge and are homogeneous research subjects.

The study enrolled self-referred participants after dissemination of recruitment information via group messages using the WeChat mobile application. All the subjects were healthy adult students (at least 18 years old) and were Chinese speakers. Applicants meeting any of the following criteria were excluded from participation in this study: physical or mental disorders; taking insomnia drugs, stimulants or other psychoactive drugs; heavy smoking and/or drinking habits. Students willingly participated in the research and were informed about all the necessary information regarding the study (aims and experiment procedure as well as precautions) and the study did not lead to any harm to the participants. All participants were contacted by phone call for a brief interview to check their eligibility for the study 3 days before beginning the experiment. The final participants consisted of 30 young adult students aged 22–28 of Beijing Forestry University. All participants were from different majors such as Law, Management and Philosophy, etc. All procedures involved in

this study were in accordance with the ethical standards of the Ethics Committee of Beijing Forestry University (Z161100001116084) and the Declaration of Helsinki from 1964. All participants gave written consent for their voluntary participation.

## 2.2. Study Sites

All experimental sites in this study were in Beijing, China (Figure 1). Three types of forest sites were in Mangshan National Forest Park of Changping District, 40 km away from downtown area. The total area of Mangshan National Forest Park is 8622 ha, and it is the largest national forest park in Beijing. The forest coverage rate is 86%.



**Figure 1.** The map of experimental locations: (A) city site, (B) mixed forest, (C) deciduous forest, (D) coniferous forest.

The urban site (CK), Wudaokou, was a city square in the center of downtown area with a large amount of people and vehicles. The surrounding area is characterized by urban elements such as subway station, shopping mall, roads, supermarkets and community houses, which is a typical urban site (Figure 2A). The first forest site was the mixed forest. The species composition was dominated by *Quercus mongolica* and *Pinus tabuliformis*, which are typical coniferous and broad-leaved mixed forest trees. Mixed forest formed a stand structure with multiple layers and thick canopy, and it had the most abundant understory vegetation (Figure 2B). The second forest site was deciduous forest. The dominant tree species was *Cotinus coggygia*, which is winter deciduous (also known as summer green forest). There were many shrubs, herbs, and other plants under the forest (Figure 2C). The third forest site was coniferous forest. The dominant tree species was *Platycladus orientalis*, which is an evergreen coniferous forest tree. The composition of the community structure was simple, and the understory shrubs were sparse (Figure 2D). All three types of forest were planted about 40 years ago, and the specific forest characteristics in forest sites are shown in Table 1.



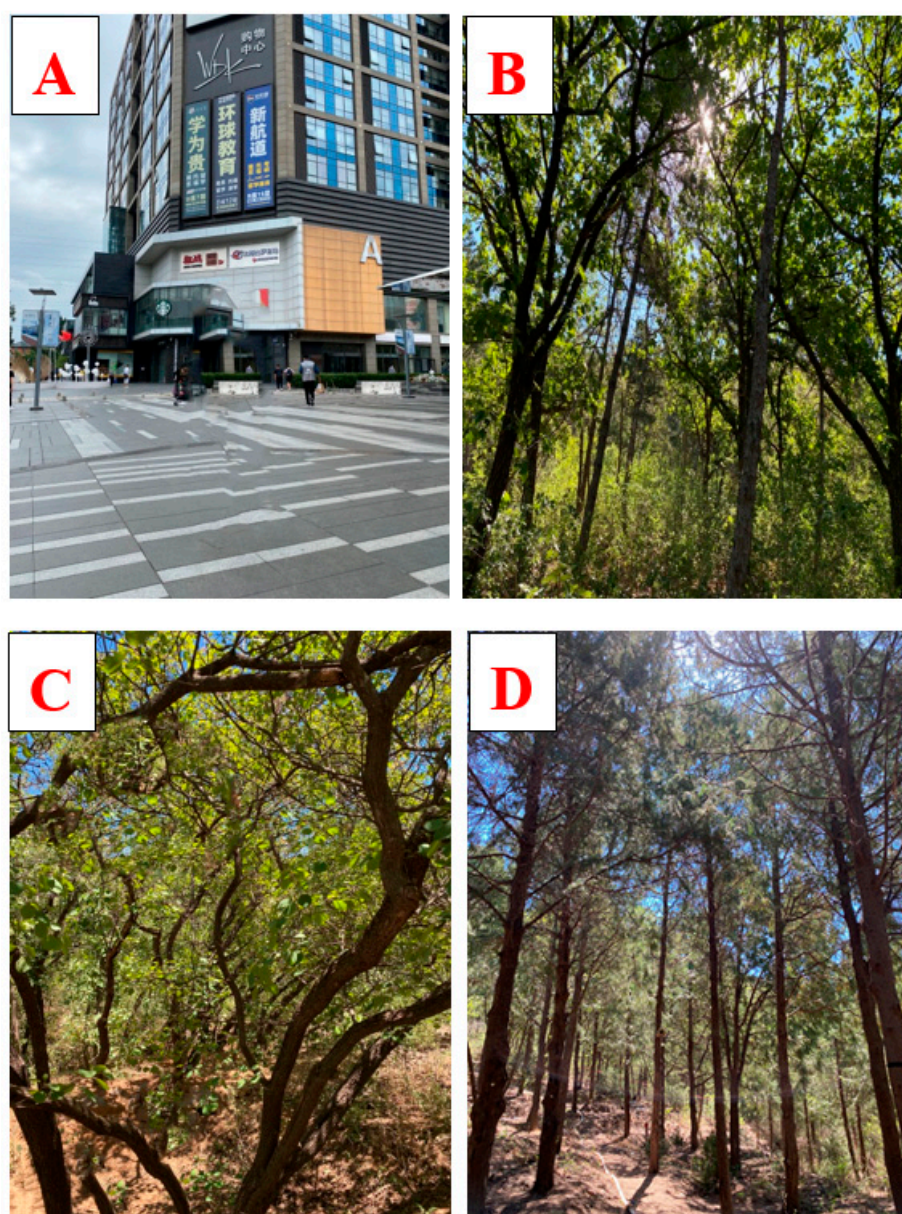


Figure 2. Photos: (A) city site, (B) mixed forest, (C) deciduous forest, (D) coniferous forest.

Table 1. Forest characteristics in forest site.

Forest Site	Mixed Forest	Deciduous Forest	Coniferous Forest
Dominant Tree Species	<i>Pinus tabulaeformis</i> <i>Quercus mongolica</i>	<i>Cotinus coggygria</i>	<i>Platycladus orientalis</i>
Tree height (m)	7 ± 1.22	5 ± 1.00	8 ± 0.81
Diameter breast height (cm)	22 ± 3.67	15 ± 3.35	16 ± 1.81
Canopy closure (%)	0.7 ± 0.03	0.55 ± 0.01	0.6 ± 0.05
Visual penetration through stand (m)	40 ± 1.47	25 ± 3.74	45 ± 1.23
Stand density (trees ha <sup>−1</sup> )	525 ± 11	664 ± 10	825 ± 8

Note. Canopy closure (%) means canopy cover rate; Visual penetration through stand (m) means distance visible in the forest. Bold letters indicate significant difference among different types of forest ( $p < 0.05$ ).

Meteorological research data were collected in the forest sites and urban site. The level of noise was measured by digital noise equipment (TES-1350R). The lighting was measured by a digital photometer (Victor 1010d). DustMate (Turnkey) handheld environmental

dust detector was used to measure total suspended particulate (TSP). Aero-anion was measured by air ions counter. Air temperature, relative humidity and wind velocity were measured by hot wire anemometer (TES-1341). All the data were measured multiple times in randomly chosen points and recorded every 30 min at each experimental site from 9:00 a.m. to 5:00 p.m. (Table 2).

**Table 2.** Mean values and standard deviation (SD) of environmental factors of four environmental sites.

Parameter		CK	MF	DF	CF
Temperature (°C)	Mean	32.67	27.44	27.78	26.33
	SD	3.00	1.33	1.99	1.50
Wind velocity (m/s)	Mean	1.03	0.23	0.23	0.64
	SD	1.17	0.18	0.17	0.46
Relative humidity (%)	Mean	31.22	44.33	43.44	39.89
	SD	3.70	1.94	2.35	2.42
Noise (dB)	Mean	63.44	47.67	47.00	48.44
	SD	4.04	5.41	4.15	5.46
Illumination (lx)	Mean	9066.67	4944.44	3424.44	5994.44
	SD	3103.63	1609.43	1897.31	2400.71
TSP ( $\mu\text{g}/\text{cm}^3$ )	Mean	120.78	31.56	35.67	39.11
	SD	57.42	30.26	31.93	19.28
Aero-anion concentration (per unit/ $\text{cm}^3$ )	Mean	350.00	872.22	788.89	846.67
	SD	102.10	147.38	136.15	166.51

Note. CK = urban site, MF = mixed forest, DF = deciduous forest, CF = coniferous forest.

### 2.3. Procedure

The physiological and psychological parameters of participants were measured at the gathering point before the nature experience activities, and then were measured after the end of the experimental fields. Measurements of physiological and psychological indicators of all participants in the study were performed at the same time. All participants undertook separate sitting and walking activities at the experimental sites. The participants were not allowed to talk to each other, drink or eat any energy drinks or food during the experiment period.

The experiment was conducted in June 2021. Participants visited the three forest sites and the urban site at the same time of different days. The same procedure was conducted for each experiment in the study. One experiment consisted of six time periods with specific measurements (T0–T6). All participants arrived at the gathering point (a classroom at the University) at 8:00 a.m. Then, participants blood pressure and heart rate were measured and all questionnaires were completed at the gathering point (baseline measurements, T0). Next, all participants took school bus (nearly 40 min) to the experimental areas (T1). Participants were randomly, but evenly, divided into three groups on the bus (group A, group B and group C). Afterwards, participants were asked to sit for 30 min in the respective forest site (T2). After sitting, researchers measured participants' blood pressure and heart rate while participants finished all questionnaires at sitting fields (T3). After a 10 min break (T4), participants were invited to walk 30 min in the respective forest study site (T5). Walking speed was moderate pace throughout the whole walking activity. After walking, researchers measured participants' blood pressure and heart rate while participants completed all questionnaires (T6). The whole sitting and walking periods were guided with three researchers in each group. The groups were formed by the same people during all visits to forest sites and urban site.

### 2.4. Measurements

Blood pressure (systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured to record participants' physiological responses. Blood pressure indicates were measured by Omron IntelliSense blood pressure monitor (HEM-7207). Heart rate was measured by Polar monitor (TEAM PRO).

Four psychological questionnaires, all in Chinese, were used to measure participants' psychological responses. The Profile of Mood States (POMS) measured mood states. POMS can measure six kinds of psychological states (tension–anxiety (T–A), anger–hostility (A–H), fatigue (F), depression (D), confusion (C) and vigor (V)) value, and its reliability and validity have been fully documented [54]. POMS had been previously used for the evaluation of the forest exposure effects on subjects' mood. In the study, participants were asked to rate 30 items with a Likert five-point scale ranging from 0 (=not at all) to 4 (=extremely). The Restorative Outcome Scale (ROS) evaluated the restorative effects, which includes relaxation and calmness, attention restoration and thought clearness; it is composed of six items and each item had a Likert seven-point scale ranging from 0 (=totally disagree) to 6 (=totally agree). In the study, we used the scale modified for forest-related experience by Takayama et al. [55]. The Subjective Vitality Scale (SVS) was used to measure level of vitality. It is composed of four items with a Likert seven-point scale ranging from 0 (=totally disagree) to 6 (=totally agree). The reliability and validity of SVS have also been confirmed in previous research [56]. The Warwick-Edinburgh Mental Well-being Scale (WEMWBS) was used to evaluate positive mental health. This scale can assess the positive emotions of mental health and satisfaction of interpersonal relationship [57]. The Chinese version has 14 items and its reliability and validity have been verified before [58]. Each item was evaluated with a Likert five-point scale ranging from 0 (=not at all) to 4 (=extremely).

All four questionnaires in this study that we used, were the same as in previous research [59,60]; the time frame “at this moment” was used for timely measurement of participant responses.

### 2.5. Data Analysis

In this study, we used Excel 2010 (Microsoft Corporation) to record raw data from physiological and psychological measurements. All statistical analysis was processed by SPSS23.0 (IBM, Armonk, NY, USA). The paired *t*-test was used for investigating the changes in variables of the subjects before and after the nature experience activities in different experiment sites. We set urban site and forest sites as factors and each measurement point (before experiment (TO), after sitting (T3) and after walking (T6)) as levels. The significant difference values of the indicators change among four experiment sites and two activities were analyzed with repeated-measures ANOVAs. Significance was considered at the  $p < 0.05$  level for both paired *t*-test and repeated-measures ANOVAs analysis.

## 3. Results

### 3.1. Physiological Parameters

#### 3.1.1. Results of Differences in Physiological Parameters

Three physiological indicators were assessed in the study, including systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR). Table 3 shows the results of repeated-measures ANOVAs for physiological parameters. There were significant interactions between “site” and “time” impacts on SBP and DBP. Significant difference was also found in both “time” and “site” of SBP, DBP and HR.

**Table 3.** Results of repeated-measures ANOVAs for physiological parameters (systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR)), degrees of freedom and *F* statistics.

	DF	SBP	DBP	HR
Site	3	37.97 **	5.15 **	19.53 **
Time	1	8.02 *	6.34 *	21.25 **
Site × time	3	12.25 **	3.87 *	0.78

Note. \*\* *F* is significant at  $p < 0.01$ . \* *F* is significant at  $p < 0.05$  level.

#### 3.1.2. Results of Changes in SBP, DBP and HR

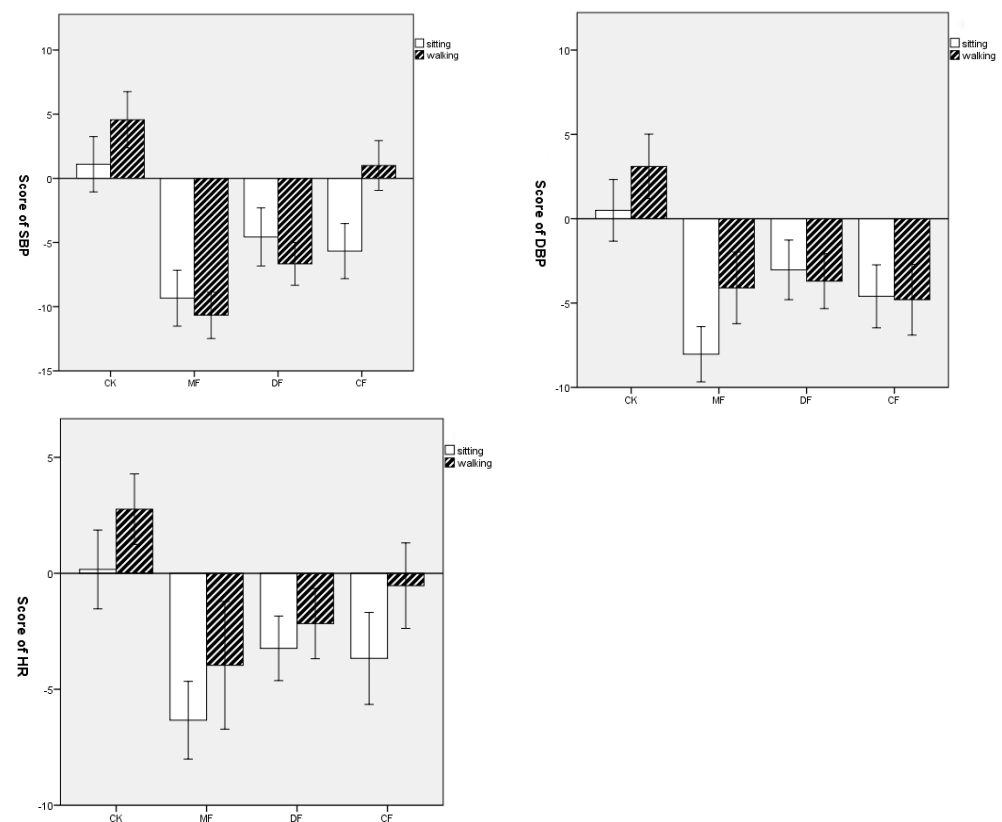
Table 4 shows the mean values and standard deviation (SD) of the measured physiological indicators. The results analysis showed that, compared with the urban site (CK),

there was a decrease in blood pressure and heart rate after the sitting activity in all three forests, with the strongest decrease in the mixed forest and the lowest decrease in the deciduous forest. The walking activity in the mixed and deciduous forest was correlated with a decrease in SBP, with a better decrease in the mixed forest, but the walking activity in the coniferous forest was related with an increase in SBP. The values of DBP and HR decreased in all three forests after the sitting and walking activities, the most significant decrease of DBP and HR was observed in the mixed forest after the sitting activity (Figure 3).

**Table 4.** Mean, standard deviation (SD) for physiological parameters (systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR)) in four experimental sites at baseline (T0), after sitting (T3) and after walking (T6) activities, corresponding significant changes with respect to baseline.

		City Site		Mixed Forest		Deciduous Forest		Coniferous Forest	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
SBP	Baseline (T0)	113.30	4.71	117.10	4.44	114.33	6.48	116.07	5.35
	Sitting (T3)	114.40	7.31	107.77 **	8.12	109.77 **	8.13	110.40 **	7.26
	Walking (T6)	117.87 **	6.78	106.43 **	7.70	107.67 **	6.34	117.07	5.41
DBP	Baseline (T0)	66.70	4.24	70.77	5.12	68.63	5.50	71.30	4.69
	Sitting (T3)	67.20	5.73	62.73 **	5.87	65.60 *	6.32	66.70 **	6.15
	Walking (T6)	69.80 *	5.88	66.67 **	7.06	64.93 **	5.17	66.50 **	5.59
HR	Baseline (T0)	79.70	4.09	82.07	3.61	78.60	3.38	80.63	3.01
	Sitting (T3)	79.87	4.22	75.73 **	4.40	75.37 **	4.00	76.97 *	5.14
	Walking (T6)	82.47 *	4.66	78.10 *	6.54	76.43 *	5.24	80.10	5.82

Note. \*\* is significant at  $p < 0.01$ . \* is significant at  $p < 0.05$  level.



**Figure 3.** Comparison of changes in SBP and DBP as well as HR at the four environmental sites after sitting and walking activities. Data were presented as the means  $\pm$  SEs. CK = city site, MF = mixed forest, DF = deciduous forest, CF = coniferous forest.



### 3.2. Psychological Parameters

#### 3.2.1. Results of Differences in Psychological Parameters

Table 5 shows the results of repeated-measures ANOVAs for physiological parameters. In the case of the ROS, SVS and WEMWBS, as well as the six subscales of POMS indicators, there was a significant change in the “site”. Great difference was found in the “time” of ROS and the vigor subscale of POMS. There were also significant interactions effects on SVS, WEMWBS and the vigor subscale of POMS between “site” and “time”.

**Table 5.** Results of Repeated-Measures ANOVAs for psychological parameters (ROS, SVS, WEMWBS and all subscales of POMS), degrees of freedom and *F* statistics.

	DF	ROS	SVS	WEMWBS	Subscales of POMS					
					T-A	A-H	F	D	V	C
Site	3	165.44 **	391.27 **	111.17 **	221.97 **	64.22 **	81.13 **	90.88 **	196.39 **	178.12 **
Time	1	18.25 **	2.40	1.19	2.16	0.51	0.06	0.03	52.25 **	0.13
Site × time	3	2.50	3.12 *	3.96 *	0.37	0.25	0.83	0.80	13.81 **	0.50

Note. \*\* *F* is significant at  $p < 0.01$ . \* *F* is significant at  $p < 0.05$  level.

#### 3.2.2. Results of Changes in ROS

The mean values and standard deviation (SD) of the Restoration Outcome Scale (ROS) score are illustrated in Table 6. In all three kinds of forests, sitting and walking activities had positive effects on the ROS of the participants. The results showed that, compared to the city site (CK), the values of ROS increased in all three types of forest. For the sitting activity, the values of ROS presented the highest increase in the coniferous forest and the lowest increase in the deciduous forest. For the walking activity, there was a similar increasing as with the sitting activity, The value of ROS showed the highest increase in the coniferous forest followed by the mixed forest and deciduous forest. In short, the values of ROS achieved the best increase in the coniferous forest after the walking activity (Figure 4).

**Table 6.** Mean, standard deviation (SD) for psychological parameters (ROS, SVS and WEMWBS scales) in four experimental sites at baseline (T0), after sitting (T3) and after walking (T6) activities, corresponding significant changes with respect to baseline.

		City Site		Mixed Forest		Deciduous Forest		Coniferous Forest	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
ROS	Baseline (T0)	2.03	0.75	2.21	0.78	2.15	0.76	1.79	0.81
	Sitting (T3)	1.12 **	0.85	4.14 **	1.36	4.04 **	1.26	3.99 **	1.16
	Walking (T6)	1.90	0.92	4.35 **	1.26	4.25 **	1.16	4.03 **	1.37
SVS	Baseline (T0)	1.83	1.03	1.74	0.88	1.80	0.95	1.97	0.91
	Sitting (T3)	1.01 **	0.74	4.43 **	1.09	4.15 **	1.29	4.03 **	1.37
	Walking (T6)	0.89 **	0.70	4.78 **	1.03	4.54 **	1.11	3.85 **	1.48
WEMWBS	Baseline (T0)	1.86	0.710	1.93	0.715	2.01	0.72	1.89	0.73
	Sitting (T3)	1.65 *	1.05	2.85 **	0.922	2.88 **	0.93	3.21 **	0.78
	Walking (T6)	1.48 **	1.01	3.04 **	0.84	3.02 **	0.90	2.83 **	0.91

Note. \*\* is significant at  $p < 0.01$ . \* is significant at  $p < 0.05$  level.

#### 3.2.3. Results of Changes in SVS

Compared with the city site (CK), the SVS increased after the sitting and walking activities in all three forests. The analysis of study showed that the highest increase in the SVS was in the mixed forest followed by the deciduous forest and coniferous forest after the sitting activity. For the walking activity, the values of the SVS also showed the highest increase in the mixed forest, a higher increase in the deciduous forest and the lowest increase level for the coniferous forest. The highest increase in the SVS was found in the mixed forest after the walking activity (Figure 4).

### 3.2.4. Results of Changes in WEMWBS

The scores on the WEMWBS were observed to increase in all forests, while they decreased in the city site. For the sitting activity, WEMWBS presented the highest increase in values in the coniferous forest, and the lowest increase in the deciduous forest. For the walking activity, WEMWBS showed the highest increase in values in the mixed forest, a higher increase in the deciduous forest and the lowest increase level for the coniferous forest. Overall, the highest value of WEMWBS was observed in the coniferous forest after the sitting activity (Figure 4).

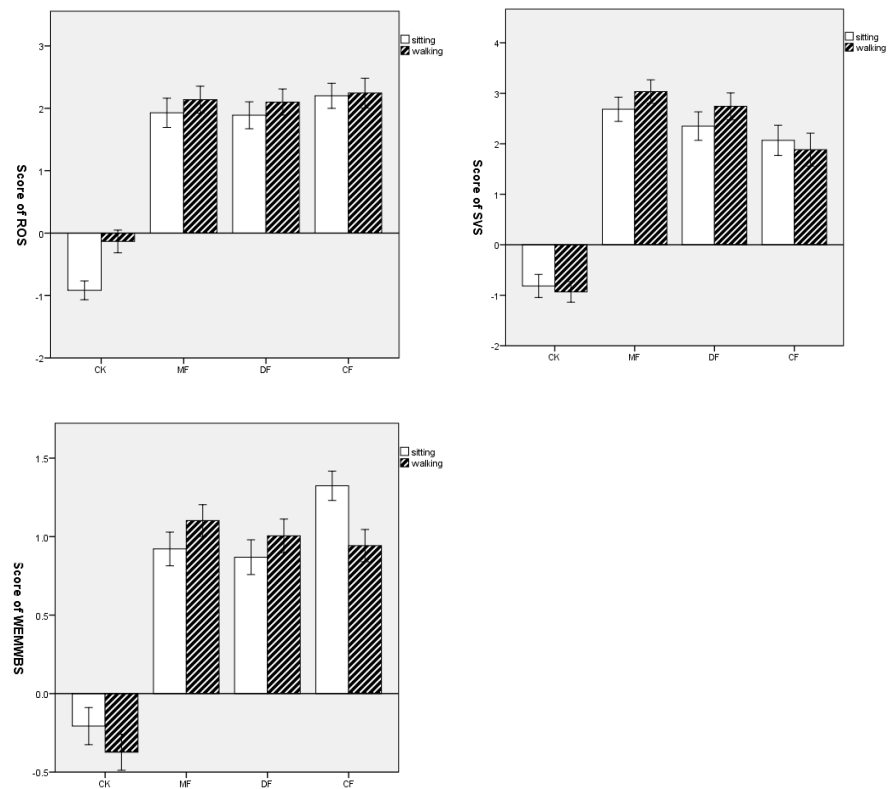
### 3.2.5. Results of Changes in POMS

In the case of the POMS, the mean values and standard deviation (SD) scores are illustrated in Table 7. The five subscales that measured negative mood state all had a lower value, while the vigor subscale indicated that positive mood state had a higher value in all three forests. The level of T-A, A-H, F and C scores had a similar decreasing trend after the sitting activity, with the highest decrease in the coniferous forest followed by the deciduous forest and mixed forest. The walking activity in the coniferous forest was correlated with the lowest level of T-A, A-H and C values, while walking in the deciduous forest was related to the lowest level of F and D values. The level of the V score indicated a similar increasing trend after both sitting and walking activities, with the highest increase in the mixed forest and the lowest increase in the coniferous forest. On the contrary, all the values of the T-A, A-H, F, D and C scores increased, while the value of V decreased in the urban site for both the sitting and walking activities (Figure 5).

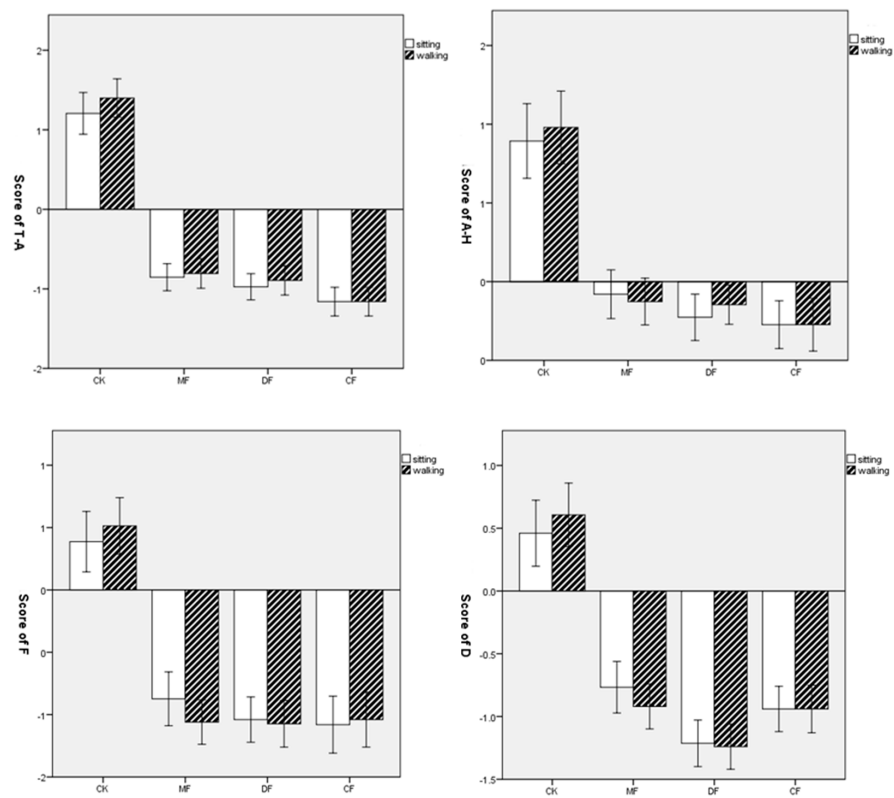
**Table 7.** Mean, standard deviation (SD) for psychological parameters (POMS subscales: tension–anxiety (T–A), anger–hostility (A–H), fatigue (F), depression (D), confusion (C) and vigor (V)) in four experimental sites at baseline (T0), after sitting (T3) and after walking (T5) activities, corresponding significant changes with respect to baseline.

		City Site		Mixed Forest		Deciduous Forest		Coniferous Forest	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
T–A	Baseline (T0)	1.31	0.83	1.42	0.81	1.50	0.76	1.70	0.83
	Sitting (T3)	2.51 **	1.38	0.57 **	0.80	0.53 **	0.70	0.54 **	0.75
	Walking (T6)	2.71 **	1.25	0.61 **	0.84	0.61 **	0.76	0.54 **	0.68
A–H	Baseline (T0)	0.65	0.85	0.67	0.80	0.73	0.71	0.08	0.83
	Sitting (T3)	1.54 **	1.25	0.59	0.92	0.50 *	0.78	0.55 **	0.86
	Walking (T6)	1.63 **	1.21	0.55	0.78	0.58 *	0.73	0.55 *	0.77
F	Baseline (T0)	1.55	0.91	1.66	0.86	1.76	0.78	1.74	0.95
	Sitting (T3)	1.94 *	1.32	0.79 **	1.00	0.72 **	0.84	0.66 **	0.91
	Walking (T6)	2.07 **	1.27	0.60 **	0.77	0.69 **	0.82	0.70 **	0.96
D	Baseline (T0)	1.35	0.89	1.47	0.83	1.79	0.83	1.48	0.83
	Sitting (T3)	1.81 *	1.28	0.70 **	0.92	0.58 **	0.74	0.54 **	0.78
	Walking (T6)	1.96 **	1.24	0.55 **	0.75	0.55 **	0.65	0.54 **	0.78
V	Baseline (T0)	1.61	0.78	1.78	0.79	1.79	0.74	1.75	0.70
	Sitting (T3)	1.31 *	0.98	3.09 **	0.82	3.46 **	0.56	2.45 **	1.08
	Walking (T6)	1.01 **	0.87	3.68 **	0.47	2.56 **	1.10	3.05 **	0.87
C	Baseline (T0)	1.29	1.03	1.46	0.95	1.63	0.83	1.65	1.02
	Sitting (T3)	2.38 **	1.40	0.73 **	0.87	0.66 **	0.86	0.64 **	0.91
	Walking (T6)	2.53 **	1.31	0.65 **	0.85	0.66 **	0.90	0.64 **	0.78

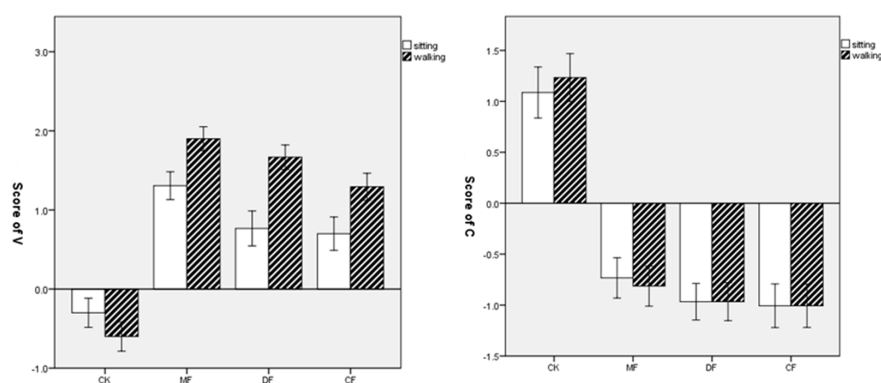
Note. \*\* is significant at  $p < 0.01$ . \* is significant at  $p < 0.05$  level.



**Figure 4.** Comparison of changes in ROS and SVS as well as WEMWBS of the four environmental sites after sitting and walking activities. Data were presented as the means  $\pm$  SEs. CK =city site, MF = mixed forest, DF = deciduous forest, CF = coniferous forest.



**Figure 5.** Cont.



**Figure 5.** Comparison of changes in POMS subscales (tension–anxiety (T–A), anger–hostility (A–H), fatigue (F), depression (D), confusion (C) and vigor (V)) of the four environmental sites after sitting and walking activities. Data were presented as the means  $\pm$  SEs. CK = city site, MF = mixed forest, DF = deciduous forest, CF = coniferous forest.

## 4. Discussion

### 4.1. Restorative Effects of Three Different Forests

In this study we investigated the restorative effects on subjects' physiological and psychological health of three different types of forest and an urban site. Results demonstrated that, compared to the urban site, all three forests were beneficial to lowering blood pressure and heart rate. The same conclusion was found in previous studies [61,62]. This study also found that all three forests could effectively reduce negative emotions and boost positive emotions, while these indicators at the urban site had the opposite results, which was in line with previous research on the restorative effects of forest [63]. The abovementioned results show that the first hypothesis of this study was confirmed.

The results also show that the restorative effects on physiological and psychological parameters are different between mixed forests, deciduous forests and coniferous forests. The second hypothesis of this study was confirmed. The mixed forest had a stronger restorative effect, with a decrease in SBP, DBP and HR, compared to the coniferous forest and deciduous forest. The values of SVS and V (subscale of POMS) were also at a higher level in the mixed forest. For other measures, the scores of ROS and WEMWBS increased effectively in the coniferous forest. In the case of the POMS, the level of T–A, A–H, F, D and C values were lowest in the coniferous forest. These results are in accordance with previous studies of forest preference, i.e., that mixed and coniferous forests are often preferred places for forest recreation compared to deciduous forests [64,65]. This preference may help individuals to obtain a better restorative effect through their emotional identification and dependence [66]. Moreover, forest characteristics are one of the important factors for the effect on human health of forest exposure. Mixed forests are more favored because the “mixed” pattern can show a contrast of vegetation colors and levels, and the form of plants is more natural and diverse [67]. Stigsdotter et al. [68] stated that the best type of forest for restoration should be an area that is semi-open, with a wide view and dense vegetation. This study also found that a higher level of vegetation within a landscape would provide a visually complex environment that is linked to a decrease in a person's stress and mental fatigue as well as enhanced feelings of restoration [16]. Some studies have emphasized the significance of forest structure for recreation and realized the importance of forest characteristics, such as forest cover, tree species composition and forest structure [21,65]. Additionally, Chiang et al. [41] found that forest density was closely connected with stress levels, and the result of their study confirmed that although medium density forests were more popular, high density forests caused higher attention levels in subjects. All of these results demonstrate that forest characteristics that have an impact on the forest landscape are associated with the restorative effects of forests.

The restorative effects of forests are also manifested in the release of beneficial substances, reduction of air pollutants and provision of a comfortable environment [69]. It was



confirmed that the blood pressure of subjects in response to quiet sound environments was lower than that of noisy sound environments [70]. The difference in air pollution may also be a reason for the impact of different types of forest environments on individual health. It was reported that particle and ozone exposure may decrease vagal tone, resulting in reduced HRV [71], and the exposure to PM<sub>2.5</sub> may be one of multiple factors that influence HRV and CRP [72]. The dust-retaining capacity of a deciduous forest is less than that of a coniferous forest, and the reason is that in a deciduous forest, the leaves usually fall in the non-growing season. Forest characteristics are also related to an environment in the forest that is conducive to improving participants' health.

#### 4.2. Restorative Effects of Two Different Experience Activities

We also hypothesized that the restorative effects of active and passive nature experience activities would be unequal. The results of this study showed the restorative effects were different between sitting and walking activities. The significant decrease in SBP and DBP remarkably relied on the walking activity performed in the forests. The sitting activity had a better decrease in HR. The values of ROS, SVS and WEMWBS greatly increased after the walking activity in the forests. Similarly, the level of V (subscale of POMS) greatly increased, while the levels of T-A, A-H, F, D and C decreased generally after walking in the forests. Overall, walking activity has a stronger restoration effect on both physiological and psychological health parameters. All of these results are broadly in line with previous findings that being physically active in a greenspace is conducive to improving health benefits rather than just exposure to the greenspace alone [49]. Walking in the forest may lower blood pressure by reducing sympathetic nerve activity [35]. Research proved that physical activity in outdoor, natural settings was more beneficial to health than the equivalent exertion in indoor or constructed settings [73]. Physical activity improves both the physiological and psychological health of all age groups, and physical activity in the presence of nature is confirmed to generate positive health outcomes [67]. Another study found that low-intensity physical activities in natural environment could increase subject positive mood by 60% and self-esteem by 70%, and the improvement effect was significant [73]. Thus, it is also important to note that the health outcomes of people who engage in different forms of experience or activity would differ.

#### 5. Limitations

The study investigated the changes in young people's physiological and psychological parameters following two activities (sitting and walking) in different types of forest. However, there are some limitations in this study. First, this study only found that short-term exposure to the forests had a positive effect on the subject's health restoration. It is not clear whether longer exposure to the forests would produce better restoration results. Second, all samples in the study consisted of university students from Beijing Forestry University. Although university students as subjects was acceptable as a suitable sample, future research should include subjects with different socio-demographic backgrounds to make the study results more widely and generally applicable. Third, most attention has concentrated on the forest performance in relation to restoration effects, and there was a lack of consideration for uncomfortable factors in the forest that may cause uncomfortable feelings, such as allergens, fear of living things and excessive exposure to ultraviolet radiation and mosquitoes.

#### 6. Conclusions

The study demonstrated the results from a field experiment of three types of forest on physiological and psychological health parameters. Results showed that all forests, compared to the urban site, were beneficial to the lowering of blood pressure and heart rate as well as for reducing negative emotions and boosting positive emotions. There were significant changes in analyzed physiological and psychological parameters in different forests after both sitting and walking compared to the baseline. In terms of blood pressure

and heart rate, the mixed forest was more effective in reducing them. Moreover, vitality had a higher-level score in the mixed forest. The levels of restoration and positive mental health increased significantly, while all subscales of the POMS (except vigor) decreased greatly in the coniferous forest. Relative to the sitting activity, obvious decreases in blood pressure and negative emotions but significant increases in restoration, vitality and positive mental health were observed after the walking activity. Therefore, it can be summarized that physiological and psychological changes were closely related to the forest types and experience and activity patterns. In conclusion, the impact on subjects' physiological and psychological restoration varied according to the forest characteristics, and the experiential characteristics of forest exposure may be helpful from the perspective of creating supportive forest interventions and lifting the benefits of forest therapy as people interact with a forest environment.

In light of the study results, walking activity is beneficial to health restoration; thus, it is necessary to choose a flat area in the forest to build trails for people to walk as almost all participants in forest therapy activities take walks at a steady and slow speed. The slope of the trail should be controlled within 8%, and the minimum width should be sufficient for one person to pass, preferably 1.5 m or more. The pavement material for the walkway can be made of soft ecological pavement materials such as soil, grass and humus that make people feel comfortable. At the same time, seats should be set up midway along the trail for rests. The results of this study showed that 30 min sitting and walking activities all decreased subjects' negative emotions and increased positive emotions. Therefore, 30 min should be considered as a suitable time period in the design of forest therapy activities. If the time is too long, it will make people feel tired. In addition, the priority should be given to multi-tree mixed forest stands or forests with abundant plant communities in the development of forest therapy activities as a mixed forest has better health improvement effects. A coniferous forest is suitable for passive activities, such as forest sitting, forest meditation and forest viewing, so exercise platforms can be added to flat areas in the forest.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** No publicly archived datasets analyzed or generated were used in this study.

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## References

1. Zhu, Y.-G.; Ioannidis, J.P.A.; Li, H.; Jones, K.C.; Martin, F.L. Understanding and Harnessing the Health Effects of Rapid Urbanization in China. *Environ. Sci. Technol.* **2011**, *45*, 5099–5104. [\[CrossRef\]](#)
2. Cox, D.T.; Hudson, H.L.; Shanahan, D.F.; Fuller, R.; Gaston, K.J. The rarity of direct experiences of nature in an urban population. *Landsc. Urban Plan.* **2017**, *160*, 79–84. [\[CrossRef\]](#)

3. Moore, M.; Gould, P.; Keary, B.S. Global urbanization and impact on health. *Int. J. Hyg. Environ. Health* **2003**, *206*, 269–278. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Dye, C. Health and Urban Living. *Science* **2008**, *319*, 766–769. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Maller, C.; Townsend, M.; Pryor, A.; Brown, P.; Leger, L.S. Healthy nature healthy people: ‘contact with nature’ as an upstream health promotion intervention for populations. *Health Promot. Int.* **2005**, *21*, 45–54. [\[CrossRef\]](#)
6. Keniger, L.E.; Gaston, K.J.; Irvine, K.N.; Fuller, R.A. What are the Benefits of Interacting with Nature? *Int. J. Environ. Res. Public Health* **2013**, *10*, 913–935. [\[CrossRef\]](#)
7. Tamosiunas, A.; Grazuleviciene, R.; Luksiene, D.; Dedele, A.; Reklaitiene, R.; Baceviciene, M.; Vencloviene, J.; Bernotiene, G.; Radisauskas, R.; Malinauskiene, V.; et al. Accessibility and use of urban green spaces, and cardiovascular health: Findings from a Kaunas cohort study. *Environ. Health* **2014**, *13*, 20. [\[CrossRef\]](#) [\[PubMed\]](#)
8. Kabisch, N.; Püffel, C.; Masztalerz, O.; Hemmerling, J.; Kraemer, R. Physiological and psychological effects of visits to different urban green and street environments in older people: A field experiment in a dense inner-city area. *Landsc. Urban Plan.* **2020**, *207*, 103998. [\[CrossRef\]](#)
9. Fan, Y.; Das, K.V.; Chen, Q. Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact. *Health Place* **2011**, *17*, 1202–1211. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Hartig, T.; Evans, G.W.; Jamner, L.D.; Davis, D.S.; Gärling, T. Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* **2003**, *23*, 109–123. [\[CrossRef\]](#)
11. Park, B.-J.; Furuya, K.; Kasetani, T.; Takayama, N.; Kagawa, T.; Miyazaki, Y. Relationship between psychological responses and physical environments in forest settings. *Landsc. Urban Plan.* **2011**, *102*, 24–32. [\[CrossRef\]](#)
12. Tsunetsugu, Y.; Lee, J.; Park, B.-J.; Tyrväinen, L.; Kagawa, T.; Miyazaki, Y. Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. *Landsc. Urban Plan.* **2013**, *113*, 90–93. [\[CrossRef\]](#)
13. Pasanen, T.P.; Ojala, A.; Tyrväinen, L.; Korpela, K.M. Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings. *J. Environ. Psychol.* **2018**, *59*, 85–93. [\[CrossRef\]](#)
14. Tyrväinen, L.; Ojala, A.; Korpela, K.; Lanki, T.; Tsunetsugu, Y.; Kagawa, T. The influence of urban green environments on stress relief measures: A field experiment. *J. Environ. Psychol.* **2014**, *38*, 1–9. [\[CrossRef\]](#)
15. White, M.P.; Pahl, S.; Ashbullby, K.; Herbert, S.; Depledge, M.H. Feelings of restoration from recent nature visits. *J. Environ. Psychol.* **2013**, *35*, 40–51. [\[CrossRef\]](#)
16. Ulrich, R.S.; Simons, R.F.; Losito, B.D.; Fiorito, E.; Miles, M.A.; Zelson, M. Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* **1991**, *11*, 201–230. [\[CrossRef\]](#)
17. Kaplan, S. The restorative benefits of nature: Toward an integrative framework. *J. Environ. Psychol.* **1995**, *15*, 169–182. [\[CrossRef\]](#)
18. Prüss, Ü.A.; Neira, M. Preventing disease through healthy environments: A global assessment of the burden of disease from environmental risks. *Rev. Epidemiol. Sante Publique* **2016**, *64*, 375. [\[CrossRef\]](#)
19. Tsunetsugu, Y.; Park, B.-J.; Miyazaki, Y. Trends in research related to “Shinrin-yoku” (taking in the forest atmosphere or forest bathing) in Japan. *Environ. Health Prev. Med.* **2009**, *15*, 27–37. [\[CrossRef\]](#)
20. Ribe, R.G. The aesthetics of forestry: What has empirical preference research taught us? *Environ. Manag.* **1989**, *13*, 55–74. [\[CrossRef\]](#)
21. Edwards, D.; Jay, M.; Jensen, F.S.; Lucas, B.; Marzano, M.; Montagné, C.; Peace, A.; Weiss, G. Public preferences for structural attributes of forests: Towards a pan-European perspective. *For. Policy Econ.* **2011**, *19*, 12–19. [\[CrossRef\]](#)
22. Daniel, T.C.; Schroeder, H. Scenic beauty estimation model: Predicting perceived beauty of forest landscapes. In Proceedings of the Our National Landscape: A Conference on Applied Techniques for Analysis and Management of the Visual Resource, Berkeley, CA, USA, 23–25 April 1979; pp. 514–523.
23. Chen, X.F.; Jia, L.M. Research on evaluation of in forest landscapes in West Beijing Mountain area. *Sci. Silv. Sin.* **2003**, *39*, 59–66. [\[CrossRef\]](#)
24. Kellomäki, S.; Savolainen, R. The scenic value of the forest landscape as assessed in the field and the laboratory. *Landsc. Plan.* **1984**, *11*, 97–107. [\[CrossRef\]](#)
25. Li, Q. What is Forest Medicine? In *Forest Medicine*; Nova Science Publishers: New York, NY, USA, 2013.
26. Zhao, Q.; Qian, W.H.; Tang, H.H.; Yang, Q.; Yan, J. Differences of health care functions of six forest stands in Yunyong Forest Park, Guangdong. *J. Zhejiang Univ.* **2018**, *35*, 750–756. [\[CrossRef\]](#)
27. Abe, T.; Hisama, M.; Tanimoto, S.; Shibayama, H.; Mihara, Y.; Nomura, M. Antioxidant Effects and Antimicrobial Activities of Phytoncides. *Biocontrol. Sci.* **2008**, *13*, 23–27. [\[CrossRef\]](#)
28. Li, Q.; Morimoto, K.; Kobayashi, M.; Inagaki, H.; Katsumata, M.; Hirata, Y.; Hirata, K.; Suzuki, H.; Li, Y.; Wakayama, 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*, 117–127. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Yokouchi, Y.; Ambe, Y. Factors affecting the emission of monoterpenes from red pine (*Pinus densiflora*). *Plant Physiol.* **1984**, *75*, 1009–1012. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Oh, B.; Lee, K.J.; Zaslowski, C.; Yeung, A.; Rosenthal, D.; Larkey, L.; Back, M. Health and well-being benefits of spending time in forests: Systematic review. *Environ. Health Prev. Med.* **2017**, *22*, 1–11. [\[CrossRef\]](#)
31. Twohig-Bennett, C.; Jones, A. The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environ. Res.* **2018**, *166*, 628–637. [\[CrossRef\]](#)

32. Park, B.-J.; Tsunetsugu, Y.; Kasetani, T.; Hirano, H.; Kagawa, T.; Sato, M.; Miyazaki, Y. 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*, 123–128. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Horiuchi, M.; Endo, J.; Takayama, N.; Murase, K.; Nishiyama, N.; Saito, H.; Fujiwara, A. Impact of Viewing vs. Not Viewing a Real Forest on Physiological and Psychological Responses in the Same Setting. *Int. J. Environ. Res. Public Health* **2014**, *11*, 10883–10901. [\[CrossRef\]](#) [\[PubMed\]](#)
34. Lanki, T.; Siponen, T.; Ojala, A.; Korpela, K.; Pennanen, A.; Tiittanen, P.; Tsunetsugu, Y.; Kagawa, T.; Tyrväinen, L. Acute effects of visits to urban green environments on cardiovascular physiology in women: A field experiment. *Environ. Res.* **2017**, *159*, 176–185. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Li, Q.; Otsuka, T.; Kobayashi, M.; Wakayama, Y.; Inagaki, H.; Katsumata, M.; Hirata, Y.; Li, Y.; Hirata, K.; Shimizu, T.; et al. Acute effects of walking in forest environments on cardiovascular and metabolic parameters. *Graefes Arch. Clin. Exp. Ophthalmol.* **2011**, *111*, 2845–2853. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Herzog, T.R.; Colleen; Maguire, P.; Nebel, M.B. Assessing the restorative components of environments. *J. Environ. Psychol.* **2003**, *23*, 159–170. [\[CrossRef\]](#)
37. Marselle, M.R.; Irvine, K.N.; Lorenzo-Arribas, A.; Warber, S.L. Moving beyond Green: Exploring the Relationship of Environment Type and Indicators of Perceived Environmental Quality on Emotional Well-Being following Group Walks. *Int. J. Environ. Res. Public Health* **2014**, *12*, 106–130. [\[CrossRef\]](#)
38. Grilli, G.; Sacchelli, S. Health Benefits Derived from Forest: A Review. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6125. [\[CrossRef\]](#)
39. Simkin, J.; Ojala, A.; Tyrväinen, L. Restorative effects of mature and young commercial forests, pristine old-growth forest and urban recreation forest—A field experiment. *Urban For. Urban Green.* **2020**, *48*. [\[CrossRef\]](#)
40. Paletto, A.; de Meo, I.; Grilli, G.; Nikodinoska, N. Effects of different thinning systems on the economic value of ecosystem services: A case-study in a black pine peri-urban forest in Central Italy. *Ann. For. Res.* **2014**, *60*, 313–326. [\[CrossRef\]](#)
41. Chiang, Y.-C.; Li, D.; Jane, H.-A. Wild or tended nature? The effects of landscape location and vegetation density on physiological and psychological responses. *Landsc. Urban Plan.* **2017**, *167*, 72–83. [\[CrossRef\]](#)
42. Saito, H.; Horiuchi, M.; Takayama, N.; Fujiwara, A. Effects of managed forest versus unmanaged forest on physiological restoration from a stress stimulus, and the relationship with individual traits. *J. For. Res.* **2019**, *24*, 77–85. [\[CrossRef\]](#)
43. Sacchelli, S.; Grilli, G.; Capecchi, I.; Bambi, L.; Barbierato, E.; Borghini, T. Neuroscience Application for the Analysis of Cultural Ecosystem Services Related to Stress Relief in Forest. *Forests* **2020**, *11*, 190. [\[CrossRef\]](#)
44. Wang, R.; Zhao, J. Effects of evergreen trees on landscape preference and perceived restorativeness across seasons. *Landsc. Res.* **2020**, *45*, 649–661. [\[CrossRef\]](#)
45. Bratman, G.N.; Anderson, C.B.; Berman, M.G.; Cochran, B.; Daily, G.C. Nature and mental health: An ecosystem service perspective. *Sci. Adv.* **2019**, *5*, eaax0903. [\[CrossRef\]](#) [\[PubMed\]](#)
46. Nutsford, D.; Pearson, A.L.; Kingham, S.; Reitsma, F. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. *Health Place* **2016**, *39*, 70–78. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Conniff, A.; Craig, T. A methodological approach to understanding the wellbeing and restorative benefits associated with greenspace. *Urban For. Urban Green.* **2016**, *19*, 103–109. [\[CrossRef\]](#)
48. Kahn, P.H.; Ruckert, J.H.; Severson, R.L.; Reichert, A.L.; Fowler, E. A Nature Language: An Agenda to Catalog, Save, and Recover Patterns of Human–Nature Interaction. *Ecopsychology* **2010**, *2*, 59–66. [\[CrossRef\]](#)
49. Breckenkamp, J.; Blettner, M.; Laaser, U. Physical activity, cardiovascular morbidity and overall mortality: Results from a 14-year follow-up of the German Health Interview Survey. *J. Public Health* **2004**, *12*, 321–328. [\[CrossRef\]](#)
50. Kobayashi, H.; Ikei, H.; Song, C.; Kagawa, T.; Miyazaki, Y. Comparing the impact of forest walking and forest viewing on psychological states. *Urban For. Urban Green.* **2020**, *57*, 126920. [\[CrossRef\]](#)
51. Zeng, C.; Lyu, B.; Deng, S.; Yu, Y.; Li, N.; Lin, W.; Li, D.; Chen, Q. Benefits of a Three-Day Bamboo Forest Therapy Session on the Physiological Responses of University Students. *Int. J. Environ. Res. Public Health* **2020**, *17*, 3238. [\[CrossRef\]](#)
52. Zhong, D.Y. Analysis of college students' physical and mental sub-health. *Educ. Vocat.* **2012**, *9*, 101–102. [\[CrossRef\]](#)
53. Regehr, C.; Glancy, D.; Pitts, A. Interventions to reduce stress in university students: A review and meta-analysis. *J. Affect. Disord.* **2013**, *148*, 1–11. [\[CrossRef\]](#) [\[PubMed\]](#)
54. Zhu, B.L. Brief introduction of POMS scale and its model for China. *J. Tianjin Inst. Phys. Educ.* **1995**, *10*, 35–37.
55. Takayama, N.; Korpela, K.; Lee, J.; Morikawa, T.; Tsunetsugu, Y.; Park, B.-J.; Li, Q.; Tyrväinen, L.; Miyazaki, Y.; Kagawa, T. Emotional, Restorative and Vitalizing Effects of Forest and Urban Environments at Four Sites in Japan. *Int. J. Environ. Res. Public Health* **2014**, *11*, 7207–7230. [\[CrossRef\]](#)
56. Ryan, R.M.; Frederick, C. On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. *J. Pers. Med.* **1997**, *65*, 529–565. [\[CrossRef\]](#)
57. Tennant, R.; Hiller, L.; Fishwick, R.; Platt, S.; Joseph, S.; Weich, S.; Parkinson, J.; Secker, J.; Stewart-Brown, S. The Warwick-Edinburgh Mental Well-being Scale (WEMWBS): Development and UK validation. *Health Qual. Life Outcomes* **2007**, *5*, 63. [\[CrossRef\]](#) [\[PubMed\]](#)
58. Zhao, B.H.; Guo, J.Q.; Zhang, X.; Pan, Y.L. Reliability, and validity of Warwick-Edinburgh Mental Well-being Scale (WEMWBS) in middle-school students. *Chin. J. Clin. Psych.* **2019**, *27*, 286–289. [\[CrossRef\]](#)



59. Janeczko, E.; Bielinis, E.; Wójcik, R.; Woźnicka, M.; Kędziora, W.; Łukowski, A.; Elsadek, M.; Szyc, K.; Janeczko, K. When Urban Environment is Restorative: The Effect of Walking in Suburbs and Forests on Psychological and Physiological Relaxation of Young Polish Adults. *Forests* **2020**, *11*, 591. [\[CrossRef\]](#)
60. Bielinis, E.; Łukowski, A.; Omelan, A.; Boiko, S.; Takayama, N.; Grebner, D.L. The Effect of Recreation in a Snow-Covered Forest Environment on the Psychological Wellbeing of Young Adults: Randomized Controlled Study. *Forests* **2019**, *10*, 827. [\[CrossRef\]](#)
61. Ikei, H.; Song, C.; Igarashi, M.; Namekawa, T.; Miyazaki, Y. Physiological and psychological relaxing effects of visual stimulation with foliage plants in high school students. *Adv. Hortc. Sci.* **2014**, *28*, 111–116. [\[CrossRef\]](#)
62. Park, B.J.; 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.* **2009**, *15*, 18–26. [\[CrossRef\]](#) [\[PubMed\]](#)
63. Lee, J.; Park, B.-J.; 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*, 93–100. [\[CrossRef\]](#)
64. Grilli, G.; Paletto, A.; de Meo, I. Economic valuation of forest recreation in an Alpine Valley. *Balt. For.* **2014**, *20*, 167–175.
65. Paletto, A.; de Meo, I.; Cantiani, M.G.; Maino, F. Social Perceptions and Forest Management Strategies in an Italian Alpine Community. *Mt. Res. Dev.* **2013**, *33*, 152–160. [\[CrossRef\]](#)
66. Pretty, J.; Peacock, J.; Sellens, M.; Griffin, M. The mental and physical health outcomes of green exercise. *Int. J. Environ. Health Res.* **2005**, *15*, 319–337. [\[CrossRef\]](#)
67. Chen, X.F.; Jia, L.M.; Wang, Y. Landscape estimation and management technique principles of different seasonal scenic and recreational forests in West Mountain, Beijing. *J. Beijing Univ.* **2008**, *30*, 39–45.
68. Stigsdotter, U.K.; Corazon, S.S.; Sidenius, U.; Refshauge, A.D.; Grahm, P. Forest design for mental health promotion—Using perceived sensory dimensions to elicit restorative responses. *Landsc. Urban Plan.* **2017**, *160*, 1–15. [\[CrossRef\]](#)
69. Li, Q. *Forest Medicine*, 1st ed.; Science Press: Beijing, China, 2013; pp. 13–31.
70. Mishima, R.; Kudo, T.; Tsunetsugu, Y.; Miyazaki, Y.; Yamamura, C.; Yamada, Y. Effects of sounds generated by a dental turbine and a stream on regional cerebral blood flow and cardiovascular responses. *Odontology* **2004**, *92*, 54–60. [\[CrossRef\]](#)
71. Gold, D.R.; Litonjua, A.; Schwartz, J.; Lovett, E.; Verrier, R. Ambient Pollution and Heart Rate Variability. *Circulation* **2000**, *101*, 1267–1273. [\[CrossRef\]](#)
72. Pope, C.A.; Hansen, M.L.; Long, R.W.; Nielsen, K.R.; Eatough, N.L.; E Wilson, W.; Eatough, D.J. Ambient particulate air pollution, heart rate variability, and blood markers of inflammation in a panel of elderly subjects. *Environ. Health Perspect.* **2004**, *112*, 339–345. [\[CrossRef\]](#)
73. Barton, J.; Pretty, J. What is the Best Dose of Nature and Green Exercise for Improving Mental Health? A Multi-Study Analysis. *Environ. Sci. Technol.* **2010**, *44*, 3947–3955. [\[CrossRef\]](#)