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Physiological and Psychological Effects of Virtual Park Therapy in Bogor City Parks on Young Adults

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ABSTRACT

Urbanization causes limited access to nature; therefore, virtual reality (VR) is needed to stay connected to nature. This study aims to identify the physiological and psychological effects of park therapy using VR. This study was conducted using experimental methods via a VR survey. The parameters observed included physiological effects, such as heart rate and blood pressure, and psychological effects, such as mood, level of anxiety, restorativeness, and landscape perception. Profile of Mood States, State-Trait Anxiety Inventory, Perceived Restorativeness Scale, and Semantic Differential questionnaires were administered to the subject. Virtual park therapy in three locations resulted in possibly lower heart rates when walking in Bogor City Alun-alun, while lower heart rates when seated viewing in Heulang Park; decreased anger, tension, confusion, and depression after walking and decreased anger, tension, confusion, and fatigue after seated viewing, increased vigor after walking and seated viewing in all locations, decreased anxiety status after seated viewing in all locations; restorative effects of fascination, coherence, and compatibility with the highest results in Heulang Park. Sempur Park provides a therapeutic effect because it has thermal comfort and gives regularity to the psychological effect. Virtual park therapy in urban greenspaces is proven to have physiological and psychological relaxation effects.

Introduction

Forest bathing-related research has been conducted in Japan, China, Korea, America, Great Britain, Finland, Hungary, Canada, Taiwan, Singapore, Malaysia, and Indonesia [1,2,11–15,3–10]. Forest bathing is defined as spending time in nature and breathing in the forest atmosphere, which can improve both physical and mental health [16,17]. Forest therapy studies on young adults showed that a 1-day forest therapy program lowered blood pressure during the program and maintained it for five days [18]. A 15-minute bamboo forest walk on young adults resulted in lower blood pressure, increased mind waves, improved mood, and decreased anxiety [5]. Park therapy is effective for urban dwellers who want free and easy access to nature [19,20]. Walking in and viewing parks can lower the heart rate [21,22] and blood pressure [23,24], stabilize sympathetic and parasympathetic balance [18,25], improve mood, and reduce anxiety in young adults [9,26]. Based on landscape standpoint, Indonesia has a high potential for health effects through park therapy owing to its high biodiversity.

Previous research conducted on college students demonstrated that walking in arboretums and campus parks can reduce heart rate; reduce negative moods such as confusion, depression, and tension; and reduce anxiety status. Most of the photos taken by the participants were taken in the arboretum and campus parks.

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The components of park therapy that correlate with decreased mood disorders and anxiety are the plant community, plant, flower, and sky [9,26]. The utilization of digital technology and information is currently the main focus for overcoming existing problems and challenges. Currently, VR technology can analyze psychological problems, especially to improve physiological and psychological well-being in young adults without direct exposure to nature [27,28]. Virtual forest and park therapy can be applied to various mental disorders, such as stress, anxiety, and depression [29].

The advantage of using the latest virtual reality (VR) is that it can increase accessibility in simulated greenspaces, which has higher benefits when immersed in a forest landscape [30]. Meanwhile, the challenges and ethics of using VR in therapy include strict ethical guidelines to ensure that mental health data remain secure, patient privacy is maintained [31–33], and the potential for dependence on technology [34]. In the future, integrating VR with other technologies, such as Artificial Intelligence (AI) and biometric sensors, offers significant potential in landscape therapy and design [35,36].

Previous laboratory-based research has used two-dimensional media, such as landscape photographs printed and displayed on a screen, to assess perceptions and preferences regarding the aesthetic qualities of a landscape [37,38]. When faced with the need for green space therapy over a certain period, various elements must stimulate the senses and provide optimal physical and physiological benefits to subjects. Landscape research is increasingly being conducted using panoramic photographs through VR glasses as visual stimulation to assess the perceptions and preferences of urban green spaces [39,40], as well as to analyze the physiological and psychological effects of green space therapy [41,42].

The VR has proven to be an accurate and powerful tool for assessing the aesthetic quality of a landscape and obtaining physical and psychological health benefits. Thus, virtual park therapy is important for studying physiological and psychological restoration in public urban green spaces, such as urban parks. This study aimed to identify the physiological and psychological effects of urban green spaces on young adults and to evaluate their perception of the landscape using a VR survey.

Materials and Methods

Study Area

The research was carried out from June to December 2022 in three locations, Bogor City Alun-alun, Sempur Park, and Heulang Park (Figure 1), while the Liaison Office of Chiba University-IPB University was used as the experimental room (Figure 2). The research stages included preparation, data collection, data processing (analysis of physiological and psychological responses, level of restoration, aesthetic preferences), and preparation of recommendations. The criteria for selecting the type of green open space are: 1) security, 2) parks or forest areas that are well maintained, and 3) control areas located near activity centers in Bogor City [12,13,21,22].

Figure 1. Viewing points and walking course in Bogor City: Alun-alun (A), Sempur Park (B), and Heulang Park (C).

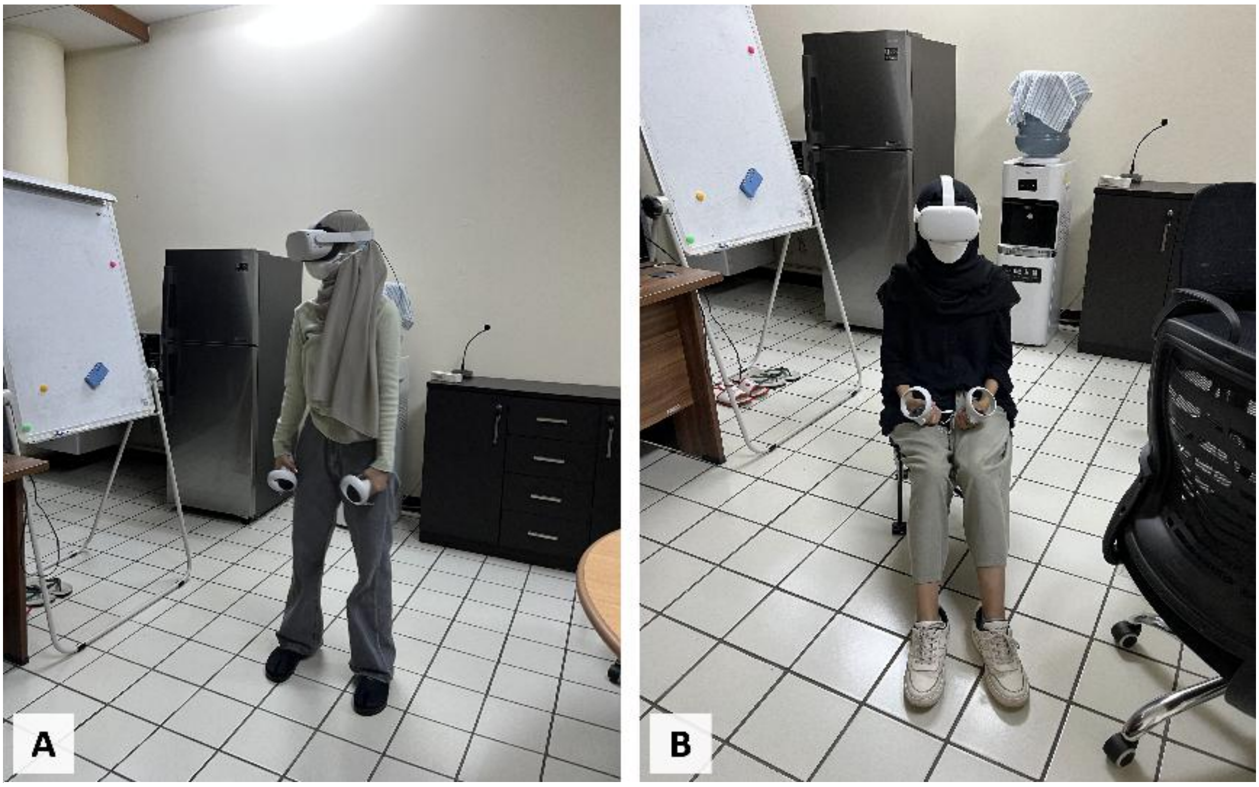


Figure 2. Virtual reality experiment: walking (A) and seated viewing (B).

Tools and Materials

Heart rate was measured as a physiological response using a sensor (MyBeat WHS-3; Union Tool, Tokyo, Japan). Blood pressure was measured using a digital sphygmomanometer (Omron HEM-1021; Omron Corp., Kyoto, Japan). The Profile of Mood States (POMS) and State-Trait Anxiety Inventory (STAI) were used to assess psychological responses. POMS is an instrument used to evaluate negative and positive emotional responses to garden displays [43,44]. The Indonesian version of the POMS questionnaire consists of 35 statements with 4-point Likert scales [45]. State anxiety is a subscale of the STAI that measures anxious states [46,47]. The Indonesian version of the STAI questionnaire consists of 20 statement items with 4-point Likert scales [48]. The Perceived Restorativeness Scale (PRS) was used to assess the stimulating environment developed by Terry Hartig based on the Attention Restoration Theory [49,50]. The Indonesian version of the PRS Questionnaire includes 17 statement items that measure the degree to which certain environments restore mental alertness; for example, "being away", "fascination", "coherence", "scope", and "compatibility" with 5-point Likert scale [50]. Semantic Differential (SD) is used to assess aesthetic quality using 20 bipolar adjectives with 7-point Likert scales [51].

Experimental Design

The Virtual Reality (VR) experiment was conducted in the Liaison Office room of Chiba University-IPB University, Department of Landscape Architecture, Faculty of Agriculture IPB. The videos were shot with a GoPro MAX (GoPro Inc., San Mateo, California, USA) and displayed with an HMD Oculus Quest 2 (Facebook Technologies, LLC, Menio Park, California, USA), which has an 1832 x 1920-pixel resolution display and provides an immersive VR experience by tracking head movements to update visual appearance. The room boundary size should be at least 2 x 1.5 m in order to achieve a realistic and comfortable VR experience [52]. Respondents were asked to stand and turn around their body following the turn in the video consistently or sit on an outdoor chair during the VR experience. Before and after viewing the video, the participants began to measure their heart rate and blood pressure and completed the same questionnaire as the on-site survey before and after watching the video (Table 1). To eliminate the sequence effect when using a headset, respondents watched random panoramic videos stored on the device [39].

Table 1. Schedule of VR experiment activities in a day.

Time	Activity (location)
08.00	Gathering in the lobby of the Faculty of Agriculture, IPB University (Landscape Workshop, Faculty of Agriculture)
08.00–08.15	Experiment orientation
08.15–08.25	Heart rate and blood pressure measurements, as well as completion of the pre-experimental 1 questionnaire (break room)
08.25–08.40	VR video showing a walking/sitting scene 1 (heart rate measurement continues)
08.40–08.55	Blood pressure measurement, post-experiment 1 questionnaire completion (break room), stopping heart rate measurement
08.55–09.05	Rest
09.05–09.15	Heart rate and blood pressure measurements, as well as completion of the pre-experimental 1 questionnaire (break room)
09.15–09.30	VR video showing a walking/sitting scene 2 (heart rate measurement continues)
09.30–09.45	Blood pressure measurement, post-experimental questionnaire filling 2 (break room), stopping heart rate measurement
09.45–09.55	Rest
09.55–10.05	Heart rate and blood pressure measurements, as well as completion of the pre-experimental questionnaire 3 (break room)
10.05–10.20	VR video showing a walking/sitting scene 3 (heart rate measurement continues)
10.20–10.40	Blood pressure measurement and completion of the post-experimental questionnaire 3, stopping heart rate measurement (break room)

Data Collection Method

Subject eligibility criteria included (1) IPB students aged 19–26 years, (2) students living in Bogor and its surroundings, (3) not currently being treated for cardiovascular disease and hypertension, and (4) ability to walk for 20 minutes or more without difficulty [9]. From an academic perspective, university students are representative of young adults. They can find experience in assessing places [53,54]. Snowball sampling was used to select the experimental participants, who included ten key informants from various faculties. The Snowball sampling method is one of the most effective methods for finding participant candidates related to the eligibility criteria [55] with three stages: (1) sending announcement posters through social networking services (SNS) using WhatsApp, American freeware, cross-platform centralized messaging, and voice-over-IP services owned by Facebook; (2) a statement of willingness to participate in the experiment via Google Forms was provided on the poster, (3) an explanation of the research objectives and procedures before the experiment, and (4) follow-up of experimental information via WhatsApp. The experimental procedure complied with the guidelines established by the Research Ethics Commission for Human Subjects of IPB University (Number: 735/IT3.KEPMSM-IPB/SK/2022).

Data Analysis Procedures

Preparation stage

In the preparation stage, the researcher distributed online questionnaires regarding participant selection and participant attributes such as gender, major, and willingness. Researchers also conducted a preliminary survey to determine the walking courses and viewing points in the park, which were recorded using GoPro MAX. There are three experimental locations, namely Bogor City Alun-alun, Sempur Park, and Heulang Park, where each park has one walking course and one viewing point, respectively.

Data processing stage

The physiological, psychological, and aesthetic quality preferences data of the 30 participants were analyzed. To examine the physiological (heart rate and blood pressure) and psychological (mood and anxiety level) responses, the tests used were: Friedman's test with three-location factor levels (Bogor City Alun-alun, Sempur Park, Heulang Park), Friedman's test with two-time factor levels (before and after walking/seated viewing) and three-location factor levels (Bogor City Alun-alun, Sempur Park, Heulang Park), and Repeated Measures ANOVA with two-time factor levels (before and after walking/seated viewing) and three-location factor levels (Bogor City Alun-alun, Sempur Park, Heulang Park). Four restorative qualities data, including "Being Away", "Fascination", Compatibility", and "Coherence" in each park, were tested with the Kruskal Wallis Test and continued with the Post Hoc test to see significant differences between different experimental locations on the restoration level subscale after doing walking and sitting activities. Data on aesthetic quality preferences after walking and sitting in the three parks were tested using Factor Analysis with the Principal Component Analysis to evaluate the visual aesthetic quality of the views of each park. All data are presented as mean standard deviation (SD), with statistical differences considered significant a $p < 0.05$. All statistical analyses were done using IBM SPSS 22 (IBM Corp., Armonk, NY, USA).

Results

Validity and Reliability of a Scale Measuring Physiological, Psychological, Restorative Value, and Landscape Perception

The internal consistency (Cronbach's alpha) of the physiological and psychological indices of the 30 subjects is shown in Table 2. The alpha reliabilities of heart rate while walking and seated viewing were 0.762 and 0.864, respectively; blood pressure while walking and seated viewing were 0.890 and 0.908, respectively. The POMS index's alpha reliability in walking and seated viewing was 0.906 and 0.907, respectively; for STAI, it was 0.917 and 0.913; for the PRS index, it was 0.911 and 0.917; and for the SD index, it was 0.769 and 0.833, respectively. The heart rate, blood pressure, POMS, STAI, PRS, and SD had high internal consistency. As a result, in this study, all indices had acceptable validity and reliability.

Table 2. Internal verification.

Parameter	Activity	Cronbach's α
POMS	Walking	0.906
	Seated-viewing	0.907
STAI	Walking	0.917
	Seated-viewing	0.913
PRS	Walking	0.911
	Seated-viewing	0.917
SD	Walking	0.769
	Seated-viewing	0.833

The representation of validity was examined using Pearson's correlation for physiological data and Spearman's correlation for psychological data. The correlation coefficient value for heart rate while walking and seated viewing was 0.575–0.809 (p = 0.025–0.000) and 0.849–0.953 (p = 0.000); for blood pressure, while walking and seated viewing was 0.710–0.877 (p = 0.000) and 0.719–0.910 (p = 0.000); for POMS while walking and seated viewing was 0.489–0.801 (p = 0.006-0.000) and 0.588–0.806 (p = 0.001-0.000); for STAI while walking and seated viewing was 0.491–0.889 (0.006–0.000) and 0.391–0.819 (p = 0.033–0.000); for PRS while walking and seated viewing was 0.363–0.895 (p = 0.049–0.000) and 0.362–0.833 (p = 0.049–0.000); for SD while walking and seated viewing was 0.362–0.834 (p = 0.049–0.000) and 0.362–0,756 (p = 0.049–0.000). As expected, the correlations of each parameter at different times and park locations varied from low to high. We found that the heart rate and blood pressure validity during walking and seated viewing were very high.

Physiological Effects

Heart rate data were analyzed using the Friedman test because the data were not normally distributed. The heart rate graph (Figure 3) shows a lower average heart rate when the subject walks in Bogor City Alun-alun than in Sempur Park and Heulang Park, with average values of 89.69 bpm, 93.45 bpm, and 93 bpm, respectively. There was no significant difference when the subjects sat in Bogor City, Alun-alun, Sempur Park, and Heulang Park, with average values of 79.20, 78.83, and 78.33 bpm, respectively. Although significant results were obtained when walking activities were virtually in all three locations (p = 0.000), sitting activities tended to have a lower heart rate (p =0.057) (Table 3).

Table 3. Friedman test results for heart rate.

Parameter	Chi-Square	df	Asymp. Sig.
Heart rate while walking	22.800	2	0.000***
Heart rate while seated viewing	5.733	2	0.057

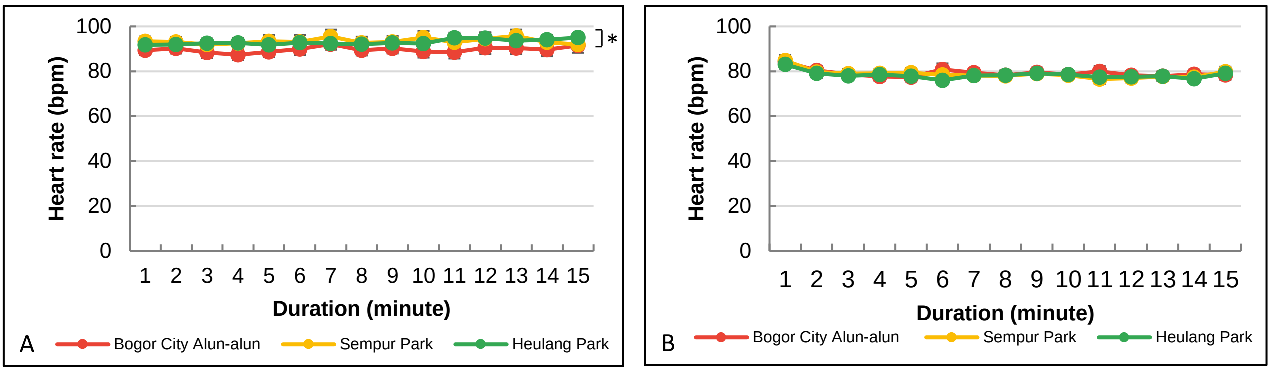


Figure 3. Average heartbeats per minute in Bogor City, Alun-alun, Sempur Park, and Heulang Park: virtual walking experiment (A) and virtual-seated viewing experiment (B). N = 30, mean ± standard error. * $p < 0.05$, determined using the Friedman test.

The blood pressure was evaluated with a Repeated Measures ANOVA because the data obtained was normally distributed. Figure 4 depicts an increase in average blood pressure when subjects visited Bogor City Alun-alun and Heulang Park, and a decrease in average blood pressure when subjects visited Sempur Park. Diastolic and systolic blood pressure measurements revealed no significant differences in walking ($p = 0.689$, $p = 0.831$) and seated viewing experiments ($p = 0.449$, $p = 0.301$) across the three parks (Table 4).

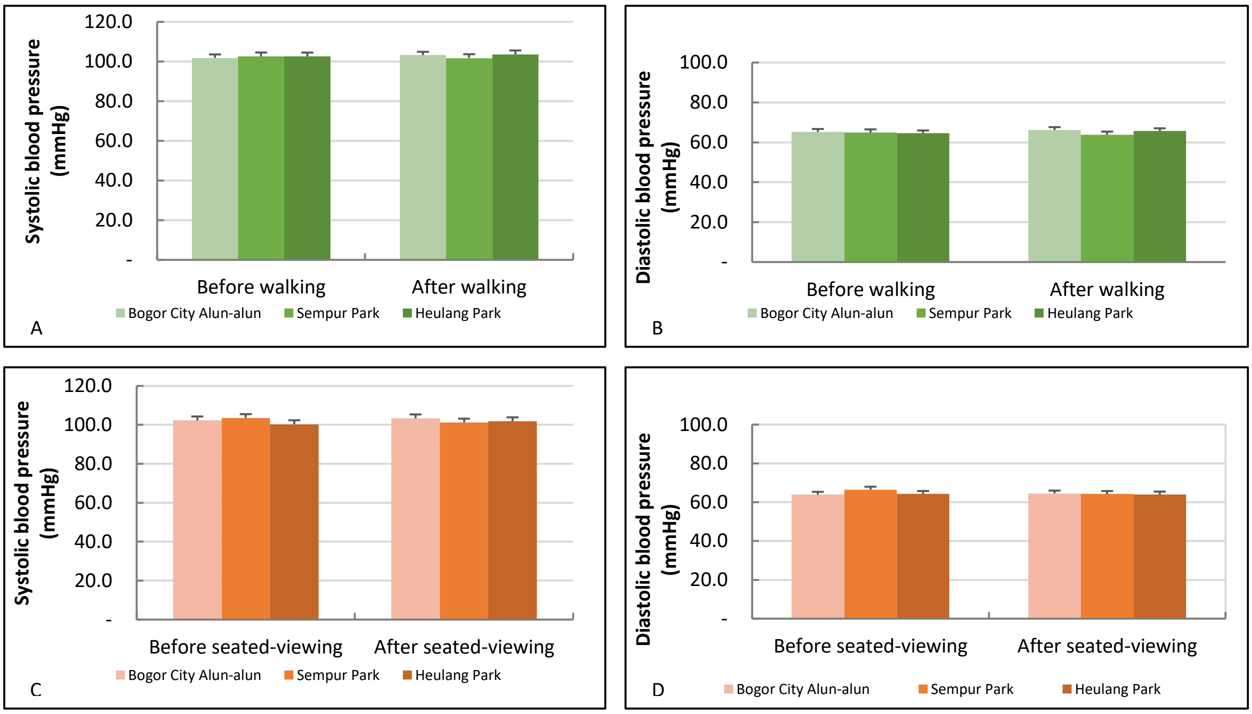


Figure 4. Average blood pressure: diastolic blood pressure in a virtual walking experiment (A), systolic blood pressure in a virtual walking experiment (B), diastolic blood pressure in a virtual seated-viewing experiment (C), and systolic blood pressure in a virtual seated-viewing experiment (D), N = 30, mean ± standard error, determined by Repeated Measure ANOVA.

Table 4. Repeated Measures ANOVA results of blood pressure.

Parameter	Sum of squares	df	Mean square	F	Sig	Partial eta squared
Systolic blood pressure while walking						
Location	28.311	2	14.156	0.284	0.754	0.010
Time	11.756	1	11.756	0.670	0.420	0.023
Time*Location	43.244	2	21.622	0.548	0.581	0.019
Diastolic blood pressure while walking						
Location	43.115	2	21.557	0.506	0.606	0.018
Time	3.310	1	3.310	0.236	0.631	0.008
Time*Location	37.345	2	18.672	0.571	0.568	0.020
Systolic blood pressure while viewing						
Location	104.311	2	55.156	1.065	0.351	0.035
Time	0.200	1	0.200	0.007	0.935	0.000
Time*Location	138.533	2	69.267	1.947	0.152	0.063
Diastolic blood pressure while viewing						
Location	56.311	2	28.156	1.195	0.310	0.040
Time	18.050	1	18.050	0.388	0.538	0.013
Time*Location	64.133	2	32.067	1.239	0.297	0.041

Psychological Effects

Figure 5 depicts the average POMS subscale scores obtained from 30 subjects before and after walking using VR in three different videos of Bogor City Parks. Significant differences were found in the confusion (p = 0.039) and tension (p = 0.032) subscales (Table 5). This resulted from decreased negative emotions and increased positive emotions before and after the walking experiment. In contrast, there were no significant differences in the negative emotions of fatigue (p = 0.646), anger (p = 0.161), depression (p = 0.519), or the positive emotions of vigor (p = 0.739).

The factors of location and time differences influence reducing the psychological response to anger, with the lowest score obtained at the Bogor City Alun-alun (3.48; 3.47), confusion with the lowest score obtained at the Heulang Park (3.48; 3.07), depression with the lowest score was obtained at the Heulang Park (3.48; 3.40), tension with the lowest score was obtained at the Heulang Park (3.30; 3.22), and vigor with the lowest score was obtained at the Sempur Park location (3.48; 3.75) and Bogor City Alun-alun (3.28; 3.55). From the average results obtained by the mood state during the walking experiment, the highest score was obtained in Heulang Park and the lowest score was obtained in Bogor City Alun-alun. Figure 6 shows the average POMS subscale scores before and after seated viewing the VR videos.

Table 5. Friedman's chi square test of POMS.

Parameter	df	Ch-Square	Asymp. Sig.
<u>POMS while walking</u>			
Anger	5	7.919	0.161
Confusion	5	11.677	0.039*
Depression	5	4.217	0.519
Fatigue	5	3.348	0.646
Tension	5	12.229	0.032*
Vigor	5	2.746	0.739
TMD	5	4.641	0.461
<u>POMS while seated viewing</u>			
Anger	5	2.611	0.760
Confusion	5	14.990	0.01*
Depression	5	6.036	0.303
Fatigue	5	3.889	0.566
Tension	5	5.229	0.389
Vigor	5	11.051	0.05*
TMD	5	11.537	0.042*

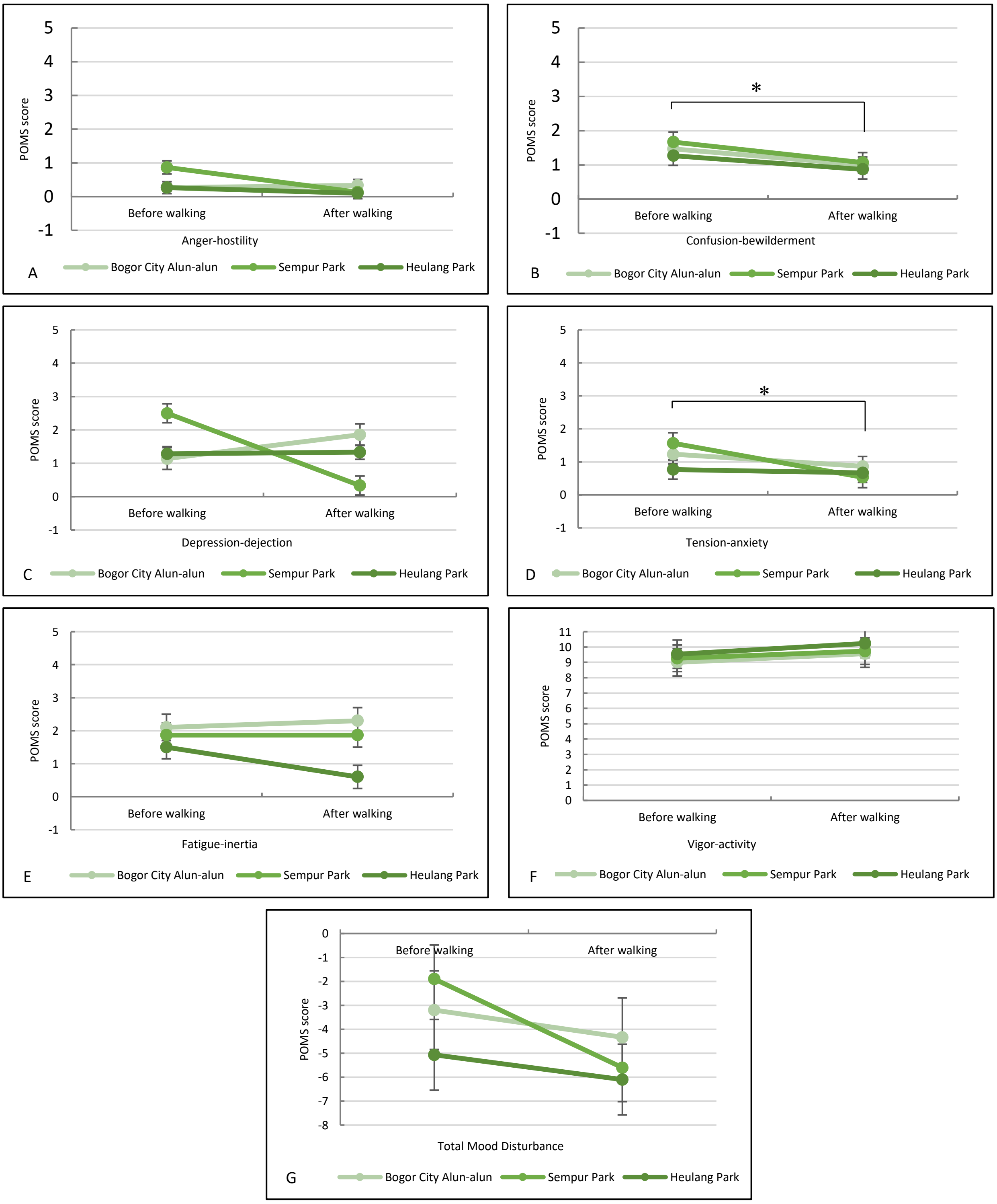


Figure 5. POMS subscale comparisons before and after the VR walking experiment: anger-hostility (A), confusion-bewilderment (B), depression-dejection (C), tension-anxiety (D), fatigue-inertia (E), vigor-activity (F), and Total Mood Disturbance (G), N = 30, mean ± standard error. * $p < 0.05$, determined using Friedman test.

Significant differences were found in the confusion ($p = 0.010$) and vigor ($p = 0.05$) subscales due to decreased negative emotions and increased positive emotions before and after seated viewing, as shown in Figure 6 and Table 5. In contrast, there were no significant differences in the negative emotions of depression ($p = 0.303$), fatigue ($p = 0.566$), anger ($p = 0.760$), or tension ($p = 0.389$). The factors of difference in location and time influence decreasing the psychological response to fatigue with the lowest score obtained at Heulang Park (3.68; 3.37), confusion with the lowest score at Sempur Park (3.40; 3.08), depression with the lowest score at Sempur Park (3.63; 3.65), tension with the lowest score at Bogor City Alun-alun (3.73; 3.47), and vigor with the lowest score at Bogor City Alun-alun (3.08; 3.27). From the average mood obtained during seated viewing, the highest score was obtained in Heulang Park, and the lowest was obtained in Bogor City Alun-alun.

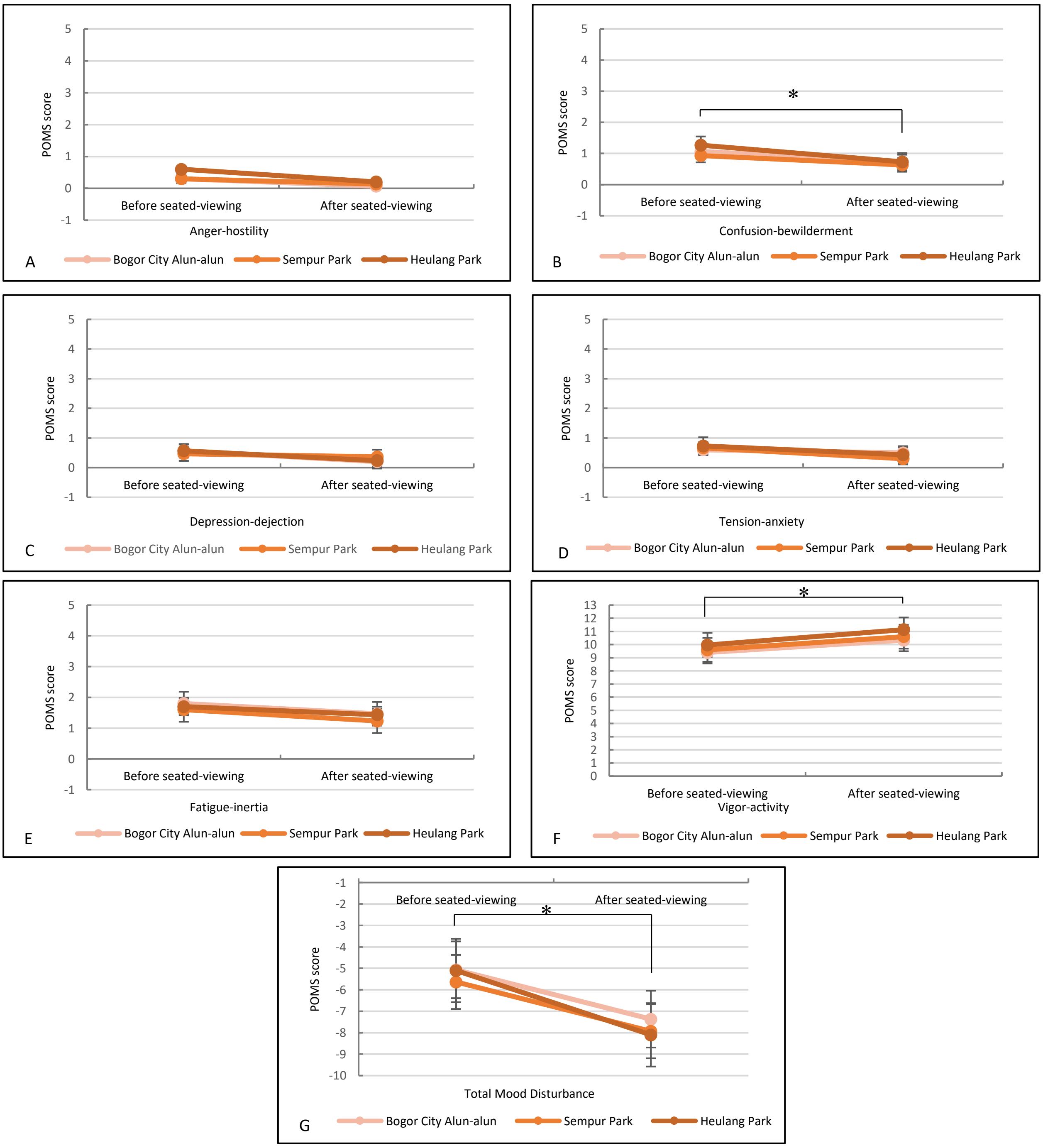


Figure 6. POMS subscale comparison before and after the seated viewing experiment using VR: anger-hostility (A), confusion-bewilderment (B), depression-dejection (C), tension-anxiety (D), fatigue-inertia (E), vigor-activity (F), and total mood disturbance (G), N = 30, mean ± standard error. * $p < 0.05$, determined using Friedman test.

As shown in Figure 7 and Table 6, the STAI score revealed that the time factor affected anxiety status while walking ($p = 0.019$) and viewing ($p = 0.007$). The location factor did not affect walking or viewing activities ($p = 0.734$; $p = 0.986$). The interaction between time and location had no effect on walking ($p = 0.543$) or viewing ($p = 0.171$). The STAI score decreased significantly after virtual walking in Bogor City Alun-alun (36.2; 33.2), followed by Sempur Park (36.2; 33.97) and Heulang Park (35.57; 33.77). The STAI score, anxiety status decreased significantly after seated viewing at Heulang Park (35.03; 31.90), followed by Sempur Park (34.3; 32.37) and Bogor City Alun-alun (34.13; 32.77). From the results, the highest decrease in anxiety status was found in Heulang Park, and the lowest decrease was in Bogor City Alun-Alun.

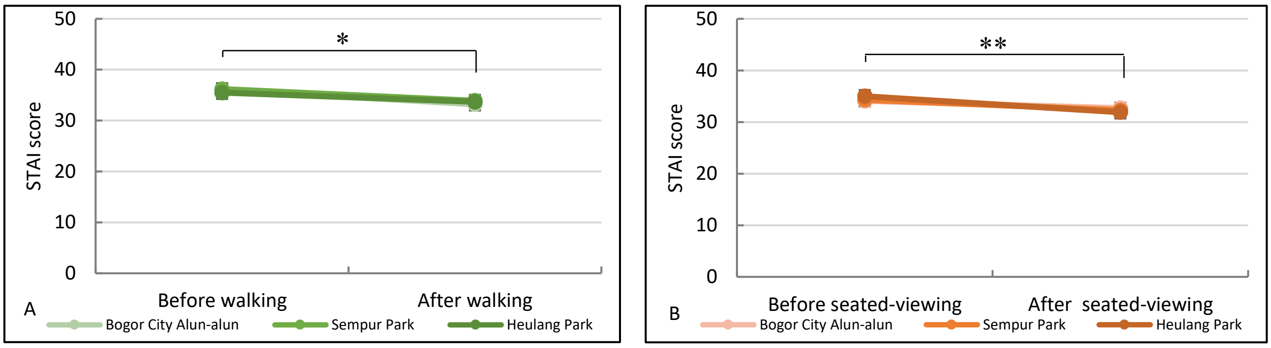


Figure 7. STAI subscale comparison before and after the VR experiment: walking (A) and seated viewing (B), N = 30, mean ± standard error. * $p < 0.05$, ** $p < 0.01$ determined by Repeated Measure ANOVA.

Table 6. Repeated Measure ANOVA results of STAI.

Parameter	Sum of squares	df	Mean square	F	Sig.	Partial eta squared
STAI while walking						
Time	240.356	1	240.356	6.136	0.019*	0.175
Location	7.233	2	3.617	0.311	0.734	0.011
Time*Location	9.211	2	4.606	0.616	0.543	0.021
STAI while seated viewing						
Time	209.089	1	209.089	8.486	0.007**	0.226
Location	0.478	2	0.239	0.014	0.986	0.000
Time*Location	24.211	2	12.106	1.823	0.171	0.059

Restorative Values of Greenspace

Through VR, the PRS score showed the restorative values of all three experimental locations (Bogor City Alun-alun, Sempur Park, and Heulang Park). Figure 8 shows the average distribution of the PRS domain, which consists of being away, fascination, coherence, and compatibility domains. The Kruskal-Wallis test revealed that the fascination domain ($p < 0.000$), coherence ($p < 0.000$), and compatibility ($p < 0.000$) had a significant effect on the subjects' level of restoration after virtual walking and seated viewing. They were associated with a significantly higher tendency among the four subscales related to restorative traits of the three locations. Being away did not significantly affect the participants' restoration level after virtual walking ($p = 0.746$) or virtual seated viewing ($p = 0.824$). Virtual activities may not be distinct among the three locations. The subjects did not feel like they escaped from their daily environments physically or conceptually. Follow-up post hoc tests showed that Heulang Park had the highest restoration trait for participants compared with the other two parks (M walking= 59.35, $p < 0.001$ and M seated viewing = 56.65, $p < 0.012$).

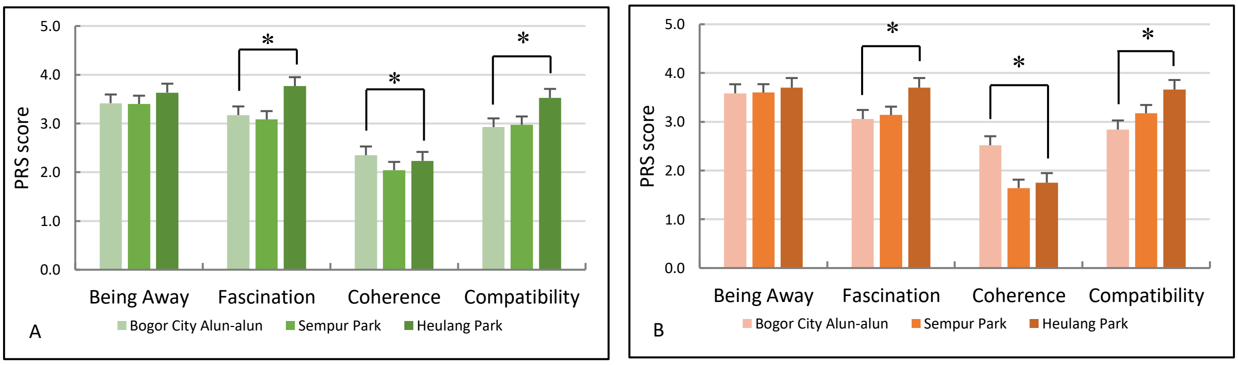
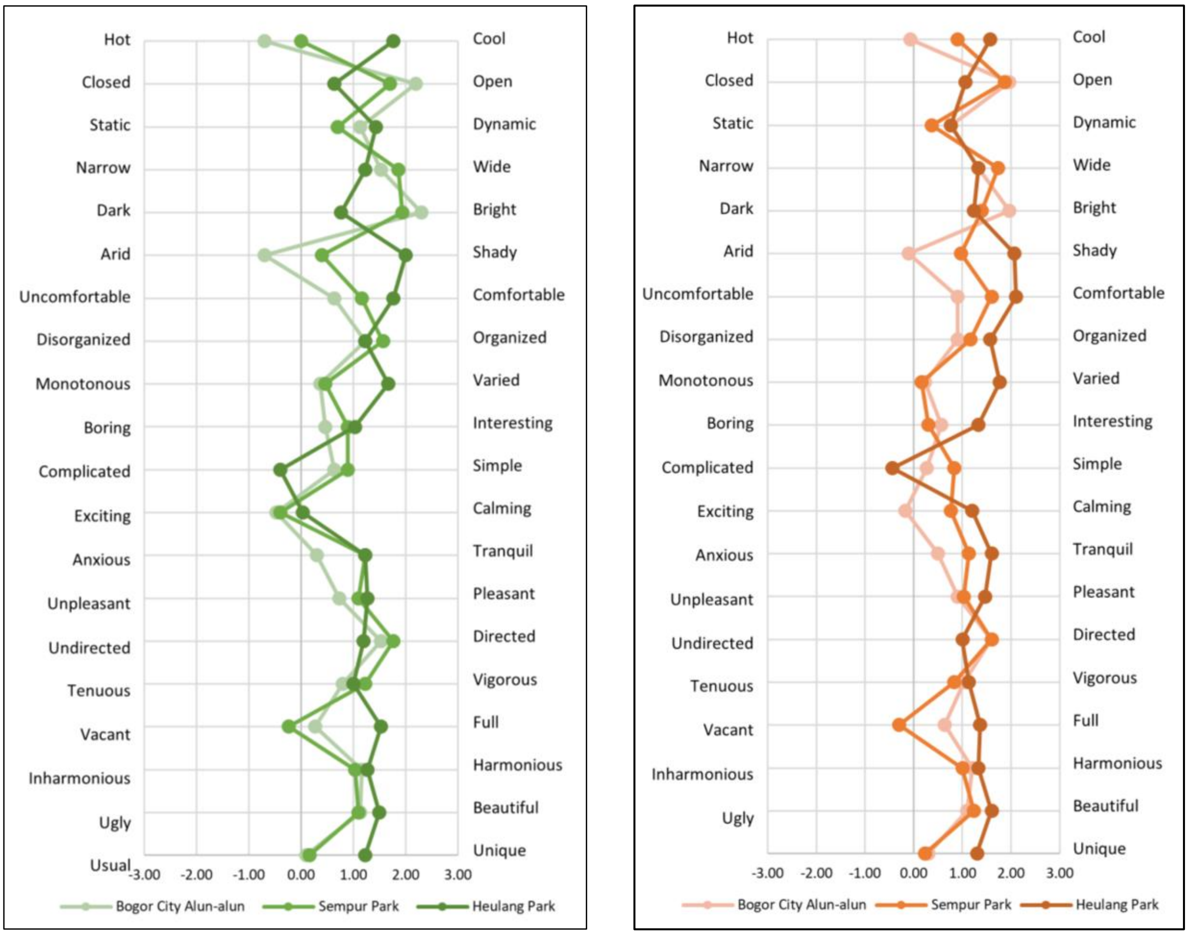


Figure 8. Comparison of the PRS subscale using VR: after the walking experiment (A) and after the seated viewing experiment (B), N = 30 (mean ± standard error). * $p < 0.05$, determined using the Kruskal-Wallis test.

Landscape Aesthetic Appreciation

The aesthetic quality in Bogor City Alun-alun after walking was hot and arid (-0.7) and open (2.2). Other characteristics of Bogor City Alun-alun were being directed, wide, dynamic, harmonious, and beautiful. The aesthetic quality of Sempur Park after walking was high (1.93). Other positive characteristics include being wide, directed, open, organized, tranquil, pleasant, harmonious, and beautiful. In comparison, the aesthetic qualities of Heulang Park after walking are shady. Positive characteristics were detected, such as cool, comfortable, varied, full, beautiful, dynamic, wide, organized, interesting, tranquil, pleasant, directed, vigorous, harmonious, and unique (Figure 9A). The aesthetic quality of Bogor City Alun-alun after seated viewing is open and bright (1.97). The other characters of Bogor City Alun-alun were directed, vigorous, harmonious, and beautiful. The aesthetic quality of Sempur Park after seated viewing was open (1.87).

The positive characters are wide, directed, comfortable, bright, organized, tranquil, pleasant, harmonious, and beautiful. After seated viewing, the aesthetic quality in Heulang Park was comfortable, followed by being shady. Positive characteristics were detected, such as cool, open, varied, tranquil, wide, bright, comfortable, full, organized, beautiful, interesting, calming, pleasant, directed, vigorous, harmonious, and unique (Figure 9B). The unique sensory perception of the three locations was hot in Bogor City Alun-alun, tranquil in Sempur Park, and cool in Heulang Park. This may be due to the land cover of each park. Bogor City Alun-Alun is more than 50% covered by the plaza. Sempur Park has an open space in the middle of the park called a multipurpose lawn surrounded by a jogging track, while Heulang Park has a vast lawn surrounded by dense and mature vegetation.



(A) (B)

Figure 9. Comparison of the distribution of aesthetic preference values for: walking (A) and seated viewing (B).

A factor analysis using the Principal Component Analysis method was also performed to evaluate the aesthetic quality of the parks using a Semantic Differential questionnaire. Landscape appreciation during virtual park therapy resulted in six factors after walking in Bogor City Alun-alun, eight factors after walking in Sempur Park, seven factors after walking in Heulang Park (Table 7), six factors after seated viewing in Sempur Park, and six factors after seated viewing in Heulang Park (Table 8). The valid factors after walking in Bogor city Alun-alun were "somewhat varied" (0.541), "somewhat interesting" (0.766), "somewhat pleasant" (0.766), "directed" (0.679), "somewhat harmonious" (0.654), "somewhat beautiful" (0.549), "neither usual nor unique" (0.781). Thus, the main factor is "minimum variation with minimum aesthetics'. The valid factors after walking in Sempur Park were "neither cool nor hot" (0.691), "neither shady nor arid" (0.772), and "somewhat tranquil" (0.786).

Table 7. Rotated factor matrix after virtual walking.

Variable	Mean (SD)	Rotated (Varimax) factors				
		1	2	3	4	5
Cool	-0.29 (1.92)	0.469	-0.048	-0.208	**0.661**	0.016
Open	1.77 (1.41)	-0.127	0.064	**0.837**	-0.096	-0.087
Dynamic	0.99 (1.83)	0.143	0.233	0.341	-0.085	-0.610
Wide	1.56 (1.35)	0.145	0.276	**0.712**	0.045	0.082
Bright	1.89 (1.40)	-0.001	0.183	**0.807**	-0.077	0.042
Shady	0.69 (1.67)	**0.567**	-0.041	-0.050	**0.663**	0.203
Comfortable	1.34 (1.22)	**0.678**	0.100	0.036	0.438	0.018
Organized	1.13 (1.64)	-0.035	**0.776**	0.230	-0.129	0.115
Varied	1.07 (1.54)	**0.743**	-0.005	-0.065	0.130	-0.237
Interesting	1.23 (1.32)	0.027	**0.726**	0.114	0.148	-0.244
Simple	0.28 (1.53)	-0.633	0.047	0.365	0.166	-0.039
Calming	0.29 (1.80)	-0.161	0.217	-0.014	**0.711**	-0.023
Tranquil	1.08 (1.36)	0.100	**0.589**	0.035	**0.563**	0.112
Pleasant	1.48 (0.99)	**0.705**	0.070	0.254	0.210	-0.042
Directed	1.21 (1.52)	0.150	**0.762**	0.078	0.056	-0.133
Vigorous	1.31 (1.52)	0.006	0.118	0.174	0.033	**0.737**
Full	0.66 (1.47)	**0.723**	0.001	-0.077	-.088	0.070
Harmonious	1.2 (1.28)	0.036	**0.758**	0.194	0.189	0.231
Beautiful	1.50 (1.01)	**0.626**	0.322	0.186	0.101	0.238
Unique	0.70 (1.56)	**0.787**	0.074	0.060	0.010	-0.158
Eigenvalue	-	4.961	3.592	1.937	1.305	1.086
% of variance	-	24.806	17.960	9.683	6.525	5.432
Cumulative %	-	24.806	42.766	52.449	58.974	64.406

Table 8. Rotated factor matrix after virtual viewing.

Variable	Mean (SD)	Rotated (Varimax) factors				
		1	2	3	4	5
Cool	0.52 (2.18)	0.473	0.088	**0.682**	-0.225	-0.003
Open	1.91 (1.39)	0.013	0.097	-0.174	**0.886**	0.021
Dynamic	0.81 (1.73)	-0.052	0.019	-0.102	0.350	**0.728**
Wide	1.71 (1.38)	0.041	**0.626**	0.030	0.159	0.265
Bright	2.11 81.18)	0.047	0.176	-0.106	**0.901**	-0.027
Shady	0.78 (1.89)	0.401	0.036	**0.766**	-0.188	0.056
Comfortable	1.34 (1.54)	**0.599**	0.303	0.494	-0.124	0.152
Organized	1.18 (1.64)	**0.504**	**0.520**	-0.251	-0.003	-0.088
Varied	0.91 (1.58)	0.218	0.117	0.471	-0.015	**0.694**
Interesting	1.22 (1.41)	**0.629**	0.215	0.139	0.347	0.240
Simple	0.58 (1.41)	0.132	0.075	-0.302	0.444	-0.562
Calming	0.48 (1.85)	**0.819**	-0.148	0.131	-0.063	-0.200
Tranquil	1.26 (1.35)	**0.821**	0.241	0.027	0.155	-0.061
Pleasant	1.39 (1.22)	**0.653**	0.372	0.136	-0.009	0.169
Directed	1.33 (1.47)	0.071	0.359	0.125	0.317	-0.541
Vigorous	1.20 (1.20)	0.045	0.727	0.153	0.130	-0.153
Full	0.64 (1.38)	-0.151	0.181	**0.764**	-0.050	0.073
Harmonious	1.47 (1.12)	0.186	**0.759**	0.045	0.092	-0.094
Beautiful	1.63 (0.95)	0.312	**0.741**	0.350	-0.035	0.078
Unique	0.80 (1.45)	0.427	0.309	0.236	-0.315	0.466
Eigenvalue	-	5.756	3.347	1.942	1.556	1.095
% of variance	-	28.781	16.733	9.712	7.782	5.475
Cumulative %	-	28.781	45.515	55.227	63.009	68.484

Thus, the main factor is defined as "thermal comfort variation". The valid factors after walking in Heulang Park were "wide" (0.723), "somewhat organized" (0.800), "varied" (0.522), "somewhat vigorous" (0.746), "somewhat harmonious" (0.744), "somewhat beautiful" (0.718). Thus, the main factor is defined as a "variation of elements that does not meet the design principles". The valid factors after seated viewing in Sempur Park were "organized" (0.771), "calming" (0.781), "somewhat tranquil" (0.833), "somewhat directed" (0.743), and "somewhat harmonious" (0.648). Thus, the main factor is "regularity with psychological effects". Valid factors after seated viewing in Heulang Park were "wide" (0.785), "somewhat beautiful" (0.754), and "somewhat unique" (0.829). Thus, the main factor is "broadness of view with minimum aesthetics".

Discussion

This study assesses the physiological, psychological, restorativeness, and landscape perception during park therapy experiments on Indonesian university students in Bogor urban greenspaces. It might be a pioneer study to exhibit virtual tropical urban parks and Alun-alun in ASEAN countries. The primary findings of this study showed that walking and seated viewing in Bogor City greenspaces led to lower heart rate, reduction in negative moods, increase in a positive mood, decrease in anxiety status, restorative effect, and therapeutic landscape appreciation.

A lower heart rate during virtual walking was detected in Bogor City Alun-alun, while a lower heart rate was detected in Heulang Park. Many studies have proven that performing physical activities, such as walking and seated viewing in green spaces, can directly affect visitors' psychological and physiological health. On-site walking in a city park can result in a significant decrease in heart rate while walking in a tropical campus landscape [9,26], walking and relaxed sitting in urban parks and Alun-alun [56], and a significant decrease in blood pressure during a half-day forest therapy program [14]. Since people cannot visit greenspaces due to urbanization, immersive experiences using head-mounted displays have become a potential finding. Comparative research using real and virtual natural environments by Nukarinen et al. [57] has demonstrated the benefits of natural forests and their virtual equivalents. Compared with the 360-degree forest video, the 3D forest video was more emotionally stimulating. Watching 360-degree nature videos with VR headsets for 6 minutes could provide hemodialysis patients with short-term physiological and psychological health benefits [58]. In addition, digital forest bathing in indoor spaces decreased the heart rate during exposure compared to resting [59].

While decreased blood pressure was not detected in any location, the significance of systolic and diastolic walking results was greater than that of systolic and diastolic seated viewing. This can be attributed to the physical activity performed. According to Sun et al. [41], visual exposure to a green room environment using VR can lower systolic blood pressure. Nevertheless, the experimental time, which is too long (15 min for one garden video), can affect this. This caused the subject to become dizzy and triggered an increase in blood pressure. This condition is called cybersickness or digital hangover, which occurs due to an imbalance between sensory inputs or, more simply, several senses in the human body, such as sight and hearing. This imbalance can cause VR technology users to feel dizzy and nauseous when used for a long time [60]. Moreover, some participants who had used VR for the first time also experienced distractions in feeling the effects of virtual park therapy due to the heavy head-mounted display used for activities, especially while walking. Physical activity can also affect blood pressure, which is higher when a person is active and lower when resting [61]. Furthermore, taking videos of winding sites resulted in less smooth movement.

Decreased negative moods, i.e., anger, tension, confusion, and depression, after walking and decreased anger, tension, confusion, and fatigue after seated viewing were found in three locations. Increased positive mood, i.e., vigour after walking and sitting, was found in three locations. A decreased anxiety status was detected only after seated viewing in the three locations. Recent studies have reported that after experiencing digital forest bathing, negative moods, such as tension, depression, anger, fatigue, and confusion, decreased [59]. The 3D model-based virtual green exercise provided additional benefits, such as increased enjoyment and movement, compared to treadmill walking without VR exposure [62]. Watching six-minute nature videos enhanced positive psychological responses in dialysis and bedridden patients Interviews with the participants also revealed that the first week of the experiment yielded the most positive reactions. The investigation revealed the most negative results at week 3 [58]. In similar studies during COVID-19, virtual exposure to forest environments reduced perceived anxiety levels in people confined to small spaces and suffering from environmental deprivation [63]. Sun et al. [41] shows that several park elements in greenspaces can help reduce depression, anxiety, and blood pressure, namely shady trees, shrubs, and grasses with a garden view.

The restorative values of the environment after walking and seated viewing on the fascination, coherence, and compatibility subscales were detected after experiencing virtual park therapy in all locations, with the highest score in Heulang Park. Following previous research, experiencing a VR environment enabled subjects to feel a sense of presence through physical activity [64]. To experience walking in VR, users must perform stepping-like movements on the spot. In terms of being perceived as more natural, a gesture such as alternately tapping each heel against the ground is closest to actual walking [65]. Moreover, Brancato et al. [66] demonstrated that virtual walks in green spaces (e.g., pine forests, farmed fields, and tree-lined urban neighbourhoods) led to perceived restoration. In addition, watching VR videos while seated decreases stress levels and heart rate while increasing parasympathetic nervous system activity. The VR videos significantly reduce overall stress, improve physical stability, and improve psychological well-being [27].

Participants' perceptions of and affective reactions to three locations showed that the park setting was a design regularity with psychological effects in Sempur Park and a broadness of view with minimum aesthetics in Heulang Park after seated viewing. Sensory perception was also detected in each park, such as heat in Alun-alun City Park, serenity in Sempur Park, and coolness in Heulang Park. The stimuli from the parks' greenery, sound, and sunlight were recorded through 360° video that transmitted the light and sound waves captured by human eyes and ears, transmitted to the brain by sensory nerves, producing an impression such as sensory perception [67].

Previous research has proven immersive VR a reliable tool for evaluating perception and aesthetic landscape preference, providing more potential for forest and park therapy studies. When people view a landscape through VR, they may perceive it as more homogeneous and spoiled. Because on-site sound must be emulated, people may not accurately set the scene noise [39]. Previous studies also showed that forest therapy made subjects feel more "comfortable," "natural," and "soothed" [27]. Surprisingly, a relationship exists between thermal comfort, mood state, and indoor environment quality using VR [68]. Park-and-forest therapy using VR is psychologically impactful for anyone who cannot access green spaces directly. VR in park and forest therapy is a technological advancement and a potential solution for bridging the gap between society and ecotourism. The VR can revolutionize tourism by immersing users in a digital environment, such as reconstructing scenic landscapes, heritage sites, and wildlife habitats. It can make travel more exciting, reduce the negative impact of tourism on the environment, and even promote sustainable tourism [69].

These findings demonstrate that VR experiences in Bogor City Parks resulted in physiological and psychological relaxation, landscape appreciation, and a restorative environment. Virtual natural settings provide the same benefits as the actual park environment but use head-mounted displays instead of direct exposure to nature. The first limitation of this study was that only students were recruited as subjects. The second is the video-watching time, which is quite long (15 minutes per video). In future studies, variation of subject groups and different and minimum lengths of watching time should be addressed to obtain more valid data and the recoverability effect.

Conclusions

This study demonstrated that virtual park therapy provides physiological and psychological effects, restoration, and landscape appreciation. Virtual Park therapy in Bogor City Parks resulted in (1) a lower heart rate while walking on the square, (2) a lower heart rate while seated viewing in Heulang Park, (3) a significant increase in a positive mood, namely vigor, (4) a significant decrease in anxiety status after seated viewing, and (5) a therapeutic effect on the fascination, coherence, and compatibility subscales. Landscape appreciation also supports the idea that Heulang Park has a variety of elements and aesthetic breadth of view. This study suggests that virtual park therapy is a promising alternative for physiological and psychological relaxation in young adults. It might be useful for the aesthetic and restorative evaluation of healing parks to help urban planners develop healing urban greenspaces to deal with uncertain public health conditions and to increase the inclusivity of public spaces.

Author Contributions

PIP: Conceptualization, Methodology, Software, Investigation, Data Curation, Writing Original Draft, Writing – Review & Editing, Supervision; **BSU**: Methodology, Investigation, Writing – Review & Editing, Supervision; **TNP**, **RF**, **MS**, **AAP**: Software, Investigation, Data Curation, Writing Original Draft.

Conflicts of interest

There are no conflicts to declare.

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References

1. An, B.Y.; Wang, D.; Liu, X.J.; Guan, H.M.; Wei, H.X.; Ren, Z.B. The effect of environmental factors in urban forests on blood pressure and heart rate in university students. *J. For. Res.* **2019**, *24*, 27–34, doi:10.1080/13416979.2018.1540144.
2. Cameron, R.W.F.; Brindley, P.; Mears, M.; McEwan, K.; Ferguson, F.; Sheffield, D.; Jorgensen, A.; Riley, J.; Goodrick, J.; Ballard, L.; et al. Where the wild things are! do urban green spaces with greater avian biodiversity promote more positive emotions in humans? *Urban Ecosyst.* **2020**, *23*, 301–317, doi:10.1007/s11252-020-00929-z.
3. Elsadek, M.; Sun, M.; Sugiyama, R.; Fujii, E. Cross-cultural comparison of physiological and psychological responses to different garden styles. *Urban For. Urban Green.* **2019**, *38*, 74–83, doi:10.1016/j.ufug.2018.11.007.
4. Goto, S.; Gianfagia, T.J.; Munafo, J.P.; Fujii, E.; Shen, X.; Sun, M.; Shi, B.E.; Liu, C.; Hamano, H.; Herrup, K. The power of traditional design techniques: the effects of viewing a japanese garden on individuals with cognitive impairment. *Heal. Environ. Res. Des. J.* **2017**, *10*, 74–86, doi:10.1177/1937586716680064.
5. Hassan, A.; Tao, J.; Li, G.; Jiang, M.; Aii, L.; Zhihui, J.; Zongfang, L.; Qibing, C. Effects of walking in bamboo forest and city environments on brainwave activity in young adults. *Evidence-Based Complement. Altern. Med.* **2018**, *2018*, 1–9, doi:10.1155/2018/9653857.
6. Mao, G.; Cao, Y.; Wang, B.; Wang, S.; Chen, Z.; Wang, J.; Xing, W.; Ren, X.; Lv, X.; Dong, J.; et al. The salutary influence of forest bathing on elderly patients with chronic heart failure. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1–12, doi:10.3390/ijerph14040368.
7. Ojala, A.; Korpela, K.; Tyrväinen, L.; Tiittanen, P.; Lanki, T. Restorative effects of urban green environments and the role of urban-nature orientedness and noise sensitivity: a field experiment. *Heal. Place* **2019**, *55*, 59–70, doi:10.1016/j.healthplace.2018.11.004.
8. Peterfalvi, A.; Meggyes, M.; Makszin, L.; Farkas, N.; Miko, E.; Miseta, A.; Szereday, L. Forest bathing always makes sense: blood pressure-lowering and immune system-balancing effects in late spring and winter in Central Europe. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1–20, doi:10.3390/ijerph18042067.
9. Pratiwi, P.I.; Sulistyantara, B.; Sisriany, S.; Lazuardi, S.N. Physiological and psychological effects of walking in campus landscape to young adults. *J. Reg. City Plan.* **2022**, *33*, 367–385, doi:10.5614/jpwk.2022.33.3.5.
10. Siah, C.J.R.; Kua, E.H.; Goh, Y.S.S. The impact of restorative green environment on mental health of big cities and the role of mental health professionals. *Curr. Opin. Psychiatry* **2022**, *35*, 186–191, doi:10.1097/YCO.0000000000000778.
11. Song, C.; Joung, D.; Ikei, H.; Igarashi, M.; Aga, M.; Park, B.J.; Miwa, M.; Takagaki, M.; Miyazaki, Y. Physiological and psychological effects of walking on young males in urban parks in winter. *J. Physiol. Anthropol.* **2013**, *32*, 1–5, doi:10.1186/1880-6805-32-18.
12. Song, C.; Ikei, H.; Igarashi, M.; Takagaki, M.; Miyazaki, Y. Physiological and psychological effects of a walk in urban parks in fall. *Int. J. Environ. Res. Public Health* **2015**, *12*, 14216–14228, doi:10.3390/ijerph121114216.
13. Song, C.; Ikei, H.; Kagawa, T.; Miyazaki, Y. Effects of walking in a forest on young women. *Int. J. Environ. Res. Public Health* **2019**, *16*, 9–13, doi:10.3390/ijerph16020229.

14. Rajoo, K.S.; Karam, D.S.; Abdul Aziz, N.A. Developing an effective forest therapy program to manage academic stress in conservative societies: a multi-disciplinary approach. *Urban For. Urban Green.* **2019**, *43*, 1–11, doi:10.1016/j.ufug.2019.05.015.
15. 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, doi:10.1016/j.jenvp.2013.12.005.
16. 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.* **2010**, *15*, 18–26, doi:10.1007/s12199-009-0086-9.
17. Song, C.; Ikei, H.; Park, B.J.; Lee, J.; Kagawa, T.; Miyazaki, Y. Psychological benefits of walking through forest areas. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1–10, doi:10.3390/ijerph15122804.
18. Song, C.; Ikei, H.; Miyazaki, Y. Sustained effects of a forest therapy program on the blood pressure of office workers. *Urban For. Urban Green.* **2017**, *27*, 246–252, doi:10.1016/j.ufug.2017.08.015.
19. Pratiwi, P.I.; Furuya, K. The neighbourhood park preferences and its factors among elderly residents in Tokiwadaira , Japan. *Asian J. Behav. Stud.* **2019**, *4*, 64–79.
20. Pratiwi, P.I.; Kim, M.; Furuya, K. Difference in perception of urban green spaces between danchi and apartment residents in Tokiwadaira, Matsudo City, Japan. *J. Mns. dan Lingkung.* **2020**, *26*, 80–90, doi:10.22146/jml.35608.
21. Pratiwi, P.I.; Xiang, Q.; Furuya, K. Physiological and psychological effects of viewing urban parks in different seasons in adults. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1–14, doi:10.3390/ijerph16214279.
22. Pratiwi, P.I.; Xiang, Q.; Furuya, K. Physiological and psychological effects of walking in urban parks and its imagery in different seasons in middle-aged and older adults: evidence from Matsudo City, Japan. *Sustainability* **2020**, *12*, 1–25, doi:10.3390/su12104003.
23. Ochiai, H.; Ikei, H.; Song, C.; Kobayashi, M.; Takamatsu, A. Physiological and psychological effects of forest therapy on middle-aged males with high-normal blood pressure. *Int J Environ Res Public Health* **2015**, 2532–2542, doi:10.3390/ijerph120302532.
24. Yu, C.P.; Lin, C.M.; Tsai, M.J.; Tsai, Y.C.; Chen, C.Y. Effects of short forest bathing program on autonomic nervous system activity and mood states in middle-aged and elderly individuals. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1–12, doi:10.3390/ijerph14080897.
25. Song, C.; Ikei, H.; Kagawa, T. Physiological and psychological effects of viewing forests on young women. *Forests* **2019**, *10*, 1–13, doi:10.3390/f10080635.
26. Pratiwi, P.I.; Sulistyantara, B.; Sisriany, S.; Lazuardi, S.N. The psychological effects of park therapy components on campus landscape preferences. *J. Contemp. Urban Aff.* **2022**, *6*, 143–155, doi:10.25034/ijcua.2022.v6n2-3.
27. Hong, S.; Joung, D.; Lee, J.; Kim, D.Y.; Kim, S.; Park, B.J. The effects of watching a virtual reality (VR) forest video on stress reduction in adults. *J. People, Plants, Environ.* **2019**, *22*, 309–319, doi:10.11628/ksppe.2019.22.3.309.
28. Gao, T.; Zhang, T.; Zhu, L.; Gao, Y.; Qiu, L. Exploring psychophysiological restoration and individual preference in the different environments based on virtual reality. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1–14 doi:10.3390/ijerph16173102.
29. Wang, X.; Shi, Y.; Zhang, B.; Chiang, Y. The influence of forest resting environments on stress using virtual reality. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1–20 doi:10.3390/ijerph16183263.
30. Yu, C.P.; Lee, H.Y.; Luo, X.Y. The Effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban For. Urban Green.* **2018**, *35*, 106–114, doi:10.1016/j.ufug.2018.08.013.
31. Adams, D.; Bah, A.; Barwulor, C.; Musabay, N.; Pitkin, K.; Redmiles, E.M. Ethics emerging: The story of privacy and security perceptions in virtual reality ethics. In Proceedings of the Fourteenth Symposium on Usable Privacy and Security, Baltimore, MD, USA, 12–14 August 2018; Zurko, M.E., Lipford, H.R., Chiasson, S., Reeder, R., Eds.; USENIX Association: Berkeley, CA, USA; pp. 443–458.

32. Dick, E. Balancing user privacy and innovation in augmented and virtual reality. *Inf. Technol. Innov. Found.* **2021**, 1–23.
33. Giaretta, A. Security and privacy in virtual reality: a literature review. *Issues Inf. Syst.* **2022**, *23*, 185–192, doi:10.48009/2_iis_2022_125.
34. Barreda-Ángeles, M.; Hartmann, T. Hooked on the metaverse? exploring the prevalence of addiction to virtual reality applications. *Front. Virtual Real.* **2022**, *3*, 1–9, doi:10.3389/frvir.2022.1031697.
35. Zhang, Z.; Wen, F.; Sun, Z.; Guo, X.; He, T.; Lee, C. Artificial intelligence ‐ enabled sensing technologies in the 5g/internet of things era: from virtual reality/augmented reality to the digital twin. *Adv. Intell. Syst.* **2022**, *4*, 1–23, doi:10.1002/aisy.202100228.
36. Zou, Z.; Ergan, S. Evaluating the effectiveness of biometric sensors and their signal features for classifying human experience in virtual environments. *Adv. Eng. Informatics* **2021**, *49*, 101358, doi:10.1016/j.aei.2021.101358.
37. Petrova, E.G.; Mironov, Y. V.; Aoki, Y.; Matsushima, H.; Ebine, S.; Furuya, K.; Petrova, A.; Takayama, N.; Ueda, H. Comparing the visual perception and aesthetic evaluation of natural landscapes in Russia and Japan: cultural and environmental factors. *Prog. Earth Planet. Sci.* **2015**, *2*, 1–12, doi:10.1186/s40645-015-0033-x.
38. Pratiwi, P.I.; Furuya, K.; Sulistyantara, B. The difference in people's response toward natural landscape between university students of Japan and Indonesia. *J. Mns. dan Lingkung.* **2014**, *21*, 247–253.
39. Shi, J.; Honjo, T.; Zhang, K.; Furuya, K. Using virtual reality to assess landscape: a comparative study between on-site survey and virtual reality of aesthetic preference and landscape cognition. *Sustain.* **2020**, *12*, 1–16, doi:10.3390/su12072875.
40. Xiang, Y.; Liang, H.; Fang, X.; Chen, Y.; Xu, N.; Hu, M.; Chen, Q.; Mu, S.; Hedblom, M.; Qiu, L.; et al. The comparisons of on-site and off-site applications in surveys on perception of and preference for urban green spaces: which approach is more reliable? *Urban For. Urban Green.* **2021**, *58*, 1–11, doi:10.1016/j.ufug.2020.126961.
41. Sun, Y.; Li, F.; He, T.; Meng, Y.; Yin, J.; Yim, I.S.; Xu, L.; Wu, J. Physiological and affective responses to green space virtual reality among pregnant women. *Environ. Res.* **2023**, *216*, 1–10, doi:10.1016/j.envres.2022.114499.
42. Guo, L.N.; Zhao, R.L.; Ren, A.H.; Niu, L.X.; Zhang, Y.L. Stress recovery of campus street trees as visual stimuli on graduate students in autumn. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1–13, doi:10.3390/ijerph17010148.
43. Konuma, H.; Hirose, H.; Yokoyama, K. Relationship of the Japanese translation of the profile of mood states second edition (POMS 2®) to the first edition (POMS®). *Juntendo Med. J.* **2015**, *61*, 517–519, doi:10.14789/jmj.61.517.
44. Hashim, H.A. *Application of Psychometrics in Sports and Exercise*; Universiti Sains Malaysia: Pulau Pinang, 2019; ISBN 9789674612894.
45. Setiawan, H.Y. Pengaruh Lingkungan Kerja Alami Pada Tingkat Stress. Thesis, Universitas Atma Jaya Yogyakarta, Sleman, Indonesia, 2016.
46. Spielberger, C.D.; Gorsuch, R.L.; Lushene, R.; Vagg, P.R.; Jacobs, G.A. *State-Trait-Anxiety-Inventory for Adults Self-Evaluation Questionnaire STAI*; The Myers-Briggs Company: Oxford, England, UK, 2003.
47. Iwata, N.; Mishima, N.; Shimizu, T.; Mizoue, T.; Fukuhara, M.; Hidano, T.; Spielberger, C.D. The Japanese adaptation of the stai form Y in Japanese working adults. The Presence or Absence of Anxiety. *Ind. Health* **2008**, *36*, 8–13, doi:10.2486/indhealth.36.8.
48. Yuliana, F. Pengaruh Kombinasi Terapi Musik Dengan Deep Breathing Exercise Terhadap Kecemasan Dan Parameter Fisiologis Pada Klien Dengan Ventilasi Mekanik. Thesis, Universitas Airlangga, Surabaya, Indonesia, 2018.
49. Hartig, T.; Mitchell, R.; de Vries, S.; Frumkin, H. Nature and Health. *Annual Review of Pulic Health* **2014**, *35*, 207–228, doi:10.1146/annurev-publhealth-032013-182443.
50. Dewi, L.O. Efektivitas Pemaparan Involuntary Attention Terhadap Perbedaan Tingkat Atensi Mahasiswa. Undergraduate Thesis, Universitas Sanata Dharma Yogyakarta, Sleman, Indonesia, 2016.

51. Osgood, C.E.; Suci, G.J.; Tannenbaum, P.H. *The Measurement of Meaning*; Univer. Illinois Press: Oxford, England, UK, 1957.
52. Hartmann, J.; Holz, C.; Ofek, E.; Wilson, A.D. RealityCheck: Blending virtual environments with situated physical reality. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland, UK, 4–9 May 2019; pp. 1–12.
53. Ueda, H.; Nakajima, T.; Takayama, N.; Petrova, E.; Matsushima, H.; Furuya, K.; Aoki, Y. Landscape image sketches of forests in Japan and Russia. *For. Policy Econ.* **2012**, *19*, 20–30, doi:10.1016/j.forpol.2012.01.002.
54. Pratiwi, P.I.; Sulistyantara, B.; Gunawan, A.; Furuya, K. A Comparative study on the perception of forest landscape using LIST method between university students of Japan and Indonesia. *Journal Trop. For. Manag.* **2014**, *20*, 167–178, doi:10.7226/jtfm.20.3.167.
55. Naderifar, M.; Goli, H.; Ghaljaie, F. Snowball sampling: a purposeful method of sampling in qualitative research. *Strides Dev. Med. Educ.* **2017**, *14*, 1–6, doi:10.5812/sdme.67670.
56. Sari, M.; Fatimah, I.S.; Pratiwi, P.I.; Sulistyantara, B. Psychological effects of walking and relaxed sitting in urban greenspaces during post-pandemic : a case study in Bogor City, Indonesia. *Journal of Contemporary Urban Affairs* **2023**, *7*, 1–17, doi:https://doi.org/10.25034/ijcua.2023.v7n1-1.
57. Nukarinen, T.; Istance, H.; Rantala, J.; Mäkelä, J.; Korpela, K.; Ronkainen, K.; Surakka, V.; Raisamo, R. Physiological and psychological restoration in matched real and virtual natural environments. In the CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA, 25–30 April 2020; pp. 1–8.
58. Hsieh, C.H.; Li, D. Understanding how virtual reality forest experience promote physiological and psychological health for patients undergoing hemodialysis. *Front. Psychiatry* **2022**, *13*, 1–17, doi:10.3389/fpsyt.2022.1007396.
59. Takayama, N.; Morikawa, T.; Koga, K.; Miyazaki, Y.; Harada, K.; Fukumoto, K.; Tsujiki, Y. Exploring the physiological and psychological effects of digital shinrin-yoku and its characteristics as a restorative environment. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1–18, doi:10.3390/ijerph19031202.
60. Shabir, A. Ujicoba penggunaan teknologi virtual reality sebagai media pembelajaran. *J. Pendidik. Tambusai* **2022**, *6*, 696–702.
61. Sutanto. *Cekal (Cegah dan Tangkal) Penyakit Modern Hipertensi, Stroke, Jantung, Kolestrol, dan Diabetes;* CV Andi Offset: Yogyakarta, Indonesia, 2010.
62. Litleskare, S.; Fröhlich, F.; Flaten, O.E.; Haile, A.; Kjøs Johnsen, S.Å.; Calogiuri, G. Taking real steps in virtual nature: a randomized blinded trial. *Virtual Real.* **2022**, *26*, 1777–1793, doi:10.1007/s10055-022-00670-2.
63. Zabini, F.; Albanese, L.; Becheri, F.R.; Gavazzi, G.; Giganti, F.; Giovanelli, F.; Gronchi, G.; Guazzini, A.; Laurino, M.; Li, Q.; et al. Comparative study of the restorative effects of forest and urban videos during covid-19 lockdown: intrinsic and benchmark values. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1–13, doi:10.3390/ijerph17218011.
64. Li, H.; Du, X.; Ma, H.; Wang, Z.; Li, Y.; Wu, J. The effect of virtual-reality-based restorative environments on creativity. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1–38, doi:10.3390/ijerph191912083.
65. Nilsson, N.C.; Serafin, S.; Steinicke, F.; Nordahl, R. Natural walking in virtual reality: a review. *Comput. Entertain.* **2018**, *16*, 1–22, doi:10.1145/3180658.
66. Brancato, G.; Van Hedger, K.; Berman, M.G.; Van Hedger, S.C. Simulated nature walks improve psychological well-being along a natural to urban continuum. *J. Environ. Psychol.* **2022**, *81*, 1–11, doi:10.1016/j.jenvp.2022.101779.
67. Widayatun, T.R. *Ilmu perilaku*; PT Fajar Interpratama: Jakarta, Indonesia, 1999.
68. Ibrahim, A.; Ali, H.; Zghoul, A.; Jaradat, S. Mood state and human evaluation of the thermal environment using virtual settings. *Indoor Built Environ.* **2021**, *30*, 70–86, doi:10.1177/1420326X19880325.
69. Grassini, S.; Ratcliffe, E. 2008. The virtual wild: Exploring the intersection of virtual reality and natural environments. In Managing Protected Areas: People and Places; Finneran, N.; Hewlett, D., Clarke, R. Eds.; Palgrave Macmillan: Cham, Switzerland, 2023; pp. 327–351.