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Effects of green exercise and walking in natural environments on physiological and cognitive health

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim Exposure to natural environments is an important factor in physical and mental well-being. However, the specific effects of outdoor walking on cognitive and physiological health still require the search for effective solutions. This study aims to examine the effects of walking exercises in natural environments on the physiological and cognitive health of university students.

Material and Methods Thirty-two university students leading a sedentary lifestyle participated in the study. The experimental group (age = 21.25 ± 1.61) walked in nature twice a week for eight weeks, covering distances ranging from 6 to 10 km. The control group (age = 22.00 ± 1.54) maintained their sedentary lifestyle during this period. Reaction time, accuracy rate, memory capacity, cognitive performance, resting heart rate (RHR), and oxygen saturation level (SpO_2) were measured before and after the study. These measurements were recorded using OpenSesame software and analyzed using the visual memory paradigm. Data were processed using SPSS 26.0 (IBM Corp., Armonk, NY), with statistical significance set at $p < 0.05$.

Results Although reaction time increased by 5.15% in the experimental group, no significant difference was found. Accuracy rate (8.42%), memory capacity (7.52%), cognitive performance (9.60%), oxygen saturation (1.03%), and RHR (4.26%) improved significantly. Pre-test and post-test comparisons revealed significant differences ($p < 0.001$) in these variables. In the control group, a statistically significant difference was observed only in RHR, while no significant changes were found in other variables. Intergroup comparisons showed no significant difference in reaction time; however, accuracy rate, memory capacity, cognitive performance, oxygen saturation, and RHR demonstrated significant differences ($p < 0.001$).

Conclusions Regular walking in natural environments positively affects cognitive and physiological health. It also improves RHR and oxygen saturation while enhancing cognitive performance.

Keywords: green exercise, natural environment, physiological, cognitive, health.

Introduction

It is well known that natural environments such as forests, countryside, parks, green spaces, and gardens have positive effects on human health. Green or natural spaces have long been recognized as beneficial for well-being. For example, during the Industrial Revolution in 19th-century England, wealthy philanthropists developed urban parks to promote public health. These parks were reported to have therapeutic properties [1]. A study conducted in the early 21st century found a correlation between the amount of green space in an environment and improved health outcomes [2]. Nature provides a restorative environment that does not directly demand attention, allowing individuals to recover from mental fatigue [3] and regain focus.

Despite a declining interest in natural environments, some people continue to seek nature and participate in outdoor activities [4]. While participation in outdoor endurance activities has been increasing, a significant proportion of the population still does not engage in adequate levels of physical activity. Studies suggest that outdoor exercise provides greater mental health benefits compared to indoor activities [5]. Moreover, exercising in natural environments has been reported to have a stronger impact on cognitive health [6]. The term "green exercise" was introduced in 2003 and entered the scientific literature in 2005 to describe the potential synergistic benefits of exercising in nature [7].

Green exercise refers to physical activity performed in natural settings. In recent years, it has gained increasing attention in the fields of health and wellness. Numerous studies have demonstrated that exercise in green spaces benefits not only physical health but also mental well-being [7, 8]. In particular, research has focused on the effects of green exercise on cognitive and physiological parameters, including attention (accuracy) [9, 10], memory capacity, cognitive flexibility [11], reaction time, oxygen saturation, and resting heart rate (RHR) [12]. Findings from experimental studies suggest that merely observing natural landscapes can have long-term immune-boosting effects, reduce

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stress, improve mood [6], and enhance attention [13]. Research has also shown that watching a five-minute video of a natural environment induces positive changes in the autonomic regulation of the heart [14].

In another study, blood pressure decreased when adults walked on a treadmill at light intensity while viewing images of a static natural environment. This reduction was significantly more pronounced in both systolic and diastolic blood pressure compared to individuals exercising in an indoor environment [7]. Given that hypertension is a global chronic health issue [15], many preventive programs recommend exercise as a non-pharmacological intervention for blood pressure reduction [16]. Understanding the role of exercise in blood pressure regulation is crucial for developing effective exercise prescriptions. Longitudinal studies have highlighted an association between outdoor physical activity and lower blood pressure values in children [17]. Additionally, regular physical activity has been linked to a higher quality of life [18]. Exercising while viewing natural landscapes may enhance the hypotensive effect of exercise, providing valuable insights for public health practitioners designing exercise programs to mitigate health risks.

The available literature does not provide specific information on the direct effects of green exercise on oxygen saturation levels. However, green exercise is defined as physical activity performed in natural environments. According to one study, as engagement in green exercise increases, interactions with nature also rise, positively influencing participants' physical activity levels [19]. Physical activity is a key factor influencing the body's oxygen consumption and concentration levels. During exercise, arterial blood oxygen saturation (%SpO_2) typically remains between 95% and 100% [20]. However, it may slightly decrease under environmental conditions with reduced oxygen availability, such as at high altitudes or during intense exercise. Regular physical activity can enhance respiratory capacity and improve the body's oxygen utilization efficiency, leading to higher oxygen saturation levels at rest. Additionally, low-intensity activities can help maintain oxygen saturation and contribute to blood pressure reduction in individuals with hypertension or cardiovascular conditions [21].

An analysis of various studies has shown that green exercise positively influences both physiological and cognitive health by enhancing oxygen saturation, reducing stress, and improving cognitive functions such as attention and memory. Researchers emphasize the role of natural environments in promoting mental well-being and physical performance, highlighting the potential benefits of integrating outdoor activities into daily life. Moreover, studies suggest that exposure to nature during exercise may enhance its restorative effects, leading to improved autonomic regulation and cardiovascular health.

Despite numerous studies addressing these issues, further research is needed to develop more effective approaches to optimizing the benefits of physical activity in natural environments. There remains a need for deeper investigation into the specific physiological mechanisms underlying these effects, particularly regarding oxygen saturation and cognitive function.

Therefore, it is essential to further explore how regular physical activity in natural environments influences both physiological and cognitive health. A comprehensive understanding of these effects could contribute to the development of more effective exercise recommendations for improving overall well-being. Based on these considerations, the following hypothesis is proposed:

H_1: Regular walking in natural environments will lead to significant improvements in university students' physiological (oxygen saturation, resting heart rate) and cognitive (reaction time, accuracy, memory capacity, cognitive flexibility) health.

This study aims to examine the effects of walking exercises in natural environments on the physiological and cognitive health of university students.

Material and Methods

Participants

Thirty-two university students participated in the study. The participants consisted of students leading a sedentary lifestyle. Students who were willing to participate in walking exercises on a voluntary basis constituted the experimental group (n = 16, age = 21.25). Students who did not wish to participate in walking exercises constituted the control group (n = 16, age = 22.00).

Ethics Approval and Consent to Participate

This study (Approval No.: 05/09, 14.05.2024) was approved by the Ethics Committee of Alanya Alaaddin Keykubat University. The study was conducted in accordance with the principles of the Declaration of Helsinki. All participants were informed about the purpose and procedures of the study, and written informed consent was obtained from each participant.

Determination of Sample Size

Power analysis was conducted using the G*Power software (version 3.1.9.2, University of Düsseldorf, Düsseldorf, Germany) based on the study by [22]. The analysis was performed with an α error probability of 0.05 and statistical power (1 - β error probability) set to 0.90. The sample size estimation was based on the difference between two independent means. With a high effect size (d = 0.80), calculations indicated that a minimum of 16 participants per group was required to achieve 89.69% statistical power. This sample size was sufficient to detect significant differences between groups.

Study Design

Data Collection

Participants' demographic, physical, and physiological data were collected using personal surveys and standardized measurement techniques. Data were gathered for the following parameters:

- Anthropometric Measurements: Age was calculated based on birth dates. Height (cm) was measured using a wall-mounted stadiometer and a measuring tape [23]. Body mass (kg) was recorded using a digital scale [24]. BMI was calculated using the formula weight/height² [25]. Body fat percentage (BFP) was assessed through bioelectrical impedance analysis [26].
- Physiological and Cognitive Assessments: Pre-test and post-test assessments included reaction time, accuracy, memory capacity, cognitive performance, resting heart rate, and oxygen saturation levels. These cognitive parameters were evaluated using the OpenSesame 3.3.8 software.

Intervention Protocol

The experimental group participated in walking exercises in nature, also referred to as green exercise, twice a week for eight weeks, covering 16 different routes ranging from 6 to 10 km. These routes were located in the Alanya district of Antalya province, Turkey. The walks took place in October (average temperature: 22°C) and November (average temperature: 17°C) of 2024 under the supervision of researchers.

The control group did not engage in any structured walking exercises. Their physical activity was limited to daily walking required for household tasks and other essential activities.

After the intervention, post-test measurements were conducted for both the experimental and control groups. The study protocol is illustrated in Figure 1.

Cognitive and Physiological Assessments Using OpenSesame

All measurements were conducted using the OpenSesame 3.3.8 software program [27]. The visual working memory task, which utilized colored squares, was developed based on the visual working memory paradigm established by Vogel and Machizawa [28].

Each trial commenced with a fixation point displayed on the screen for 200 ms, accompanied by an arrow indicating the direction of the colored squares in which participants needed to detect changes. The arrow pointed either to the left or the right. Following the presentation of the fixation point and the arrow, the arrow disappeared, and a memory array consisting of one to four squares was presented for 100 ms on either side of the fixation point. Participants were instructed to remember the colors of the squares indicated by the arrow. Subsequently, the fixation point was shown for 900 ms.

Finally, a test array was presented, similar to the previous memory array, containing one to four colored squares on either side of the fixation point. The number of squares in the test array was equal to that in the memory array for each trial. In half of the trials, one square in the test array differed in color. Participants were required to respond by pressing the "C" key if they detected a change and the "M" key if there was no change. If participants responded correctly, the fixation point turned green for 95 ms following the correct answer. Conversely, if an incorrect response was given, the fixation point turned red for the same duration.

A visual representation of each trial is illustrated in Figure 2. The tasks were conducted on a computer with a 21.5-inch display (resolution: 1920 × 1080), powered by an Intel® Core™ i5 (3.2 GHz) processor. Images were presented at a viewing distance of 50 cm, creating a visual angle of 31.57° × 29.48°. Participants responded using a computer keyboard and mouse.

Participants first completed a practice session consisting of sixteen trials presented in a block

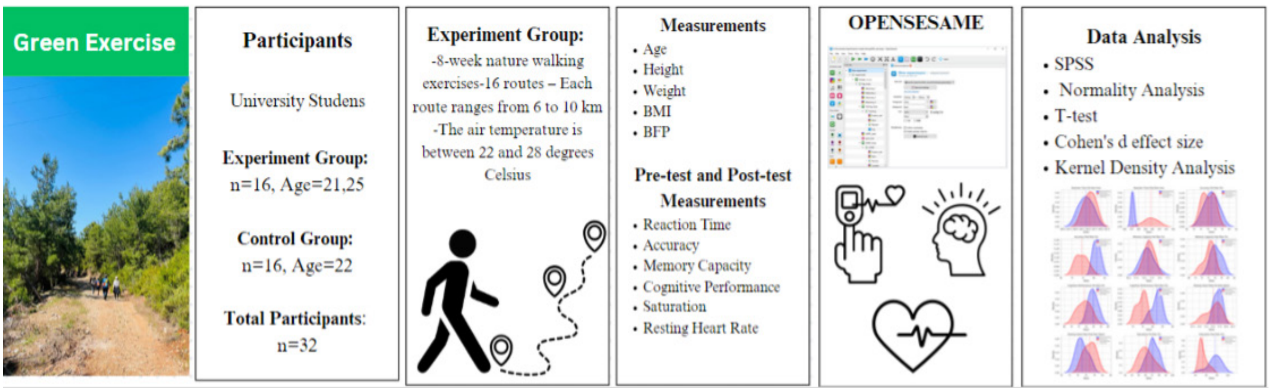

Figure 1. Study Design

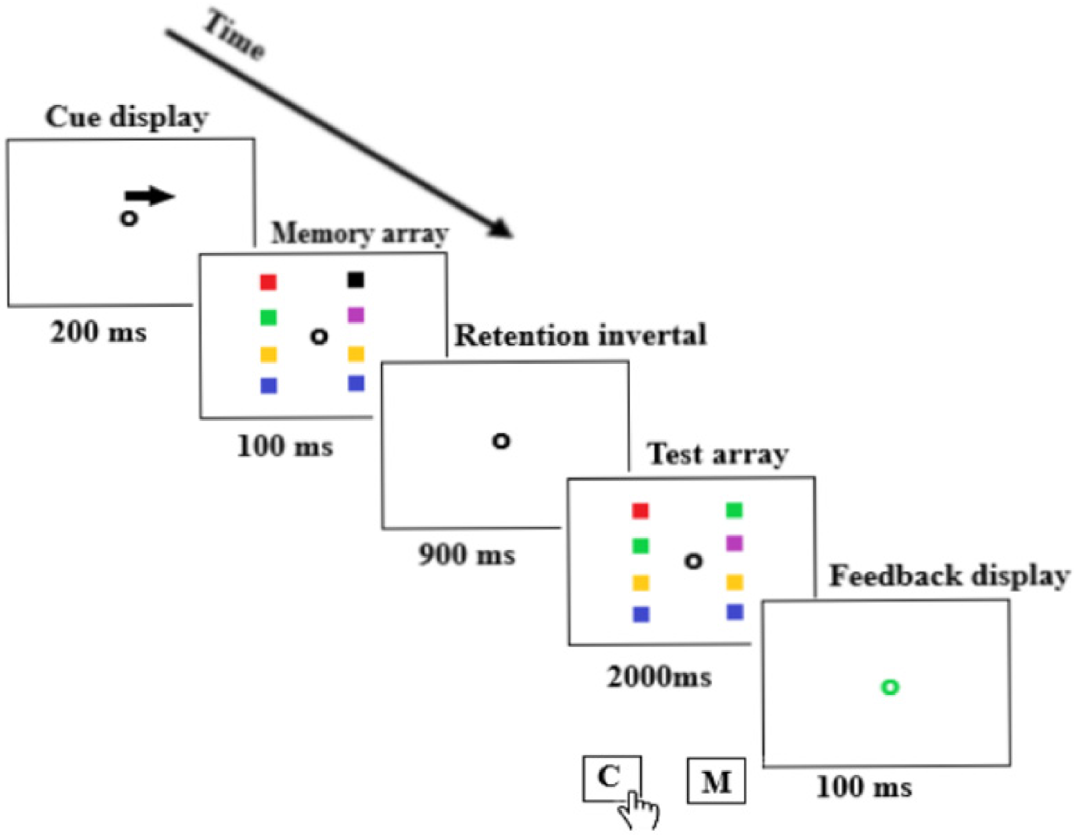

Figure 2. Procedure Used in the Visual Working Memory Experiment

format before proceeding to the main task. After this practice session, a feedback screen displaying their reaction times and accuracy rates was shown. They then transitioned to the main task, which comprised 160 randomized trials divided into ten blocks, each containing sixteen trials. At the end of the main task, participants received feedback identical to that provided after the practice session. The entire experiment lasted between ten and fifteen minutes.

Assessment Measures

- Reaction Time: The time recorded while transitioning between different tasks was calculated and noted as the reaction time. In OpenSesame, reaction time is measured by calculating the time it takes for participants to respond after a specific stimulus is presented. Here, "Time of Response" represents the time at which the participant responds, while "Time of Stimulus Onset" indicates when the stimulus was first shown. This duration is typically defined by the following formula:

$$\text{Reaction Time (RT)} = \text{Time of Response} - \text{Time of Stimulus Onset}$$

- Accuracy Rate: The number of correct responses given throughout the task was calculated. The accuracy rate is determined by the ratio of the number of correct responses provided by the participants during the task to the total number of responses. This ratio is typically defined by the following formula:

$$\text{Accuracy Rate} = \left(\frac{\text{Number of Correct Answers}}{\text{Total Number of Answers}}\right) \times 100$$

- Cognitive Performance: Reaction time and accuracy rates have been utilized to calculate cognitive flexibility. Cognitive performance is assessed based on these two measures, which are used to evaluate the participants' cognitive flexibility. By combining these two criteria, the ability to respond quickly and accurately is analyzed as an indicator of performance in cognitive tasks.

$$\text{CP} = \left(100 - \frac{\text{Reaction Time (RT)}}{100}\right) + \text{Accuracy Rate (AR)}$$

- Memory Capacity: Memory capacity is assessed through tasks in OpenSesame, where specific stimuli are presented to participants, followed by requests to recall these stimuli. The collected data are analyzed to evaluate participants' memory capacity using the number of correct responses and reaction times.

$$\text{Memory Capacity} = \frac{\text{Accuracy Rate (AR)} \times \text{Information Processed}}{\text{Reaction Time (RT)}}$$

- Oxygen Saturation Levels and Resting Heart Rate Measurements: RHR and SpO_2 (oxygen saturation) levels were measured using a digital pulse oximeter (M170 OLED—Shenzhen Fitfaith Technology Co., Ltd) [29]. Such devices are widely used for rapidly and non-invasively monitoring blood oxygen levels and

RHR. Studies have demonstrated that these oximeters provide reliable data in both clinical and research settings [29].

Statistical Analysis

The data were analyzed using SPSS 26.0 (IBM Corp., Armonk, NY) and presented as mean ± standard deviation with 95% confidence intervals. A significance level of $p < 0.05$ was adopted. The Shapiro-Wilk test was used to assess normality, while Levene›s test was employed to evaluate variance homogeneity, which was confirmed. An independent *t*-test and a paired-sample *t*-test were applied to analyze the data. Cohen's *d* was used to determine effect sizes, classified as large ($d > 0.8$), medium ($d = 0.5–0.8$), small ($d = 0.2–0.5$), and insignificant ($d < 0.2$) [30]. The within-group percentage change between pre-test and post-test measurements was calculated using Microsoft Excel. For the independent *t*-test, Cohen's *d* was calculated by determining the mean difference between the two groups and dividing it by the pooled standard deviation, using the following formula:

$$d = \frac{M_2 - M_1}{SD_{\text{pooled}}}$$

Results

The anthropometric characteristics of the participants are presented in Table 1. Table 1 indicates that both groups exhibited similar values in terms of age, height, body mass, body mass index (BMI), and body fat percentage (BFP), suggesting that the groups were comparable in their baseline anthropometric characteristics.

Table 2 presents the pre-test and post-test results of cognitive and physiological variables for the experimental and control groups. The analyzed variables included reaction time, accuracy, memory capacity, cognitive performance, oxygen saturation (SpO_2), and resting heart rate (RHR). In the experimental group, reaction time improved, but the change was not statistically significant ($p = 0.095$). No significant change was observed in the control group ($p = 0.509$). The accuracy rate increased significantly in the experimental group ($p < 0.001$), while no significant difference was found in the control group ($p = 0.072$). Memory capacity also showed a statistically significant improvement in the experimental group ($p < 0.001$). A significant change was observed in the control group ($p < 0.05$), but the effect size was low. Cognitive performance increased significantly in the experimental group ($p < 0.001$), whereas no significant change was found in the control group ($p = 0.188$). Oxygen saturation levels showed a statistically significant increase in the experimental group ($p < 0.001$), while no significant change was observed in the control group ($p = 0.164$). Resting heart rate (RHR) significantly decreased in both the experimental ($p < 0.001$) and control groups ($p < 0.001$), though the effect size was larger in the experimental group.

Kernel density analysis indicates that the experimental group experienced a reduction in reaction time of approximately 5.15% in the post-test (Figure 3). This finding supports the notion that walking in natural green spaces positively influences cognitive functions. Additionally, accuracy rates in the experimental group increased by approximately 8.5%, while memory capacity improved by 8%. A similar upward trend was observed in cognitive performance, and resting heart rate (RHR) decreased by an average of 5.1%. Oxygen saturation levels in the experimental group increased by 1.03%, whereas the control group showed a more limited increase.

Overall, the experimental group demonstrated improvements in reaction time, attention, memory capacity, cognitive performance, and heart rate. These findings suggest that the intervention was effective in enhancing cognitive functions and promoting cardiovascular adaptation. In contrast, the minimal changes observed in the control group indicate that the observed improvements were likely attributable to the experimental intervention.

Kernel density analysis was used to assess distributional differences between pre-test and post-

Table 1. Anthropometric Characteristics of Participants

Variables	Group	n	$\bar{X} \pm SD$
Age (year)	Experiment	16	21.25 ± 1.61
	Control	16	22.00 ± 1.54
Height (m)	Experiment	16	1.69 ± 0.05
	Control	16	1.69 ± 0.04
Body Mass (kg)	Experiment	16	72.25 ± 2.62
	Control	16	72.31 ± 2.33
BMI (kg/m^2)	Experiment	16	25.23 ± 1.14
	Control	16	25.11 ± 0.93
BFP (%)	Experiment	16	15.50 ± 0.89
	Control	16	15.25 ± 0.93

Table 2. Pre- and Post-Test Results for Cognitive and Physiological Variables in Experiment and Control Groups

Variables	Group	n	Pre-Test X±SD	Post-Test X±SD	95% CI Lower	95% CI Upper	t	p	intra-group change (%)	F	p	Effect size (Cohen's d)
Reaction Time (ms)	Experiment	16	293.75±2.38	278.62±10.93	-21.09	-9.17	1.783	0.095	15.13 (5.15)	3.544	0.069	2.39
	Control	16	294.68±2.70	295.87±8.11	-3.36	5.74	0.677	0.509	1.19 (0.40)			0.19
Accuracy (%)	Experiment	16	74.87±1.89	81.18±1.60	4.99	7.63	23.419	<0.001*	6.31 (8.42)	242.955	<0.001*	3.60
	Control	16	74.12±1.54	74.62±1.96	-0.83	1.83	1.936	0.072	0.5 (0.67)			0.28
Memory Capacity (%)	Experiment	16	70.68±1.85	76.00±1.59	4.02	6.62	17.000	<0.001*	5.32 (7.52)	176.809	<0.001*	3.08
	Control	16	70.75±1.43	71.25±1.52	-0.61	1.62	2.739	<0.05*	0.5 (0.70)			0.33
Cognitive Performance (%)	Experiment	16	75.50±1.15	82.75±1.23	6.35	8.15	137.452	<0.001*	7.25 (9.60)	146.639	<0.001*	6.07
	Control	16	73.37±1.58	73.56±1.78	-1.08	1.46	1.379	0.188	0.19 (0.25)			0.11
Oxygen Saturation (%)	Experiment	16	96.87±0.88	97.87±0.88	0.34	1.66	8.474	<0.001*	1 (1.03)	245.000	<0.001*	1.13
	Control	16	96.75±0.93	96.80±0.81	-0.61	0.71	1.464	0.164	0.05 (0.05)			0.05
RHR (bpm)	Experiment	16	77.56±1.09	74.25±1.34	-4.23	-2.39	15.174	<0.001*	3.31 (4.26)	31.444	<0.001*	2.70
	Control	16	77.06±1.12	75.50±0.51	-2.22	-0.90	7.006	<0.001*	1.56 (2.02)			1.79

*: p<0.05

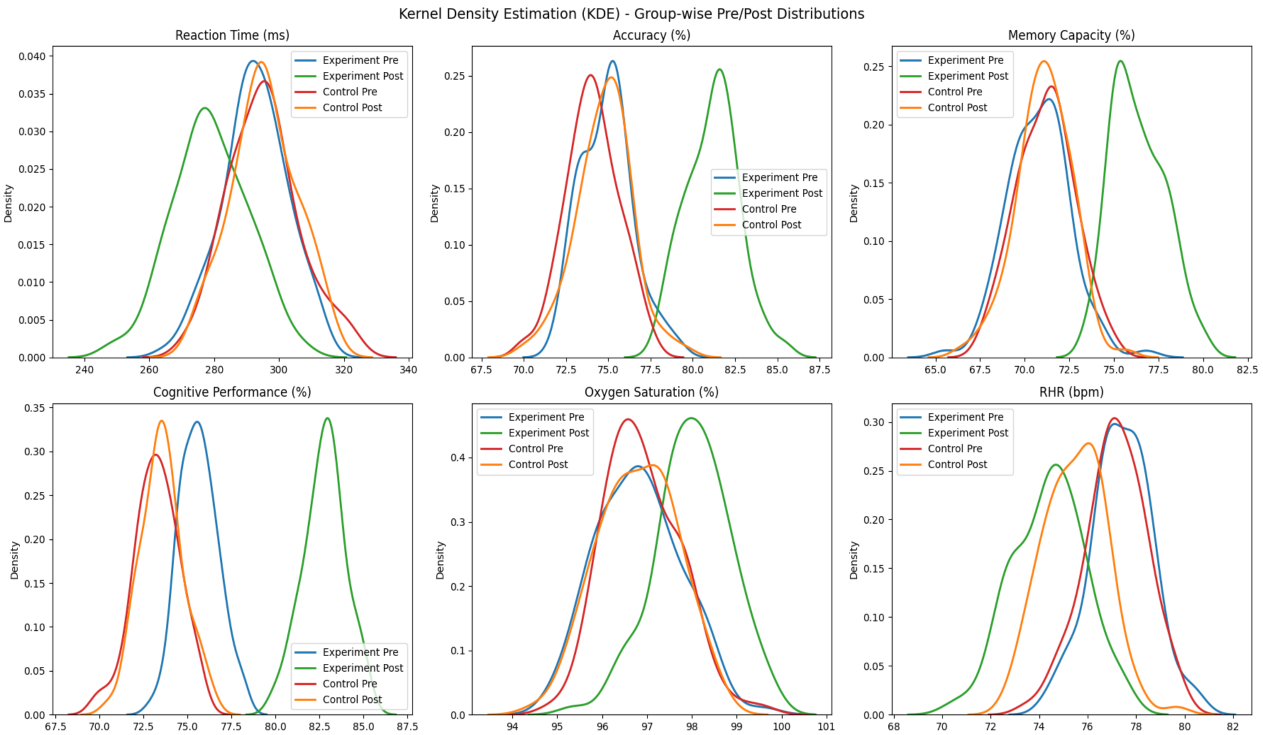

Figure 3. Kernel density analysis for all parameters in experimental and control groups

test measurements in both groups. The post-test distributions in the experimental group highlight improvements in accuracy and memory capacity, whereas the distributions in the control group show no significant changes, limiting the impact of the intervention. Regarding physiological parameters such as oxygen saturation, kernel density analysis suggests that small shifts were not statistically significant.

In conclusion, kernel density analysis confirmed the positive effects on cognitive performance while visualizing only limited physiological effects.

Discussion

The aim of this study was to investigate the effects of walking exercises in natural green environments on physiological and cognitive health. The findings indicate that regular walking in nature led to significant improvements in cognitive performance, including enhanced accuracy, memory capacity, and reaction time. Additionally, positive changes were observed in physiological parameters, such as a decrease in resting heart rate and a slight increase in oxygen saturation levels.

The effects of walking exercises on physical and mental health have been increasingly studied in recent years. Walking in natural green spaces has been shown to contribute to overall well-being. Frumkin et al. emphasize that spending time in nature provides significant benefits by reducing stress levels and supporting mental health [31]. Additionally, some studies suggest that walking can enhance cognitive performance. For example, Kaczynski and Henderson found that engaging in physical activities in nature improves memory and attention skills [32]. Furthermore, improvements in physiological parameters, such as a reduction in resting heart rate (RHR), support the beneficial effects of walking on cardiovascular health [33]. In this context, natural green environments encourage the adoption of a lifestyle that positively impacts both physiological and cognitive health.

Our research indicates that regular walks in natural green spaces may contribute to improvements in reaction time. The findings show that the mean reaction time in the experimental group decreased by 5.15% from the pre-test to the post-test; however, this change was not statistically significant ($p = 0.095$).

Although the observed improvement did not reach statistical significance, existing theories and previous research suggest that exposure to natural environments can positively influence cognitive function. In particular, mechanisms such as reduced mental fatigue and enhanced attentional capacity may play a role in improving reaction times. Theories such as the Attention Restoration Theory [34] and the Biophilia Hypothesis [35] suggest that time spent in nature reduces mental fatigue and enhances cognitive performance. Additionally, a meta-analysis by Colcombe and Kramer demonstrated that aerobic exercise has a positive impact on reaction time and cognitive function [36]. Similarly, Pretty et al. reported that exercising in green environments can alleviate mental fatigue and improve performance [7].

These theoretical frameworks and empirical findings support the potential benefits of regular nature walks for reaction time improvement. However, a longer walking program or alternative assessment methods may be necessary to observe more pronounced effects.

Our research has shown that regular walks in natural environments can enhance participants' accuracy (attention), cognitive flexibility, and memory capacity. The accuracy rate in the experimental group increased significantly by 8.42% from pre-test to post-test ($p < 0.001$). Similarly, cognitive performance improved by 9.60% over the same period ($p < 0.001$).

These findings align with the Attention Restoration Theory proposed by Kaplan and Kaplan [34]. This theory emphasizes that prolonged cognitive effort depletes attentional resources, leading to mental fatigue, emotional disturbances, behavioral changes, and reduced performance. Exposure to natural environments is suggested to aid in cognitive recovery by restoring attentional capacity.

In addition to environmental influences, physical activity has been widely recognized for its benefits to both physical and psychological health [37]. A meta-analysis of 134 studies demonstrated that physical activity contributes to cognitive functioning, with an effect size of 0.25 [38]. Furthermore, Colcombe and Kramer conducted a comprehensive meta-analysis indicating that aerobic exercise, such as walking, enhances executive functions and cognitive abilities, including attention [36]. These findings provide strong empirical support for the cognitive benefits of physical activity.

Additionally, Hillman et al. [39] suggested that aerobic exercise may improve attention, memory, and learning capacities by promoting neuroplasticity. Taken together, these theoretical perspectives and empirical findings suggest that walking not only benefits physical health but also enhances cognitive functions, such as cognitive flexibility and attentional accuracy.

In addition, Gladwell et al. reported that nature walks have positive effects on attention and concentration [4]. Regular walks and time spent in nature are likely to enhance cognitive flexibility and attentional performance. These findings support the idea that regular exposure to natural green spaces can significantly improve cognitive functions and mental performance.

However, there is also evidence suggesting that these positive effects are not conclusive. Bowler et al. reported that the impact of green exercise on attention is relatively modest [40]. Additionally, the potential benefits of green exercise for attentional improvement may depend on an individual's level of focus during the activity [9]. Some studies indicate limited evidence that green exercise provides superior benefits for attentional ability compared to other forms of exercise [8].

Cohen [41] suggests that while individuals tend to adapt to environmental stressors such as noise and air pollution, the adaptation process itself may lead to side effects, including impaired cognitive performance. The rate of attentional exhaustion is influenced by factors such as the complexity, predictability, and controllability of incoming information, with the presence of stressors increasing the risk of cognitive overload. Moreover, exercise in natural environments may serve as a distracting stimulus for the human mind, requiring lower levels of directed attention [42]. In a study conducted by Rider et al., it was reported that a 10-minute walk in nature, in an urban environment, or indoors had no significant effect on attention [37].

Therefore, the effects of green exercise on attentional ability remain inconclusive, highlighting the need for further research.

Our research indicates that regular walking can reduce participants' resting heart rate (RHR) and improve cardiovascular health. In the experimental group, RHR significantly decreased by 4.26% from pre-test to post-test ($p < 0.001$).

Previous studies support the relationship between exposure to nature and autonomic function. Ulrich et al. [43] demonstrated that individuals exposed to stressful visuals exhibited increased parasympathetic activity after viewing nature scenes, which was associated with a lower RHR. Similarly, RHR, as an indicator of autonomic function, has been shown to increase during forest scene viewing and after hiking [44]. Park et al. [45] found that participants sitting in a forest exhibited higher RHR values, indicating increased parasympathetic activity. Additionally, viewing nature scenes indoors significantly influenced parasympathetic activity and led to a decrease in RHR.

Duncan et al. [12] confirmed the positive effects of both green space exercises and walking on RHR, while also demonstrating that various aerobic training programs contribute to RHR reduction. Furthermore, Nemoto et al. [46] reported that walking exercises reduced RHR from 80 to 77 bpm in men and from 79 to 77 bpm in women.

These findings suggest that regular walking, particularly in natural environments, strengthens the autonomic nervous system, enhancing parasympathetic activity and promoting cardiovascular health.

Our research indicates that walking exercises in natural environments can lead to an increase in participants' oxygen saturation levels. In the experimental group, oxygen saturation significantly increased by 1.03% from pre-test to post-test ($p < 0.001$).

Lopez-Pousa et al. [47] reported that oxygen saturation levels reached 95.3% in young individuals walking in the forest and 97.4% in older individuals. Additionally, numerous studies have highlighted the positive health effects of direct exposure to nature [5,7]. These findings suggest that nature walks may enhance overall health by improving oxygen uptake and supporting physiological function.

Our research indicates that eight weeks of nature walks can positively impact students' overall cognitive and physiological health. Significant improvements in cognitive and physiological variables were observed in the experimental group, with statistically significant differences ($p < 0.05$). In contrast, changes in the control group were minimal and generally not statistically significant.

These findings align with existing literature suggesting that time spent in nature enhances both physiological and cognitive health. A systematic review by Lahart et al. [8] compared the effects of indoor and outdoor physical activity on physiological and cognitive well-being in adults, reporting lower perceived exertion and better emotional responses in green exercise conditions. Similarly, other studies have highlighted the superior restorative effects, enhanced emotional responses [48], and improved mental health [49] associated with green exercise compared to activities conducted indoors or in urban environments.

Thompson Coon et al. [5] further suggested that physical activity in natural settings provides greater psychological benefits than indoor exercise. More broadly, research indicates that activities in natural environments contribute to positive psychological outcomes, including rejuvenation, increased social interactions, elevated energy levels, and reduced negative emotions.

Although the advantages of physical activity in natural settings are complex to quantify, existing evidence suggests that such activities support both physical and cognitive health, reinforcing the role of nature-based exercise in overall well-being.

Study Limitations

This study has several limitations. First, the relatively small sample size may limit the generalizability of the findings. Additionally, given the age range of the participants in the experimental group, the applicability of the results to a broader population remains uncertain.

Another limitation concerns the control group, which did not engage in structured physical activity. While this may have contributed to the clearer effects observed in the experimental group, it also introduces the possibility that other individual differences between the groups influenced the results. Furthermore, variations in walking time and distance among participants may have affected experimental control.

Finally, this study focused solely on cognitive and physiological variables. The exclusion of other potentially relevant factors, such as participants' baseline cognitive status and environmental influences, may have limited the scope of the findings.

Future Research Directions

Future studies should aim to increase the sample size and include participants from different age groups to enhance the generalizability of the results. Standardizing the duration and intensity of physical activity will also improve comparability across studies.

Additionally, examining the effects of diverse environmental conditions beyond natural settings could broaden the scope of research in this field. Incorporating cognitive and social variables into future investigations will provide a more comprehensive understanding of how walking influences both mental and physical well-being.

Conclusions

This study examined the relationship between nature, exercise, and physiological and cognitive health. The results indicate that hiking in natural environments has a significant impact on both physiological and cognitive health in university students. Specifically, the findings suggest that nature walks can enhance cognitive performance (reaction time, accuracy rate, and cognitive flexibility) and improve physiological parameters (resting heart rate and oxygen saturation). Moreover, time spent in nature may contribute to mental well-being by supporting cognitive benefits such as stress reduction and attention restoration. Overall, the evidence suggests that engaging in physical activity in natural environments can promote long-term health and improve quality of life.

Practical Implications

The findings of this study demonstrate the positive effects of walking in nature on cognitive and physiological health. These results underscore the importance of promoting nature-based physical activities, particularly for stress reduction and overall mental well-being. However, the feasibility of nature walking programs may be influenced by factors such as seasonal changes and access to green spaces. Depending on weather conditions, encouraging the development of indoor alternatives or the use of appropriate equipment may help maintain participation.

Expanding green spaces in urbanized areas or improving accessibility through public transportation can facilitate greater engagement with nature. Practitioners can implement walking programs in university settings and community initiatives to enhance both mental and physical health. Additionally, health professionals and educators can integrate such activities into public health policies to promote regular interaction with natural environments. Raising awareness of the benefits of nature walks can contribute to improving public health and fostering a more active lifestyle.

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Conflict of Interest

The authors declare no financial, personal, or professional conflicts of interest related to this study.

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