Original Article

The effectiveness of exposure to green space on absolute power of alpha wave and stress reduction in people with attention deficit hyperactivity disorder

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Abstract

The purpose of this study was to investigate the effectiveness of exposure to green space on absolute power of alpha wave and stress reduction in people with attention deficit hyperactivity disorder. The population of the present study includes 150 university students of Mohaghegh Ardabili in different stages grades with attention deficit/hyperactivity disorder (ADHD) in the academic year 2022-2023 who were selected using convenience sampling. Therefore, 32 volunteer students with the highest average score in attention deficit hyperactivity disorder were exposed to green space for 10 minutes. In order to collect the data, quantitative electroencephalography (QEEG) and Connors adult ADHD questionnaire (1999) and Ertanir et al.'s student stress questionnaire (2021) were used. For data analysis, the frequency data of brain waves, Neuroguide software was used, and for statistical analysis of quantitative data, Duncan's mean square test used statistical software Statistical Analysis System (SAS). The findings of the present study show that the effect of exposure to green space compared to the environment without green space on the absolute power of alpha waves in the anterior, central and posterior regions have a significant difference. Also, the results of the statistical analysis of the data obtained from the questionnaire tool were significant (P<0.05) in reducing the stress of people suffering from attention deficit/hyperactivity disorder. The results of the present research have shown that the changes in the absolute power of the alpha band in two different thinking situations indicate different functional mechanisms of alpha waves in different brain regions.

Introduction

Psychiatric disorders stress large burdens on society around the world. And psychiatric disorders, depression, anxiety, dementia, schizophrenia, and ADHD afflict an increasing number of individuals (Zhang et al., 2024). ADHD is a neurodevelopmental disorder (Hashemi et al., 2024). Depending on the analysis technique. mental illnesses could be attributed to between 4.9% (GBD, 2022) - 16% (Arias et al., 2022) of global disability-adjusted life years (DALYs) in 2019. Mental health encompasses the absence of mental illness and the presence of psychological well-being (Bratman et al., 2019). Attention Deficit Hyperactivity Disorder is one of the most common childhood and adolescent psychiatric disorders characterized by persistent symptoms of inattention, impulsivity, and inactivity (Narimani et al., 2020; Arshadi et al., 2022), The patterns of human contact with nature have undergone fundamental changes. Urbanization has become one of the leading international trends in the 21st century, which has a vital impact on human health. So that currently more than half of the world's population lives in cities and this ratio is expected to increase over time; which will result in more people not having access to green space and its consequences may be significant for humans (Diana et al., 2022). According to the World Health Organization, approximately 50% of the world's population lives in urban areas. It is predicted that this figure will increase to about 68% by 2050 (Pferschy-Wenzig et al., 2022). So that some studies have shown that up to 44% of the adult population of the United States may be facing disorders caused by mental stress, anxiety disorder and lack of concentration in performing activities (Kavalares, 2023).

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The empirical findings of recent studies point to the importance of discovering ways to reduce the incidence of these psychiatric disorders. Some studies suggested the positive effect of communication with nature and greenery on the level of relaxation and mental fatigue, promotion of social integration, treatment of mental-psychological diseases, increase of attention and concentration capacity, reduction of stress level due to the aesthetic effects of nature plants and greenery (Lumber et al., 2017). This trend is supported by theories like the attention restoration theory and psycho-evolutionary stress reduction theory, which claim the natural environment serves as a practical component for mental stability and attention recovery in humans (Wu et al., 2022). It is argued that exposure to green spaces can reduce the likelihood of developing a range of these psychiatric disorders in individuals (Engman et al., 2019). On the other hand, the existence of brain activities of absolute power is interpreted as signs of the nervous system inhibiting the factors of psychiatric disorders (Zhao et al., 2023). Based on experimental studies of brain activities, absolute power plays a role in many neuro-cognitive processes, including active memory, as a result, it increases alertness, flourishes and matures the brain and improves executive-cognitive performance in people (Wianda & Ross, 2019). The frequency of brain activities of absolute power can have therapeutic effects, and affect the sympathetic and parasympathetic nervous system (Loong et al., 2022) and by affecting the central nervous system, lead to the improvement of cognitive and psychological functions. The central nervous system, composed of the spinal cord and the brain, plays an important role in the pattern of human behavior. People's hearing, tasting, smelling, feeling and seeing are all controlled by the central nervous system (Zhang et al., 2023).

In recent years, measuring the activities of the central nervous system has been an objective method to evaluate the understanding, diagnosis of neurological and physiological factors, and with the advancement of engineering knowledge and the possibility of converting electrical activities into numerical values, it has become possible to determine the pattern of brain activities. converted into quantity in the form of computational algorithms (Lee et al., 2011). One of the basic paraclinical tools to measure the pattern of brain activities is the quantitative electroencephalography device (QEEG), which is also considered an important clinical test tool for diagnosing many brain diseases (Goenka, 2018). Computer electroencephalography paved the way for the emergence of quantitative electroencephalography (QEEG). When a group of neurons fire at the same time, a wave-like effect is created, called a brain wave. These waves caused by the electrochemical activities of the brain have been measured and studied by doctors and other specialists in the form of quantitative electroencephalography. Although both electroencephalography and quantitative electroencephalography (QEEG) are not 100% in documenting the main causes of neuropsychological

emergence defects in neurodevelopmental disorders, there are studies that support the use of quantitative electroencephalography tools in the diagnosis and differentiation of various disorders (McCarthy et al., 2005). In the electroencephalography device, a kind of frequency analysis of the waves of the central nervous system (brain) is done in the form of analog EEG images in the form of digital images. This problem makes it possible to analyze the electrical potentials resulting from the processing of central nervous system cells during various mental activities (such as concentration, memory, decision-making, etc. (Basharpour et al., 2019). The oscillations of the electroencephalogram device are located on a wide range of frequencies. Frequencies are actually one of the functional parameters of the central nervous system and show the number of repetitions of waves (rise and fall) per second. One of the direc information that is determined by the signal of the electroencephalogram device is the power value of the band, which is located in a region under the Fourier spectrum domain curve in a certain frequency spectrum (Liu et al., 2018). Also, the findings of several experiments in studies have shown that absolute power frequency is an indicator for the speed of cognitive performance and learning memory in particular. The evidence shows that the activity of the absolute power band will undergo changes during the memory function (Magosso et al., 2019). A normal EEG tape consists of a complex combination of multiple frequencies. Highly balanced alpha waves are waves with a frequency of 8-13 Hz that appear in the waking state, the occipital cortex is the best area for the activity of this wave, and the amount of alpha activity decreases by moving to earlier areas (Franco et al., 2017).

Beiser's (1999) studies in the field of neurology argue that neural oscillations (intensity and frequency of brain waves) in the Quantitative electroencephalogram device (QEEG) with some functions of the central nervous system, such as recording feelings, tracking, perception, movement, and cognitive processes related to attention. Learning and memory are related. The environments of educational centers where students spend most of their time in that environment. Prevalence of high level of stress is predicted, which is very important in the mental health of students, and neglecting it will bring unfortunate consequences. Reducing stress and mental pressure is an important and fundamental step to increase people's learning and training. In a group of studies conducted on stress, the activity of the alpha and beta bands of the two brain hemispheres in the frontal and prefrontal areas were investigated (Lewis et al., 2017). However, the level of stress and anxiety among students is increasing and puts them at risk of developing mental disorders and related diseases, such as behavioral disorders and learning disorders (Safer, 2018). Perceived stress is a person's assessment of the importance and difficulty of his environmental and personal challenges (Imani et al., 2023). ADHD is one of the most common childhood neurodevelopmental disorders. It is usually first diagnosed in childhood and often continues into

adulthood (Ariapooran et al., 2022), which is characterized by attention and concentration problems, impulsivity, disorganization, stress intolerance, and emotional and mood changes in adulthood, especially for students was (Clarke et al., 2020). Also, the findings of the studies of Taylor and Ko (2011) have been confirmed with the positive effect of natural habitats or green spaces in attention deficit hyperactivity disorder through increasing people's attention and concentration. Specific QEEG patterns have been identified in ADHD individuals with heterogeneous symptoms,19 and there have been attempts to classify the subtypes of ADHD using QEEG (Clarke et al., 2002). Recently, Byeon et al analyzed QEEG among identified who were either ADHD, ADHD not otherwise specified (NOS), or neurotypical (NT) as a result, it is now possible to classify ADHD into subtypes with either high delta power and low theta power, high theta power and low–fast frequency, or elevated alpha waves. The authors suggested that it is necessary to investigate whether the group with the elevated alpha waves are a new subtype of ADHD or whether it reflects the characteristics of adulthood depression. The results of the studies analyzing subtypes of ADHD using QEEG suggest that ADHD is a physiologically heterogeneous disease presenting with differences in behavior, emotion, and cognition for each QEEG subtype. However, the number of studies that classify the QEEG subtypes for identified with ADHD is small, making it generalization difficult (Byeon et al., 2020). Research has shown that the group diagnosed with attention deficit hyperactivity disorder (ADHD) had a high level of alpha wave activity during continuous visual performance. An increase in low-frequency activity (alpha) and a decrease in high-frequency activity (beta) are observed in hyperactive/inattentive people (Ogrim et al., 2012). In general, in attention deficit hyperactivity disorder (ADHD), a decrease in the activity of the frontal areas has been identified. The increase in slow brain waves and the decrease in the activity of fast waves in the central and frontal areas probably indicate a lack of stimulation of the central nervous system (Winking, 2023). The etiology of ADHD is still not fully understood, but both genetic and environmental factors are involved in its development (Thomas et al,2015). One often-overlooked factor in the development of adulthood behavioral disorders is green space in the living environment. It is hypothesized that exposure to greenness may improve behavioral and mental health (Thygesen et al., 2020) by advancing physical activity, promoting social activity and decreasing harmful environmental exposures such as air pollution heat and noise (Klompmaker et al., 2020). In recent decades, a growing body of epidemiological studies has investigated the associations between green space and hyperactivity behaviors, but the results are inconsistent. Several researches by Afonso (2009), Hughes et al. (1999), Chabo et al. (2005) have pointed out the important role of the quantitative electroencephalogram device in the diagnosis of learning disorders. Also, the previous studies of Elsadek et al. (2019) on the

relationship between views related to green space (nature) and improving mental health, Yun et al. (2019) Real Foliage Plants as Visual Stimuli to Improve Concentration and Attention in Elementary Students. Zhang et al. (2022), Physiological Effects of a Garden Plant Smellscape from the Perspective of Perceptual Interaction, Tang et al. (2022) Psychophysiological response of cut flower fragrances as an olfactory stimulus with electroencephalogram measurement in adults Zhang et al. (2023) the physiological effects of the smell of garden plants from the perspective of perceptual interaction, Cardinali et al. (2024) investigating the characteristics of green space for the consequences of social cohesion and mental health of people, Kivani et al. (2021) investigating the effects of green space in the interior design of residential spaces on mental health and Users' sense of belonging, Yazdani (2021) The role of urban green spaces in the mental health and quality of life of citizens, Vafadari Kamar Alia (2021) Investigating the role of landscapes and urban green spaces in improving mental health, Karimi et al. (2022) Assessing the impact of urban design qualities on health Mentality and happiness of citizens (case example: Chaharbagh and Soran neighborhoods in Sanandaj city) , Falke (2023), a residential village for the elderly, has been focused on the effect of green space on the health of the body and soul of the elderly.

As aforementioned, the useful effects of nature and plants on human physiological and psychological states have been well reported. However, limited studies investigating the effectiveness of green space on brain activity of absolute power have been focused on the level of stress reduction and learning disorder using electroencephalography device. Therefore, a kind of research vacuum is felt in this field, which requires more studies. Therefore, in the current study, the investigate the effectiveness of exposure to green space on absolute power of alpha wave and stress reduction in people with attention deficit hyperactivity disorder. and hyperactivity, in the anterior (Fp1,F7,F3,T3,C3,T5,P3,O1), middle (Fz,Cz,Pz), posterior (Fp2,F4,F8,C4,T4,P4,T6,O2) areas have been quantitatively investigated using an electroencephalography device. Therefore, in the current research, the researcher has sought to investigate the effect of exposure to green space consisting of ornamental flower plants and ornamental leaf plants on brain activity with absolute alpha power and stress reduction in students with attention deficit/hyperactivity disorder.

Method

Participants

Research design and participants: The current research is of an applied, quasi-experimental, field and analytical type, comparing exposure to green space (ornamental leafy plants and ornamental flowering plants) as an independent variable and brain activity, absolute alpha power and stress reduction. In people with attention deficit hyperactivity disorder, it was selected as a dependent,variable research. The statistical population

of the present study includes the university students of mohaghegh ardabili in different stages of the 2022-2023 academic year and was selected using Convenience Sampling method. This study was conducted among university students (phd and undergraduate and graduate students) aged 20–40 years old. The way to collect information was that first, after obtaining permission from University of Mohaghegh Ardabili, the student health treatment and counseling center was referred. So that the subjects were people who were voluntarily or forcibly referred to the counseling center by the university. The psychometric characteristics of the subjects were recorded by clinical interview by the experts of the center based on the diagnostic signs of stress level and attention deficit disorder and hyperactivity. The results of these clinical interviews were used to select subjects. Therefore, among these people, they were invited voluntarily and knowingly to participate in the experiment. After a preliminary survey of the invited people, they were selected according to the initial selection criteria with an emphasis on the research objectives. Entry criteria included no history of brain damage, no physical disability and sensory and movement problems of any kind, age 20 to 40, normal or corrected vision, right-handed people, and exit criteria included people's unwillingness to cooperate. Based on the report received from the Student Health and Counseling Center, 150 adult Connors standard questionnaires were distributed and collected among students of different levels and the total score of the inattention/hyperactivity scale of each student was calculated in the minimum/maximum range. Scores of zero, minimum and maximum 27. Statistical analysis of the obtained data, a score higher than 27 was identified with attention deficit/hyperactivity disorder. Finally, 32 students with the highest score in attention deficit/hyperactivity disorder (16 women and 16 men) were selected to participate in the test process. After that, they responded to the standard stress questionnaire test of Ertanir et al. (2021) and the electroencephalography device and were exposed to green space. In order to ensure the effect of the experiment and avoid a practice effect caused by repeated participation of the subjects (Mo, 2008), the subjects in each group did not overlap. In order to check the level of stress and the possibility of attention deficit/hyperactivity disorder in the samples studied in this research, Three measurement methods are used, including: 1- questionnaire containing the basic information of the samples and specialized questions of adults by Conner's (1999) and a stress questionnaire 2- examination quantitative electroencephalography (QEEG) device Through the recording of brain waves of the studied samples, based on the advanced analysis of brain signals and brain maps, 3-Also, the measurement of physiological indicators selected in this study: indicators related to the autonomic nervous system (ANS), including (blood pressure, pulse pressure difference, pulse and skin conductance) during and before the test process using an electronic arm sphygmomanometer it has been used.

Conner's' Adult ADHD Rating Scales questionnaire(1999): In order to measure the attention deficit-hyperactivity disorder variable of the students, the Connors standard adult questionnaire compiled by Connors (1999) was used. This questionnaire has 30 items (questions). It measures the probability of learning disorder in adults in the indicators (lack of attention, Aggressive – impulse control, Restlessness - hyperactivity, ADHD Index, Problems with self-image). The measurement scale of the items in this questionnaire was based on a 4-item Likert scale which consists of never (not at all), a little (sometimes), almost most of the time (most of the time), a lot (always). which is scored based on (0: never, not at all; 1: a little, every now and then; 2: almost most of the time, most of the time; 3: a lot, always). Validation and examination of the psychometric features of the Persian version in the Iranian population has been carried out by the studies of Moghadsin et al. (2020). that the results of confirmatory factor analysis based on 30 scale questions have shown a high fit with the original American model. In other words, the fit indices of the confirmatory factor analysis have shown a high fit. The results of retesting in two implementations of the questionnaire indicate the stability of this test in the Iranian population. That the results of confirmatory factor analysis based on 30 scale questions have shown a high fit with the original American model. In other words, the fit indices of the confirmatory factor analysis have shown a high fit. The results of retesting in two implementations of the questionnaire indicate the stability of this test in the Iranian population. The first study was conducted on 839 healthy subjects and the second study was conducted on a clinical sample of 167 subjects diagnosed with attention deficit hyperactivity disorder. Cronbach's alpha coefficients for the scales are reported between 0.80 and 0.90. The results of exploratory and confirmatory factor analysis have also confirmed this factor scale. Reversed questions are not used in this questionnaire, and its scoring method is based on the number 0 to 3. Also, for more trust and confidence, its validity and reliability have been investigated in the current research. Its validity has been confirmed by specialists, experts, professors of the educational group. And its reliability has been calculated through Cronbach's alpha coefficient test, which numerical value of 0.888 indicates the desired reliability of this measurement tool.

Instrument

Artanir et al.'s (2021) student stress questionnaire:

In order to measure the students' stress variable, the standard questionnaire for measuring students' stress, compiled by Artanir et al. (2021), was used. This questionnaire has 27 items (questions) that measure students' stress in the components (stress of being in the university environment, stress of professors' interaction, stress of performance, stress of peer pressure) of the

university. The measurement scale of the items in this questionnaire was based on a 4-item Likert scale. which is classified from low to very high, as follows (1: low), (2: medium), (3: high), (4: very high). Validation and examination of the psychometric features of the Persian version in the Iranian population has not been addressed. In order to verify and validate this questionnaire, several steps have been taken. In the first step, the original version of the questionnaire was translated into Persian, in the second step, the translated questionnaire was translated into the original language, and in the third step, the questions that were translated with The original version was different, it has been corrected, at this stage the problems have been fixed by a person who was fluent in Farsi but his mother tongue was English. In the fourth stage, preliminary features of psychometric questionnaire have been checked on 30 people. In the fifth stage, the translation problems of the questionnaire were resolved, the content validity of the questionnaire was examined by expert evaluators and experts and it was adapted to the Iranian culture. Also, in the research of Ertanir et al. (2021), the validity of this questionnaire has been confirmed in the form of factor loading. The average factor loading has been obtained as 0.881. Also, its reliability has been obtained through composite reliability and Cronbach's alpha coefficient to numerical values of 0.976 and 0.908. The scoring of this questionnaire is based on the points you get from answering the questions in the questionnaire. In this regard, the respondent has given a score from 1 to 4, and the higher scores indicate the positive feelings of the respondents. In addition, in the present study, the reliability level of Cronbach's alpha coefficient on the participants in the experiment has been obtained with numerical values of 0.955, which shows the good reliability of the measurement tool. Finally, Cronbach's alpha coefficient indicating internal consistency is used to calculate the internal consistency of the measurement tool that measures different characteristics. In the method of Cronbach's alpha coefficient, more than 0.7 indicates the acceptable reliability of the questionnaire (Hair et al., 2021). Questionnaires have been distributed and collected according to timing and planning in different stages of the test process. In this way, the questionnaires were designed through the online link of the questionnaire, which was designed to facilitate and save the participants' response time in the computer system of the laboratory, which was provided to the participants (study sample) for completion at different stages of the study. The validity of the questionnaire was determined by experts and professors of the Department of Agricultural Education, psychology experts and expert students, and its reliability was determined through reliability tests and Cronbach's alpha. And to check the relationship between the variables, the mean square test was used, the results of which are presented in the findings section.

Procedure

Study design: The present research experiment was conducted in Simulation Room University of Mohaghegh Ardabili Faculty of Educational Sciences and Psychology and with the presence of participants (subjects) according to planning and timing. The first stage of the experiment

process was done by filling out the consent form by the participants, explaining the objectives of the research and the method of conducting the experiment to the participants (subjects) by the researcher. This study used two visual stimuli: Therefore, according to the daily schedule with a special arrangement and program for 20 days at a certain time from 9/30 to 12/30, except for official holidays when facing the green space consisting of ornamental flowering plants and ornamental leaves and observing the wall of the laboratory room without Exposure to green space and the absence of ornamental flowering plants and ornamental leafy plants has been done in suitable environmental conditions of pleasant air with favorable temperature. The experiment was carried out in a room with white walls and ceilings, and the interior space was 2m (long) × 3 m (wide) × 3.1 m (high). In order to prevent the mood of the subjects from being affected by weather and light, the indoor environment was kept the same. The average conditions of the experimental space were as follows:

temperature,21.8 C; humidity, 25.2% ;and illumination, 1465.8 lux (Zhang et al., 2023). The selection of green space consisting of flowering plants and ornamental leafy plants in the test room with the approval of experts and professors of the horticulture, green space, psychology educational department by covering the leaves of perennial ornamental plants, perennial flowering plants (Kalan Koeh, Gal Arous, Shamdani) Dutch, Trumpet, wheat flower, Crassula, Naz Beshagabi flower). Which among the important features of these plants, it is mentioned that they are compatible with the climatic situation, can be cultivated in all seasons and can be used in a closed environment inside pots.

Experimental procedure and EEG Recording: In this experiment, after training the participants about the full details of the test conditions and the test process, and testing the communication between the systems, the test was conducted. For this purpose, the participants (subjects) were seated on the desired chair by adjusting the environmental conditions and the comfort and height of the chair. The height of the chair was adjusted so that both feet of the subject would reach the ground. To minimize external visual stimulation, white hardboard paper was placed before the desk, and ivory-colored curtains were installed on either side of it; a 1.8-by-1.6-m space was thus enclosed. Before conducting the tests, participants' height, weight, demographic information such as age and gender were collected through a survey. Also, the physiological indicators selected in this study are divided into two parts: indicators related to the autonomic nervous system (ANS) (blood pressure, pulse pressure difference, pulse and skin conductance) and indicators related to the central nervous system (CNS) (absolute power of waves alpha brain) were divided. After sitting for 20 min and taking a full rest, the subjects were fitted with equipment, and their blood pressure (BP) and pulse (P) were measured using an upper-arm electronic sphygmomanometer (OMRON, HEM-7211, Kyoto, Japan). Both BP and P were measured twice and averaged for analysis. After the intervention, BP and P were measured again. Pulse is an important indicator of

cardiovascular health. Generally speaking, when the human body is in a stressful state or environment, p values increase; otherwise, they fall (Zhang et al., 2023).

A wireless EEG was attached to the head of the subjects who were then seated in the experimental space for 15 min in order to habituate them to the novel environment. to present the tow visual stimuli (actual plant, and no plant). Before each stimulus was presented, the subjects were asked to look at the white wall in front of them for 1 min to encourage relaxation. Then, the testing process has started by installing ear electrodes and a special cap for recording brain waves on people's heads. These special electrodes for standard EEG recording are based on the standard model of the international 10-20 system of 19 channels made in medicom Russia, including left prefrontal cortex (Fp1), right prefrontal cortex (Fp2), left frontal (F3 and F7), right frontal (F4 and F8), left Temporal lobe (T3 and T5), right Temporal lobe (T4 and T6), left posterior (P3 and C3), right posterior (P4 and C4), left occipital lobe (O1), (right occipital lobe (O2) and the central regions (Pz, Cz, Fz)(Oh et al ., 2019), placed on the Scalp and fixed on the head by the EEG cap . Reference electrodes A1 and A2 were also connected to the ears. Electrogel was injected to create conductivity of the electrode and the surface of the scalp, and the gel was injected until the resistance level reached less than 10 ohms. up to the brain activity of each of the subjects in a relaxed state and in a sitting position in design modes, observing the wall room (control mode without flowers and plants) for 10 minutes with open eyes, observing an ornamental leaf plant for 10 minutes, resting for 15 minutes and viewing the flowering plant for 10 minutes with open eyes was recorded by a quantitative electroencephalography device. Also, the measurement of physiological indicators selected in this study: indicators related to the autonomic nervous system (ANS), including (blood pressure, pulse pressure difference, pulse and skin conductance) during and before the test process using an electronic arm sphygmomanometer it has been used.

Data collected by an electroencephalogram (EEG) device when participants are faced with a stimulus are more objective and can better reflect participants' true thoughts compared with data collected by traditional methods such as interviews or questionnaire surveys, and they are a kind of real-time physiological data (Igarashi et al., 2015). Brainwaves are an internal scientific indicator of mood changes (Park et al., 2016). alpha waves are called 'relaxing waves' and 'creative waves' and are related to the active activity of the brain (Du, 2014). when the energy released by alpha waves is strong, this represents the brain being in a heightened state of learning and thinking. Also, by using the brain wave analysis software, the brain signals of the users were isolated and averaged while viewing the images. Then, for each image, the brain signals of all users were averaged. The data collected from the brain is very much affected by the artifact of the data (EEG) . In this study, MATLAB software was used to optimize the data.

Statistical Analyses: In the current research, in order to collect data through a quantitative electroencephalography device and the resulting waves by the Fourier transform system using a complex mathematical process (FFT), the waves recorded into numbers and numbers are also converted into quantitative data and with the help of Neuroguide software had been analyzed. As a result, the data obtained from the brain registration in the three parts of the right hemisphere, the left hemisphere and the center of the brain cortex for the alpha wavelength, in two situations consisting of 1- green space with ornamental leaf plants and ornamental flowering plants 2- no flowers (green space) Has been studied , Also, the standard questionnaire tool was used for quantitative-statistical analysis of symptoms of stress reduction and attention deficit hyperactivity disorder. The survey method was used to record the demographic characteristics and apply the criteria of entry and exit in the form of self-report. At the end of all the statistical analysis of the quantitative data obtained from this experiment, using SAS 1.9 &IBM SPSS statistical software, analysis of variance and mean comparisons were done, and comparing the means using Duncan's multiple range test in the significance level (0.05 and 0.01) was done at the confidence level of 99% and 95%; And for frequency analysis, Neuroguide software was used.

Results

The results obtained from the data analysis of the descriptive statistics section of the present study show that 16 people from the studied sample are women and 16 people from the majority of the studied sample are men. Therefore, it is argued that the volume of the studied sample is chosen equally. 58.2% of the frequency of the study was selected in the age group (20 to 25 years) and 41.8% of the frequency of the study was selected in the age group (25 to 40 years). Based on this, it is argued that the study volume of people in the age group (20-25) is more selected. The maximum number of studied subjects (subjects) in the sample volume related to the level of education is reported with the undergraduate group with a value of 84% and the minimum studied sample group is related to the doctoral level study group with a value of 7%. The largest number of people studied in the statistical sample size was in the field of study related to the Faculty of Psychology and Educational Sciences, Psychology Department, and the smallest sample size was studied in the study field of the Green Space Department. 93.8% of the studied sample consisted of single people and 6.2% of the studied sample consisted of married people. Among the selected statistical sample, the average height of men was 175.94 cm and the average height of women was 162.16 cm. Among the selected statistical sample, the average weight of men was 70.94 kg, and the average weight of men was 57.56 kg. In this research, the paired t-test was used to analyze the physiological indicators of the subjects before and during exposure to visual stimulation (green space consisting of ornamental leafy plants and ornamental flowering plants) and the control environment (white wall without flowers and plants), and the data were processed by SPSS25.0 software. Table 1 shows that from before to during: visual

stimulation, the subjects' systolic blood pressure (SBP) values did not change significantly. but their diastolic blood pressure (DBP) values increased significantly and their pulse pressure difference (PP) values and pulse (P) values increased significantly. During control, the subjects exhibited no significant changes in their SBP, DBP, PP and p values. During visual stimulation, significant increases in the subjects' DBP and SC values were recorded, and there was a significant decrease in their PP values while their SBP and p values no change significantly. As shown in Table 1, the subjects control no significant changes in their SC values during visual stimulation values increased significantly durin.

Table 1. Changes in physiological indicators before and during exposure to green space and no exposure to green space (room wall) and stress reduction symptoms in people with attention deficit hyperactivity disorder

Stimulus Type	Variable (Unit)	Before		During		
		Mean	SD	Mean	SD	T
V	SBP (mm Hg)	105.89	11.14	104.91	9.81	0.60
C		105.80	7.92	105.22	7.85	0.57
V	DBP (mm Hg)	64.30	6.93	61.04	6.48	2.78 **
C		61.00	7.93	62.46	7.48	-1.42
V	PP (mm Hg)	45.19	8.29	40.63	7.05	3.51 **
C		42.41	8.58	41.02	10.34	0.57
V	P (bpm)	77.67	12.56	75.33	11.40	2.87 **
C		73.96	11.82	73.80	11.29	0.16
V	SC (µ˜Ω)	3.40	2.48	2.95	2.14	2.82 **
C		74.38	10.40	74.40	9.86	-0.21
Green space	Stress	28.26	4.431	15.93	3.95	0.004** 0.22

$p < 0.01$ indicates an extremely significant difference; $0.01 < p < 0.05$ indicates a significant difference; $p > 0.05$ indicates that the difference was not significant. Statistical data analysis of the questionnaire. V: visual stimulation (green space), C: control; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure difference; P: pulse; SC: skin conductance. ** indicates that the difference between the two was extremely significant, $p < 0.01$; * indicates a significant difference between the two, $0.01 < p < 0.05$.

The results of statistical data analysis through questionnaire and mean square comparison using SPSS software are shown in Table 1. Therefore, the results obtained at the 95% confidence level show a significant level in the stress variable. Also, in the attention deficit and hyperactivity disorder variable, except for the subscale of stress and attention deficit, it shows the lack of significance level in the relevant subscales (Table 1). The results of statistical analysis using SPSS software are shown in Table 1. This coefficient, as shown in the relevant table, at the 95% confidence level of exposure to greenery (flowers and ornamental leafy plants, flowers and ornamental flowering plants) at the educational level of the environment on the level of stress reduction in people with ADHD Attention Deficit Activity (ADHD) has been determined, so according to the values obtained from Table 2, the effect of exposure to green space on reducing the stress level in these people has been significant. (p<0.05). Therefore, the hypothesis that exposure to green spaces (ornamental leafy plants, ornamental flowering plants) shows signs of reducing stress levels in people with attention deficit hyperactivity disorder is confirmed.

Table 2. Variance analysis of the effect of the tested factors on the alpha absolute power index (AVE-FFT (uv sq)) in the left hemisphere of the cerebral cortex

SOV	DF	(MS)							
		FP1	F7	F3	T3	C3	T5	P3	O1
gender	1	0.04 ns	0.29 ns	0.21 ns	0.56 ns	0.57 ns	0.26 ns	1.96 ns	5.33 *
treatment	2	6.96 **	22.71 **	19.69 **	17.01 **	27.28 **	17.88 **	26.03 **	25.17 **
Age	1	0.77 ns	1.33 ns	2.83 ns	8.46 *	1.31 ns	0.95 ns	0.02 ns	3.03 ns
Gender* treatment	2	0.28 ns	0.53 ns	0.35 ns	0.58 ns	0.38 ns	0.05 ns	1.39 ns	2.79 ns
Gender* age	1	0.09 ns	0.29 ns	0.84 ns	0.14 ns	2.41 ns	0.06 ns	0.05 ns	0.40 ns
Treatment* age	2	0.06 ns	1.19 ns	0.45 ns	1.28 ns	0.10 ns	1.31 ns	0.99 ns	0.55 ns
Gender* treatment* age	2	0.01 ns	0.08 ns	1.24 ns	0.89 ns	5.69 ns	0.10 ns	0.86 ns	0.48 ns
error	84	0.92	1.59	1.55	1.80	2.24	1.80	1.97	1.35
CV (%)	-	31.0	29.1	40.4	36.7	44.7	50.1	39.9	43.5

Source: research findings

Data analysis using software Statistical Analysis System (SAS) As can be seen in Table 3, the results of the mean square test analysis of the absolute brain power activity of the studied sample, the power of the left hemisphere of

the cerebral cortex, the activity of the brain channel, the gender variable, the channel in the left occiput (1Q) with significant values (0.05) at the ability level 95% reliability is significant. The treatment index of all channels of the brain regions is significant with a significant level value (0.01) with 95% reliability; And the variable sources of gender in the left occipital regions

(O1) have a significant level value (0.05) or 95% reliability, and the variable sources of age in the regions of theleft brain canal (T3) are significant. In the rest of the variable sources and the examination of the mutual effects of these variables in the absolute power index channel, it shows the lack of significance by examining the mean square in all brain channels with power (ns).

Table 3. Results of variance analysis of the effect of the tested factors on the alpha absolute power of the brain in the right hemisphere of the cerebral cortex and the central part

SOV	DF	(MS)										
Electrodes	-	FP2	F4	F8	C4	T4	P4	T6	02	Fz	Cz	Pz
gender	1	6.226 ns	2.560 ns	2.038 ns	0.414 ns	4.758 ns	1.610 ns	1.683 ns	0.525 ns	1.363 ns	0.515 ns	1.940 ns
treatment	2	25.470 **	16.469 **	19.726 **	16.407 **	13.275 **	28.700 **	18.298 **	34.686 **	21.358 **	37.117 **	36.844 **
Age	1	2.513 ns	4.773 ns	1.747 ns	2.786 ns	1.436 ns	1.700 ns	3.378 ns	0.040 ns	7.406 *	13.451 *	0.046 ns
Gender* treatment	2	2.132 ns	2.596 ns	2.051 ns	0.441 ns	1.662 ns	1.124 ns	2.082 ns	2.135 ns	1.961 ns	2.264 ns	0.517 ns
Gender*age	1	1.191 ns	0.461 ns	0.870 ns	1.160 ns	0.113 ns	0.726 ns	2.490 ns	0.630 ns	0.064 ns	0.514 ns	2.000 ns
Treatment* age	2	0.304 ns	0.252 ns	0.115 ns	0.221 ns	0.047 ns	0.079 ns	0.049 ns	0.452 ns	0.720 ns	0.317 ns	0.329 ns
Gender* treatment * age	2	0.292 ns	0.550 ns	0.215 ns	0.919 ns	0.097 ns	0.273 ns	0.515 ns	0.487 ns	0.730 ns	0.876 ns	0.712 ns
error	84	1.962	1.420	1.332	1.694	1.682	1.736	1.939	2.317	1.605	2.148	1.665
CV (%)	-	40.3	39.8	33.2	45.9	43.4	36.7	40.6	38.0	35.4	46.9	43.3

Source: Research findings

Data analysis using software Statistical Analysis System (SAS),As can be seen in Table 4, the results of the analysis of the mean square of absolute brain power activity of the studied sample in the right hemisphere of the cerebral cortex and the central part according to Table 3, the sources of treatment change in all channels of the activity power of the channel on the skull at a significant level (0.01) It is significant with 99% confidence; The highest level of significance was related to the central areas (Cz) and the lowest level of significance was related to the right gage (T4). Also, the

age variable is significant in the channel level of the central areas (F). Examining the mean square of other variables under test as well as the interaction effect of each of these variables in brain channels with power (ns) shows the lack of significance level in the variable under investigation. After determining the mean difference between the test groups (significance level of the mean square test in Tables 2 and 3), Duncan's multi-range test (1955) was used to compare the mean between the groups, and the results of Duncan's multi-range test in Tables 4 and 5 can be seen.

Table 4. Comparison of the average effect of the tested factors on the alpha absolute power of the brain in the left hemisphere of the cerebral cortex

Factor	(AC)							
	FP1	F7	F3	T3	C3	T5	P3	O1
male	9.221 a	9.263 a	9.321 a	6.154 a	7.406 a	3.962 a	5.104 a	5.877 a
female	8.956 a	8.586 a	8.739 a	5.384 a	6.560 a	4.415 a	6.538 a	7.983 a
proof (control)	12.683 a	15.835 a	15.315 a	10.596 a	13.935 a	8.667 a	12.113 a	13.195 a
Flowering plant	7.173 b	6.021 b	5.729 b	3.333 b	4.151 b	2.572 b	3.397 b	4.062 b
ornamental plant	7.844 b	6.327 b	7.270 b	4.425 b	4.550 b	2.436 b	3.519 b	4.315 b
Under 25 years	8.540 a	8.211 a	7.997 a	4.365 b	6.351 a	3.764 a	5.725 a	4.315 b
Over 25 years old	9.653 a	9.659 a	10.118 a	7.337 a	7.629 a	4.627 a	5.877 a	7.650 a

Source: research finding

Based on the results of the analysis of the average comparison between the groups (Tables 5), the averages

with the same letters in each column do not have a statistically significant difference based on Duncan's

multi-range test; Based on this, the most significant difference (0.01) in the level of samples with green space and without green space is show.

Table 5. Comparison of the average effect of the tested factors on the alpha absolute power of the brain in the right hemisphere and the central part of the cerebral cortex

Factor	(AC)										
	FP2	F4	F8	C4	T4	P4	T6	O2	F_Z	C_Z	P_Z
male	5.891a	4.694 a	5.877 a	7.149 a	9.790 a	13.296 a	10.326 a	16.066 a	11.446 a	8.800 a	7.555 a
female	8.725 a	6.289a	7.434a	7.893a	7.132a	11.439a	12.139 a	14.883 a	13.150 a	9.715 a	9.250 a
proof (control)	13.940a	10.175a	12.260a	12.814a	17.935a	21.384a	13.395a	26.520a	19.708a	18.545a	17.300a
Flowering plant	4.050 b	3.362b	4.054b	4.859b	8.753b	8.588 b	6.127 b	10.877 b	8.111 b	5.427 b	4.955b
ornamental plant	5.333 b	3.886b	4.821b	5.902b	8.100b	8.874 b	6.543 b	11.179 b	10.367 b	6.105 b	5.194b
Under 25 years	6.369a	4.425 a	5.931a	6.581a	7.696a	11.414a	9.966 a	15.633a	10.375b	6.105b	8.251a
Over 25 years old	8.170 a	6.604a	7.373a	8.510a	9.157a	13.323a	12.535a	15.306a	14.347a	11.731a	8.515a

Source: research findings

Discussion

the present study compared the purpose of this study was to investigate the effectiveness of exposure to green space on absolute power of alpha wave and stress reduction in people with attention deficit hyperactivity disorder, while other studies have only investigated the advantages of green plants. The results of the mean square test and the mean square comparison between the test groups in the absolute power of the activity in the left hemisphere, right hemisphere and central cortex of the brain show that the participants when viewing flowering plants and ornamental leaves compared to the control condition (room without flowers and plants) in The significance level (P<0.01) had a significant difference. In the present study, the subjects encountered a significant increase or decrease in the absolute power of brain waves when observing the green space (including ornamental and flowering plants), which has been effective in improving their attention and concentration in their different brain channels. According to the experimental results of Park's studies, it has been reported that controlling the absolute power of brain waves greatly helps the performance of people's brain activities (Park et al., 2017). Among different brain waves, alpha wave has the most connection with cognitive functions, especially learning processes, attention and short-term memory (Park et al., 2017). However, the results of the present study have shown that the design environment with ornamental plants and natural flowers can significantly affect the absolute power of the waves. This problem has been associated with the increase and decrease of the absolute power of brain waves in different parts of the brain structure Probably, these results show that all the five senses, and not only the sense of sight, played a role in changing neural activity in some way (Van den Berg et al., 2003). Since the QEEG recorded in different conditions is a good indicator of the metabolic activities in certain areas of the brain, the alpha brain wave is the absolute power of the bridge between the conscious and non-conscious thinking of people. In other words, the alpha brain wave is the range between the beta and Theta is located so that in the process of stress, the person will experience alpha blockage, which includes intense beta activities and reduced alpha activity. Beta waves necessarily prevent the production of alpha, which makes people very excited. More activity than usual will cause daydreaming, inability to concentrate, calmness more than normal and to some extent carelessness. And less activity than usual causes anxiety, high stress, etc., the presence of the right amount can cause relaxation, proper visual attention. By comparing the absolute power of alpha brain waves in different areas of the brain channels of people in the environment of exposure to green space, based on, statistical findings (Tables 1 to 5) show that these effects are similar to the emotional stabilization of mental activities.

According to Kaplan's attention rehabilitation theory (ART), green spaces and plants are effective in restoring attention in humans, according to which green space provides an environment that is temporarily deactivated from a person who needs to concentrate to a person who needs to Focusing with involuntary attention on the beauty of the green space during this period, the absolute mental power finds the opportunity to rehabilitate cognitive abilities and ultimately leads to increased attention and concentration and reduced stress (Kaplan, 1989). Ulrich's stress recovery theory (SRT) believes that connecting with the green space of the motivational process of sensory powers occurs more than cognitive processes, reduces stress and creates a balanced state in people's behavior. According to the theory of sensory integration, people act as sensory receptors and receive environmental information, and in the meantime, the natural environment and green space and flowering and ornamental plants have more sensory stimuli than other environments and the potential to

apply Awareness and focus provide emotional and psychological capacity for rehabilitation (Ulrich, 1991). In addition, the present study also showed that these effects were greater when observing natural flowering plants than when observing ornamental plants. This finding may be related to the activation of parasympathetic nerves and suppression of the sympathetic nervous system. In addition, when viewing plants, parasympathetic nerve activity increases and the concentration of left frontal cortex oxidizes and hemoglobin levels among people who deal with plants (Table 4 and 5), are reduced compared to those who are not (Jang, 2014). Son reported that the placement of green plants in a room changed the brain waves of the people therein, improved their concentration, and relieved their visual fatigu. Kuo reported that living in a natural environment is closely related to the enhancement of attention, and contact with nature has been shown to improve the attention of both adults and children (Oh et al., 2019).

Exposure to the green space consisting of (ornamental flowering plants and ornamental leafy plants) of the subjects, a significant difference in the desired indicators has been observed according to the presence and absence of ornamental and flowering plants (Tables 4 and 5). The RLB frequency band is observed in the sensorimotor cortex of the brain, which is also called the "sensorimotor rhythm" and a high value indicates higher concentration (Epstein et al., 2014). This index measures attention with theta wave (Dupuy et al., 2021). Because its increase is known to reduce hyperactivity , in neurofeedback studies, ADHD subjects increased the amplitude of RLB (12 to 15 Hz) to improve attention and reduce ADHD symptoms. were trained (Epstein et al., 2014). In general, it has been determined in (ADHD) that the increase in slow brain waves and the decrease in the activity of fast waves in the central and frontal areas probably indicate a lack of stimulation of the central nervous system (Winking, 2023). That in the current research, the increase in absolute alpha power in the central part of the channel (Fz) was probably associated with an increase in the level of attention and concentration in people. Also, in explaining the lack of significant level in other subscales based on Avzton 's (Lansbergen et al., 2011), theory, it can be stated that exposure to visual stimuli causes neurological and brain changes and reaching the actual power of these changes will require the passage of time, that is, despite the issue of attention and planning. Planning and organization, attention and memory, the efficiency of which can be seen earlier, the pattern of brain waves need the passage of time in order to have enough time to fully use the brain movements made in shaping their capabilities. These findings are based on The hypothesis of brain plasticity has been explained.

In addition to these conditions of stress and non-stress, the absolute power of the brain has been reported based on advanced analyzes of brain signals. Studies have shown that during stress, the ratio of the power of alpha waves decreases and the power of beta waves increases, and this increase in the power of the beta band is related to a decrease in heart rate fluctuations and an increase in cortisol (Pascucci et al., 2025). The ratio of theta to beta waves, which is an indicator of the prefrontal cortex's attentional function, decreases under stress conditions (Putman et al., 2013). These results indicate that in stressful conditions due to the increase of anxiety, the top-down control role of the medial prefrontal cortex decreases, and on the other hand, catecholamines released due to stress directly affect the medial prefrontal attention function and flexibility. They reduce synaptic plasticity. As a result, the person's cognitive power decreases, and by observing flowering and ornamental plants, the activity of the absolute alpha power becomes closer to the normal state. Also, the results of the statistical analysis of the questionnaire showed an increase in the level of meaning in the field of reducing the stress of people facing the environment (Table 1). As for any study, the current findings should be interpreted in light of some limitations. Since the present research was conducted in two age groups in the group of men and women in the educational environment, it is suggested that in the future research, it should be evaluated and analyzed by choosing other demographic and age groups in different environments. It is suggested that in future researches, in addition to quantitative electroencephalography (QEEG), HRV and unsupervised learning algorithms should be used to characterize the level of learning stress of subjects. Among the limitations of the current research, we can mention the selection of the studied sample in this current research. Since this research was conducted on students in specific fields of study, its generalizability to students of different courses is done with caution.

Conclusion

The current research has scientifically supported the physiological and psychological effectiveness of observing and encountering green spaces. The visual stimulation of exposure to green space has increased the absolute power of alpha waves in some of the brain activities, which indicates an increase in attention and concentration. Also, the changes in the absolute power of the alpha band in two different positions indicate different functional mechanisms of alpha waves in different environments. In the state of observin and facing the green space consisting of ornamental and flowering plants in the educational environment, it has been in a favorable and ideal state.

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Disclosure Statement

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