

Review Article

The Impact of Natural University Campuses on Students' Psychological Status: A Meta-Analysis Study*

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Abstract

Problem statement: Based on recent reports, students in the current era are experiencing psychological disorders at unprecedented levels. Concurrently, natural university campuses positively influence the students' psychological Components. This study aims to synthesize previous research and quantitatively estimate the magnitude of this effect.

Research objective: This study aims to determine the extent to which natural university campuses influence psychological Components among students by reviewing prior research and conducting a meta-analysis.

Research method: This study examined research conducted between the years 2000 and 2023 by searching four databases: Web of Science, Scopus, PsycInfo, and PubMed. The inclusion criteria for studies in this meta-analysis were publication in English, implementation of short-term interventions, use of experimental or quasi-experimental methods, application of standardized cognitive assessment tools, availability of appropriate statistical data for meta-analysis, and publication in reputable journals. After all researchers independently screened the studies, out of the 8,010 identified articles, 34 studies were initially selected in the first stage. Subsequently, 10 studies were excluded due to not meeting the meta-analysis criteria, and 24 were selected for final review. The process of preparing the meta-analysis report was conducted according to the PRISMA guidelines (2020 version).

Conclusion: The exploration of previous studies led to the identification of 18 psychological Components among students. Fifteen Components—including anxiety, stress recovery, self-esteem, restorativeness, relaxation, negative/ positive health effects, mental health, perceived recovery, psychological well-being, reflection, attention recovery, energetic, clear thought, total mood disturbance, and good-natured—were significantly influenced by the natural campuses of the university. Two Components, depression, and positive/negative feelings, showed moderate influence, while happiness exhibited minimal influence. Overall, the natural campuses of universities had a substantial impact on students' psychological Components (Cohen's index = 0.759). Additionally, the studies included in the research did not show any publication bias.

Keywords: *Meta-Analysis, Psychological Components, Natural Landscape, University Campus.*

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Introduction

Universities, as the most important educational institutions, play a critical role in developing specialized human capital and, consequently, in advancing societal progress. Nevertheless, students in university settings encounter a wide array of academic, social, and personal challenges (Kamalpour et al., 2017, 477). These challenges inevitably result in university students experiencing significantly greater psychological stress compared to elementary and secondary students. The prevalence of mental disorders peaks during the university entry age as a consequence (Gao et al. 2020, 292; De Girolamo et al., 2012, 47). However, this issue persists to the present day, with mental health challenges among students emerging as a global concern. For instance, the World Health Organization, in a study examining the mental health status of students across eight countries, found that 35% of students were affected by at least one mental disorder (Auerbach et al., 2018, 624). A meta-analysis conducted in Iran revealed that approximately 33% of students experience psychological disorders, with the prevalence of such disorders on the rise (Zare et al., 2016, 1).

Psychological pressures within university environments are among the primary contributors to poor mental health, mental fatigue, stress, and insomnia among students (Taylor et al., 2013, 339-340). This is mainly due to the substantial amount of time students dedicate to activities such as learning, studying diverse subjects, solving problems, completing assignments, participating in projects, preparing presentations, taking exams, and engaging in extracurricular activities—all of which demand significant focus and cognitive effort (Felsten, 2009, 160; Fu & Cheng, 2017, 403; DiPlacito-DeRango, 2022, 1423-1424). In addition to these factors, in certain countries such as Iran, extreme individualism stemming from the competitive nature of the educational system diminishes the potential benefits of social interaction for psychological well-being (Asadi et al., 2006, 21; Feng et al., 2020). Consequently, exploring solutions to enhance mental health and mental restoration among students in academic environments is critically important.

Various disciplines have proposed diverse strategies for enhancing mental health and facilitating mental restoration.

Among these, architecture and environmental sciences have introduced the concept of “restorative environments” (Kaplan & Kaplan, 1989). A growing body of evidence highlights the potential of green spaces on university campuses to promote mental restoration and enhance the health and well-being of students in this context (Foellmer et al., 2021; Liu et al., 2022a). Despite extensive research exploring the relationship between natural campus environments and their psychological effects on students, the assessment of these spaces’ impact on psychological indicators has not received sufficient attention. The significance of university campus spaces has become increasingly evident in recent years, particularly during the COVID-19 pandemic. These spaces are not merely akin to schoolyards rather, they constitute an integral part of students’ lives with which they have long-term and frequent connections (Xiao, 2015, as cited in Zhang & Li, 2023). The findings of a meta-analysis study demonstrated that exposure to natural environments significantly enhances working memory, cognitive flexibility, and attentional control (Stevenson et al., 2018, 277). Similarly, another meta-analysis by Vella-Brodrick & Gilowska (2022, 1217) revealed that contact with green spaces positively influences working memory, selective attention, and sustained attention in students aged 5 to 18.

This meta-analysis focused on psychological components within the student population. Given the distinct physical, psychological, and social conditions of university students compared to students of schools, this study is anticipated to yield results that differ from those of prior research. Accordingly, a systematic search of reputable academic databases was conducted, encompassing studies published between 2000 and 2023. Twenty-four articles were selected from this pool based on predefined inclusion criteria. This research calculated the effect size of natural campus environments on students’ psychological components and examined the homogeneity of results, publication bias, participant characteristics, methodologies, and measurement tools employed in the selected studies.

Theoretical Foundations

Previous research has demonstrated that natural environments are more effective than built environments

in facilitating mental restoration and has identified nature as a critical resource for the psychological well-being of people (Sullivan & Li, 2021, 38). According to the biophilia hypothesis, humans have an innate affinity for nature, stemming from their biological evolution over time (Stephen & Edward, 1993). Attention restoration theory (ART) further posits that non-threatening natural environments foster involuntary or soft fascination, which promotes mental restoration and alleviates mental fatigue (Kaplan & Kaplan, 1989; Sullivan & Li, 2021, 38). Another significant theoretical framework in this domain is the stress reduction theory (SRT), which suggests that natural environments contribute to reducing psychophysiological stress (Ulrich et al., 1991). Beyond these foundational theories, additional approaches and frameworks have been proposed to explain mental restoration across various environments. This study identified and analyzed several of these theories and approaches through a comprehensive review of articles published between 2000 and 2023.

Several theoretical frameworks employed in recent studies have explored the influence of social supports and interactions on mental restoration. Ramos (2018), for instance, applied the theory of socially regenerative urbanism, highlighting the role of the social dimension of university campuses and examining its impact on mental restoration. Similarly, Jang & Son (2020, 108), drawing on the theory of supportive environments, identified various forms of support provided in urban settings as significant factors contributing to the mental restoration of citizens, particularly housewives and the elderly. Several other theories have explored the influence of cognitive-psychological load in the environment on mental restoration. Notably, Asim et al. (2021) employed prospect-refuge and arousal theories as their theoretical framework. These theories emphasize the importance of psychological safety in the environment and the optimal level of arousal in fostering restorative environments. Additionally, Von Lindern (2017), drawing on the behavior setting theory, established a connection between the sense of detachment from everyday concerns and mental health, linking these to the extent of individuals' cognitive activities during their leisure time. Colley et al. (2016, 598) further established a connection between

the quality of urban green spaces and the psychological well-being of employees during working hours, drawing on the affordance theory. Additionally, other theoretical frameworks emphasize the role of individual emotions in mental restoration. Zhang et al. (2019), for example, explored the impact of visual, auditory, and tactile stimuli on mental restoration, employing the theory of multi-sensory environments. Rout & Galpern (2022) employed the savanna theory, which highlights the role of biological evolution in shaping human preferences for natural environments. Similarly, Meyer-Grandbastien et al. (2020) investigated the influence of green spaces on individuals' psychological well-being through the lens of the sense of place theory. This framework emphasizes key concepts such as a sense of belonging, place identity, and emotional connections to the environment. Several theoretical frameworks place greater emphasis on the physical health dimension. Notably, Kristjánsdóttir et al. (2020) employed the Sense of coherence theory and Salutogenic approach as the theoretical foundation for their research. This theory posits that environmental design encompasses a continuum of stages, from prevention to treatment, ultimately contributing to the maintenance of health and the psychological restoration of individuals.

A review of various theoretical frameworks indicates that both natural and designed environments can promote mental restoration by offering social support, alleviating cognitive-psychological load, fostering positive emotions, and enhancing physical health. These theories collectively address distinct dimensions of the human-environment relationship, contributing to a more holistic understanding of the factors influencing mental and physical well-being.

Research Background

Recent research in the field of mental restoration has frequently examined the impact of urban green and blue spaces on citizens' mental health (Jahani & Saffariha, 2020; Guo et al., 2022; Luo et al., 2023). Additional studies have explored factors influencing psychological restoration in residential environments (Tanaka et al., 2013) as well as in healthcare and caregiving facilities (Sharghi & Salehi Kousalari, 2017, 346; Zeynali Azim et al., 2025). In this regard, the growing body of research on

psychological restoration across various environments has led to increased attention toward evaluating the impact of university campuses on students' mental health (Wang et al., 2025; Gulwadi et al., 2019, 36). University campuses serve as important spaces that not only facilitate social interactions but also function as sanctuaries to alleviate the pressures of student life (Puhakka, 2021). Given the restorative potential of nature, active engagement with the natural elements of campus environments enhances students' quality of life, improves mood, and reduces stress (Holt et al., 2019; Ibes & Forestell, 2022, 99; Best, 2019). The natural landscapes on university campuses are remarkably diverse, and prior research has extensively investigated the effects of various green spaces, blue spaces, sky views, and soundscapes on students' mental restoration.

A survey conducted among students at several universities in Turkey and the United States has highlighted a significant relationship between campus greenery and mental restoration variables, as well as the quality of life at the university (Gulwadi et al., 2019, 36; Hipp et al., 2016, 1292). Furthermore, the distribution of trees, plant diversity, the presence of colorful vegetation, and expansive lawn areas are identified as key natural green variables on university campuses that contribute to mental restoration (Yang et al., 2022; Guo et al., 2023). A study focusing on a university campus found that a botanical garden with high plant diversity was more effective than other green spaces in reducing mental fatigue, alleviating stress, restoring attention, and enhancing student comfort (Liprini & Coetzee, 2017, 155). Another study revealed that the richness of plant species and natural soundscapes on campus are associated with improved student mood (Ha & Kim, 2021). The connection between natural soundscapes and mental restoration may be attributed to increased environmental awareness and more effective interaction with the surroundings (Karimi et al., 2025, 27). Additionally, research has emphasized the negative impact of high-density building environments surrounding universities on students' psychological restoration (Asim et al., 2023). Supporting this view, another study investigating the effects of natural versus built landscapes visible through classroom windows reported that built

environments negatively affect attention restoration and stress reduction (Sullivan & Li, 2021). According to the literature, in addition to environmental greenery, seasonal landscape changes also significantly influence students' mental restoration and visual preferences (Wang & Zhao, 2020, 649). This underlines the importance of landscape dynamics from the users' viewpoint.

Waterscape, as another natural variable influencing the psychological restoration of students on university campuses, has garnered significant attention from researchers. Studies indicate that various types of waterscapes, including natural and semi-natural water features, can foster a sense of Relaxation and psychological well-being in users (Sakici, 2015, 182; Yang et al., 2022; Wang et al., 2018, 303). Ning et al. (2023) demonstrated in a study that, in addition to the benefits of spending time near university wetlands, the duration of exposure to such environments significantly enhances students' mental restoration and positive mental effects (Lee et al., 2021, 246). Based on these findings, waterscapes can be regarded as an important factor in mental restoration and should be considered in the design of university campuses.

Other studies have highlighted the visual appeal and the sense of being away created by viewing the sky within university campus environments as factors contributing to the psychological restoration of students (Masoudinejad & Hartig, 2020, 401; Asim et al., 2023). The concept of being away has been identified as one of the four components of Kaplan's theory (Kaplan & Kaplan, 1989) of psychological restoration and has been explored in studies in two forms: physically being away and mentally being away (Malekinezhad et al., 2020, 6). Mentally being away can be achieved by viewing natural surroundings and the sky from the windows of dormitory rooms or classroom spaces (Yusli et al., 2021; Li & Sullivan, 2016, 149). Consequently, Heidari et al. (2021, 546) emphasized the importance of window dimensions in restoring mental focus in classroom settings. Additionally, windows serve as entry points for natural light, which, according to Asim et al. (2023), also possesses psychological restorative properties.

This paper employed tools such as the Bibliometrix library

in RStudio software and the BiblioShiny bibliographic data analysis software to achieve a more comprehensive understanding of the connections between concepts related to the research topic. The output of these analyses was a relationship diagram in which the number of lines branching from each keyword represents the degree of its connections to other variables. This three-field plot illustrates the relationships among keywords, keywords plus, and the titles of studies included in the article (Fig 1).

Research Method

• Literature search and inclusion criteria for meta-analysis

This paper employs a quantitative and systematic review approach to assess the extent to which the independent variable (campus landscape) influences the dependent variable (psychological effects) among students. A comprehensive review of studies published over 24 years (2000 to 2023) was conducted to achieve this, utilizing selected keywords (Table 1) across reputable academic databases. The objective was to systematically identify, synthesize, and summarize the commonalities and differences among prior studies. The keyword search strategy was designed to maximize the retrieval of relevant studies from the databases.

The initial search phase retrieved a total of 8,010 articles from databases. Following the review of topics and abstracts of relevant articles and the completion of initial screening, 35 articles were included in the research process. In the subsequent stage, the full texts of the selected studies were reviewed, and any articles that did not meet the meta-analysis criteria were excluded. At this stage, 11 articles

were excluded from the final review process for various reasons. This study applied the PICOS criteria to determine the inclusion or exclusion of studies, as outlined below (Nang et al., 2015; Bikomeye et al., 2021): Population (P): University students; Intervention (I): Access to university landscapes and their impact on students' psychological Components; Comparison (C): The influence of the number of natural elements available on university campuses or the extent of their use on students' psychological Components; Outcomes (O): Enhancement or reduction of psychological characteristics, such as stress relief or restoration of concentration; Study Design (S): Inclusion of experimental or quasi-experimental studies in the meta-analysis. Additional criteria for the inclusion of studies in the meta-analysis included: publication in English, relevance to architecture and environmental studies, implementation of short-term interventions, use of standardized cognitive measures in assessments, availability of appropriate statistical indicators for meta-analysis, and publication in reputable journals.

After a careful review of the relevant sources listed in the references section 24 articles that met the inclusion criteria and were selected for meta-analysis. The results of these 24 articles were subsequently combined, and the findings of this study were reported following the steps outlined in the PRISMA checklist (Fig. 2). A standardized coding list was then utilized to collect data for meta-analysis calculations, which were input into the Comprehensive Meta-Analysis (CMA) software, version 4. During this process, the test statistics from the hypotheses of the various studies were analyzed after converting them into effect sizes.

• Reviewing the summary of selected studies

The studies included in the meta-analysis will be reviewed in detail in the following sections. Table 2 summarizes key characteristics of these studies, including authors' names, sampling methods, country of origin, sample size, intervention types, and measurement instruments and facilitates a comprehensive understanding of the selected studies and enables a comparative analysis.

The data extracted from the 24 analyzed studies included 18 psychological components. The frequency of these components was as follows: Restorativeness (N= 10), mental health (N= 5), stress reduction (N= 4), relaxation

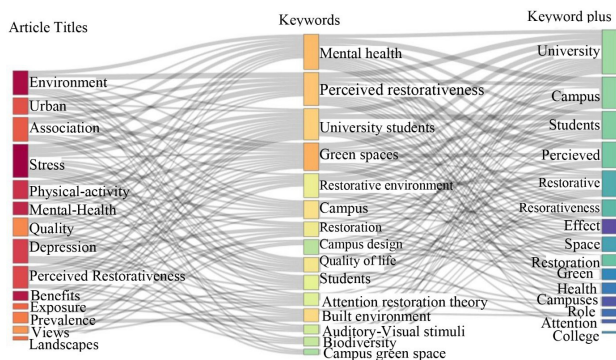


Fig. 1. Three-field plot of keywords in articles included in the meta-analysis based on biblioshiny software output. Source: Authors.

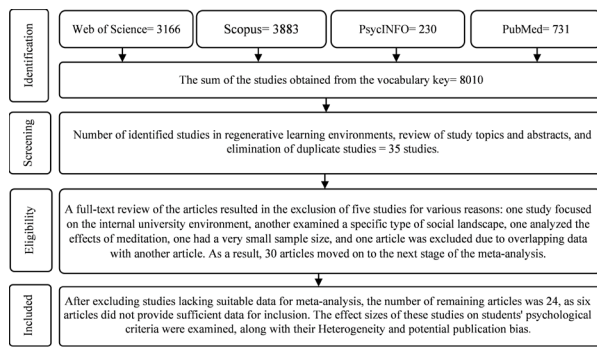


Fig. 2. Systematic review protocol of the impact of natural university campuses on students' psychological Components, following the PRISMA guidelines. Source: Authors.

(N= 3), depression, negative/positive effects on health, and happiness (frequency of each = 2). The remaining components were examined only once in the selected studies. Additionally, the statistical results extracted from each study are presented in Table 3.

Discussion

• Effect size calculation

Bakhshandeh et al. (2016) present the foundational principles of the meta-analysis approach based on effect size, which is defined as the ratio of the significance test to the study volume. According to these researchers, relying solely on the significance level is insufficient for rejecting or confirming a hypothesis; instead, the effect size must also be considered. Meta-analysis experts compute the effect size by extracting the mean, variance, and standard deviation of the groups. However, the most commonly used statistics in this field are r (for correlation studies) and d (for group differences). Additionally, the effect size for chi-square, z, t, and F tests is calculated using the following formulas (Eqs. 1 & 2).

The r index was employed in this study to calculate the effect size, which was computed alongside the significance or lack of significance for each case and is reported in Table 4.

Based on the findings outlined in Table 4, all psychological components of natural spaces on university campuses demonstrate a significant impact on students' psychological well-being, with the exception of the psychological reconstruction component reported in the study by Van den Bogerd et al. (2018)

$$d = \frac{2t}{\sqrt{df}} \quad d = \frac{2\sqrt{f}}{df} \quad d = \frac{2r}{\sqrt{1-r^2}} \quad \text{Eq. 1}$$

$$r = \sqrt{\frac{x^2}{n}} \quad r = \sqrt{\frac{t^2}{t^2 + df}} \quad r = \sqrt{\frac{F}{F + df}} \quad \text{Eq. 2}$$

(Z-values > 1.96, P-values < 0.05). Furthermore, the effect sizes for the fixed and random effects models were calculated as 0.605 and 0.759, respectively, with corresponding Z-values of 469.73 and 311.8, both of which are statistically significant. Consequently, the effect size of all psychological components of natural university campus environments on students is statistically significant.

• Publication bias in the results of the studies

This study utilized a funnel plot (Fig. 3) to assess publication bias among the articles included in the meta-analysis. The funnel plot generated by CMA4 software revealed an approximately symmetrical distribution with minimal scatter at the base of the graph, suggesting the absence of publication bias and underscoring the reliability and statistical significance of the findings.

The symmetry observed in the funnel plot confirmed the lack of publication bias in the studies incorporated into this meta-analysis. Inferential tests were employed to rigorously evaluate the potential presence of publication bias and further validate the findings. Three distinct tests—Egger’s regression test, Begg and Mazumdar’s rank correlation test, and the fail-safe N test—were conducted. The results of these tests consistently demonstrated no evidence of publication bias, as outlined in Table 5.

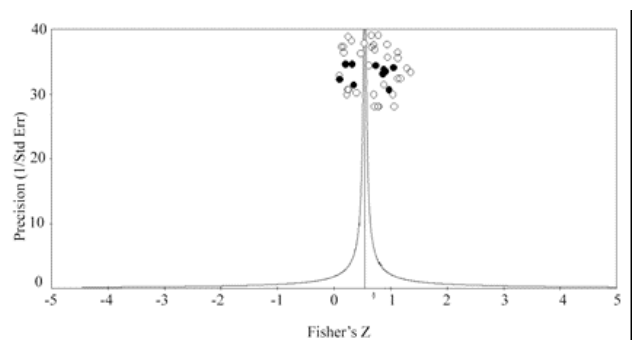


Fig. 3. Publication bias in all studied papers based on the funnel graph based on CMA4 software output. Source: Authors.

Table 1. List of keyword searches conducted in databases and the corresponding results obtained for the period 2000–2023. Source: Authors.

Databases	Databases and keywords	Number of studies
Web of Science database	Student* (Topic) and restore* (Topic) and environment* (Topic)	495
	“Mental* fatigue” (Topic) and environment* (Topic) and student* (Topic)	24
	Restore* (Topic) and university* (Topic) and environment* (Topic)	579
	Restore* (Topic) and college* (Topic) and environment* (Topic)	102
	“Mental* fatigue” (Topic) and restore* (Topic) and campus* (Topic)	3
	Restore* (Topic) and campus* (Topic) and Well-being* (Topic)	26
	Green* (Topic) and environment* (Topic) and student* (Topic)	1937
Scopus database	(TITLE-ABS-KEY (student*) AND TITLE-ABS-KEY (restore*) AND TITLE-ABS-KEY (environment*))	613
	(TITLE-ABS-KEY (mental* fatigue) AND TITLE-ABS-KEY (environment*) AND TITLE-ABS-KEY (student*))	126
	(TITLE-ABS-KEY (restore*) AND TITLE-ABS-KEY (university*) AND TITLE-ABS-KEY (environment*))	969
	(TITLE-ABS-KEY (restore*) AND TITLE-ABS-KEY (college*) AND TITLE-ABS-KEY (environment*))	138
	(TITLE-ABS-KEY (mental* fatigue) AND TITLE-ABS-KEY (restore*) AND TITLE-ABS-KEY (campus*))	3
	(TITLE-ABS-KEY (restore*) AND TITLE-ABS-KEY (campus*) AND TITLE-ABS-KEY (well-being*))	21
	(TITLE-ABS-KEY (green*) AND TITLE-ABS-KEY (environment*) AND TITLE-ABS-KEY (student*))	2013
PsycINFO database	Abstract: student* AND Abstract: university* AND Abstract: environment*	142
	Any Field: “mental fatigue” AND Any Field: environment* AND Any Field: student*	3
	Any Field: restore* AND Abstract: university* AND Any Field: environment *	0
	Any Field: restore* AND Any Field: college* AND Any Field: environment*	9
	Any Field: “mental* fatigue” AND Any Field: restore* AND Any Field: campus*	0
	Any Field: restore* AND Any Field: campus* AND Any Field: Well-being	1
	Any Field: Green* AND Any Field: environment* AND Any Field: student*	75
PubMed database	((Student* [Title/Abstract]) AND (restore*[Title/Abstract])) AND (environment* [Title/Abstract])	199
	((“Mental fatigue” [Title/Abstract]) AND (environment* [Title/Abstract])) AND (student*[Title/Abstract])	8
	((Restore* [Title/Abstract]) AND (university* [Title/Abstract])) AND (environment* [Title/Abstract])	177
	((Restore* [Title/Abstract]) AND (college* [Title/Abstract])) AND (environment* [Title/Abstract])	39
	((“Mental* fatigue”) AND (restore*)) AND (campus*)	2
	((Restore *) AND (campus*)) AND (well-being*)	0
	((Green*[Title/Abstract]) AND (environment* [Title/Abstract])) AND (student* [Title/Abstract])	306

• **Heterogeneity in results of studies and the significance of the effect size of each Component**

Before evaluating the significance of the effect size for each component, it is essential to assess the homogeneity or heterogeneity of the effect sizes associated with each Component. To this end, the Cochrane Q-test and the I² index were employed (Table 6). When the effect sizes demonstrate

homogeneity, a fixed-effects model is appropriate for analysis. If the effect sizes exhibit heterogeneity, a random-effects model is advised for appropriately testing the hypothesis. Researchers utilize random-effects meta-analyses for two primary purposes: 1) to estimate the average effect size, and 2) to quantify the heterogeneity of effect sizes across studies (Borenstein, 2020, 35).

Table 2. Summary of studies examining the relationship between the university’s natural environment and students’ psychological characteristics. Source: Authors.

Author(s), year	Type of sampling	Country; Setting	N ¹	Mean of age	Type of exposure to the environment; Activity; Duration of activity	Research tool
Felsten, 2009	RCT ²	United States; Indiana, Purdue, and Columbus universities	236	±6.6 23.2 years	Presence in a virtual environment, duration of activity= NR ³	Single-item scales of Berto (2005) and Herzog et al. (2003)
Hipp et al., 2016	Snowball sampling	United States and Scotland; Three green campuses	441	years 23.6	Use of real environment; Duration of activity= NR	The world health organization’s quality of life; Perceived greenness scale; (PRS) ⁴
Van den Bogerd et al., 2018	RCT	Netherlands; Eight universities in the Netherlands.	722	years 21	Presence in a virtual environment, duration of activity= NR	Visual questionnaire
Liu et al., 2018	RCT	China; Campus of 8 Universities in Fuzhou	2550	22.6 ±2.2 years	Presence in the real environment; Duration of activity= NR	Self-rated naturalness scale
Wang et al., 2018	Snowball sampling	China; Campus of (CUMT)	323	23.1 years	simulation; Duration of activity= NR	Measurement scale of landscape characteristics (rated by Experts); Self-rating method
Holt et al., 2019	RCT	United States; University campus	207	NR	A minimum presence of 15 minutes per day, four days a week, in the environment	Green user scale questionnaire; 10-item Perceived stress scale
Gulwadi et al., 2019	RCT	Turkey and the United States; 4 University campuses	1079	21.5 years	Presence in the university campus; Duration of activity= NR	(PG) Scale ⁵ , (PRS) Scale, (WHOQOL-BREF) Scale ⁶
Guo et al., 2020	RCT	China; The campus of A&F University	150	23.75 ± 1.01 years	Six minutes of virtual viewing of campus trees	(TSST) ⁷ , (EEG), (STAI-S) ⁸ and (PRS)
Ibes & Forestell, 2022	RCT	United States; A window facing the university campus	234	19.22±1.23 years	One week of daily 20-minute meditation sessions in enclosed spaces, outdoor areas, and journaling	Mood states-short form (POMS-SF) ⁹
Malekinezhad et al., 2020	RCT	Malaysia; University campus	48	19 to 30 years	Presence on campus over two months	(ROS-6 items) ¹⁰ ; (RCS-22 items) ¹¹ ; PSD items
Foellmer et al., 2021	RCT	Germany; Bonn campus University	100	23 years	A minimum presence of two hours during the week or one hour on weekends in the environment	A questionnaire inspired by SF-36 and WHOQOL-SRPB ¹²
Chou & Hung, 2021	RCT	Taiwan; Huafan campus university	10	22.3 ±0.8 years	A 30-minute walk over two months in a forested campus	(MHC-SF) ¹³ ; attention recovery and reflection scale; Learning engagement scale for college students
Ha & Kim, 2021	RCT	United States; University campus’ 360-degree video	319	18 to 33 years	Six minutes of virtual viewing of the environment	(RSS) ¹⁴ and (POMS-SF) scales; Type of camera= Samsung gear 360
Lee et al., 2021	RCT	Malaysia; University campus	788	23±5.4 years	Viewing the university wetland more than once a week until no visits	A self-administered questionnaire, DASS-42 ¹⁵ , and (RSES) ¹⁶ scales
Yusli et al., 2021	RCT	Malaysia; Views of the university campus	192	30.64±2.73 years	A dormitory window facing the campus landscape or buildings	(PWB) ¹⁷ and (PRAS) ¹⁸ scales
Liu et al., 2022b	RCT	China; Fujian Agriculture and forestry (university) (FAFU)	897	NR	Frequency of environmental visits ranging from zero to more than three times per week	Demographic information, naturalness survey, and report on the frequency of environmental visits
Koning et al., 2022	RCT	United States (Michigan state university)	161	NR	Online survey on the amount of time spent on campus	K10 scale and researcher-developed survey, demographic information.

Rest of Table 2.

Author(s), year	Type of sampling	Country; Setting	N ¹	Mean of age	Type of exposure to the environment; Activity; Duration of activity	Research tool
Du et al., 2022	RCT	China; Sichuan technology and business university	243	17-24 years	Presence in the environment; duration of activity= NR	Camera, researcher-developed questionnaire
Liu et al., 2022a	RCT	China; Two university campuses in hunan and heilongjiang provinces.	474	NR	Presence in the environment; duration of activity= NR	students' personal information, (SRNS) ¹⁹ , (PANAS), (PAS) ²⁰ , landscape preference assessment form
Sun et al., 2023	RCT	China; 45 Universities	1261	NR	Presence in the environment; Duration of activity= NR	(WHO-5) ²¹ ; Researcher-made questionnaire
Asim et al., 2023	RCT	India; A sustainable university campus	429 and 22	20.4 ± 1.5 years	Presence in the environment for three minutes	Map-based questionnaire, EEG headset
Zhang & Li, 2023	RCT	China; The northernmost forest university in Harbin	24	23 ± 4 years	Each participant must proceed along a predetermined path to one of 24 designated points	Facial expression recognition software, ECG, mindfulness scale
Migl et al., 2023	RCT	United States; The main campus of the university of texas	91	18-23 years	User participation through photography; duration of activity not specified	Personal camera for each user, discussion
Guo et al., 2023	RCT	China; 22 Spaces on the SCUT university campus	478	NR	Utilization of architectural spaces, landscapes, rest facilities, and communal activity areas	Researcher-developed questionnaire and structural equation modeling

* The study conducted by Asim et al. (2023) involved 429 participants in a questionnaire-based survey and 22 participants in brainwave recording sessions.

Table 3. Values extracted from papers published from 2000 to 2023. Source: Authors.

Author(s), year	Psychological factors	Statistical value					
		N	Beta	F	P-value	Mean	STD
Felsten, 2009	Restorativeness	172	-	-	-	4.335	1.065
Hipp et al., 2016	Restorativeness	441	0.53	-	0.001	-	-
van den Bogerd et al., 2018	Restorativeness	142	-	-	-	2.27	0.93
	Perceived recovery	722	-	-	-	2.7	0.9
Liu et al., 2018	Mental health	45	0.341	-	0.001	-	-
Wang et al., 2018	Relaxation	15	0.51	3.308	0.004	-	-
	Good-natured	15	0.485	3.142	0.006	-	-
Holt et al., 2019	Stress recovery	207	-	2.895	0.001	-	-
	Happiness	207	-	3.452	0.001	-	-
Gulwadi et al., 2019	Restorativeness	1079	-	8.87	0.001	-	-
Guo et al., 2020	Stress recovery	150	-	-	-	23.75	1.01
Ibes & Forestell, 2022	Total mood disturbance	234	-	-	-	7.73	3.26
Malekinezhad et al., 2020	Restorativeness	550	-	-	-	5.65	1.17
	Relaxation	550	-	-	-	5.35	1.04
	Clear thought	550	-	-	-	5.57	1.02
Foellmer et al., 2021	Happiness	100	0.21	-	0.037	-	-
	Relaxation	100	0.47	-	0.001	-	-
	Energetic	100	0.2	-	0.042	-	-

Rest of Table 3.

Author(s), year	Psychological factors	Statistical value					
		N	Beta	F	P-value	Mean	STD
Chou & Hung, 2021	Mental health	10	-	7.154	0.023	-	-
	Reflection	10	-	16.722	0.001	-	-
	Attention recovery	10	-	18.885	0.001	-	-
Ha & Kim, 2021	Depression	319	-	3.678	0.001	-	-
	Restorativeness	319	-	2.77	0.001	-	-
Lee et al., 2021	Depression	788	-	24.32	0.0001	-	-
	Anxiety	788	-	21.93	0.0001	-	-
	Stress recovery	788	-	24.25	0.0001	-	-
	Self-esteem	788	-	35.88	0.0001	-	-
Yusli et al., 2021	Psychological well-being	192	0.206	13.894	0.001	-	-
Liu et al., 2022b	Negative/ positive feelings	474	0.44	-	0.001	-	-
Koning et al., 2022	Mental health	182	-	3.291	0.001	35.5	8.88
Du et al., 2022	Restorativeness	243	-	-	-	4.621	0.83
Liu et al., 2022a	Stress recovery	897	0.61	-	0.001	-	-
	Restorativeness	897	0.226	-	0.001	-	-
	Mental health	897	0.78	-	0.001	-	-
Sun et al., 2023	Mental health	45	0.37	11.823	0.001	-	0.051
Asim et al., 2023	Restorativeness	22	0.779	-	0.001	-	0.539
Zhang & Li, 2023	Negative/ positive health effects	24	-	130.679	0.001	53.65	9.34
Migl et al., 2023	Negative/ positive health effects	91	-	-	0.001	4	2
Guo et al., 2023	Restorativeness	478	-	3.978	0.001	-	-

Table 4. Measuring effect size of psychological components in campus natural spaces. Source: Authors.

Author(s), year	Factors	r	95% Confidence Interval		Z-Value	P-Value	Status
			Lower limit	Upper limit			
Felsten, 2009	Restorativeness	0.908	0.793	0.961	6.796	0.000	Sig.
Hipp et al., 2016	Restorativeness	0.156	0.064	0.246	3.295	0.001	Sig.
van den Bogerd et al., 2018	Restorativeness	0.750	-1.000	1.000	0.032	0.975	Rej.
	Perceived recovery	0.804	0.525	0.927	4.139	0.000	Sig.
Liu et al., 2018	Mental health	0.341	0.053	0.577	2.302	0.021	Sig.
Wang et al., 2018	Relaxation	0.676	0.251	0.883	2.847	0.004	Sig.
	Good-natured	0.657	0.218	0.875	2.728	0.006	Sig.
Holt et al., 2019	Stress recovery	0.198	0.064	0.326	2.869	0.004	Sig.
	Happiness	0.234	0.101	0.359	3.411	0.001	Sig.
Gulwadi et al., 2019	Restorativeness	0.100	0.041	0.159	3.293	0.001	Sig.
Guo et al., 2020	Stress recovery	0.996	0.996	0.997	74.791	0.000	Sig.
Ibes & Forestell, 2022	Total mood disturbance	0.968	0.851	0.993	5.049	0.000	Sig.
Malekinezhad et al., 2020	Restorativeness	0.943	0.881	0.973	9.024	0.000	Sig.
	Relaxation	0.937	0.875	0.968	9.393	0.000	Sig.
	Clear thought	0.941	0.888	0.970	10.143	0.000	Sig.
Foellmer et al., 2021	Happiness	0.210	0.014	0.390	2.099	0.036	Sig.
	Relaxation	0.470	0.301	0.610	5.024	0.000	Sig.
	Energetic	0.200	0.004	0.381	1.997	0.046	Sig.

Rest of Table 4.

Author(s), year	Factors	r	95% Confidence Interval		Z-Value	P-Value	Status
			Lower limit	Upper limit			
Chou & Hung, 2021	Mental health	0.930	0.725	0.984	4.387	0.000	Sig.
	Reflection	0.986	0.940	0.997	6.554	0.000	Sig.
	Attention recovery	0.989	0.952	0.997	6.872	0.000	Sig.
Ha & Kim, 2021	Depression	0.202	0.095	0.305	3.647	0.000	Sig.
	Restorativeness	0.154	0.045	0.259	2.755	0.006	Sig.
Lee et al., 2021	Depression	0.655	0.614	0.693	21.980	0.000	Sig.
	Anxiety	0.616	0.571	0.658	20.137	0.000	Sig.
	Stress recovery	0.654	0.612	0.692	21.927	0.000	Sig.
	Self-esteem	0.788	0.760	0.813	29.869	0.000	Sig.
Yusli et al., 2021	Psychological well-being	0.710	0.632	0.774	12.194	0.000	Sig.
Liu et al., 2022b	Negative/ positive feelings	0.440	0.364	0.510	10.249	0.000	Sig.
Koning et al., 2022	Mental health	0.238	0.096	0.371	3.250	0.001	Sig.
Du et al., 2022	Restorativeness	0.918	0.849	0.956	9.552	0.000	Sig.
Liu et al., 2022a	Stress recovery	0.610	0.567	0.650	21.197	0.000	Sig.
	Restorativeness	0.226	0.163	0.287	6.876	0.000	Sig.
	Mental health	0.780	0.753	0.804	31.256	0.000	Sig.
Sun et al., 2023	Mental health	0.874	0.782	0.929	8.761	0.000	Sig.
Asim et al., 2023	Restorativeness	0.779	0.532	0.904	4.546	0.000	Sig.
Zhang & Li, 2023	Negative/ positive health effects	0.999	0.998	1.000	18.425	0.000	Sig.
Migl et al., 2023	Negative/ positive health effects	0.339	0.143	0.510	3.315	0.001	Sig.
Guo et al., 2023	Restorativeness	0.150	0.061	0.237	3.295	0.001	Sig.
	Fixed model	0.605	0.593	0.617	73.469	0.000	Sig.
	Random model	0.759	0.641	0.842	8.311	0.000	Sig.

The present analysis utilized a sample of 24 articles, assuming that these studies were drawn from a randomized sample. The mean effect size was estimated at 0.759, with a 95% confidence interval spanning 0.641 to 0.842. This suggests that the true effect size within the broader statistical population is likely to reside within this interval. The significance of the effect size was assessed using the z-value test, which yielded a statistical value of 8.311 and a p-value of less than 0.001 ($P < 0.001$). These findings provide strong evidence that the effect size in the population is significantly distinct from zero.

The Q-test was applied to assess heterogeneity across the included studies. The Q-test yielded a statistic of 533.043 ($P < 0.001$) with 22 degrees of freedom, indicating significant and non-random variability in the effect sizes among the studies. Furthermore, the I^2 index was employed to quantify the extent of heterogeneity. The I^2 value was 99%, demonstrating a substantial level of heterogeneity in the

study outcomes. The tau-squared (τ^2) index, representing the variance of the true effect sizes, was estimated at 0.515, while the tau (τ) index, reflecting the standard deviation of the true effect sizes, was 0.717. Both indices were computed based on the Fisher Z-transformation.

Moreover, the prediction interval was evaluated under the assumption of a normal distribution of the true effect sizes (expressed in Fisher Z-units). This interval was estimated to span from 0.446 to 0.986, indicating that the true effect size, at a 95% confidence level, may fall anywhere within this range. The significant findings from the Q test and the I^2 highlight substantial heterogeneity in the effect sizes across the included studies, thereby justifying the application of a random-effects model for subsequent analyses. The research hypothesis was examined in the subsequent analysis using the random-effects model, based on the results of the Cochran test and the I^2 index, as detailed in Table 7.

Table 5. Evaluation of publication bias. Source: Authors.

Test	Statistics	Value
Fail-safe N	Z-value for observed studies	64.094
	P-value for observed studies	0.001
	Alpha	0.05
	Tails	2
	Z for alpha	1.961
	Number of observed studies	23
Egger's regression test	Standard error	3.88261
	95% lower limit (2-tailed)	-4.05747
	95% upper limit (2-tailed)	8.813394
	t-value	6.48411
	df	22.00000
	P-value (one-tailed)	0.015
	P-value (two-tailed)	0.031
	Begg and Mazumdar's rank correlation	Kendall's S statistic (P-Q)
Tau		0.27260
Z-value for tau		2.44357
P-value (one-tailed)		0.00727
P-value (two-tailed)		0.01454
Tau		0.27126
Z-value for tau		2.43147
	P-value (one-tailed)	0.00752

According to the findings presented in Table 7, natural spaces on university campuses exert a significant influence on all psychological Components of students. The effect sizes calculated in this study were categorized into three ranges based on Cohen's criteria (Borenstein, 2019): less than 0.3 (small effect), between 0.3 and 0.5 (medium effect), and greater than 0.5 (strong effect). Accordingly, the effect of the natural campus environment on the happiness component was found to be small (effect size = 0.227), while its effects on the components of depression (effect size = 0.459) and Negative/ positive feelings (effect size = 0.44) were assessed as medium.

The remaining 15 psychological components of students demonstrated strong effects, including anxiety (effect size = 0.616), stress reduction (effect size = 0.831), self-esteem (effect size = 0.788), restorativeness (effect size = 0.549), relaxation (effect size = 0.767), negative/ positive health effects (effect size = 0.975), mental health (effect size=0.706), perceived recovery (effect size=0.804), psychological well-being (effect size = 0.71), reflection (effect size = 0.986), attention recovery (effect size=0.989), energetic (effect size=0.872), clear thought (effect size=0.941), total mood disturbance (effect size = 0.968), and good-natured (effect size = 0.657). These components were

Table 6. Results of heterogeneity tests of Q and I2. Source: Authors.

ID	Components	Q	I ²	Significance
1	Depression	75.623	98.67	0.001
2	Anxiety	81.235	99.42	0.001
3	Stress recovery	2709.223	99.88	0.001
4	Self-esteem	425.136	82.36	0.001
5	Restorativeness	195.872	95.4	0.001
6	Relaxation	33.153	93.96	0.001
7	Negative/ positive health effects	228.024	99.56	0.001
8	Mental health	121.083	96.69	0.001
9	Negative/ positive feelings	25.458	83.16	0.001
10	Perceived recovery	49.356	83.74	0.001
11	Psychological well-being	712.356	91.84	0.001
12	Reflection	425.468	88.64	0.001
13	Attention recovery	169.745	99.17	0.001
14	Happiness	813.745	79.75	0.001
15	Energetic	126.872	99.48	0.001
16	Clear thought	42.67	99.785	0.001
17	Total mood disturbance	704.92	83.14	0.001
18	Good-natured	164.25	86.42	0.001

Table 7. Significance of effect size of each component. Source: Authors.

ID	Components	Model	Number of studies	Effect size	95% CI		T-value	Results
					Lower	Upper		
1	Depression	Random	2	0.459	0.171	0.787	2.992	Accepted
2	Anxiety	Random	1	0.616	0.571	0.658	20.137	Accepted
3	Stress recovery	Random	4	0.838	0.191	0.985	1.981	Accepted
4	Self-esteem	Random	1	0.788	0.76	0.813	29.869	Accepted
5	Restorativeness	Random	10	0.549	0.399	0.671	6.219	Accepted
6	Relaxation	Random	3	0.767	0.188	0.95	2.413	Accepted
7	Negative/ positive health effects	Random	2	0.975	0.182	1	1.990	Accepted
8	Mental health	Random	5	0.706	0.383	0.875	3.625	Accepted
9	Negative/ positive feelings	Random	1	0.44	0.364	0.51	10.249	Accepted
10	Perceived recovery	Random	1	0.804	0.525	0.927	4.139	Accepted
11	Psychological well-being	Random	1	0.71	0.632	0.774	12.194	Accepted
12	Reflection	Random	1	0.986	0.94	0.997	6.554	Accepted
13	Attention recovery	Random	1	0.989	0.952	0.997	6.872	Accepted
14	Happiness	Random	2	0.227	0.117	0.331	4.000	Accepted
15	Energetic	Random	1	0.872	0.004	0.381	1.997	Accepted
16	Clear thought	Random	1	0.941	0.888	0.97	10.143	Accepted
17	Total mood disturbance	Random	1	0.968	0.851	0.993	5.049	Accepted
18	Good-natured	Random	1	0.657	0.218	0.875	2.728	Accepted

strongly influenced by students’ connection with the natural environment of university campuses.

Furthermore, based on Cohen’s index, the overall effect size for the 18 components combined was calculated to be 0.759, with a statistically significant z-value of 8.311, placing it within the range of a strong effect size. The visual comparison and reporting of these values are presented in [Table 8](#).

Conclusion

This article aims to synthesize quantitative and qualitative studies on the mental restoration of students within natural university campus environments. The natural variables present in university campuses play a significant role in facilitating students’ mental restoration and mitigating stress induced by cognitive activities. These environmental variables may encompass green landscapes (e.g., plants, diverse trees, flowers, and grass), water features (including natural and semi-natural forms of water), skylines, natural lighting, and even natural soundscapes. Access to these spaces can be visual (e.g., through window views) or physical (e.g., presence in the environment). Consequently,

designers and planners of university campuses should strategically incorporate these variables to support students’ mental health and its subsequent outcomes, such as academic achievement.

Psychological components of students, including feelings of energy, clear thought, reduction of total mood disorders, Good-Natured, decreased anxiety and stress, enhanced self-esteem, mental restoration, relaxation, Negative/ Positive Health Effects, promotion of mental health, Perceived Recovery, psychological well-being, Reflection, and Attention Recovery are strongly influenced by the natural elements of university campuses. Additionally, the natural campus environment has a moderate to slight influence on components such as depression, positive/negative feelings, and happiness. Therefore, leveraging the capacity of natural university campuses can serve as a valuable strategy to enhance students’ mental health, subsequently improving their physical health and positively shaping their future outcomes.

The findings of this study are not only valuable for university campus designers and planners but also hold significant importance for researchers in the fields of

Table 8. High-resolution plot based on CMA4 software output. Source: Authors.

Study name	Psychological component	Statistics for each study							Std diff in means and 95% CI
		Std diff In means	Std error	Var.	Lower Limit	Upper Limit	Z-Value	P-Value	
Felsten, 2009	Restorative ness	4/335	1.065	1.134	2.248	6.422	4.070	0.000	
Hipp et al., 2016	Restorative ness	0.316	0.097	0.009	0.127	0.506	3.268	0.001	
Van den Bogerd et al., 2018	Restorative ness	2.270	93	8649	-180	84.547	0.024	0.001	
	Perceived recovery	2.700	0.900	0.810	0.936	4.464	3.000	0.003	
Liu et al., 2018	Mental health	0.725	0.328	0.108	0.082	1.369	2.210	0.027	
Wang et al., 2018	Relaxation	1.835	0.784	0.614	0.299	3.371	2.342	0.019	
	Good-natured	1.743	0.766	0.586	0.242	3.244	2.276	0.023	
Holt et al., 2019	Stress recovery	0.404	0.143	0.020	0.124	0.684	2.831	0.005	
	Happiness	0.482	0.144	0.021	0.200	0.765	3.348	0.001	
Gulwadi et al., 2019	Restorativeness	0.201	0.061	0.004	0.081	0.321	3.282	0.001	
Guo et al., 2020	Stress recovery	23.75	1.01	1.02	21.77	25.73	23.515	0.000	
Ibes & Forestell, 2022	Total mood disturbance	3.73	3.260	10.628	1.341	14.119	2.371	0.018	
Malekinezhad et al., 2020	Retorativeness	5.650	1.170	369/1	3.357	7.943	4.829	0.000	
	Relaxation	5.350	1.040	1.082	3.312	7.388	5.114	0.000	
	Energetic	5.570	1.020	1.040	3.571	7.569	5.461	0.039	
Foellmer et al., 2021	Happiness	0.430	0.208	0.043	0.022	0.837	2.068	0.000	
	Relaxation	1.065	0.230	0.053	0.614	1.516	4.629	0.049	
	Energetic	0.408	0.207	0.043	0.002	0.814	1.970	0.014	
Chou & Hung, 2021	Mental health	5.059	2.056	4.227	1.029	9.088	2.460	0.009	
	Reflection	11.824	4.533	20.545	2.94	20.708	2.609	0.000	
	Attention recovery	13.354	5.104	26.046	3.351	23.356	2.617	0.006	
Ha & Kim, 2021	Depression	0.413	0.115	0.013	0.188	0.638	3.596	0.000	
	Restorativeness	0.311	0.114	0.013	0.088	0.534	2.73	0.000	
Yusli et al., 2021	Psychological well-being	2.016	0.207	0.043	1.611	0.421	9.760	0.000	
Lee et al., 2021	Depression	1.735	0.094	0.009	1.550	1.920	18.359	0.000	
	Anxiety	1.564	0.091	0.008	1.387	1.742	17.262	0.000	
	Stress recovery	1.730	0.094	0.009	1.545	1.915	18.329	0.000	
	Self- esteem	2.560	0.116	0.013	2.332	2.787	22.077	0.000	
Liu et al., 2022a	Neg./pos. feelings	0.980	0.103	0.011	0.779	1.181	9.549	0.000	
Koning et al., 2022	Mental health	0.491	0.154	0.024	0.189	0.792	3.187	0.000	
Du et al., 2022	Restorativeness	4.621	0.830	0.689	2.994	6.248	5.567	0.000	
Liu et al., 2022b	Stress recovery	1.540	0.084	0.007	1.374	1.705	18.239	0.000	
	Restorativeness	0.464	0.069	0.005	0.329	0.599	6.757	0.000	
	Mental health	2.493	0.107	0.011	2.283	2.702	23.322	0.000	
Sun et al., 2023	Mental health	3.606	0.636	0.405	2.359	4.853	5.667	0.000	
Asim et al., 2023	Restorativeness	2.485	0.732	0.535	1.051	3.919	3.396	0.001	
Zhang & Li, 2023	Neg./pos. health effects	55.722	12.167	148.43	31.784	79.569	4.58	0.000	
Migl et al., 2023	Neg./pos. health effects	0.721	0.227	0.051	0.277	1.166	3.183	0.000	
Guo et al., 2023	Restorativeness	0.304	0.093	0.009	0.122	0.485	3.270	0.001	
Pooled		1.989	0.186	0.035	1.625	2.354	10.694	0.000	
Prediction interval		1.989			-0.035	4.013			

architecture, landscape architecture, and psychology. The absence of significant differences in effect sizes or publication bias between studies conducted in real and virtual environments suggests that research outcomes derived from virtual environments are equally valid as those obtained in real-world settings. Furthermore, future research in this domain could explore the reciprocal effects of natural campus environments on psychological restoration by incorporating cultural, climatic, and seasonal variables, as well as individual differences such as gender, age, academic level, and field of study among students. Additionally, given the limited attention paid to the topic of psychological restoration in university environments in prior literature, this study encountered constraints regarding the availability of sources for a more exhaustive review. Nevertheless, it is anticipated that the findings of this study will underscore the importance of natural environments on university campuses, provide a foundation for future research to better understand the process of psychological restoration and its relationship with natural campus settings, and facilitate the identification of gaps for further investigation.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Endnotes

1. Number of participants
2. Randomized controlled trial
3. Not responded
4. Perceived restorativeness scale
5. 17 item perceived greenness scale
6. 26 item quality of life short survey scale
7. Trier social stress test
8. State-trait anxiety inventory
9. Short form of the profile of mood states
10. The restorative outcome scale
11. The restorative components scale
12. World health organization quality of life – spirituality, religiousness and personal beliefs field-test instrument.
13. Mental health continuum short form
14. Restorative state scale
15. Depression, anxiety, and stress scale-42
16. Rosenberg self-esteem scale
17. Ryff's scale of psychological wellbeing
18. Perceived restorativeness scale for activity
19. Self-rated naturalness scale
20. A form for evaluating students' place attachment in their university based on the place attachment scale
21. Who-5 happiness index

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