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**CIDADES SAUDÁVEIS E SUSTENTÁVEIS: EFEITO DE VARIAÇÕES NA
FORMA DE CONTATO COM A NATUREZA E EFEITOS SOBRE A SAÚDE
PÚBLICA COMO SUBSÍDIO AO DESIGN DE ESPAÇOS VERDES URBANOS**

Bauru
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de Mesquita Filho”, Área de
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Orientador: Prof. Dr. Adriano Bressane



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Aos 01 dias do mês de fevereiro do ano de 2024, às 08:00 horas, por meio de Videoconferência, realizou-se a defesa de DISSERTAÇÃO DE MESTRADO de ANNA ISABEL SILVA LOUREIRO, intitulada **CIDADES SAUDÁVEIS E SUSTENTÁVEIS: EFEITO DE**

VARIAÇÕES NA FORMA DE CONTATO COM A NATUREZA SOBRE A SAÚDE PÚBLICA COMO SUBSÍDIO AO DESIGN DE ESPAÇOS VERDES URBANOS. A Comissão Examinadora foi constituída pelos seguintes membros: Prof. Dr. ADRIANO BRESSANE (Orientador(a) - Participação Virtual) do(a) Departamento de Engenharia Ambiental / Universidade Estadual Paulista (UNESP) - Instituto de Ciência e Tecnologia de São José dos Campos - Câmpus São José dos Campos, Prof.^a Dr.^a MARGARIDA MARIA CORREIA MARQUES (Participação Virtual) do(a) Departamento de Biologia e Ambiente da Escola de Ciências da Vida e do Ambiente (ECVA) / Universidade de Trás-os-Montes e Alto Douro, Prof. Dr. RICARDO ALMENDRA (Participação Virtual) do(a) Departamento de Geografia e Turismo / Universidade de Coimbra. Após a exposição pela mestrande e arguição pelos membros da Comissão Examinadora que participaram do ato, de forma presencial e/ou virtual, a discente recebeu o conceito final: **APROVADA** Nada mais havendo, foi lavrada a presente ata, que após lida e aprovada, foi assinada pelo(a) Presidente(a) da Comissão Examinadora.



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Resumo

Com a crescente urbanização é crucial desenvolver estratégias para o alcance de cidades saudáveis e sustentáveis, que promovam a qualidade de vida em contato com a natureza. Essa pesquisa tem como objetivo analisar o efeito de variações na forma de contato com a natureza sobre a saúde, visando gerar evidências capazes de contribuir com o design de espaços verdes urbanos mais saudáveis e sustentáveis. A pesquisa obteve aprovação do Comitê de Ética em Pesquisa envolvendo seres humanos, com registro CAAE 58149622.3.0000.0077 e Parecer 5465967. Para o estudo, foram coletados dados sobre o perfil dos respondentes, indicadores de estresse, ansiedade e depressão, a intensidade de atividades realizadas em contato com a natureza, sua duração e frequência. A coleta foi realizada através de formulário online de autopreenchimento, alcançando de 2136 respondentes, necessário para um nível de confiança de 95% ($\alpha = 0.05$), poder de teste de 80% ($\beta = 0.20$) e uma diferença mínima detectável de 10% ($q = 0.1$). Para a análise estatística dos dados foi aplicada uma análise de variância, seguida de teste post-hoc para comparações múltiplas pareadas, entre grupos com variações na duração, na frequência e na intensidade de atividades físicas durante o contato com a natureza. Espera-se que os resultados possam contribuir com evidências para subsidiar o design de espaços verdes urbanos, no que se refere à sua forma e funcionalidade, adequados às atividades, e à promoção de eventos de lazer e recreação em contato com a natureza, com a duração e a frequência adequadas à melhoria da saúde pública.

Palavras-chave: infraestrutura verde; saneamento ambiental; sustentabilidade.

Abstract

With increasing urbanization, it is crucial to develop strategies for achieving healthy and sustainable cities that promote a quality life in connection with nature. This project aims to analyze the effect of variations in contact with nature on health, with the goal of generating evidence to contribute to the design of urban green spaces. The research has been approved by the Ethics Committee for Research Involving Human Subjects, with registration CAAE 58149622.3.0000.0077. For the study, data will be collected on respondents' profiles, stress, anxiety, and depression indicators, as well as the intensity of activities conducted in contact with nature, their duration, and frequency. Data collection will be carried out through a self-completion online form, aiming to reach a minimum sample size of 1160 respondents, required for a 95% confidence level ($\alpha = 0.05$), a test power of 80% ($\beta = 0.20$), and a minimum detectable difference of 10% ($q = 0.1$). For the statistical analysis of the data, an analysis of variance will be applied, followed by post-hoc tests for pairwise comparisons among groups with variations in the duration, frequency, and intensity of physical activities during contact with nature. The results are expected to provide evidence to support the design of urban green spaces in terms of their form and functionality, suitable for physical activities, and the promotion of leisure events and recreation in contact with nature, with appropriate duration and frequency to enhance public health.

Keywords: green infrastructure; environmental sanitation; sustainability.

Índice de Figuras

Artigo submetido

Figure 1. Effect of nature-engagement intensity on mental wellbeing	11
Figure 2. UGS design for high-intensity nature-based activities.....	15

Minuta de artigo

Figure 1. Effect of weekly frequency of nature engagement on mental distress	30
Figure 2. Effect of duration of nature engagement on mental distress	32
Figure 3. UGS design for longer stays in the green space.....	36

Índice de Tabelas

Artigo submetido

Table 1. Effect of nature-engagement intensity on mental wellbeing	11
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Minuta de artigo

Table 1. Potential interaction between dose and sociodemographic profile.....	27
Table 2. Effect of weekly frequency of nature engagement on mental distress.....	29

SUMÁRIO

RESUMO	I
ABSTRACT	II
ÍNDICE DE FIGURAS	III
ÍNDICE DE TABELAS	III
SUMÁRIO	V
1 INTRODUÇÃO	1
2 OBJETIVOS	4
2.1 OBJETIVO GERAL	4
2.2 OBJETIVOS ESPECÍFICOS	4
3 ARTIGO SUBMETIDO	5
4 MINUTA DE ARTIGO	21
5 CONCLUSÕES E RECOMENDAÇÕES	42
5.1 PRINCIPAL	42
5.2 ESPECÍFICAS	43
5.3 RECOMENDAÇÕES	44
6 REFERÊNCIAS BIBLIOGRÁFICAS	45

1 INTRODUÇÃO

O distanciamento do homem das adversidades do ambiente natural trouxe alguns benefícios. Abrigos mais seguros, maior produção e acesso aos alimentos estão entre as vantagens proporcionadas pela urbanização, reduzindo riscos e proporcionando melhorias em diversos campos, como recursos energéticos, transporte e medicamentos (WANG et al., 2021).

No entanto, a crescente desconexão com o ambiente natural, devido à sociedade moderna concentrada no trabalho, no ambiente construído e no entretenimento projetado, começou a levantar preocupações sobre a saúde humana (SILVERMAN; CORNEAU, 2017; BRATMAN et al., 2019).

Como alternativa para reconexão da sociedade com a natureza, um número crescente de estudos tem demonstrado os efeitos positivos das áreas verdes urbanas para a saúde pública. Melhora na pressão arterial, qualidade do sono, sistemas cardiovascular e respiratório, bem como na saúde mental, especialmente na redução dos sintomas de estresse, depressão e ansiedade, estão entre os principais benefícios revelados ao longo das últimas décadas ao redor do mundo (ULRICH et al., 1991; PARSONS et al., 1998; TOPPER et al., 2010; FAN et al., 2011; BEYER et al. 2014; NEWBY et al., 2014; SONG et al., 2014; PRETTY et al.,

2014; COX et al., 2018; RAUTIO et al. 2018; BARRETO et al. 2019; OWENS; BUNCE, 2022; BRESSANE et al., 2022).

Usando medidas fisiológicas como frequência cardíaca e tensão muscular, Ulrich et al. (1991) investigaram os impactos da exposição a ambientes naturais e urbanos em pessoas residentes em cidades dos Estados Unidos da América (EUA), sujeitas a situações estressantes. O estudo constatou que o tempo de recuperação do estresse foi mais curto quando os indivíduos foram expostos a ambientes naturais em comparação com ambientes urbanos.

Também desenvolvido nos EUA, o estudo de Parsons et al. (1998) avaliou a recuperação do estresse em motoristas que percorreram uma das quatro rotas: floresta/rural, áreas externas de campos de golfe, urbana e cenários mistos. Os autores verificaram que os motoristas em rotas com paisagens mais naturais se recuperaram do estresse mais rapidamente do que aqueles que foram expostos a cenários projetados, ou seja, espaços dominados por edifícios.

Estudos realizados em outros países, como Austrália, Países Baixos, Coreia do Sul, Japão e Reino Unido, também relataram uma associação inversa entre contato com a natureza e problemas de saúde mental comuns, como depressão e ansiedade (RAUTIO et al., 2018; COX et al., 2018). Por exemplo, Cox et al. (2018) observaram que indivíduos que residem em áreas rurais com maior acesso à natureza apresentam melhor saúde mental, do que aqueles que vivem em áreas urbanas carentes de áreas verdes.

Estudos também têm verificado que atividades na natureza, como banhos de floresta e caminhadas em ambientes naturais, podem reduzir a frequência de pensamentos negativos repetitivos e contribuir positivamente para os sintomas de depressão e ansiedade, mais do que atividades indoor, como academias e clubes esportivos (TOPPER et al., 2010; NEWBY et al., 2014). Ainda foi revelado que atividades em áreas naturais têm reduzido os sintomas de estresse e ansiedade mais do que aquelas realizadas em áreas construídas (SONG et al., 2014).

Apesar das evidências crescentes nos últimos anos, a maioria dos estudos tem sido realizada no exterior, limitando a validação dos resultados empíricos para outros países (ROSA, PROFICE; COLLADO, 2018). Na revisão desenvolvida por Nawrath et al. (2021), um único estudo teria sido realizado no Brasil até então, investigando a associação entre a exposição a áreas verdes em o entorno da residência e a ocorrência de transtornos mentais (BARRETO et al., 2019).

Recentemente, outro estudo desenvolvido no Brasil por Bressane et al. (2022) também trouxe análises exploratórias, visando a compreensão inicial de uma população pouco estudada. Os resultados apontaram que pessoas com maior frequência de contato com a natureza apresentam menor ocorrência de sintomas associados ao estresse, ansiedade e depressão. Entretanto, o referido estudo não avaliou se variações na forma desse contato com a natureza têm efeito sobre tais benefícios. Logo, propõe-se um estudo realizado no Brasil, respondendo a demanda por mais pesquisas em países em desenvolvimento (ROSA et al., 2019).

2 OBJETIVOS

2.1 Objetivo Geral

Esse projeto tem como objetivo analisar o efeito de variações na forma de contato com a natureza sobre a saúde, visando contribuir com diretrizes aplicáveis ao design de espaços verdes em cidades saudáveis e sustentáveis.

2.2 Objetivos específicos

- (i) verificar se variações na duração e na frequência do contato com a natureza têm efeito sobre a depressão, ansiedade e estresse;
- (ii) verificar se variações na intensidade do engajamento com a natureza têm efeito sobre a depressão, ansiedade e estresse;
- (iii) gerar subsídios à gestão de espaços verdes urbanos, no que se refere à promoção de atividades com duração e frequência adequadas à melhoria da saúde pública; e
- (iv) propor diretrizes para o design de espaços verdes urbanos, no que se refere à sua forma física e funcionalidade, adequados à realização de atividades físicas.

3 ARTIGO SUBMETIDO

Enhancing Urban Green Spaces through a Study of the Effect of Nature-Based Activity Intensity on Public Health

Abstract

While a substantial body of research has confirmed the benefits of nature engagement, the association between its intensity and mental wellbeing remains underexplored, particularly in developing countries. Applying Welch's ANOVA, data from a survey involving 2,136 respondents in Brazil were analyzed, focusing on the benefits for depression, anxiety, and stress symptoms. The results revealed a significant association, but the size of the observed effect depends on the intensity level of the nature-based outdoor activities. Our findings contribute to expanding the evidence base, providing deeper insights into how this association can support the design of urban green spaces (UGS), as a health enabling and supporting environments.

Keywords. Greener cities, Nature-based activities, Urban health.

Introduction

The bustling streets, towering concrete structures, and frenetic pace of urban life often inadvertently sever the vital bond between individuals and nature. The urban landscape is undergoing transformations characterized by the rapid sprawl of built-up areas, increased population density, and a growing awareness of their impact on public health (Bressane et al., 2022). In response to this, the concept of greener cities has emerged as an alternative, aiming to foster urban environments capable of providing contact with nature into our daily lives (Giles-Corti et al., 2020; Cerin et al., 2022; Giles-Corti, et al., 2022; Adlakha and John, 2022). A paradigm shift underscores the significance of understanding how various intensities of nature engagement affect its health benefits, revealing insights for designing urban green spaces (UGS).

Adlakha and John (2022) discuss the rapid increase in urban population and the need for integrated planning policies to create healthy and sustainable cities. It emphasizes the importance of aligning city design with societal goals, public health, and environmental sustainability. In turn, Cerin et al. (2022) aimed to identify the minimum thresholds for urban design that are associated with physical activity criteria and meeting WHO's target for increasing neighborhood's physical activities.

Giles-Corti et al. (2020) examined the extent to which the UN sustainability indicators can help cities evaluate their efforts to achieve public health outcomes.

The authors propose a more comprehensive approach to benchmarking and monitoring policies for healthy and greener cities. In consonance, Giles-Corti et al. (2022) focuses on the feasibility of consistently measuring spatial indicators of urban design that enable active and healthy lifestyles in cities. The authors emphasize the need for evidence-informed indicators to measure city planning policies and outcomes, which can be used worldwide to benchmark and monitor progress towards a healthy and sustainable future.

The burgeoning urban landscape has witnessed an alarming rise in mental health issues. Contact with nature have long been recognized for their benefits for blood pressure, sleep quality, and respiratory system (Xie et al., 2020), as well as reducing the prevalence of cardiovascular diseases, stress, depression, and anxiety (Crouse et al., 2021; Liu et al., 2022).

On the other hand, despite substantial body of research, the association between intensity of nature engagement and mental wellbeing remains understudied, particularly in developing countries (Bressane et al., 2022; Lee et al., 2022; Darcy et al., 2022; Papastergiou et al., 2023). As pointed out by Lee et al. (2022), there is currently insufficient evidence regarding this association. This gap limits the capability of designing the UGS appropriately to improve nature engagement activities and their public health benefits. This research endeavors to address this issue, by offering a data-driven approach and expanding evidence-based recommendations for urban planners and policymakers to design UGS.

Material and method

A total of 2,136 respondents took part in an online public survey conducted in September 2023. The survey adhered to ethical guidelines for human studies in Brazil, approved under protocol number #58149622.3.0000.0077. To be eligible for participation, individuals had to be at least 18 years old, and resident at metropolitan urban regions in Brazil. The research participants provided a significant diversity with regard to demographic profile: 59.6% identified as female, 15.7% fell within the young age group (18 to 25 years), 55.2% adults (25 to 45 years), and 21% were in the middle-aged (45 to 60 years). Concerning monthly income, 16.2% belonged to the lower bracket (0 to 2 minimum wages), 21.9% to the lower-middle class (2 to 4 minimum wages), 37% to the middle class (4 to 10 minimum wages), and 17.7% to the upper-middle class (10 to 20 minimum wages). In terms of education, 0.3% had only completed elementary education, 16.2% had completed high school, 83.5% had a university degree.

Respondents provided details about the activities during nature engagement. These activities were later categorized based on their intensity level, which was classified as either low, moderate, or high. Numerous studies have consistently demonstrated an inverse relationship between depression, anxiety, and stress on one hand, and positive factors like mental wellbeing (Bibi et al., 2020), and resilience (Teismann et al., 2018) on the other. Thus, to assess the state

of mental wellbeing within this context, participants were asked to respond to questions derived from the Depression, Anxiety, and Stress Scale (DASS-21) questionnaire, a widely recognized assessment tool (Bibi et al., 2020). The DASS-21 employs a scoring system based on a four-point Likert-type response scale. In this scale, '0' corresponds to "at no time," '1' represents "some of the time," '2' indicates "a good part of the time," and '3' signifies "most of the time." For each mental disorder, scores were calculated by summing the responses according to these numerical values.

Before evaluating the fixed and main effects of nature engagement intensity on wellbeing, we excluded the potential interaction with sociodemographic profile factors ($p = > 0.05$). Then, one-factor Welch's ANOVA, a robust statistical test suitable for cases where homogeneity of variances is not assured, along with the Games-Howell post-hoc test, were carried out to explore and compare the effects of varying intensity of nature engagement on mental wellbeing. The effect size (d_{Cohen}) was determined by measuring the largest difference between means, as given by:

$$d_{Cohen} = \frac{\mu_{i+1} - \mu_i}{\sqrt{\frac{(n_{i+1} - 1)\sigma_{i+1}^2 + (n_i - 1)\sigma_i^2}{n_{i+1} + n_i - 2}}}$$

where, n , μ , and σ are the sample size, mean and standard deviation of the i^{th} group, respectively. In line with Cohen's (1988) guidelines, effect sizes less than 0.40 were classified as small, those falling between 0.40 and 0.80 were considered

medium, and effect sizes equal to or greater than 0.80 were categorized as large. These effect size classifications allow us to gauge the practical significance of the observed relationships between nature-based activities and mental health outcomes. Furthermore, all our analyses maintained a test power ($1 - \beta$) of 0.8, ensuring a high probability of detecting meaningful effects, while adhering to a significance level (α) of 0.05, which is a standard threshold for statistical significance in scientific research. Additionally, we considered a minimum detectable effect size (ρ) of 5% (Faul et al., 2013), which serves as a reference point for determining the smallest effect size of practical importance that our analyses could reliably detect. These methodological choices were made to ensure the rigor and validity of our statistical findings.

Results and discussion

Concerning the association between intensity of nature engagement activities and levels of mental distress, the study yielded several key findings (Figure and Table 1). Individuals engaging in high-intensity activities in natural environments exhibited significantly lower levels of depression compared to those with no contact with nature ($p < 0.001$), with this difference being of large size ($d \geq 0.8$). Even the low and moderate-intensity engagement groups displayed reduced depression levels compared to the group with no nature interaction, emphasizing the potential benefit of even mild nature engagement for mitigating depression.

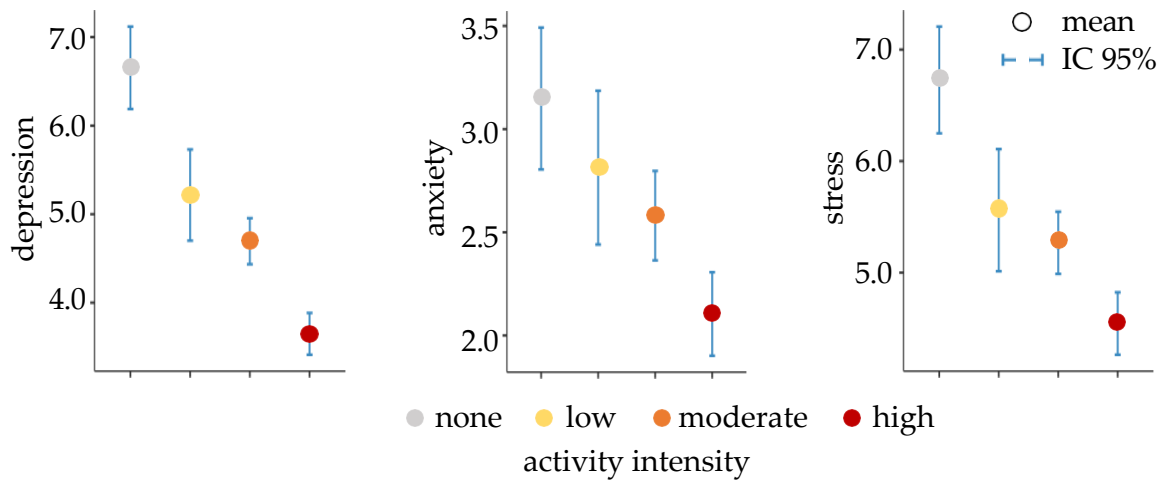


Figure 1. Effect of nature-engagement intensity on mental wellbeing.

Table 1. Effect of nature-engagement intensity on mental wellbeing.

			low	moderate	high
depression	none	difference	1.438***	1.959***	3.005***
		d_{Cohen}	0.380	0.517	0.801
	low	difference	----	0.521	1.567***
		d_{Cohen}	----	<i>ns</i>	0.414
	moderate	difference	----	----	1.046***
		d_{Cohen}	----	----	0.276
anxiety	none	difference	0.335	0.568*	1.044***
		d_{Cohen}	<i>ns</i>	0.187	0.344
	low	difference	----	0.233	1.567*
		d_{Cohen}	----	<i>ns</i>	0.234
	moderate	difference	----	----	0.476*
		d_{Cohen}	----	----	0.157
stress	none	difference	1.167**	1.460***	2.183***
		d_{Cohen}	0.284	0.355	0.531
	low	difference	----	0.292	1.016**
		d_{Cohen}	----	<i>ns</i>	0.247
	moderate	difference	----	----	0.724**
		d_{Cohen}	----	----	0.176

* $p < 0.05$; ** $p < 0.01$; *** $p < .001$; *ns* = non-significant effect;

yellow = small; blue = medium; green = large effect.

The high-intensity engagement group displayed significantly lower stress levels compared to those with no nature exposure, corresponding to a moderate effect size ($0.4 \leq \text{size} < 0.8$). Both the low and moderate-intensity nature activity groups also reported lower stress levels. Interestingly, there was no statistically significant difference in stress levels between the low-intensity and moderate-intensity groups ($p = 0.864$). The moderate-intensity engagement group demonstrated lower anxiety levels than the group with no nature contact ($p = 0.008$). Furthermore, a more pronounced reduction in anxiety was observed in the high-intensity group when compared to individuals who reported no nature interaction ($p < 0.001$). However, there was no statistically significant difference in anxiety levels between the low-intensity and the no-nature interaction groups ($p = 0.919$).

In the literature review conducted by Nawrath et al. (2021), only one study in Brazil was reported at that time, exploring the association between nature exposure around residences and residents' mental wellbeing (Barreto et al., 2019). A more recent study by Bressane et al. (2022) also in Brazil aimed to provide insights into this understudied population. However, the authors did not explore how variations in this contact may influence the observed benefits.

Considering studies in other countries worldwide, our results align with and extend the findings of previous studies in the field. They reinforce the notion

that high-intensity nature-engagement can have substantial mental benefits, as evidenced in this present study, by significantly lower levels of depression, anxiety, and stress among individuals engaging in nature-based outdoor activities. This is consistent with research conducted by Vujcic et al. (2017), which reported marked reductions in depressive symptoms among participants involved in intensive nature-based programs.

Moreover, these results highlight a crucial point: even lower-intensity nature interactions can contribute to reduced levels of mental distress when compared to individuals with no contact with nature. This is in line with the work of Thompson et al. (2012), who discovered that regular, albeit mild, exposure to natural environments was associated with lower self-reported stress levels. It also reinforces the idea that nature-based interventions need not be demanding or time-consuming to yield meaningful mental health benefits.

Darcy et al. (2022) employed semi-structured interviews to investigate the correlation between nature engagement and wellbeing in adults with pre-existing health conditions during the initial UK lockdown amid the COVID-19 pandemic. The study concluded that nature engagement was pivotal in supporting health, particularly for vulnerable groups, by offering opportunities for therapeutic activities. However, variations in the form of contact with nature were not explored.

Among the studies focusing on UGS planning, Lee et al. (2022) addressed

characteristics that influence its use, such as accessibility, quality, facilities, attractiveness, and security, assuming a causal relationship, when in reality, the association between influencing factors is likely more complex and multifactorial. In the next section, recommendations are discussed to support the design of UGS, including examples of some initiatives around the world.

Recommendation to provide high-intensity nature-based activities

As a practical implication, the findings from the present study provide some insights, which can support a strategic design of the UGS, as a health enabling and supporting environments. One of the most direct applications of the study's findings is the integration of nature-infused. For instance, Singapore's "City in a Garden" initiative has led to the creation of UGS, including strategic designs to ensure that they cater to a variety of nature-engagement activities.

Given the results of the present study, it is strongly recommended to designate multi-functional activity zones within the UGS, able to support moderate- and high-intensity activities, such as jogging, cycling, or outdoor fitness stations. These zones should have clear pathways and designated spaces for exercise equipment. Another recommendation is design exercise stations equipped with various fitness machines or equipment for strength training, cardio workouts, and flexibility exercises. These stations can be strategically placed to create circuits for full-body workouts (Figure 2).

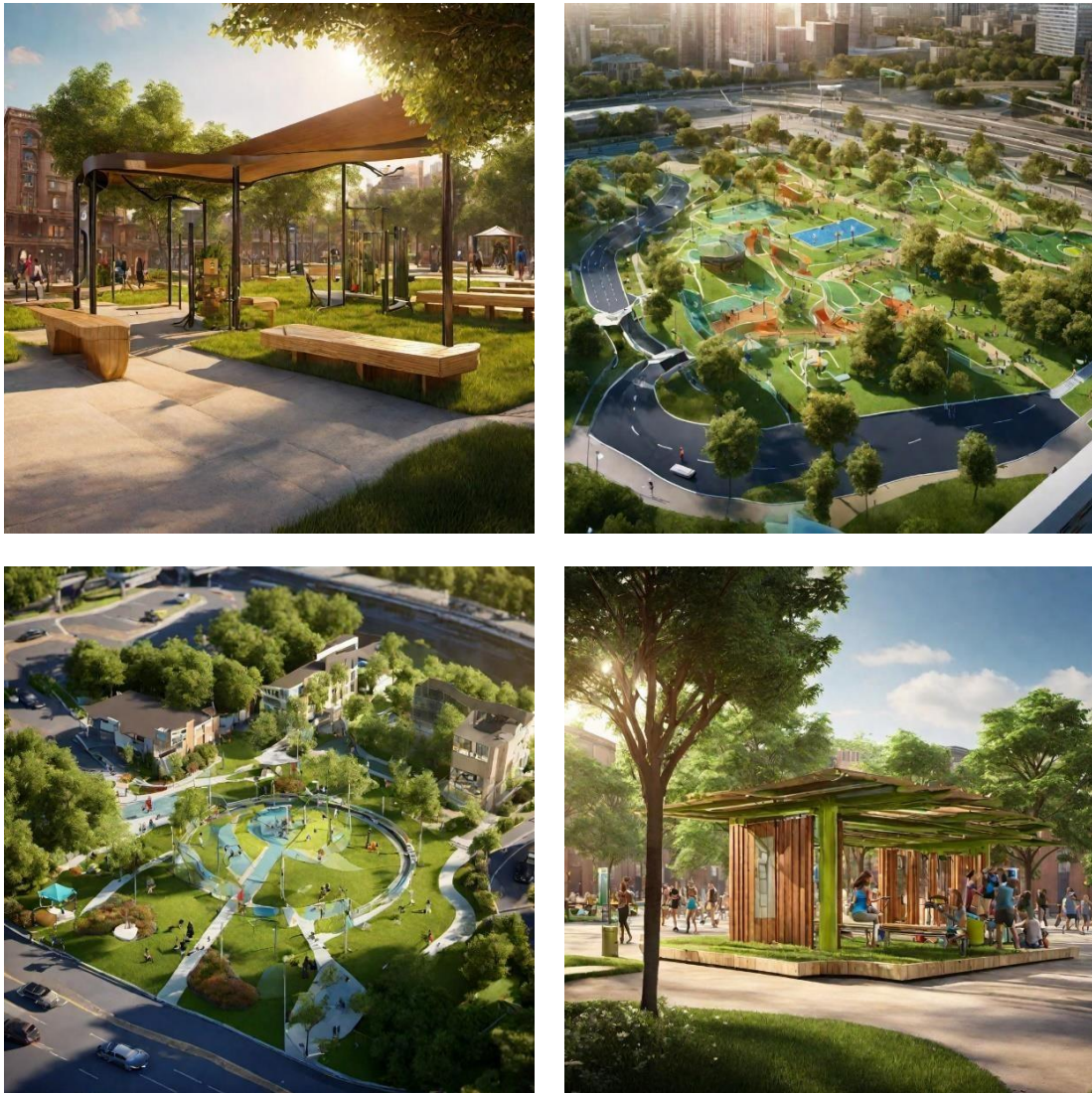


Figure 2. UGS design for high-intensity nature-based activities.

Provide shaded areas or small pavilions near the activity zones where people can rest, seek shelter from the sun or rain, and engage in group exercises or classes. Install water fountains or hydration stations with clean drinking water to keep users well-hydrated during and after their workouts. Build public restrooms nearby to accommodate users' needs and ensure their comfort while spending extended periods in the green space. Implement safety measures such as first aid

stations, emergency call boxes, and proper lighting to ensure users' safety, especially during early mornings or evenings.

Encouraging active transportation modes through UGS designed to allow green walking and cycling. In this sense, Cities like Copenhagen, Denmark, have successfully implemented bike-friendly UGS and pedestrian-friendly streetscapes. By providing safe and scenic routes for physical activities in contact with nature, UGS can promote both physical fitness and mental wellbeing.

The study's insights into the relationship between the intensity of nature engagement and mental health can also support the development of nature-based programs and interventions within UGS. Examples can be found in Japan, where forest bathing programs have gained popularity. These programs encourage people to immerse themselves in natural environments, often resulting in reduced stress and improved mental health. UGS allows adopting similar initiatives to make nature-based activities accessible to their residents.

Melbourne, Australia, is known for its "30-Minute City" concept, which aims to ensure that essential services and recreational opportunities are within a few minutes reach for all residents. This approach aligns with the study's suggestion that even moderate durations of nature-engagement can be beneficial. Strategic actions include zoning regulations that promote mixed-use developments and the creation of neighborhood hubs with green spaces and nature-based amenities.

Educating residents about the mental health benefits of nature engagement is essential for maximizing the utilization of UGS. Vancouver, Canada, has been proactive in this regard with programs like "Rewild Vancouver," which encourages residents to connect with local natural environments. Cities can take actions with community organizations to provide nature-based educational initiatives and engage residents in outdoor activities.

Final remark

The study delved into the influence of nature engagement intensity on wellbeing, providing empirical evidence that reveals a noteworthy reduction in symptoms of mental distress. This nuanced understanding and insights hold practical implications for the realms of urban planning and policymaking, specifically in shaping UGS to function as health-supporting environments. Future research avenues could investigate the intricate mechanisms and long-term effects of sustained nature engagement, offering the potential for a more comprehensive understanding of how UGS can be optimized to provide enduring mental and emotional support.

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4 MINUTA DE ARTIGO

Nature-Engagement and Wellbeing: Understanding the Dose-effect Relationship for Designing Urban Green Spaces

Statement of problem. While existing research highlights the positive impact of urban of nature-engagement, the association between its dose and mental wellbeing remains underexplored, particularly in developing countries. *Research gap.* Expanding our understanding of this dose-effect relationship is a crucial step in promoting greener and healthier cities. *Purpose.* This study aims to assess the effect of both the duration and frequency of nature-engagement on depression, anxiety, and stress. *Method.* Applying Welch's ANOVA, data from a survey involving 2,136 residents at metropolitan urban regions in Brazil were analyzed, focusing on verifying potential effect by reducing mental distress symptoms. *Results and conclusions.* The study reveals that spending at least 60 to 90, with a weekly frequency ranging from 2 to 3 times, significantly reduces the observed symptoms. *Practical implication.* Our findings not only align with and extend the results of previous studies but also go beyond, providing insights for the evidence-based design of Urban Green Spaces, as environments that enable and support health.

Keywords. nature-engagement, dose-effect relationship, UGS design.

Introduction

In recent years, several studies have delved into the association between nature engagement and mental wellbeing (Shuvo et al., 2020; Kolokotsa et al., 2020; Coventry et al., 2021; Smith et al., 2021; Liu et al., 2022; Bray et al., 2022; He et al., 2022; Grigoletto et al., 2023; Pasanen et al., 2023; Gittins et al., 2023; Smith and Turner, 2023).

Van den Berget al. (2016) and Liu et al. (2022) investigate the association between spending time in urban green spaces (UGS) and its impact on mental health. Van den Berget al. (2016) examined the effect of purposeful visits to green spaces and perceived mental health in European cities. Their findings highlighted a significant positive correlation, regardless of cultural and climatic contexts. This underscores the importance of ensuring easy access to UGS and promoting programs that encourage their use, especially among individuals with lower education levels and less childhood exposure to nature. Liu et al. (2022) explored the impact of greenspace visits on mental wellbeing. They found that nature connectedness had a stronger influence, underlining the importance of individuals' emotional connection to nature.

In their studies, Panno et al. (2017) and Grigoletto et al. (2023) assessed the cognitive benefits of UGS. Panno et al. (2017) verified a positive impact on wellbeing, as well as reduced ego depletion, among individuals visiting urban

parks during the summer. Grigoletto et al. (2023) explored the relationship between visiting green spaces, engaging in various activities, and mental health restoration. Their findings suggested that individuals with poorer mental health were more sensitive to the positive effects of greenspace visits. The type of activity in green spaces had varying effects on mental health, with picnic activities associated with higher restoration scores.

Nath et al. (2018) and Vujcic et al. (2019) investigate the perceived benefits of UGS on the physical and mental wellbeing. Nath et al. (2018) conducted research in Kuala Lumpur, Malaysia, to gauge park users' perceptions. Their findings emphasized the positive influence on stress reduction and overall wellbeing. Vujcic et al. (2019) consider residents in Belgrade, Serbia, who report benefits by alleviating self-reported nervous problems and medication use, advocating for further research in this area.

Smith et al. (2021) and Kong et al. (2022) touch upon the impact of nature-based interventions (NbI) on urban wellbeing. Smith et al. (2021) conducted a quantitative synthesis of the health impacts of urban blue spaces (UBS), revealing favorable associations with obesity, all-cause mortality, general health, and self-reported mental health and wellbeing. While the overall quality of evidence was good, the authors underscored the need for further research to harness the benefits of UBS. Kong et al. (2022) used social media data to quantify park visitors' positive emotions, highlighting the influence of park type and landscape attributes on

visitors' emotional experiences. The study emphasized the importance of park design in enhancing visitors' positive emotions.

Researches developed Pasanen et al. (2023) and Gittins et al. (2023) explore the relationship between UGS and wellbeing from a community and personal satisfaction perspective. Pasanen et al. (2023) found that visits to green spaces were associated with better mental health. Gittins et al. (2023) investigated the longer-term effects of NbI on personal wellbeing, reporting significant positive increases in psychosocial measures. The study underscored the importance of sustained funding and support for NbI projects to deliver therapeutic and preventative outcomes for health and wellbeing.

Among other related works, Bray et al. (2022) investigated the impact of green and blue spaces on anxiety and depression among young people in urban settings. They found that being in these spaces improved mood and reduced state anxiety, with social interaction, physical activity, and mindfulness. In turn, He et al. (2022) focused on the role of urban forest parks (UFPs) in physical activity and mental health benefits. Their study, conducted in Stanley Park, Canada, emphasized the therapeutic effect of UFPs for visitor satisfaction and mental wellbeing.

Kolokotsa et al. (2020) analyzed the impact of NbI on citizens' health and wellbeing in urban environments. Their comprehensive review of case studies showcased the positive effects on stress levels, air quality, urban overheating, and

physical activity. Smith and Turner (2023) examined the psychological and cognitive benefits reported by individuals experiencing green space. They highlighted the role of a sense of self and others in contributing to mental wellbeing, identifying altered thinking and emotional processes as pathways to psychological wellbeing in green spaces.

Some studies have conducted comprehensive literature reviews to explore this association. Van den Bosch and Sang (2017) offered a broader perspective by evaluating the evidence on the public health benefits of exposure to natural environments, emphasizing the potential for greener cities to enhance mental health. Shuvo et al. (2020) focused on low and middle-income countries (LMICs), emphasizing the need for more comprehensive research. Moreover, Coventry et al. (2021) conducted a review of NbI aimed at improving mental health outcomes in community-based adults. In conclusion the authors found the effectiveness of NbI in reducing depressive mood and anxiety. Finally, Potter et al. (2023) discussed the impact of green, blue, and gray spaces on human health and emphasized the need for improved exposure assessment tools to better evaluate the health implications of different types of urban spaces.

In summary, this vast body of studies converge in verify the crucial role of UGS in promoting mental wellbeing. On the other, limited research considers the geographic and sociodemographic context of developing countries, such as the Brazil's, with unique environmental, cultural, and lifestyle factors, which may

differ from those in previous studies conducted elsewhere. To contribute for filling this gap, this study aims to assess the effect of both the duration and frequency of nature-engagement on depression, anxiety, and stress. As a main contribution, we expect to provide insights for the evidence-based design of UGS, as environments that enable and support health.

Material and method

An online public survey was conducted involving 2,136 participants, following ethical standards for research, receiving approval under protocol number #58149622.3.0000.0077. To qualify for participation, individuals needed to be 18 years old or older, and resident at metropolitan urban regions in Brazil. The participants in the study exhibited notable diversity in their demographic characteristics. In terms of gender, 59.6% identified as female. Age distribution indicated that 15.7% fell within the young age group (18 to 25 years), 55.2% were adults (25 to 45 years), and 21% were in the middle-aged category (45 to 60 years). Regarding monthly income, 16.2% belonged to the lower bracket (0 to 2 minimum wages), 21.9% to the lower-middle class (2 to 4 minimum wages), 37% to the middle class (4 to 10 minimum wages), and 17.7% to the upper-middle class (10 to 20 minimum wages). In terms of education, 0.3% had completed only elementary education, 16.2% had completed high school, and 83.5% held a university degree.

This survey questionnaire was structured into some main sections. In the first section, respondents were asked about the weekly frequency of their nature

engagement, by choosing from the following responses: "< 1 time," "1 time," "2 times," "3 times," or "> 3 times". In the subsequent section, participants were asked to indicate the duration of their weekly nature engagement by choosing from options based on intervals spanning 30 minutes each, ranging from 30 minutes to over 240 minutes. To evaluate the mental wellbeing, in the last section participants answered questions based on Depression, Anxiety, and Stress Scale (DASS-21), a well-recognized assessment tool (Bibi et al., 2020b). The DASS-21 employs a scoring system that relies on a four-point Likert-type response scale, where '0' corresponds to "never," '1' represents "occasionally," '2' indicates "quite often," and '3' signifies "most of the time".

Before assessing the fixed and main effects of the dose (duration and frequency) on wellbeing, we ruled out its potential interaction with sociodemographic profile factors, as illustrated in Table 1.

Table 1. Potential interaction between dose and sociodemographic profile.

		p-value*		
	interaction	depression	anxiety	stress
gender	frequency	0.188	0.326	0.099
	duration	0.054	0.581	0.052
age	frequency	0.051	0.122	0.115
	duration	0.542	0.918	0.976
income	frequency	0.985	0.124	0.078
	duration	0.085	0.678	0.409
education	frequency	0.901	0.690	0.310
	duration	0.125	0.687	0.660

* nonsignificant for p-value > 0.05.

Then, one-factor Welch's ANOVA and Games-Howell post-hoc test were carried out, focusing on verifying potential effect of the nature engagement dose on mental distress symptoms using the statistical software Jamovi (JProject, 2022). Given the large sample size, assumptions for parametric testing were satisfied, consistent with the Central Limit Theorem (Mwiti et al., 2019). To estimate the effect size (d_{Cohen}), the most substantial mean difference was considered, given by:

$$d_{Cohen} = \frac{\mu_{i+1} - \mu_i}{\sqrt{\frac{(n_{i+1} - 1)\sigma_{i+1}^2 + (n_i - 1)\sigma_i^2}{n_{i+1} + n_i - 2}}}$$

where, n , μ , and σ are the sample size, mean and standard deviation of the i^{th} group, respectively. Following Cohen's (1988) recommendations, the effect sizes were categorized as: values below 0.40 were labeled as small, those ranging from 0.40 to 0.80 were deemed medium, and sizes equal to or exceeding 0.80 were designated as large.

All of our analyses considered a test power ($1 - \beta$) of 0.8, ensuring a strong likelihood of detecting substantial effects, while adhering to a significance level (α) of 0.05. Furthermore, we took into account a minimum detectable effect size (rho) of 5% (Faul et al., 2013), which acts as a benchmark for identifying the effects with practical relevance.

Results and discussion

Regarding the weekly frequency of nature engagement, distinct patterns concerning depression, anxiety, and stress were found (Table 2 and Figure 1).

Table 2. Effect of weekly frequency of nature engagement on mental distress.

			few days	sometimes	moderately	oftentimes
					y	
depression	almost	difference	1.598***	1.894***	2.470***	2.633***
	never	d_{Cohen}	0.418	0.496	0.647	0.689
	few days	difference	-----	0.297	0.872*	1.035***
		d_{Cohen}	-----	ns	0.228	0.271
	sometimes	difference	-----	-----	0.575	0.738*
		d_{Cohen}	-----	-----	ns	0.193
anxiety	moderately	difference	-----	-----	-----	0.163
		d_{Cohen}	-----	-----	-----	ns
	almost	difference	0.453	0.732**	0.932***	1.444***
	never	d_{Cohen}	ns	0.243	0.309	0.479
	few days	difference	-----	0.279	0.480	0.992***
		d_{Cohen}	-----	ns	ns	0.329
stress	sometimes	difference	-----	-----	0.200	0.712**
		d_{Cohen}	-----	-----	ns	0.236
	moderately	difference	-----	-----	-----	0.512
		d_{Cohen}	-----	-----	-----	ns
	almost	difference	1.015**	1.521***	1.527***	2.492***
	never	d_{Cohen}	0.247	0.371	0.372	0.608
stress	few days	difference	-----	0.506	0.512	1.477***
		d_{Cohen}	-----	ns	ns	0.360
	sometimes	difference	-----	-----	0.006	0.965**
		d_{Cohen}	-----	-----	ns	0.235
stress	moderately	difference	-----	-----	-----	0.971*
		d_{Cohen}	-----	-----	-----	0.237

* $p < 0.05$; ** $p < 0.01$; *** $p < .001$; ns = non-significant effect; yellow = small; blue = medium; green = large effect.

Individuals who reported "almost never" having nature engagement exhibited significantly higher score of depression. However, there were no significant differences between groups reporting "few days" and "sometimes," nor between "sometimes" and "moderately," or "moderately" and "oftentimes." This suggests that a lack of nature contact is associated with elevated depressive symptoms, but the frequency of contact beyond "few days" does not significantly affect depression symptoms.

Significant reductions in anxiety were observed when comparing "sometimes" to "almost never", but the most substantial effect occurred between "almost never" and "oftentimes" nature engagement groups. In general, a higher frequency of nature engagement corresponded to lower stress. However, there were exceptions in the comparisons between intermediary groups, where no significant decreases in stress levels were observed, mirroring the findings for anxiety.

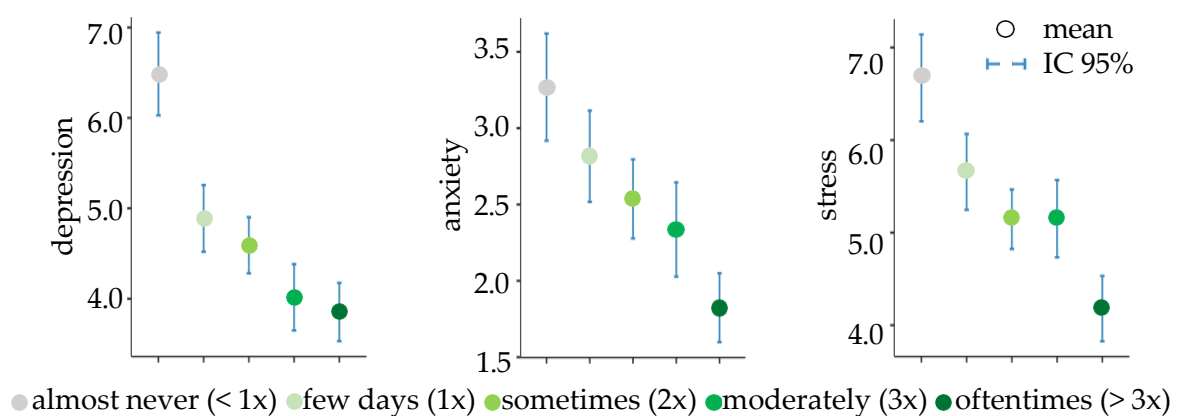


Figure 1. Effect of weekly frequency of nature engagement on mental distress.

In the comparison between groups reporting different durations of nature engagement over a week, both depression and stress exhibited a significant progressive decrease in symptoms up to 60 to 90 minutes. Beyond this duration, there was a slight, but nonsignificant trend towards further symptom reduction, with another significant drop observed after approximately 210 minutes for depression and 240 minutes for stress. For anxiety, despite a trend indicating a decline in levels with increasing duration of nature engagement, statistically significant reductions were observed only after approximately 60 to 90 minutes and, subsequently, after more than 240 minutes. In the intermediate duration intervals, there were no statistically significant decreases in anxiety levels (Figure 2).

Overall, our results align with and extend the findings of previous studies, conducted in other parts of the world. Bratman et al. (2019) found that individuals who spent more time in nature reported significantly lower levels of psychological distress. Specifically, our results underscore that regular nature engagement, occurring sometimes or more frequently, is linked to lower anxiety and stress levels.

In turn, the results concerning the duration of the engagement provide intriguing insights into the nuanced relationship with mental wellbeing. Meredith et al. (2020) reported that individuals engaging in nature for a longer duration experienced significant improvements in psychological wellbeing. In the present

study, it was found that moderate durations of nature engagement, particularly ranging from 1 to 1.5 hours per week, are associated with a notable reduction in both depression and stress levels aligns with previous research. This deeper understanding not only corroborates but also extends previous knowledge of how time spent in nature is linked to mental wellbeing.

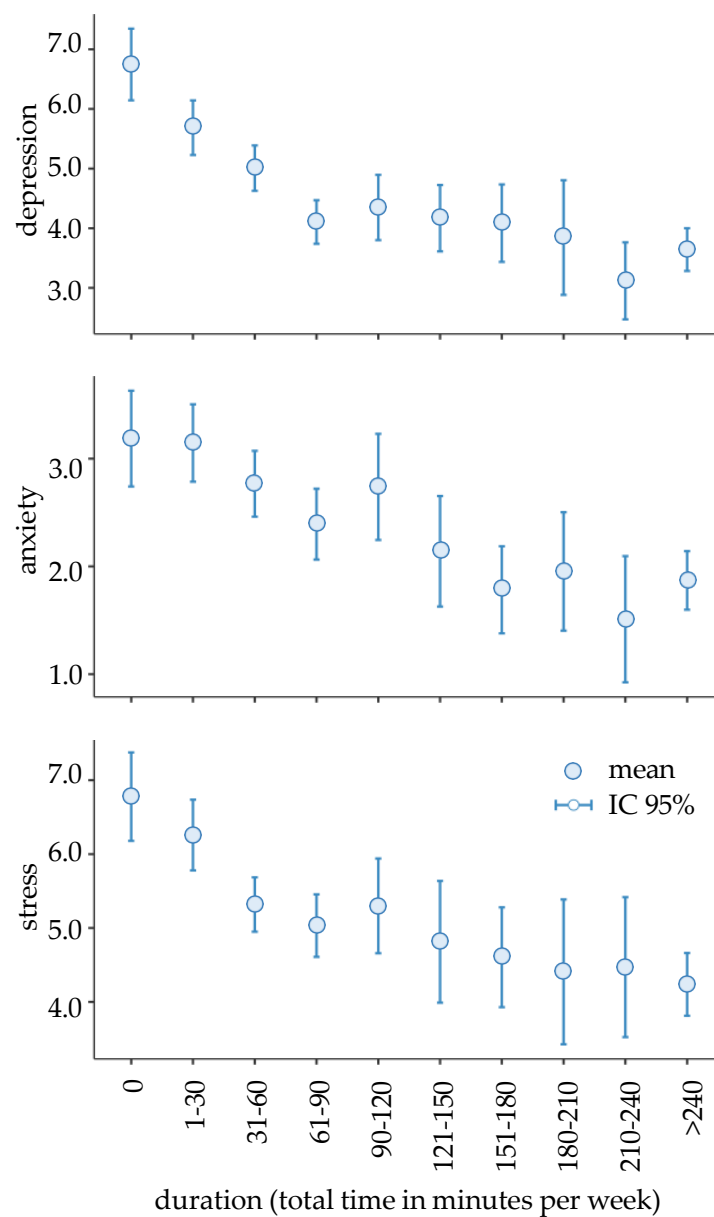


Figure 2. Effect of duration of nature engagement on mental distress.

The convergence of evidence suggests that the duration of the nature engagement represents a key factor for mental wellbeing benefits. Additionally, the findings demonstrate that prolonged engagement beyond a certain threshold does not yield significant additional benefits, introducing a practical and interesting perspective. This result echoes the findings of Shanahan et al. (2016), who found that while more extended periods of nature engagement were associated with various health benefits, including reduced stress, there appeared to be diminishing returns beyond a certain duration.

The relationship between anxiety and the duration of nature contact presents a nuanced picture. While there is a general trend towards reduced anxiety with longer durations of nature contact, significant reductions in anxiety levels are primarily observed after more prolonged nature engagement. This aligns with the findings of Li and Sullivan (2016), who found that spending at least 120 minutes per week in nature was associated with substantial reductions in anxiety levels. This underscores the importance of both the minimum threshold and the optimal duration of nature exposure for achieving meaningful reductions in anxiety.

These nuanced insights into the dose-effect relationship between nature engagement and mental well-being have practical implications for the design of Urban Green Spaces (UGS). Specifically, they highlight the importance of

providing longer stays for users, necessitating appropriate structure and functionality, as discussed in the next section.

Implications for designing urban green spaces

Based on the above, this study provides a major understanding of how the dose of nature engagement correlates with mental well-being, by identifying practical thresholds for the weekly frequency and duration that enhance health benefits. Considering that the study revealed the prevalence of benefits associated with longer engagements, we present some evidence-based recommendations for the design of Urban Green Spaces (UGS) as environments that enable and support health.

Designate areas with picnic tables, benches, and trash receptacles to encourage people to bring food, enjoy meals, and socialize with family and friends. Include playgrounds for children with age-appropriate equipment and safety features to make the green space family-friendly. Provide free Wi-Fi access and charging stations, allowing visitors to work, study, or enjoy entertainment while staying in the green space. Incorporate natural elements like ponds, small lakes, or streams, where visitors can engage in activities like fishing or simply relax by the water.

In addition, allocate space for community gardens, enabling residents to cultivate plants, fostering a sense of ownership and engagement. Organize regular events, such as outdoor movie nights, fitness classes, or cultural festivals, to attract

people to the green space regularly. Install bike racks and encourage cycling to the green space, promoting eco-friendly transportation and longer stays. Scatter benches, comfortable seating areas, and hammocks throughout the green space to offer relaxation spots with scenic views. Ensure an ample number of trash and recycling bins throughout the space to maintain cleanliness and encourage responsible waste disposal. Place information kiosks with maps, activity schedules, and points of interest to guide visitors (Figure 3).

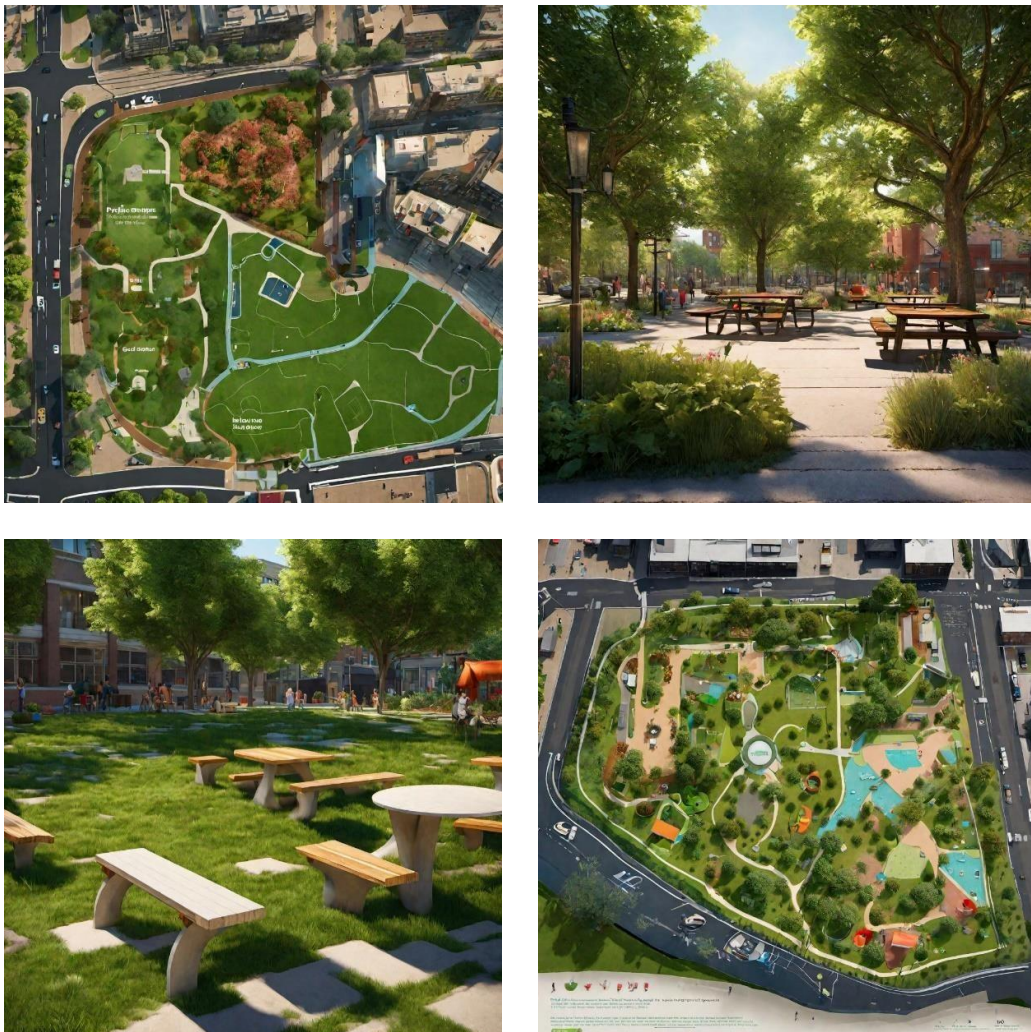


Figure 3. UGS design for longer stays in the green space.

Final remark

This study aimed to expand the understanding of the dose-effect relationship between the dose of nature engagement and mental wellbeing, which remains underexplored in developing countries. The convergence of evidence corroborates that the weekly frequency and duration of the engagement represents a key factor for the health benefits. As a practical implication, our results also support the achievement of greener and healthier cities, by providing some evidence-based recommendations for the design of UGS, as environments that enable and support mental wellbeing. Future research paths could explore the complex mechanisms and enduring consequences of prolonged engagement with nature, presenting an opportunity for a more thorough comprehension of how UGS can be fine-tuned to deliver lasting mental and emotional support.

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4. CONCLUSÕES E RECOMENDAÇÕES

4.1 Principal

Os resultados revelam que os indivíduos envolvidos em atividades de alta intensidade em contato com a natureza experimentaram níveis significativamente mais baixos de depressão, ansiedade e estresse. Além disso, mesmo o envolvimento com a natureza de baixa e moderada intensidade mostrou benefícios na redução dos sintomas depressivos e da ansiedade, embora em graus variados. Além disso, durações consistentes e moderadas de contato com a natureza, variando de 60 a 90 minutos por semana, foram associadas a reduções notáveis nos níveis de depressão e estresse. No entanto, foi observado um retorno decrescente para além deste limiar, destacando a importância de uma duração prática para benefícios ótimos para a saúde mental.

Como principais contribuições do estudo, podem ser destacadas:

- (i) Fornecer evidências empíricas dos benefícios para a saúde mental associados às atividades ao ar livre em contato com a natureza, aprofundando as teorias existentes.
- (ii) Destacar a relevância do design de paisagem urbana na promoção do

bem-estar mental e oferecer recomendações específicas para a integração de intervenções baseadas na natureza.

- (iii) Oferecer recomendações práticas para o design de espaços verdes urbanos, como a criação de zonas de atividades multifuncionais para atividades de alta intensidade e a designação de áreas para estadias mais longas, incluindo áreas de piquenique, playgrounds e jardins comunitários, para atender às diversas necessidades dos usuários.

4.2 Específicas

- (i) Passar pelo menos 60 a 90 minutos em contato com a natureza regularmente reduz significativamente os sintomas de depressão, ansiedade e estresse;
- (ii) Atividades de menor intensidade também em contato com a natureza tiveram um impacto positivo na redução dos sintomas depressivos.
- (iii) Tanto atividades de moderada como de alta intensidade desempenham um papel significativo na redução dos níveis de ansiedade;
- (iv) Atividades de alta intensidade levam a reduções substanciais nos níveis de estresse, com atividades de moderada intensidade também contribuindo de forma positiva.

4.3 Recomendações

Para aprofundar a compreensão dos benefícios do contato com a natureza para a saúde e apoiar o desenvolvimento de cidades mais sustentáveis e centradas no bem-estar, seguem recomendações específicas para pesquisas futuras:

- (i) estudos longitudinais por um período significativo de tempo, para uma compreensão mais profunda dos efeitos a longo prazo do contato com a natureza na saúde;
- (ii) estudos que investiguem intervenções específicas baseadas na natureza, como trilhas para caminhadas urbanas e jardins terapêuticos;
- (iii) estudos para incluir populações diversas em termos de idade, gênero, etnia e nível socioeconômico, para determinar se os benefícios são consistentes em diferentes grupos demográficos;
- (iv) estudos para aprofundar a investigação sobre como as estratégias de design urbano, como a criação de parques, áreas verdes e espaços multifuncionais, afetam a saúde mental da comunidade; e
- (v) estudos para desenvolver diretrizes práticas para incorporar espaços verdes e intervenções baseadas na natureza em políticas de planejamento urbano.

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