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Potential benefits of immersion in nature: stress, sleep quality, and cortisol levels in health workers

Beneficios potenciales de la inmersión en la naturaleza: estrés, calidad del sueño y niveles de cortisol en trabajadores de la salud

Benefícios potenciais da imersão na natureza: estresse, qualidade do sono e níveis de cortisol em profissionais de saúde

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Abstract

Introduction: This pilot study was conducted as part of the project "Effects of Nature Immersion Therapy 'Vitamin N' on Stress Levels in Healthcare Workers in Bogotá: An Intervention Evaluation Study, 2022-2024." **Objective**: To evaluate the benefits of nature immersion in an active working population, with the aim of reduce perceived stress and anxiety, improve sleep quality, and regulate cortisol levels in saliva. **Methodology:** A longitudinal study was conducted using a non-probabilistic consecutive sampling method. The intervention took place once a week for one hour per session over the course of a month. Measurements were taken before and after the nature immersion, and participants were divided into three groups (control, parks, and forests). Psychological scales were used to assess perceived stress (PSS-14), subjective fatigue (Yoshitake), anxiety (STAI), and sleep quality (Pittsburgh). Additionally, saliva cortisol levels were measured in a subsample. Differences in mean scores between groups were estimated. **Results**: The intervention groups in forests and parks showed an average reduction of 2.6 points on the PSS-14 scale, while the control group showed a reduction of only 0.4 points. A decrease in general fatigue was observed in the parks group, but there were no significant changes in physical or mental fatigue. STAI levels did not change in any of the groups after the intervention. Although the intervention groups showed a slight improvement in sleep quality,

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it remained moderate and not statistically significant. Finally, a reduction in cortisol levels was observed in the intervention groups after the therapy. **Conclusions:** The results suggest that nature immersion therapy may have beneficial effects in reducing stress and fatigue, as well as in improving sleep quality and regulating cortisol levels in actively working individuals.

Keywords: Nature; Therapy; Stress, Psychological; Stress, Physiological; Fatigue; Anxiety; Sleep Quality ; Health Personnel.

Resumen

Introducción: El presente estudio piloto se realizó como parte del proyecto "Efectos de la terapia de inmersión en la naturaleza 'Vitamina N' sobre los niveles de estrés en trabajadores de la salud en la ciudad de Bogotá: un estudio de evaluación de intervención, 2022-2024". **Objetivo**: Evaluar los beneficios de la inmersión en la naturaleza en una población laboralmente activa, para reducir el estrés percibido, ansiedad, mejorar la calidad del sueño y en regular los niveles de cortisol en saliva. **Metodología:** Se llevó a cabo un estudio longitudinal utilizando muestreo consecutivo no probabilístico. La intervención se realizó una vez a la semana con una duración de una hora al día a lo largo de un mes. Se realizaron mediciones antes y después de la inmersión en la naturaleza, la población se clasificó en tres grupos (control, parques y bosques). Se utilizaron escalas psicológicas para evaluar: estrés percibido (PSS-14), fatiga subjetiva (Yoshitake), ansiedad (STAI) y la calidad del sueño (Pittsburgh). Adicionalmente, se midieron los niveles de cortisol en saliva en una submuestra. Se estimaron las diferencias de medias entre los grupos. **Resultados:** Los grupos de intervención en bosques y parques mostraron una reducción promedio de 2.6 puntos en la escala PSS-14, mientras que el grupo control redujo solo 0.4 puntos. Se observó una disminución en la fatiga general en el grupo de parques, pero no hubo cambios significativos en la fatiga física y mental. Los niveles STAI no variaron tras la intervención en ninguno de los grupos. Aunque hubo una ligera mejora en la calidad del sueño en los grupos de intervención, esta siguió siendo moderada y no significativa. Finalmente, se observó una reducción en los niveles de cortisol en los grupos de intervención al finalizar la terapia. **Conclusiones:** Los resultados sugieren que la terapia de inmersión en la naturaleza podría tener efectos benéficos en la reducción del estrés y fatiga, así como una mejora en la calidad del sueño y regulación de los niveles de cortisol en trabajadores laboralmente activos.

Palabras clave: Naturaleza; Terapia; Estrés Psicológico; Estrés Fisiológico; Fatiga; Ansiedad; Calidad del Sueño; Personal de Salud.

Introduction

It is estimated that mental health issues are one of the leading causes of occupational disability worldwide [1]. Diagnoses and tools used for mental illnesses are clearly defined in the International Classification of Diseases, Tenth Revision (ICD-10), and in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), with established treatment and rehabilitation practices. The most common work-related diagnoses include stress, anxiety, depression, and burnout [2].

Although workplace stress management programs focus on psychosocial aspects, there is a growing body of research on the environmental psychology of the work environment that remains unaddressed [3,4]. Workplace interventions can be classified as primary, secondary, and tertiary, with primary prevention interventions seeking to change the work environment to counteract mental health issues [5].

Connection with nature has become essential for our health and well-being, and the practice of nature immersion has emerged as a promising strategy for reducing stress and promoting mental and physical health. Studies have found that nature-based interventions foster psychological detachment from work and have positive effects on the regulation of physiological stress [6].

Cortisol, a strong modulator of brain function, behavior and cognition, plays a key role in the stress response and can be influenced by environmental factors and sleep quality [7]. Immersion in nature has been shown to be effective in modulating cortisol levels, which is critical, as the diurnal rhythm of this hormone interacts with the environment to predict adaptation to stress. The sleep quality, which includes the ease of falling asleep, continuity without prolonged awakenings, and the feeling of rest upon awakening, has a significant influence on workers' perception of stress and their ability to manage work demands [8].

Inspired on forest bathing, nature immersion involves consciously immersing oneself in natural environments and harnessing the therapeutic benefits offered by nature, such as walking, exploring with our senses, and engaging in outdoor activities in forests, parks, or green areas. It has been shown that this practice reduces stress, modulates cortisol levels, and decreases symptoms of anxiety and depression [9].

In the workplace, high demands and stressful environments negatively affect the physical and mental health of employees. Therefore, it is crucial to explore effective interventions to reduce stress and improve well-being in the work environment. The objective was to evaluate the benefits of nature immersion in an active working population, with the goal of reducing perceived stress and anxiety, improve sleep quality, and regulate cortisol levels in saliva.

Methodology

Study Design, Population, and Selection Criteria

This pilot longitudinal intervention study used a consecutive non-probabilistic sampling method to enroll actively employed individuals, including bacteriologists, nurses, physicians, technicians, and professionals aged 18 and older. Students, smokers, personnel from radiology services, pregnant women, and individuals with chronic illnesses were excluded from the study. The invitation to participate was extended through the Human Talent Area at the *Instituto Nacional de Salud in Bogota*, on August 2022.

Upon the participant's agreement to join the study and confirmation of meeting the eligibility criteria, a unique code was assigned. Using a random number generator in Excel®, participants were then randomly distributed into three distinct groups: a control group, an intervention group in metropolitan parks, and an intervention group in urban forests (**Figure 1**).

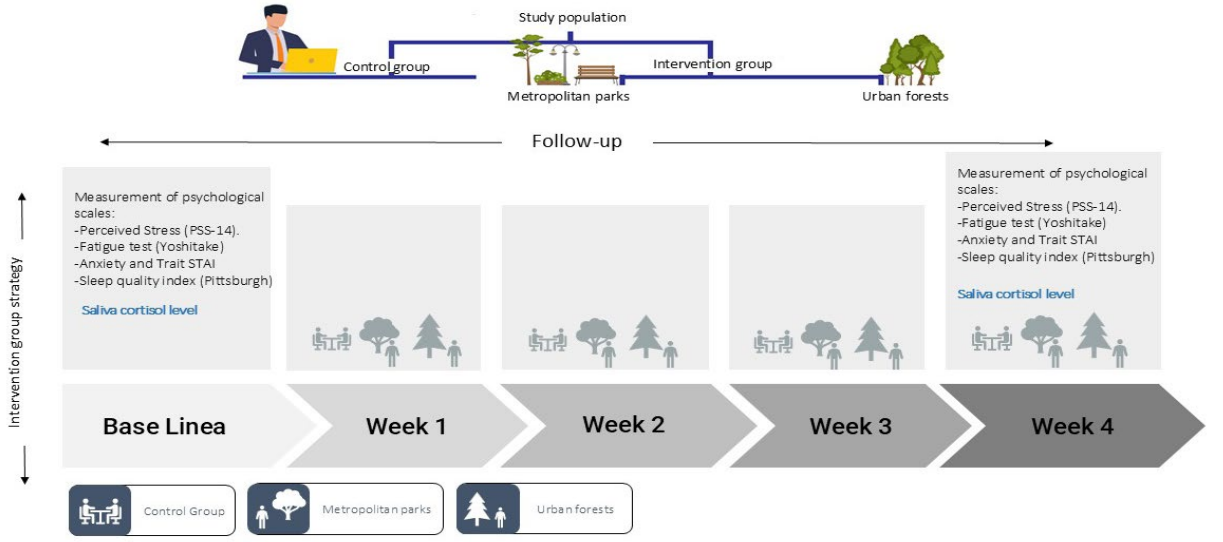

Figure 1. Timeline of and intervention and control groups

Intervention description

The interventions took place during the first and final weeks of October 2022. Each participant engaged in a weekly therapy session, lasting an hour under the skillful guidance of experts from Bogotá's Botanical Garden, well-versed in the Nature, Culture, and Health Program. The selection of natural areas was a meticulous process, rooted in criteria established by the botanical garden's experts. These criteria encompassed several factors including biodiversity, tree density, canopy cover, accessibility, fauna presence, and a purposeful limitation of human intervention. Notably, all nature immersion sessions unfolded in the tranquil morning hours, specifically between 8 and 11 am.

The intervention unfolded across four distinct phases: a warm welcome and the provision of general directions, followed by a relaxation segment, an activation of the senses phase, and culminating with an experiential sharing of their personal encounters.

General directions preceded the intervention, marked by a warm welcome extended to participants. Following this, an orientation talk provided participants with insight into the upcoming experience and offered overarching guidelines for their participation.

The second stage involved relaxation, guided by an instructor adept at leading participants through breathing exercises. This stage emphasized the crucial significance of channeling one's attention toward their sensory experiences.

The third phase was centered on the activation of the senses, which entailed releasing any preconceived notions and embracing an awareness and recognition of the environment. This was further complemented by activities such as passive walking, mindful breathing, heightened senses awareness, and an immersive experiential component, all of which encouraged participants to engage fully through their bodily sensations and emotions.

During the leisurely and unhurried walks, participants were encouraged to adopt an attitude of keen observation and mindfulness. The idea behind the therapies was to foster a deep connection with the natural environment. The instructors emphasized the value of silence, a reduced pace, and the focused direction of attention towards bodily sensations and sensory perceptions.

The fourth and final stage involved the sharing of experiences. To facilitate this, a designated station was thoughtfully provided, offering participants the opportunity to exchange and discuss their individual encounters in the program.

Psychological Scales and Physiological Measurement

Several psychological scales were used to assess stress levels, fatigue, anxiety, and sleep quality. These scales included the Perceived Stress Scale-14 (PSS-14) with Cronbach Alpha 0.83, Yoshitake's Subjective Fatigue Questionnaire with Cronbach Alpha 0.89, the State-Trait Anxiety Inventory (STAI) with Cronbach Alpha 0.90, and the Pittsburgh Sleep Quality Index with Cronbach Alpha 0.78 [10,11]. In addition, a physiological measurement of cortisol levels in saliva was conducted on a subset of participants. Saliva samples were processed using a specific ELISA kit to quantify cortisol. Two sets of measurements, including cortisol levels and neuro-psychological scales, were conducted. The initial measurement was taken a week prior to the commencement of the intervention. The subsequent measurement occurred four weeks after the first assessment.

Statistical Analysis and Ethical Considerations

Statistical analyses were performed to compare variables before and after the intervention, using Pearson's chi-square tests and mean difference tests. A p-value <0.05 was considered statistically significant. All analyses were conducted in R® Version 4.2. The study received approval from the Ethics Committee of the *Instituto Nacional de Salud* (021-2022), and informed consent was obtained from the participants.

Results

The study included a sample of 25 individuals. The control group had a median age of 40.50 (25th, 75th = 35.50, 49.50) years, the metropolitan parks group had a mean age of 39.00 (25th, 75th = 32.00, 44.00) years, and the forest group had a mean age of 36.00 (25th, 75th = 30.00, 60.00) years, and there were no significant differences (p = 0.89). In terms of sex, the female accounted for 56.00% of the participants (n = 14/25), with no significant differences (p> 0.9). Regarding educational level, 62.50% of the control group reported having a postgraduate degree, while 55.56% of the metropolitan parks group had a university level education. In the forest group, 50.00% of the population had an educational level below university. Lastly, in socioeconomic status, 57.14% of participants in the control group and 50.00% in the forest group reported belonging to level 3; while in the metropolitan parks group, 55.56% belonged to level 4 (**Table 1**).

Table 1. Sociodemographic characteristics of the study population.

Sociodemographic characteristics	Control (n=8)	Parks (n=9)	Forest (n=8)	p^2
Age; median (IQR)	40.50 (35.50, 49.50)	39.00 (32.00, 44.00)	36.00 (30.00, 60.00)	0.89[a]
Sex; n (%)				0.88 [b]
Male	3 (37.50)	4 (44.44)	4 (50.00)	
Female	5 (62.50)	5 (55.56)	4 (50.00)	
Marital status; n (%)				0.32[b]
Single	3 (37.50)	3 (33.33)	6 (75.00)	
Married	3 (37.50)	4 (44.44)	1 (12.50)	
Common-law marriage	1 (12.50)	2 (22.22)	--	
Divorced	1 (12.50)	--	--	
Widowed	--	--	1 (12.50)	
Educational level; n (%)				0.22[b]
Highschool	1 (12.50)	1 (11.11)	2 (25.00)	
Technical	--	2 (22.22)	2 (25.00)	
University	2 (25.00)	5 (55.56)	1 (12.50)	
Postgrade	5 (62.50)	1 (11.11)	3 (37.50)	
Socioeconomic status; n (%)				0.06[b]
2	2 (28.57)	4 (44.44)	3 (37.50)	
3	4 (57.14)	--	4 (50.00)	
4	1 (14.29)	5 (55.56)	1 (12.50)	

IQR: interquartile range. *p* values were obtained by [a]Kruskal-Wallis test and [b]Fisher

In the psychological scales, no significant differences were observed between the intervention groups compared to the control group at the beginning of the intervention ($p>0.05$) (**Table 2**). In perceived stress scale-14 (PSS-14), no significant differences were observed for any of the study groups between initial stress levels and after the intervention (**Table 3**). In Yoshitake's subjective fatigue, in the metropolitan parks group, a significant decrease in physical fatigue was found ($p=0.04$), while no significant changes were found in the other subcategories of fatigue (mental $p=0.41$, and general $p=0.42$) (Table 4). In the control group, a statistically significant decrease in physical fatigue ($p=0.01$) and general fatigue ($p=0.03$) was found, while no significant differences were observed for any of the parameters of the scale in the urban forests group.

Table 2. Psychological scales scores. [Mean (SD)]

Characteristics	Forest+ Parks (n = 17)	Control (n = 8)	*p*
Yoshitake			
General symptoms of fatigue	2.47 ± 2.67	4.62 ± 2.92	0.09
Mental fatigue	1.88 ± 1.96	3.25 ± 1.67	0.07
Physical fatigue	1.47 ± 2.10	2.38 ± 1.41	0.06
Pittsburgh	7.80 ± 3.30	8.50 ± 2.90	0.30

p was obtained using the Wilcoxon rank-sum test.

Table 3. Perceived stress levels in the study population.

Group /PSS-14	Pre-intervention	Post-intervention	*p*
Forest			0.25
1. Almost never stressed	1 (12.50)	1 (12.50)	
2. Occasionally stressed	6 (75.00)	7 (87.50)	
3. Often stressed	1 (12.50)	-	
Parks			0.42
1. Almost never stressed	-	1 (11.11)	
2. Occasionally stressed	7 (77.78)	7 (77.78)	
3. Often stressed	2 (22.22)	1 (11.11)	
Control			0.14
1. Almost never stressed	-	11 (12.50)	
2. Occasionally stressed	5 (62.50)	3 (37.50)	
3. Often stressed	3 (37.50)	4 (50.00)	

p was obtained using the Fisher exact test

The State-Trait Anxiety Inventory (STAI) was observed in all three-study groups and showed similar levels of state and trait anxiety at the beginning and end of the intervention. Regarding the Pittsburgh Sleep Quality Index, no changes were observed in the percentage of individuals reporting good sleep quality in the control group. In the intervention groups, both in the urban forests and metropolitan parks, an increase in the number of individuals with improved sleep quality was observed, with a delta of 25 and 11.11, respectively. However, no statistically significant differences were found (**Table 4**).

Table 4. Yoshitake and Pittsburgh scales scores in the study groups.

Group / Scale	Pre-intervention	Post-intervention	Delta	*p*
Forest				
Yoshitake-Physic	1.75 ± 2.71	1.50 ± 2.07	0.25	0.52[a]
Yoshitake-General	3.00 ± 2.78	2.13 ± 1.96	0.88	0.13[a]
Yoshitake-Mental	1.75 ± 1.98	1.38 ± 2.00	0.38	0.28[a]
Pittsburgh	25.00%	50.00%	25.00	0.43[b]
Parks				
Yoshitake- Physic	1.22 ± 1.48	0.89 ± 1.27	0.33	0.08[a]
Yoshitake-General	2.00 ± 2.65	1.89 ± 2.52	0.11	0.85[a]
Yoshitake-Mental	2.00 ± 2.06	1.89 ± 2.15	0.11	0.82[a]
Pittsburgh	33.33%	44.44%	11.11	0.52[b]
Control				
Yoshitake- Physic	2.38 ± 1.41	1.25 ± 1.04	1.13	0.01[a]
Yoshitake-General	4.63 ± 2.92	3.00 ± 2.51	1.63	0.06[a]
Yoshitake-Mental	3.25 ± 1.67	3.00 ± 2.14	0.25	0.78[a]
Pittsburgh	12.50%	12.50%	0.00	0.13[b]

p values were obtained by [a]Paired t-test and [b]Fisher exact test.

Finally, salivary cortisol levels were measured across all groups. In the control group, the mean cortisol level at baseline was 6.5 ng/mL, with an increase of 0.4 ng/mL observed after the intervention (**Figure 2**). In the

metropolitan parks group, the baseline cortisol level averaged 10.7 ng/mL, followed by a reduction of 2.6 ng/mL post-intervention. Similarly, in the forests group, the initial cortisol level averaged 4.3 ng/mL, with a subsequent decrease of 2.7 ng/mL after the intervention.

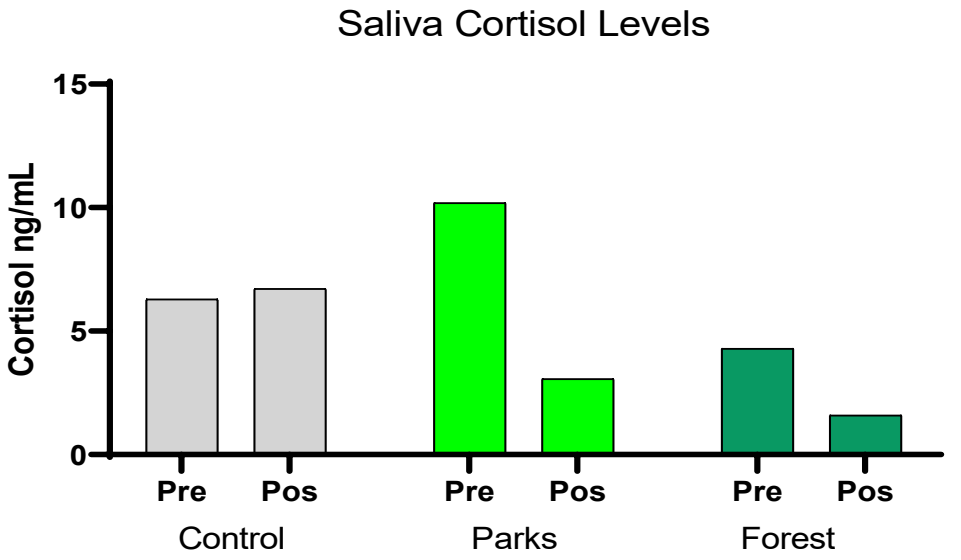

Figure 2. Salivary Cortisol Levels changes among the intervention and control group

Discussion

In this study, it was found that nature immersion therapy had positive effects on reducing perceived stress and cortisol levels in healthcare workers. These results suggest that exposure to natural environments may contribute to improve the mental and physiological health of the working population. A significant decrease in general fatigue was observed in the parks group after nature immersion therapy. However, both the control group and the urban forests intervention group did not show significant changes in the parameters of this biomarker. Regarding the STAI questionnaire, elevated levels of anxiety were found in all study groups, with no significant changes observed before and after the intervention [12,13]. In contrast to our results, a study conducted by Chen et al. [14] in a population of middle-aged women in Taiwan found a significant decrease in this anxiety scale ($p<0.01$) after the intervention, which took place in the National Forest Recreation Area, with a duration of two days and an intensity of 2.5 hours/day.

Numerous studies have reported the positive effects of nature immersion on reducing symptoms of stress, anxiety, depression, anger, and fatigue [15–21]thereby decreasing cortisol levels and work-related stress. This study showed that forest bathing therapy can reduce mental fatigue. In the Pittsburgh Sleep Quality Index, it was found that participants in the control group maintained a moderate sleep quality throughout the study. On the other hand, the intervention groups in metropolitan parks and urban forests experienced an improvement in sleep quality, although they remained at a moderate level overall. These results are consistent with other studies that have evaluated the effects of nature immersion therapies on healthcare workers. For example, a study in Korea found that forest therapy was associated with a significant decrease in stress levels and an improvement in sleep quality, as well as relief from insomnia, reduction in daytime sleepiness, and decrease in depression, anxiety, and somatic symptoms [22].

In 1988, the North American Nursing Diagnosis Association (NANDA) introduced occupational fatigue as a nursing diagnosis, defining it as a "sustained and overwhelming feeling of exhaustion with a decreased capacity for usual mental and physical work". The condition is described as having a multi-causal nature (intra, inter, and extra-organizational factors) and directly impacting physiological and psychological well-being. Systematic

reviews and meta-analyses have shown a high prevalence of symptoms related to trauma and stress among healthcare workers, with women, nurses, and frontline workers being the most affected by occupational stress and fatigue. A 2022 systematic review highlighted that over 70% of healthcare professionals in Latin America experience occupational fatigue, reporting symptoms such as physical and mental fatigue, muscle pain, and weight imbalance. Factors like multiple jobs, sleep deprivation, and excessive workload significantly contribute to this issue, which is influenced by individual, interpersonal, and organizational factors, indicating a high psychosocial risk in the healthcare sector [23–25].

Occupational stress is one of the main predisposing factors of fatigue in healthcare personnel. Some studies indicate that healthcare workers have higher rates of substance abuse and suicide compared to other workers. Additionally, high rates of depression and anxiety have been found in this group (DHHS (NIOSH) Publication No. 2008-136). According to data from the Colombian Federation of Insurers (Fasecolda) in 2021, 1,249 cases of occupational diseases linked to mental health were reported, with women accounting for 62% of the cases [26]. In a study by Castillo et al. [27], occupational stress was evaluated in healthcare workers, and a high stress level of 33.97% was found.

In the quantification of cortisol, it was found that participants in the control group maintained stable cortisol levels throughout the study, indicating an absence of significant changes in the physiological stress response. In contrast, the intervention groups experienced a decrease in cortisol levels after nature immersion therapy. These results support the idea that nature immersion therapy can have a positive impact on regulating cortisol levels, indicating a decrease in the physiological stress response. These findings align with previous studies that have reported a reduction in cortisol concentrations in natural environments compared to urban environments [28,29]. Although various research studies have evaluated the effect of nature immersion therapies on psychological scales measuring stress and anxiety levels, as well as physiological parameters including cortisol concentration, a direct comparison of our results has not been possible due to a significant discrepancy in the study design approach. Typically, the control group in most studies undergoes an intervention in an indoor or urban area [29,30], the study populations are diagnosed with some form of illness [31–33], and the studies include student populations [34,35], the latter being one of the exclusion criteria in our study.

This study has numerous limitations. Firstly, the sample size is small, which means that the results are only representative of the specific population of the pilot study and cannot be generalized to other groups of workers. Additionally, since the participants had to go back to work immediately after the sessions, encountering significant traffic on their commute and were exposed to multiple stressful situations during their workday, these may have influenced the results. It was not possible to control whether participants had other nature contact experiences during the study, which could have affected the results as well. The neuropsychological tests used, although validated in Colombian and Latin American populations, may not be sensitive enough to detect changes in such short periods of time as those evaluated in this study (as in PSS-14 where frequency is used rather than intensity). The salivary cortisol test was conducted on an extremely limited group, limiting the generalizability of the results. These limitations highlight the need for future research with larger sample sizes and longitudinal designs to obtain more robust and broadly applicable results.

In summary, this study suggests that nature immersion therapy may have beneficial effects on reducing cortisol levels, perceived stress, and improving sleep quality in healthcare workers. These findings highlight the value of nature-based interventions as a promising strategy for occupational health care. Moreover, their applicability extends beyond the context of daily practice and can be integrated into occupational wellness management programs and serve as a basis for new lines of occupational health research. However, further studies with larger samples and longitudinal designs are needed to confirm and extend these findings. Incorporating these interventions into health policy could contribute to the development of healthier and more resilient work environments, which would benefit both future research and the effective management of employee health.

Contributions of Authors

N.N.V: conceptualization, methodology, formal analysis, writing—original draft preparation, writing—review and editing, approval the final version of the manuscript.
D.M.P: conceptualization, methodology, formal analysis, writing—original draft preparation, writing—review and editing and approval the definitive version of the manuscript.
Y.TP: conceptualization, formal analysis, writing—original draft preparation and approval the final version of the manuscript.
R.L: conceptualization, methodology, writing—review and editing and approval the final version of the manuscript.
A.PL: conceptualization, methodology, writing—review and editing, approval the final version of the manuscript.
V.R: methodology, writing—review and editing and approval the final version of the manuscript.
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L.Z: methodology, writing—review and editing and approval the final version of the manuscript.
M.P: methodology, writing—review and editing and approval the final version of the manuscript.
E.M.T: methodology, writing—review and editing and approval the final version of the manuscript.
J.MR: conceptualization, methodology, writing—review and editing, supervision, project administration and approval the final version of the manuscript.

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Ethical considerations

Ethics declaration: This study was approved by the Ethics and Technical Committee of the National Institute of Health (Code number: 21–2021).

Declaration of Conflicts of Interest

The authors of this article declare that they have no conflicts of interest related to the research presented.

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