RBTCC
e-ISSN: 1982-3541
Revista Brasileira de Terapia Comportamental e Cognitiva
ABPMC
ASSOCIAÇÃO BRASILEIRA DE CIÊNCIAS DO COMPORTAMENTO

Efeitos da terapia florestal nas funções cognitivas e executivas: uma revisão sistemática sob uma perspectiva comportamental e cognitiva

Effects of forest therapy on cognitive and executive functions: a systematic review from a behavioral and cognitive perspective

Efectos de la terapia de bosque en las funciones cognitivas y ejecutivas: una revisión sistemática desde una perspectiva conductual y cognitiva

RESUMO: Introdução: A terapia de floresta tem sido proposta como uma intervenção não farmacológica com potencial impacto sobre processos cognitivos, particularmente atenção e funções executivas. Objetivo: Sintetizar sistematicamente a evidência disponível sobre os efeitos cognitivos da terapia de floresta em adultos cognitivamente saudáveis. Métodos: Foi realizada uma revisão sistemática seguindo as diretrizes PRISMA. Estudos experimentais que avaliaram desfechos cognitivos objetivos após intervenções de terapia de floresta foram incluídos. Resultados: Os estudos incluídos indicam tendências positivas preliminares no desempenho atencional, relaxamento autonômico e estados psicológicos/afetivos. A evidência sobre velocidade de processamento e flexibilidade executiva permanece escassa e não significativa, limitada pelo alto risco de viés e heterogeneidade. Conclusão: A terapia florestal oferece evidência preliminar e de baixa certeza para a recuperação atencional e regulação emocional em estruturas cognitivo-comportamentais. Os achados são geradores de hipóteses e requerem validação por meio de ensaios randomizados rigorosos.

Palavras-chave: Atenção; Funções executivas; Intervenções não farmacológicas; Saúde cognitiva; Terapia de floresta.

ABSTRACT: Background: Forest therapy has been proposed as a non-pharmacological intervention with potential benefits for cognitive functioning, particularly attentional and executive processes. Objective: To systematically synthesize the available evidence on the cognitive effects of forest therapy in cognitively healthy adults. Methods: A systematic review was conducted following PRISMA guidelines. Experimental studies assessing objective cognitive outcomes after forest therapy interventions were included. Results: Nine studies were included. Preliminary positive trends were observed in attentional performance, autonomic relaxation, and psychological/affective states. Evidence regarding processing speed and executive flexibility remains sparse and non-significant. Findings were constrained by high risk of bias, small samples, and heterogeneity. Conclusion: Forest therapy provides preliminary, low-certainty evidence for attentional recovery and emotional regulation within cognitive-behavioral frameworks. Current findings are hypothesis-generating and require confirmation through rigorous, pre-registered randomized trials.

Felipe Jerez-Salas [1,2]
Valentina Luksic-Cataldo [1,3]
Cristal Pavez-Álvarez [4]

[1] University of the Americas, Chile
[2] Universidad Andres Bello, Chile
[3] Universidad Mayor, Chile
[4] Universidad Católica Silva Henriquez, Chile

Correspondente
* felipe.jerez.salas@edu.udla.cl

Dados do Artigo
DOI: 10.31505/rbtcc.v28i1.2294
Recebido: 20 de Fevereiro de 2026
1ª Decisão: 24 de Setembro de 2026
Aprovado: 01 de Outubro de 2026
Publicado: 10 de Outubro de 2026
Editor-Chefe: Dr. Fábio Henrique Baia
Editor Adjunto: Prof. Dr. Angelo A. S. Sampaio
Editora Associado: Willian de Sousa Rodrigues
Estagiária: Bruna Navratilova

Como citar este documento
Jerez-Salas, F., Luksic-Cataldo, V. & Pavez-Álvarez, C. (2026). Efeitos da terapia florestal nas funções cognitivas e executivas: uma revisão sistemática sob uma perspectiva comportamental e cognitiva. *Revista Brasileira de Terapia Comportamental e Cognitiva,* 28, 277-297. https://doi.org/10.31505/rbtcc.v28i1.2294

CC BY OPEN ACCESS
É permitida a distribuição, remixe, adaptação e criação a partir deste trabalho, mesmo para fins comerciais, desde que lhe atribuam o devido crédito pela criação original.

Keywords: Attention; Cognitive health; Executive functions; Forest therapy; Non-pharmacological interventions.

RESUMEN: Introducción: La terapia de bosque ha emergido como una intervención no farmacológica con potencial impacto sobre la cognición, especialmente en procesos atencionales y funciones ejecutivas. Objetivo: Sintetizar sistemáticamente la evidencia disponible sobre los efectos cognitivos de la terapia de bosque en adultos cognitivamente sanos. Métodos: Se realizó una revisión sistemática conforme a las directrices PRISMA, incluyendo estudios experimentales que evaluaron resultados cognitivos objetivos tras intervenciones de terapia de bosque. Resultados: Se incluyeron nueve estudios. Se observaron tendencias positivas preliminares en atención, relajación autonómica y estados psicológicos/afectivos. La evidencia sobre velocidad de procesamiento y flexibilidad ejecutiva sigue siendo escasa y no significativa, limitada por un alto riesgo de sesgo y heterogeneidad. Conclusión: La terapia de bosque ofrece evidencia preliminar de baja certeza para la recuperación atencional y regulación emocional en marcos cognitivo-conductuales. Los hallazgos son generadores de hipótesis y requieren validación mediante ensayos aleatorizados rigurosos.

Palabras clave: Atención; Funciones ejecutivas; Intervenciones no farmacológicas; Salud cognitiva; Terapia de bosque.

Subjective cognitive fatigue and mental overload represent issues of growing relevance among healthy working-age adults (Salari et al., 2025), arising largely from environmental, occupational, and psychosocial stressors associated with modern urban living (Song et al., 2024). Among healthy individuals, prolonged exposure to highly demanding environments characterized by sensory overload and constant multitasking can deplete attentional resources, leading to temporary declines in executive control and functional performance (Fan et al., 2025; Shibaoka et al., 2023). From a preventive and health-promotion perspective, non-pharmacological interventions targeting these early functional fluctuations may contribute to maintaining cognitive efficiency and supporting psychological well-being (Cieza et al., 2020; Gustavson et al., 2025).

The adult population between 18 and 60 years of age constitutes a group of particular interest for the study of cognition, as this period of the life course is characterized by relative neurocognitive stability (Breit et al., 2024), coexisting with high exposure to work-related, social, and environmental stressors (Van Der Molen et al., 2020). In contrast to older adulthood, where cognitive decline associated with aging and neurodegenerative processes plays a central role (Gonzales et al., 2022), the cognitive alterations observed in early and middle adulthood tend to be closely related to states of stress, mental overload, and subclinical psychological distress (Zhu et al., 2022). Evidence suggests that these factors significantly impact cognitive domains that are fundamental for decision-making, emotional regulation, and adaptive functioning (Girotti et al., 2024; Koay & Van Meter, 2023). From a neurobiological perspective, chronic exposure to stress is associated with persistent activation of the hypothalamic pituitary adrenal axis (Lei et al., 2025), as well as functional modifications in brain networks involved in cognitive control and emotional regulation (Chen et al., 2025). In this regard, cognition and mental health should be understood as interdependent dimensions, in which emotional disturbances modulate cognitive performance without necessarily implying structural deterioration (Zhu & Leng, 2025). Although these alterations do not constitute formal cognitive impairment, they are associated with decreased work productivity, impaired decision-making, and reduced adaptive capacity in daily activities (Chui et al., 2024). From a preventive and rehabilitative perspective, interventions targeting these early

functional changes may contribute to maintaining cognitive efficiency and preventing future decline (Gustavson et al., 2025). In this context, the study of non-pharmacological strategies capable of modulating cognitive performance and psychophysiological regulation in healthy adults aligns with the broader goals of rehabilitation, including prevention, health promotion, and functional optimization (Cieza et al., 2020).

In this context, growing interest has emerged in nature-based interventions as potential strategies to promote cognitive restoration and psychological well-being (Fu et al., 2025). Among these, forest therapy, also known as *Shinrin-Yoku* or "forest bathing," has gained relevance in recent decades (Szitás et al., 2024). This practice, originating in Japan, is defined as a conscious and multisensory immersion in forest environments, with the aim of fostering states of relaxation and connection with the natural environment, without intense physical activity constituting its primary component (Hansen et al., 2017). Conceptually, forest therapy is grounded in theoretical frameworks such as Attention Restoration Theory and Stress Reduction Theory (Oh et al., 2017), which posit that natural environments possess restorative properties capable of facilitating the recovery of attentional resources and reducing the psychophysiological load associated with stress (Kuo, 2015). Therefore, it is proposed as a therapeutic intervention with physiological, cognitive, and health-related implications (Sung et al., 2011).

From a cognitive-behavioral perspective, cognitive control and affective regulation are closely interdependent processes (Schulze et al., 2026). Subclinical anxiety and mental fatigue may increase cognitive demands and interfere with executive resources, thereby compromising top-down attentional control (Nguyen et al., 2025). Assessing psychological/affective and emotional states alongside objective cognitive performance may provide a more comprehensive assessment of attentional restoration, capturing both the subjective experience of restoration and changes in cognitive functioning (Bolouki, 2022).

Although previous systematic reviews have synthesized the health benefits of nature exposure (Stier-Jarmer et al., 2021; Wen et al., 2019), they relied predominantly on self-reported questionnaires and mixed clinical with non-clinical populations. A gap remains regarding how forest therapy specifically modulates objective performance-based neurocognitive tasks and neurophysiological parameters in healthy adults. At the neurophysiological level, Wen et al. (2019) further reports that this intervention significantly increases alpha and high beta brain wave activity, which is associated with relaxation, attentional processes, and problem-solving. Likewise, regarding stress-related hormonal regulation and cognitive processes, Antonelli et al. (2019) propose that forest therapy contributes to reductions in salivary and serum cortisol levels, thereby mitigating the toxic effects of chronic stress on structures such as the hippocampus, which is vital for memory.

Nevertheless, the available literature shows considerable heterogeneity in terms of populations, methodological designs, intervention protocols, and outcome measures. Considering that approximately 25% of systematic reviews and meta-analyses become outdated within two years, and nearly half within five years, it is necessary to periodically update this evidence (Shojania et al., 2007). In this context, the primary objective of the present systematic review was to systematically synthesize and critically examine the evidence regarding the effects of forest therapy on objective neurocognitive and executive function outcomes in healthy adult populations. Secondarily, this review aimed to evaluate associated neurophysiological and psychological/affective responses to offer a

comprehensive, multidimensional perspective on cognitive restoration and emotional regulation, thereby informing clinical practice and future research.

Materials and methods

Study Design

The review protocol was developed in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines. The study was registered in the PROSPERO international systematic review registry, with the registration number CRD420251275609. No major deviations from the original protocol occurred during the review process.

Eligibility Criteria

Inclusion Criteria. Population (P): Cognitively healthy adults aged 18 to 60 years without a formal diagnosis of neurological, psychiatric, or neurodegenerative disorders. Participants experiencing subclinical levels of stress, mental fatigue, or mild psychological distress were considered eligible, as these states reflect normative, non-clinical psychological responses to daily environmental demands in healthy populations rather than formal clinical impairments. Intervention (I): Eligible interventions included forest therapy-based approaches, such as *Shinrin-yoku*, forest bathing, or other structured nature-based interventions conducted in forest or wooded environments, regardless of duration or frequency. Comparison (C): No restrictions were applied regarding the presence or type of comparator; studies with active control groups, passive control groups, or pre–post designs without a control group were considered. Outcome (O): The review included studies reporting cognitive outcomes as a primary or secondary measure, assessed through behavioral, neuropsychological, neurocognitive, or neurophysiological methods (e.g., cognitive tasks, standardized tests, EEG-based measures), encompassing domains such as attention, executive functions, working memory, cognitive flexibility, or mental fatigue. Study Design (S): Regarding study design, randomized controlled trials (RCTs) and non-randomized controlled or quasi-experimental studies were eligible for inclusion. Both acute (single session) and longitudinal interventions were considered, provided that the study reported objective cognitive outcomes assessed either pre- and post-intervention or post-intervention only.

Exclusion Criteria. Studies were excluded if they involved children, adolescents, or adults over 60 years of age, as well as participants with diagnosed neurological disorders, psychiatric conditions, chronic pain syndromes (e.g., fibromyalgia), cognitive impairment, or neurodegenerative diseases. Studies that did not report any direct or indirect cognitive outcomes were not considered. Interventions in which forest therapy was implemented as part of a multi-component program without the possibility of isolating its effects were also excluded. Further exclusion criteria included cross-sectional studies, case reports, qualitative studies, conference abstracts, and narrative or systematic reviews.

Search Strategy and Selection Process

The systematic search across PubMed, Web of Science, Scopus, and CINAHL Complete was conducted between December 30, 2025, and January 30, 2026. Detailed search strings for each database are provided in Supplementary Material S2. No limits regarding publication date, sex, or language were applied.

Study selection was executed in two sequential stages: (1) title and abstract screening, and (2) full-text eligibility assessment. Both stages were performed independently by two reviewers (F.J.S. and V.L.C). Discrepancies or disagreements

at either stage were resolved through consensus or, when necessary, by consulting a third reviewer (C.P.A.).

Data Extraction and Management

Essential data from each included study were systematically extracted and summarized in structured tables to support qualitative and narrative synthesis (Rai et al., 2020). Extracted information included authorship, year of publication, study design, sample size, group allocation, demographic characteristics (mean age, age range, and sex distribution), and the criteria used to define cognitively healthy adult populations. Intervention characteristics were documented, including setting, total duration, session frequency and length, and comparator conditions. In line with the focus of this review, extracted outcomes encompassed behavioral, neuropsychological, neurocognitive, and neurophysiological measures, such as attention and executive function tasks, EEG-based indicators, and other objective measures of cognitive processing. Data extraction was conducted independently by two reviewers (F.J.S. and V.L.C.), with discrepancies resolved by a third reviewer (C.P.A.). When essential information was missing, corresponding authors were contacted following established protocols (Butler et al., 2016); studies were retained for qualitative synthesis if core eligibility criteria were met.

Risk-of-Bias of the Studies

The risk of bias of the included studies was independently assessed by two reviewers (V.L.C. and C.P.A.). Randomized controlled trials (RCTs) were evaluated using the revised Cochrane Risk of Bias tool (RoB 2), which assesses bias across five domains: bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each domain, as well as the overall risk of bias, was classified as "low risk", "some concerns", or "high risk" (Sterne et al., 2019). Non-randomized controlled trials (n-RCTs) were assessed using the Risk Of Bias In Non-randomized Studies of Interventions tool (ROBINS-I). This tool evaluates bias across seven domains, including confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported results. Based on these domains, studies were categorized as presenting "low", "moderate", "serious", or "critical" risk of bias (Sterne et al., 2016). A third reviewer was consulted to arbitrate any discrepancies between reviewers (F.J.S.). The risk of bias assessments were considered in the interpretation of the findings and informed the qualitative synthesis of the evidence. The certainty of the body of evidence was not formally graded (e.g., using GRADE), as the purpose of this review was to provide a structured synthesis of current evidence and to identify research gaps, rather than to issue clinical recommendations (Kolaski et al., 2023).

Data analysis

Data analysis was conducted using a structured qualitative and narrative synthesis approach, following the recommendations for systematic reviews where quantitative pooling is not deemed appropriate (Page et al., 2021). Given the heterogeneity across studies in terms of study design, participant characteristics, forest therapy protocols, cognitive domains assessed, and measurement instruments, a meta-analysis was not undertaken (Vasilopoulos et al., 2023). Instead, findings were synthesized by systematically grouping studies according to key analytical dimensions, including executive function domains (working memory, inhibitory control, cognitive flexibility), characteristics of the forest session

(modality, intensity, and duration), and study design (randomized vs. non-randomized). For each study, the direction, magnitude, and consistency of cognitive effects were descriptively summarized. Greater interpretative weight was given to results derived from studies with a lower risk of bias and clearer methodological reporting. Patterns and discrepancies across studies were examined to identify potential sources of variability, and the overall strength of the evidence was interpreted in light of methodological quality and consistency of findings across cognitive domains.

Results

For clarity and methodological consistency, outcomes were classified into three predefined domains: (1) neurocognitive outcomes, defined as objective, performance-based measures of cognitive processing (e.g., working memory and accuracy tasks) (Zorowitz & Niv, 2023); (2) neurophysiological outcomes, encompassing electrophysiological (EEG) and autonomic biological indicators (Fernández-Rubio et al., 2025); and (3) psychological/affective outcomes, referring to self-reported mental and emotional states measured via validated instruments (Webster-Cordero & Giménez-Llort, 2025).

Study selection

The literature search across the selected databases identified a total of 6,381 records. After the removal of duplicate entries, titles and abstracts were screened based on the predefined eligibility criteria. Studies deemed potentially relevant were subsequently retrieved and assessed in full text. A total of nine studies met all inclusion criteria and were included in the qualitative synthesis. The identification of only nine eligible studies highlights the current scarcity of primary research utilizing objective cognitive metrics in this field. Selection procedures were detailed in Figure 1. Selected studies are presented in Table 1.

Figure 1. PRISMA flow diagram.

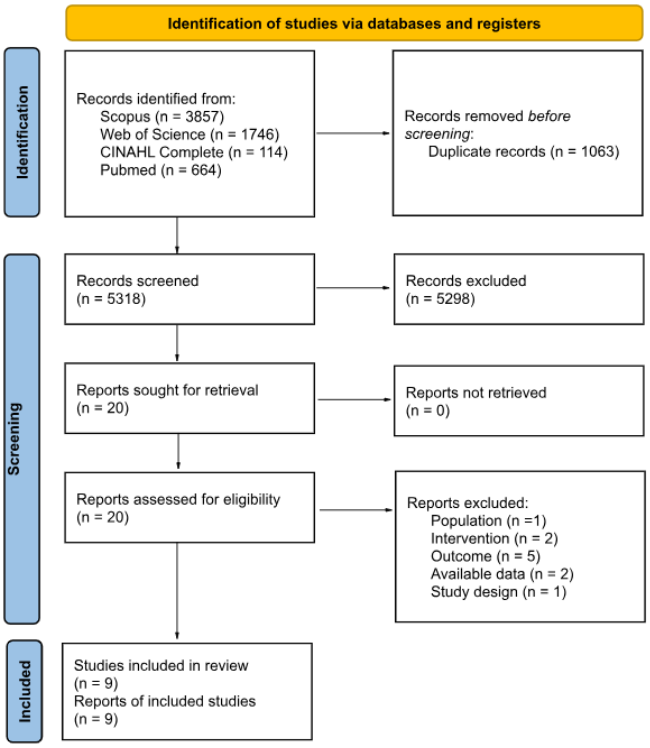


Table 1. *Sample characteristics*

Reference	Study design	n	Age	Sex (M/F)	Healthy condition criteria
Bayrakdar and Güneş (2025)	n-RCT	32; EX: 16; CG: 16	EX: 21.25 ± 1.61; CG: 22.00 ± 1.54	Not reported.	Students with a sedentary lifestyle; no reported physical or mental illnesses.
Bielinis et al. (2019)	RCT	32; EX: 16; CG: 16	20.97 ± 0.65	M: 0; F: 32	Healthy and fit; no use of medication, alcohol, or tobacco.
Hassan et al. (2018)	RCT	60; A:30; B: 30	19.6 ± 1.42	M: 30; F: 30	University students; no physical or mental illness; no history of drug/alcohol/tobacco use.
Nam et al. (2025)	RCT	30	51.2 ± 3.20	M: 0; F: 30	Healthy urban dwellers; no physical or mental disorders; no medication; no physical disabilities.
Ochiai et al. (2015)	n-RCT	9	56.0 ± 13.0	M: 9; F: 0	Middle-aged males with high-normal blood pressure; no medication for chronic conditions.
Bielinis et al. (2018)	RCT	62	21.45 ± 0.18	M: 36; F: 26.	University students; no history of physical or psychiatric disorders; no obesity or metabolic syndrome.
Chen et al. (2018)	n-RCT	16	46.88 ± 7.83	M: 0; F: 16	Middle-aged women in good physical condition; capable of walking for 2 hours.
Song et al. (2018)	RCT	624	21.7 ± 1.6	M: 624; F: 0	University students; no history of physical or psychiatric disorders.
Song et al. (2019)	RCT	60	21.0 ± 1.3	M: 0; F: 60	University students; no history of physical or psychiatric disorders.

CG = Control group; EX = experimental group; F = female; M = male; n-RCT = non randomized controlled; RCT = randomized controlled trial

Study characteristics

Interventions primarily involved forest therapy or nature-based exposure, including forest walking, passive viewing of forest landscapes, and structured forest therapy programs, with urban environments or usual daily activities serving as control conditions. Protocols ranged from single-session exposures (n = 3) to short-term interventions lasting up to 8 weeks (n = 1), with session durations between 15 minutes (n = 5) and several hours (n = 2). Most interventions were delivered at low to moderate intensity (n = 8), and adherence was generally high. Neurocognitive and neurophysiological outcomes were assessed using task-based paradigms and EEG-derived indicators, including measures of attentional performance and alpha, beta, and gamma wave activity (n = 2). Psychological/affective outcomes were evaluated using validated self-report instruments assessing mood, mental fatigue, anxiety, psychological restoration, and vitality, most commonly the POMS, STAI, PANAS, ROS, and SVS (n = 6). Psychophysiological outcomes, when included, focused on stress-related biological markers such as salivary cortisol and heart rate variability (n = 2). Overall, forest-based interventions were consistently associated with improvements in attentional processes, reductions in mental fatigue and negative mood states, and favorable modulation of stress related physiological responses compared with control conditions. Intervention characteristics and outcome measures are presented in Table 2.

Risk-of-Bias of the Studies

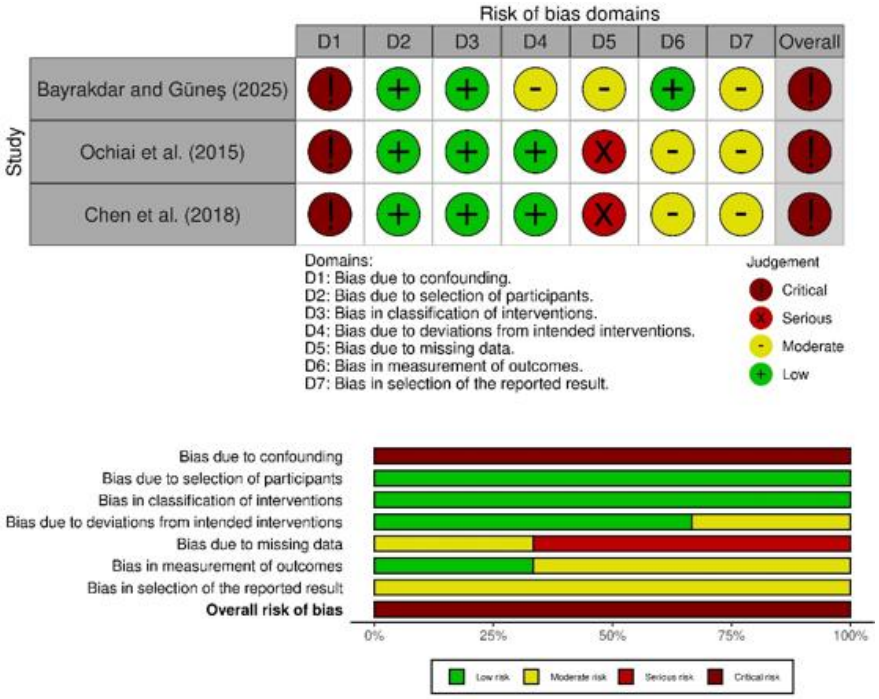
The risk of bias for randomized controlled trials (n = 6) was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool. As shown in Figure 2, two studies were judged to have a low risk of bias arising from the randomization process (domain 1). Deviations from intended interventions and missing outcome data (domains 2 and 3) were generally well reported, with most studies presenting a low risk of bias. Regarding outcome measurement (domain 4), most studies were rated as having a high risk of bias, and only one study was judged to have a low risk. All studies presented some concerns related to the selection of the reported results (domain 5). Overall, five of the six RCTs were classified as having a high risk of bias, while one study was rated as presenting some concerns.

Figure 2. Risk of bias for randomized controlled trial studies.



For non-randomized studies (n = 3), the ROBINS-I tool was applied to assess potential sources of bias across seven domains. As shown in Figure 3, all studies were judged to have an overall critical risk of bias, primarily due to confounding (domain 1). In contrast, the domains related to selection of participants (domain 2) and classification of interventions (domain 3) were rated as having a low risk of bias. Only the study by Bayrakdar and Güneş (2025) was rated as having a low risk of bias for deviations from intended interventions (domain 4). Two of the three studies showed a serious risk of bias due to missing data (domain 5). Overall, bias in measurement of outcomes (domain 6) and in the selection of the reported results (domain 7) was rated as moderate.

Figure 3. Risk of bias for non-randomized controlled trial studies.



Discussion

The interpretation of the findings of this systematic review must be approached with considerable caution, taking into account both the substantial heterogeneity observed across intervention protocols (in terms of modality, duration, and intensity) and, critically, the high or critical risk of bias identified across the majority of included primary studies. Consequently, the observed cognitive and psychophysiological effects should be regarded as preliminary and hypothesis-generating rather than confirmatory.

Neurocognitive effects

The neurocognitive component focuses on evaluating behavioral task performance and attentional execution through objective behavioral paradigms (Zorowitz & Niv, 2023).

Within this domain, primary studies provide preliminary evidence regarding working memory and sustained attention. Specifically, a non-randomized study reported improvements in visual working memory capacity, accuracy, and overall performance following an 8-week nature walking program (Bayrakdar & Güneş, 2025).

Similarly, acute exposure during a bamboo forest walk demonstrated elevated attention scores (Hassan et al., 2018). However, these behavioral findings must be interpreted with substantial caution: the study by Bayrakdar and Güneş (2025) was evaluated as carrying a critical risk of bias under ROBINS-I due to non-randomized participant self-selection, while Hassan et al. (2018) presented methodological concerns regarding allocation concealment and outcome measurement under RoB 2.

These initial observations align conceptually with previous systematic reviews (Stier-Jarmer et al., 2021; Wen et al., 2019) suggesting that exposure to natural environments may reduce mental fatigue and subjective cognitive load. From the perspective of Attention Restoration Theory, optimization of attentional task performance is hypothesized to reflect the recovery of directed attention, allowing prefrontal networks to recover from exhaustion caused by continuous exposure to demanding urban stimuli (Bayrakdar & Güneş, 2025; Bielinis et al., 2019; Hassan et al., 2018). Nevertheless, given the methodological limitations of the primary literature, these underlying mechanisms remain speculative hypotheses that require validation through well-controlled, randomized trials.

With respect to processing speed, evidence remains sparse. Evaluated exclusively in the study by Bayrakdar and Güneş (2025), reaction times showed a slight trend toward improvement that did not achieve statistical significance. As noted by Stier-Jarmer et al. (2021), subtle shifts in processing speed or task accuracy following nature exposure may not necessarily signify a direct enhancement of intrinsic cognitive capacity, but rather an indirect benefit resulting from attenuated environmental sensory noise, which temporarily facilitates cognitive performance.

Neurophysiological effects

Neurophysiological outcomes encompass objective, physical instrument-based measurements of biological, autonomic, and electrical nervous system activity (Fernández-Rubio et al., 2025).

Overall, preliminary observations within this domain align conceptually with previous systematic reviews (Wen et al., 2019). At the electrophysiological level, initial findings suggest that immersive forest therapy may modulate brainwave patterns, showing increases in alpha wave activity (associated with relaxed wakefulness), beta wave activity (linked to attentional alertness), and gamma wave activity (related to higher-order cognitive processing) (Hassan et al., 2018; Nam et al., 2025). Furthermore, preliminary observations suggest subtle shifts toward enhanced prefrontal cortex activation and electrical signal stability relative to urban baseline exposures (Nam et al., 2025). However, these neurophysiological metrics must be interpreted with caution, as field-based EEG recording remains susceptible to environmental artifacts, and the small sample sizes across primary studies limit generalizability.

Regarding autonomic nervous system regulation, several studies reported a trend toward increased parasympathetic activity—indexed by heart rate variability (HRV) parameters—accompanied by a concomitant attenuation of sympathetic drive (Bielinis et al., 2018; Chen et al., 2018; Song et al., 2018). While these autonomic shifts suggest a state of acute physiological relaxation, the overall evidence remains constrained by methodological heterogeneity in exposure protocols and potential carryover effects in cross-over designs.

Finally, regarding stress-related endocrine biomarkers, analyzed studies documented reductions in serum and salivary cortisol levels, alongside non-significant decreasing trends in

salivary alpha-amylase (Ochiai et al., 2015). Although these hormonal shifts are often interpreted as a deactivation of the hypothalamic-pituitary-adrenal (HPA) axis, as noted by Antonelli et al. (2019), such endocrine changes may be partially mediated by an "anticipatory placebo effect", wherein stress reduction is driven by psychological expectations associated with scheduled recreational nature activities rather than the natural environment alone. Given the high or critical risk of bias across primary trials, these neurophysiological mechanisms should be regarded as preliminary hypotheses requiring confirmation in rigorously blinded, controlled designs.

Psychological and affective effects

Psychological/affective variables consist of validated self-report scales that assess conscious perceptions of affective and mental states, serving as secondary outcomes to contextualize overall neuropsychological functioning (Webster-Cordero & Giménez-Llort, 2025).

The primary psychological/affective outcomes across included studies were evaluated using the Profile of Mood States (POMS). Consistent with observations from previous systematic reviews (Antonelli et al., 2019; Stier-Jarmer et al., 2021; Wen et al., 2019), primary studies reported preliminary reductions in perceived negative affective states—specifically confusion or mental noise, fatigue, tension–anxiety, anger, and depressive symptoms (Ochiai et al., 2015; Song et al., 2019)—alongside reported increases in perceived vigor and energy (Bielinis et al., 2018; Song et al., 2018). However, because participants in nature-based field trials cannot be blinded to their environmental setting, these self-reported affective improvements must be interpreted with caution, as they are inherently vulnerable to expectation bias and social desirability.

Regarding anxiety, evaluated primarily via the State-Trait Anxiety Inventory (STAI), studies observed reductions in acute state anxiety levels following forest exposures (Chen et al., 2018; Hassan et al., 2018; Song et al., 2018). Notably, exploratory analyses suggest that these reductions may be moderated by baseline individual differences, with participants exhibiting higher trait anxiety deriving a relatively greater subjective benefit (Song et al., 2018).

Perceived restoration and subjective vitality were assessed using the Restorative Outcome Scale (ROS) and the Subjective Vitality Scale (SVS). Participants reported enhanced clarity of thought, alertness, and vitality following forest exposure, even during winter interventions in environments with snow cover or leafless deciduous stands (Bielinis et al., 2018; Bielinis et al., 2019). From a cognitive-behavioral perspective, these psychological/affective outcomes (framed here as secondary indicators) highlight how emotional de-escalation and subjective restorative experiences may act as synergistic, modulating pathways that support attentional recovery, even if the primary evidence remains exploratory due to methodological limitations in allocation concealment and blinding.

Strength and limitation for futures research

The primary strength of this systematic review lies in its integrative, multidimensional approach, synthesizing neurocognitive, neurophysiological, and psychological/affective evidence to provide a holistic framework of forest therapy's potential impact on adult cognitive functioning. Furthermore, by categorizing outcomes into objective performance-based metrics, physiological markers, and secondary self-reported states, this review offers a structured perspective aligned with contemporary cognitive-behavioral paradigms.

Nevertheless, several substantial limitations

must be acknowledged when interpreting these findings. Foremost among these is the methodological quality of the primary literature; a significant proportion of included studies exhibited a high or critical risk of bias under Cochrane RoB 2 and ROBINS-I tools, primarily driven by non-randomized participant allocation, lack of allocation concealment, and the inherent impossibility of blinding participants to natural vs. urban environments. This lack of blinding introduces potential expectation bias and placebo-like effects, making it difficult to completely isolate the specific therapeutic properties of the forest setting from contextual factors, social desirability, or novelty. Additionally, marked heterogeneity across intervention protocols (ranging from 15-minute static viewing sessions to 8-week walking programs), small sample sizes, and non-standardized assessment tools restrict direct comparability and limit the generalizability of the results across broader demographic groups.

Consequently, despite a relatively consistent directionality of positive trends across certain attentional and autonomic outcomes, the overall certainty of the body of evidence remains limited. The findings of this review must therefore be regarded as preliminary and hypothesis-generating rather than confirmatory. To advance the field, future research should prioritize rigorously designed, pre-registered randomized controlled trials with adequate statistical power. Such studies should implement standardized intervention protocols (precisely reporting frequency, duration, and environmental characteristics), rely on validated objective cognitive endpoints, and incorporate longitudinal follow-up assessments to evaluate the persistence, dosage-dependency, and functional significance of forest therapy on cognitive health.

Conclusions

This systematic review provides preliminary, low-certainty evidence suggesting that forest therapy represents a promising, non-pharmacological, hypothesis-generating intervention with potential benefits for attentional recovery, autonomic stress reduction, and affective regulation in healthy adults. From a cognitive-behavioral perspective, the interplay between physiological relaxation and subjective emotional de-escalation may serve as a supportive framework for cognitive restoration. However, given the limited number of eligible studies and the high or critical risk of bias across the primary literature, these findings must be interpreted with substantial caution. Forest therapy cannot yet be established as a definitive clinical intervention for cognitive enhancement. Future well-powered, pre-registered randomized controlled trials utilizing standardized exposure protocols and objective neurocognitive endpoints are strictly required to evaluate the clinical efficacy, persistence, and therapeutic boundary conditions of nature-based interventions.

Declaração de Contribuição de Autoria CRediT

Conceptualization, F.J.-S., V.L.-C. & C.P.-A.; methodology, F.J.-S., V.L.-C. & C.P.-A.; drafting - preparation of the original draft, F.J.-S., V.L.-C.; writing - revision and editing, F.J.-S., V.L.-C.; supervision, C.P.-A. All authors read and agreed to the published version of the manuscript.

Declaração de Conflito de Interesses

The authors F.J.-S., V.L.-C. & C.P.-A. declare that they have no conflict of interest.

Nota dos autores:

This review did not receive external funding.

Referências

Antonelli, M., Barbieri, G., & Donelli, D. (2019b). Effects of forest bathing (shinrin-yoku) on levels of cortisol as a stress biomarker: A systematic review and meta-analysis. *International Journal of Biometeorology*, *63*(8), 1117–1134. https://doi.org/10.1007/s00484-019-01717-x

Bayrakdar, A., & Güneş, E. (2025). Effects of green exercise and walking in natural environments on physiological and cognitive health. *Physical Education of Students*, *29*(1), 73–84. https://doi.org/10.15561/20755279.2025.0108

Bielinis, E., Łukowski, A., Omelan, A., Boiko, S., Takayama, N., & Grebner, D. L. (2019). The effect of recreation in a snow-covered forest environment on the psychological wellbeing of young adults: Randomized controlled study. *Forests*, *10*(10), 827. https://doi.org/10.3390/f10100827

Bielinis, E., Takayama, N., Boiko, S., Omelan, A., & Bielinis, L. (2018). The effect of winter forest bathing on psychological relaxation of young Polish adults. *Urban Forestry & Urban Greening*, *29*, 276–283. https://doi.org/10.1016/j.ufug.2017.12.006

Bolouki, A. (2022). Exploring the association between self-reported and objective measures in search of the restorative quality of natural environments: a systematic review. *International Journal Of Environmental Health Research*, *33*(12), 1316-1330. https://doi.org/10.1080/09603123.2022.2085675

Breit, M., Scherrer, V., Tucker-Drob, E. M., & Preckel, F. (2024). The stability of cognitive abilities: A meta-analytic review of longitudinal studies. *Psychological Bulletin*, *150*(4), 399–439. https://doi.org/10.1037/bul0000425

Butler, A., Hall, H., & Copnell, B. (2016). A guide to writing a qualitative systematic review protocol to enhance evidence-based practice in nursing and health care. *Worldviews on Evidence-Based Nursing*, *13*(3), 241–249. https://doi.org/10.1111/wvn.12134

Chen, H., Yu, C., & Lee, H. (2018). The effects of forest bathing on stress recovery: Evidence from middle-aged females of Taiwan. *Forests*, *9*(7), 403. https://doi.org/10.3390/f9070403

Chen, M., Gao, M., Shao, R., Tong, H., Liu, J. M., Cheung, A. K., & Lee, T. M. (2025). Chronic stress modulates the relationship between acute stress-related cortical-limbic circuit functional connectivity and depression symptoms. *Journal of Affective Disorders*, *395*, 120725. https://doi.org/10.1016/j.jad.2025.120725

Chui, A., Boccone, G., Rico, P., Ngo, V., Zhang, A., Colquhoun, H., & Rotenberg, S. (2024). Everyday functioning among older adults with subjective cognitive decline: A scoping review. *Disability and Rehabilitation*, *46*(24), 5761–5770. https://doi.org/10.1080/09638288.2024.2313127

Cieza, A., Causey, K., Kamenov, K., Hanson, S. W., Chatterji, S., & Vos, T. (2020). Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10267), 2006–2017. https://doi.org/10.1016/s0140-6736(20)32340-0

Fan, X., Hu, D., Fan, Y., Yang, J., Liang, H., Gao, T., & Qiu, L. (2025). Urban restorative environments: The critical role of building density, vegetation structure, and multi-sensory stimulation in psychophysiological recovery. *Building and Environment*, *281*, 113190. https://doi.org/10.1016/j.buildenv.2025.113190

Fernández-Rubio, G., Vuust, P., Kringelbach, M. L., & Bonetti, L. (2025). The neurophysiology of healthy and pathological aging: A comprehensive systematic review. *Brain Structure and Function*, *230*(8), 146. https://doi.org/10.1007/s00429-025-03012-5

Fu, Y., Yang, P. B., Lam, T. L. H., Lau, B. W. M., & Tan, D. G. H. (2025). The effect of the natural environment on cognition, mood and stress in adults: A systematic review. *Journal of Environmental Psychology*, *107*, 102802. https://doi.org/10.1016/j.jenvp.2025.102802

Girotti, M., Bulin, S. E., & Carreno, F. R. (2024). Effects of chronic stress on cognitive function – From neurobiology to intervention. *Neurobiology of Stress*, *33*, 100670. https://doi.org/10.1016/j.ynstr.2024.100670

Gonzales, M. M., Garbarino, V. R., Pollet, E., Palavicini, J. P., Kellogg, D. L., Kraig, E., & Orr, M. E. (2022). Biological aging processes underlying cognitive decline and neurodegenerative disease. *Journal of Clinical Investigation*, *132*(10), e158453. https://doi.org/10.1172/jci158453

Gustavson, D. E., Borriello, G. A., Karhadkar, M. A., Rhee, S. H., Corley, R. P., Rhea, S., DiLalla, L. F., Wadsworth, S. J., Friedman, N. P., & Reynolds, C. A. (2025). Stability of general cognitive ability from infancy to adulthood: A combined twin and genomic investigation. *Proceedings of the National Academy of*

Sciences, *122*(21), e2426531122. https://doi.org/10.1073/pnas.2426531122

Hassan, A., Tao, J., Li, G., Jiang, M., Aii, L., Zhihui, J., Zongfang, L., & Qibing, C. (2018b). Effects of walking in bamboo forest and city environments on brainwave activity in young adults. *Evidence-Based Complementary and Alternative Medicine*, *2018*, 9653857. https://doi.org/10.1155/2018/9653857

Hansen, M. M., Jones, R., & Tocchini, K. (2017). Shinrin-Yoku (Forest Bathing) and Nature Therapy: A State-of-the-Art Review. *International Journal Of Environmental Research And Public Health*, *14*(8), 851. https://doi.org/10.3390/ijerph14080851

Koay, J. M., & Van Meter, A. (2023). The effect of emotion regulation on executive function. *Journal of Cognitive Psychology*, *35*(3), 315–329. https://doi.org/10.1080/20445911.2023.2172417

Kolaski, K., Logan, L. R., & Ioannidis, J. P. A. (2023). Guidance to best tools and practices for systematic reviews. *British Journal of Pharmacology*, *181*(1), 180–210. https://doi.org/10.1111/bph.16100

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, *6*, 1093. https://doi.org/10.3389/fpsyg.2015.01093

Lei, A. A., Phang, V. W. X., Lee, Y. Z., Kow, A. S. F., Tham, C. L., Ho, Y., & Lee, M. T. (2025). Chronic stress-associated depressive disorders: The impact of HPA axis dysregulation and neuroinflammation on the hippocampus—A mini review. *International Journal of Molecular Sciences*, *26*(7), 2940. https://doi.org/10.3390/ijms26072940

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1), 1. https://doi.org/10.1186/2046-4053-4-1

Nam, E., Jeon, S., Nam, E., & Jeon, S. (2025). Effects of forest trail and ground walking on mental and physical health promotion in middle-aged women living in urban areas. *Healthcare*, *13*(22), 2876. https://doi.org/10.3390/healthcare13222876

Nguyen, L., Walters, J., Hutchinson, E., Liu, Y., Li, X., & Gudmundsson, C. (2025). Executive functioning in individuals with generalized anxiety disorder: A systematic review and meta-analysis. *Journal Of Affective Disorders*, 389, 119683. https://doi.org/10.1016/j.jad.2025.119683

Ochiai, H., Ikei, H., Song, C., Kobayashi, M., Takamatsu, A., Miura, T., Kagawa, T., Li, Q., Kumeda, S., Imai, M., & Miyazaki, Y. (2015). Physiological and psychological effects of forest therapy on middle-aged males with high-normal blood pressure. *International Journal of Environmental Research and Public Health*, *12*(3), 2532–2542. https://doi.org/10.3390/ijerph120302532

Oh, B., Lee, K. J., Zaslawski, C., Yeung, A., Rosenthal, D., Larkey, L., & Back, M. (2017). Health and well-being benefits of spending time in forests: Systematic review. Environmental Health and Preventive Medicine, 22(1), 71. https://doi.org/10.1186/s12199-017-0677-9

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Alonso-Fernández, S. (2021c). Declaración PRISMA 2020: Una guía actualizada para la publicación de revisiones sistemáticas. *Revista Española de Cardiología*, *74*(9), 790–799. https://doi.org/10.1016/j.recesp.2021.06.016

Rai, H. K., Barroso, A. C., Yates, L., Schneider, J., & Orrell, M. (2020). Involvement of people with dementia in the development of technology-based interventions: Narrative synthesis review and best practice guidelines. Journal of Medical Internet Research, 22(12), e17531. https://doi.org/10.2196/17531

Salari, N., Lotfi, F., Abdolmaleki, A., Heidarian, P., Rasoulpoor, S., Fazeli, J., Najafi, H., & Mohammadi, M. (2025). The global prevalence of mild cognitive impairment in geriatric population with emphasis on influential factors: A systematic review and meta-analysis. *BMC Geriatrics*, *25*(1), 313. https://doi.org/10.1186/s12877-025-05967-w

Schulze, K., Mueller, I., Holt, D. V., Putz, S., Barnow, S., & Pruessner, L. (2026). Rethinking the link between cognitive control and emotion regulation: A meta-analytic review. *Neuroscience & Biobehavioral Reviews*, 188, 106708.

https://doi.org/10.1016/j.neubiorev.2026.106708

Shibaoka, M., Masuda, M., Iwasawa, S., Ikezawa, S., Eguchi, H., & Nakagome, K. (2023). Relationship between objective cognitive functioning and work performance among Japanese workers. *Journal of Occupational Health*, *65*(1), e12385. https://doi.org/10.1002/1348-9585.12385

Shojania, K. G., Sampson, M., Ansari, M. T., Ji, J., Doucette, S., & Moher, D. (2007). How quickly do systematic reviews go out of date? A survival analysis. Annals of Internal Medicine, 147(4), 224–233. https://doi.org/10.7326/0003-4819-147-4-200708210-00179

Song, C., Ikei, H., Kagawa, T., & Miyazaki, Y. (2019). Effects of walking in a forest on young women. *International Journal of Environmental Research and Public Health*, *16*(2), 229. https://doi.org/10.3390/ijerph16020229

Song, C., Ikei, H., Park, B., Lee, J., Kagawa, T., & Miyazaki, Y. (2018). Psychological benefits of walking through forest areas. *International Journal of Environmental Research and Public Health*, *15*(12), 2804. https://doi.org/10.3390/ijerph15122804

Song, Y., Liu, Y., Bai, X., & Yu, H. (2024). Effects of neighborhood built environment on cognitive function in older adults: A systematic review. *BMC Geriatrics*, *24*(1), 194. https://doi.org/10.1186/s12877-024-04776-x

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., . . . Higgins, J. P. T. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*, *366*, l4898. https://doi.org/10.1136/bmj.l4898

Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., . . . Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, *355*, i4919. https://doi.org/10.1136/bmj.i4919

Stier-Jarmer, M., Throner, V., Kirschneck, M., Immich, G., Frisch, D., & Schuh, A. (2021). The psychological and physical effects of forests on human health: A systematic review of systematic reviews and meta-analyses. *International Journal of Environmental Research and Public Health*, *18*(4), 1770. https://doi.org/10.3390/ijerph18041770

Sung, J., Woo, J., Kim, W., Lim, S., & Chung, E. (2011). The effect of cognitive behavior therapy-based "forest therapy" program on blood pressure, salivary cortisol level, and quality of life in elderly hypertensive patients. *Clinical and Experimental Hypertension*, *34*(1), 1–7. https://doi.org/10.3109/10641963.2011.618195

Szitás, D., Halamová, J., Ottingerová, L., & Schroevers, M. (2024). The effects of forest bathing on self-criticism, self-compassion, and self-protection: A systematic review. *Journal of Environmental Psychology*, *97*, 102372. https://doi.org/10.1016/j.jenvp.2024.102372

Van Der Molen, H. F., Nieuwenhuijsen, K., Frings-Dresen, M. H. W., & De Groene, G. (2020). Work-related psychosocial risk factors for stress-related mental disorders: An updated systematic review and meta-analysis. *BMJ Open*, *10*(7), e034849. https://doi.org/10.1136/bmjopen-2019-034849

Vasilopoulos, F., Jeffrey, H., Wu, Y., & Dumontheil, I. (2023). Multi-level meta-analysis of physical activity interventions during childhood: Effects of physical activity on cognition and academic achievement. *Educational Psychology Review*, *35*(2). https://doi.org/10.1007/s10648-023-09760-2

Webster-Cordero, F., & Giménez-Llort, L. (2025). A systematic review on subjective cognitive complaints: Main neurocognitive domains, myriad assessment tools, and new approaches for early detection. *Geriatrics*, *10*(3), 65. https://doi.org/10.3390/geriatrics10030065

Wen, Y., Yan, Q., Pan, Y., Gu, X., & Liu, Y. (2019b). Medical empirical research on forest bathing (Shinrin-yoku): A systematic review. *Environmental Health and Preventive Medicine*, *24*(1), 70. https://doi.org/10.1186/s12199-019-0822-8

Zhu, S., & Leng, X. (2025). Mental health and creativity in university students: A multidimensional mediation model of cognition, emotion, and motivation. *Frontiers in Psychology*, *16*, 1647823. https://doi.org/10.3389/fpsyg.2025.1647823

Zhu, X., Yan, W., Lin, X., Que, J., Huang, Y., Zheng, H., Liu, L., Deng, J., Lu, L., & Chang, S. (2022). The effect of perceived stress on

cognition is mediated by personality and the underlying neural mechanism. *Translational Psychiatry*, *12*(1), 199. https://doi.org/10.1038/s41398-022-01929-7

Zorowitz, S., & Niv, Y. (2023). Improving the reliability of cognitive task measures: A narrative review. *Biological Psychiatry Cognitive Neuroscience and Neuroimaging*, *8*(8), 789–797. https://doi.org/10.1016/j.bpsc.2023.02.004

Supplementary S2. Search strategy. Terms used in the search strategy according to each database.

Database	Search strategy
CINAHL Complete	((XB ("General cognition")) OR (XB (Cognitions)) OR (XB (Cognitive)) OR (XB ("executive functioning")) OR (XB ("executive function*")) OR (XB ("executive control")) OR (XB (cognition)) OR (XB ("cognitive function*")) OR (XB ("mental-health")) OR (XB ("mental health")) OR (XB (stress)) OR (XB ("well-being")) OR (XB ("well being"))) AND ((XB ("Nature experience")) OR (XB ("Green environment")) OR (XB ("Nature therapy")) OR (XB ("Forest therapy")) OR (XB (National park)) OR (XB ("Forest walking")) OR (XB ("Forest Medicine")) OR (XB ("Shinrin-Yoku")) OR (XB ("forest environment")) OR (XB ("forest")) OR (XB ("forest bathing"))) AND (XB (adult*))
Pubmed	("cognitive function*"[Title/Abstract] OR "cognition"[Title/Abstract] OR "executive control"[Title/Abstract] OR "executive function*"[Title/Abstract] OR "executive functioning"[Title/Abstract] OR "Cognitive"[Title/Abstract] OR "Cognitions"[Title/Abstract] OR "General cognition"[Title/Abstract] OR "mental-healt"[Title/Abstract] OR "mental health"[Title/Abstract] OR "stress"[Title/Abstract] OR "well-being"[Title/Abstract] OR "well-being"[Title/Abstract]) AND ("forest bathing"[Title/Abstract] OR "forest"[Title/Abstract] OR "forest environment"[Title/Abstract] OR "Shinrin-Yoku"[Title/Abstract] OR "Forest Medicine"[Title/Abstract] OR "national park"[Title/Abstract] OR "Forest walking"[Title/Abstract] OR "Forest therapy"[Title/Abstract] OR "Green environment"[Title/Abstract] OR "Nature therapy"[Title/Abstract] OR "Nature experience"[Title/Abstract]) AND "adult*"[Title/Abstract]
Scopus	((TITLE-ABS-KEY ("General cognition")) OR (TITLE-ABS-KEY (Cognitions)) OR (TITLE-ABS-KEY (Cognitive)) OR (TITLE-ABS-KEY ("executive functioning")) OR (TITLE-ABS-KEY ("executive function*")) OR (TITLE-ABS-KEY ("executive control")) OR (TITLE-ABS-KEY (cognition)) OR (TITLE-ABS-KEY ("cognitive function*") OR (TITLE-ABS-KEY ("mental-health")) OR (TITLE-ABS-KEY ("mental health")) OR (TITLE-ABS-KEY (stress)) OR (TITLE-ABS-KEY ("well-being")) OR (TITLE-ABS-KEY ("well being"))) AND ((TITLE-ABS-KEY ("forest bathing")) OR (TITLE-ABS-KEY ("forest")) OR (TITLE-ABS-KEY ("forest environment")) OR (TITLE-ABS-KEY ("Shinrin-Yoku")) OR (TITLE-ABS-KEY ("Forest Medicine")) OR (TITLE-ABS-KEY (National park)) OR (TITLE-ABS-KEY ("Forest walking")) OR (TITLE-ABS-KEY ("Forest therapy")) OR (TITLE-ABS-KEY ("Green environment")) OR (TITLE-ABS-KEY ("Nature therapy")) OR (TITLE-ABS-KEY ("Nature experience"))) AND (TITLE-ABS-KEY (adult*)))
Web of Science	((TS = ("cognitive function*" OR cognition OR "executive control" OR "executive function*" OR "executive functioning" OR Cognitive OR Cognitions OR "General cognition" OR "mental-health" OR "mental health" OR stress OR "well-being" OR "well being")) AND TS = ("forest bathing" OR "forest" OR "forest environment" OR "Shinrin-Yoku" OR "Forest Medicine" OR National park OR "Forest walking" OR "Forest therapy" OR "Green environment" OR "Nature therapy" OR "Nature experience")) AND TS = (adult*)

Table 2. *Intervention characteristics*

Reference	Intervention Program	Control Condition	Compliance	Total Duration	Frequency	Session Duration	Intensity	Cognitive Measurement	Main Result
Bayrakdar and Güneş (2025)	Green exercise (nature walking).	Sedentary lifestyle.	100%	8 weeks.	2/week.	6 to 10 km walking routes.	Low-to-Moderate	Working Memory (Memory capacity); Cognitive Flexibility (Cognitive performance index).	Positive Effect. Significant improvement in accuracy rate (8.42%), memory capacity (7.52%), and overall cognitive performance (9.60%) ($p<0.001$). Reaction time improved (5.15%) but not significant.

Bielinis et al. (2019)	Snow-covered forest recreation.	Urban street environment.	100%	Single session.	Once	15 min of viewing (+20 min walk to site).	Very low (Standing relaxation).	Restorative Outcome Scale (ROS).	Significant increase in psychological restoration and directed attention capacity.
Hassan et al. (2018)	Bamboo forest walking.	City area walking.	100%	2 days.	1/week	15 minutes.	Moderate.	EEG (Attention & Meditation scores); Alpha/Beta waves.	Positive Effect. Significant increase in mean attention scores compared to the urban environment ($p<0.01$). Higher high-beta wave activity indicated increased attentiveness.

Nam et al. (2025)	Forest trail walking.	School playground walking.	100%	Single session.	Once	EX: 20 min.	Vigorous (70–85% HRmax).	Attention (Beta waves); Cognitive Activation (Gamma waves).	Positive Effect. Significant increase in Alpha, Beta, and Gamma waves ($p<0.001$).
Ochiai et al. (2015)	Viewing forest landscape while sitting in a chair.	Viewing city center landscape.	85%	2 days.	1/week	15 minutes.	Very Low.	Salivary Cortisol (stress marker) and POMS.	Significant reduction in cortisol; more peaked/stable distribution in forest vs. city.
Bielinis et al. (2018)	Winter forest recreation.	Viewing an urban landscape while standing.Sin	100%	Single session.	Once	15 minutes.	Very Low.	POMS, PANAS, ROS, SVS.	Significant decrease in POMS confusion, fatigue, and anxiety; significant increase in vigor and restoration (ROS).

Chen et al. (2018)	Forest therapy program (guided walk, night walk)	None	16%	2 days.	1/week	2.5h of guided walk and 1h of night walk.	Moderate.	POMS, STAI (State anxiety).	Significant reduction in confusion, fatigue, anger, and anxiety; significant increase in vigor.
Song, et al. (2018)	Walking through predetermined forest courses.	Walking through city areas.	93%	2 days.	1/week	15 minutes.	Moderate.	POMS, STAI (Trait anxiety).	Significant decrease in negative mood states and increase in vigor. High-trait anxiety group showed better recovery.

Song et al. (2019)	Walking through forest areas.	Walking through city areas.	100%	2 days.	Once/week	15 minutes.	Moderate.	POMS, STAI, Heart Rate Variability (HRV).	Reduction in tension-anxiety, confusion, and fatigue. Higher parasympathetic activation compared to city walking. Increased parasympathetic activity and decreased sympathetic activity ($p<0.01$).

EEG = Electroencephalography; DIY = do it you; PANAS = Positive and Negative Affect Schedule; POMS = Profile of Mood States; ROS = Restorative Outcome Scale; STAI = State-Trait Anxiety Inventory; SVS = Subjective Vitality Scale.