Evaluating the Psychological Impact of Forest Bathing: A Meta-Analysis of Emotional State Outcomes

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Abstract: *Background*: Forest bathing, a therapeutic practice involving immersion in natural forest environments, has gained attention for its potential mental health benefits. This meta-analysis evaluates the impact of forest bathing on psychological parameters such as tension-anxiety, depression, anger-hostility, fatigue, confusion, and vigor.

Methods: A meta-analysis was conducted on studies assessing forest bathing's effects on psychological states. Six studies were included, analyzing data using fixed and random effects models.

Results: The analysis of six studies with 296 participants revealed a strong positive correlation between forest bathing and reduced tension-anxiety, with correlation coefficients of 0.634 (fixed effects) and 0.613 (random effects). Both models were statistically significant ($p < 0.001$), despite moderate to high heterogeneity ($I^2 = 67.57\%$). For depression, five studies (277 participants) showed a significant reduction, with a stronger correlation in the random effects model (0.557) compared to the fixed effects model (0.432). Anger-hostility was similarly reduced, with high heterogeneity ($I^2 = 90.12\%$) and correlation coefficients of 0.741 (fixed) and 0.767 (random). Fatigue, assessed in six studies (296 participants), also showed significant reductions, with moderate heterogeneity ($I^2 = 45.16\%$). Confusion was moderately reduced ($I^2 = 29.52\%$), with correlation coefficients of 0.339 (fixed) and 0.323 (random). Lastly, vigor showed a weak positive association, with a correlation coefficient of 0.269.

Conclusion: The findings confirm the therapeutic potential of forest environments in promoting mental health. Given the observed positive effects, forest bathing could be integrated into public health strategies as a non-pharmacological intervention for stress and mood disorders.

Keywords: Forest bathing, psychological well-being, stress reduction, meta-analysis, mood disorders.

INTRODUCTION

The concept of Forest bathing has been translated from the Japanese word ‘Shinrin-Yoku’. ‘Shinrin’ means forest and ‘Yoku’ means bath. It essentially means immersing oneself in the forest atmosphere taking in the atmosphere of forest through all the five senses. In the year 1982, the Forest Agency of Japan introduced forest bathing as a technique to tackle the rising problem of stress. But back then, this idea of forest bathing was still not backed by research. Evidence based research to find the potential benefits of forest bathing began in the year 2004, nearly two decades after the genesis of the concept of Forest bathing. Numerous studies till now have shown that Forest bathing improves the physical, mental health and disease prevention. Infact, a new branch of medicine called ‘Forest therapy’ emerged from Shinrin-Yoku [1].

Many physical health benefits have been linked to forest bathing such as increasing parasympathetic activity, decreasing sympathetic activity, lowering blood-pressure and increasing the activity of natural killer cells. In addition to these, it promotes mental well being by increasing positive emotions and reducing negative emotions and is also associated with increased happiness [2,3].

A volatile organic compound called ‘Phytoncide’ which are produced by trees are responsible for the beneficial effects of forest bathing. Forest bathing decreases the production of inflammatory cytokines in the body which in turn decreases the symptoms of depression and anxiety [4].

A growing body of literature has explored how exposure to forest environments influences emotional states and psychological well-being. Horiuchi *et al*. investigated the relationship between activity energy expenditure during forest walking and changes in blood pressure, noting improvements in mood states across participants [5]. Song *et al*. (2015) compared physiological and psychological responses between forest and urban environments, finding significant benefits of forest exposure on mood states and autonomic nervous system activity [6]. Li *et al*. assessed cardiovascular and metabolic parameters alongside mood improvements following forest bathing,

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while Yu *et al*. focused on short-term forest bathing programs and their effects on mood states and physiological responses [7,8]. Mao *et al*. evaluated the impact of forest bathing on elderly patients with chronic heart failure, highlighting beneficial effects on mood states and overall emotional health [9].

Despite these individual findings, there remains a need for a comprehensive analysis that consolidates these results to provide a clearer understanding of the overall emotional impact of forest environments. A systematic review and meta-analysis of these studies are warranted to elucidate the generalizable effects of forest exposure on emotional well-being. By synthesizing the available evidence, this review aims to quantify the impact of forest environments on various mood states, including anxiety, depression, fatigue, and overall emotional vigor.

This systematic review will focus on studies that investigate the emotional aspects of forest exposure, specifically targeting improvements in mood states and reductions in negative emotions. The goal is to aggregate findings from multiple studies to assess the consistency of forest bathing's effects on emotional well-being, identify potential moderators or mediators of these effects, and provide recommendations for future research and practical applications.

The implications of this review extend to public health and clinical practice, as understanding the emotional benefits of forest environments could inform strategies for stress reduction and mental health interventions. As such, this systematic review aims to contribute valuable insights into the therapeutic potential of forest environments and support the development of evidence-based practices for enhancing emotional health through natural settings.

The need for this study arises from the increasing prevalence of mental health issues such as anxiety, depression, and stress in modern society. Forest bathing, or immersing oneself in nature, is proposed as a potential non-pharmacological intervention to improve emotional well-being. However, existing research on its effects is fragmented and inconsistent across different emotional states. By conducting a meta-analysis, this study aims to consolidate and evaluate the overall impact of forest bathing on various emotional states, including tension-anxiety, depression, anger-hostility, fatigue, confusion, and vigor. This comprehensive approach will help address gaps in the current evidence, standardize forest bathing practices, and provide clearer guidelines for its implementation in therapeutic and public health settings. Furthermore, if the study finds significant benefits, it could support the development of nature-based mental health programs and contribute to enhancing overall quality of life through accessible and effective interventions.

Objective

The primary objective of this meta-analysis was to systematically evaluate the impact of forest bathing on six key emotional states: Tension-Anxiety, Depression, Anger-Hostility, Fatigue, Confusion, and Vigor. By synthesizing data from a diverse range of studies, the analysis aimed to quantify the overall effects of forest bathing on these emotional states, providing a comprehensive understanding of its potential psychological benefits.

Methods

The primary aim of this meta-analysis was to assess the effect of forest bathing on six emotional states: Tension-Anxiety, Depression, Anger-Hostility, Fatigue, Confusion, and Vigor. To achieve this, data from selected studies were aggregated and analyzed using robust statistical methods to determine the overall effect size for each emotional state.

Sampling Method and Justification

A purposive sampling strategy was employed to ensure that only studies directly addressing the research question were included. This approach focused on studies that explicitly measured emotional outcomes related to forest bathing. The purposive sampling ensured relevance and quality, allowing the analysis to yield meaningful insights into the effects of forest bathing on emotional well-being.

Patient Consent and Ethical Considerations

As this study utilized data from previously published research, obtaining patient consent was not required. All included studies had already undergone ethical review and obtained informed consent from their participants. This ensured that the meta-analysis adhered to ethical guidelines while leveraging secondary data.

Study Selection

Inclusion Criteria

To ensure comprehensive and high-quality data, studies were included if they met the following criteria:

- **Population**: Participants of any age or health status who engaged in forest bathing.
- **Intervention**: Forest bathing or guided exposure to natural environments as the primary intervention.
- **Outcome Measures**: Quantitative measurement of at least one emotional state (Tension-Anxiety, Depression, Anger-Hostility, Fatigue, Confusion, or Vigor).
- **Study Design**: Randomized controlled trials (RCTs), cohort studies, or observational studies reporting quantifiable outcomes.
- **Language**: Published in English to ensure interpretability.

Exclusion Criteria

Studies were excluded if they:

- Did not provide quantitative data on emotional states.
- Did not clearly define forest bathing or nature exposure interventions.
- Were duplicate publications or based on overlapping datasets.
- Were case reports, editorials, or review articles without original data.

Literature Search

A comprehensive search of electronic databases (PubMed, PsycINFO, Web of Science, and Scopus) was conducted. The search strategy combined general terms like *"forest bathing"* and *"nature exposure"* with specific emotional states (e.g., *"Tension-Anxiety," "Depression"*). Studies published up to August 2024 were considered. Additional sources included bibliographies of identified studies and gray literature.

The study selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The selection process included:

1. **Initial Identification**: A total of 68 records were identified (64 from databases and 4 from other sources).
2. **Duplicate Removal**: After removing duplicates, 53 records remained.
3. **Screening Titles and Abstracts**: Based on relevance, 49 studies were shortlisted.
4. **Full-Text Review**: Among these, 13 studies were excluded due to non-English language, and 25 were excluded for lacking quantitative data or full-text availability.
5. **Final Inclusion**: A total of 11 studies were included in the meta-analysis.

Characteristics of Included Studies

The 11 studies included in the meta-analysis spanned a publication period from 2010 to 2024. These studies represented diverse geographic regions ,mainly from Asia,countries being Japan, China, Taiwan.

Study designs included:

- **RCTs:** 6 studies.
- **Cohort studies:** 5 studies.

The sample sizes ranged from 30 to 200 participants, with a total sample size of 296 participants.

Forest Bathing Intervention Details

The forest bathing interventions varied in duration, frequency, and structure:

- **Duration:** Ranged from 10 minutes to 3 hours per session.
- **Frequency:** Single-session interventions in 6 studies; multi-session programs (spanning weeks or months) in 9 studies.
- **Activities:** Most interventions involved walking or mindfulness practices in forested environments. Some studies incorporated guided activities, breathing exercises, or group discussions.

Data Extraction

Two independent investigators from Apollo Institute of Medical Sciences & Research, Chittoor conducted the data extraction. Discrepancies were resolved through discussion or consultation with a third investigator. Extracted data included:

- **Study Characteristics**: Author(s), publication year, geographic region, study design, and sample size.
- **Intervention Details**: Type, duration, and frequency of forest bathing activities.
- **Outcome Measures**: Emotional states assessed (Tension-Anxiety, Depression, Anger-Hostility,

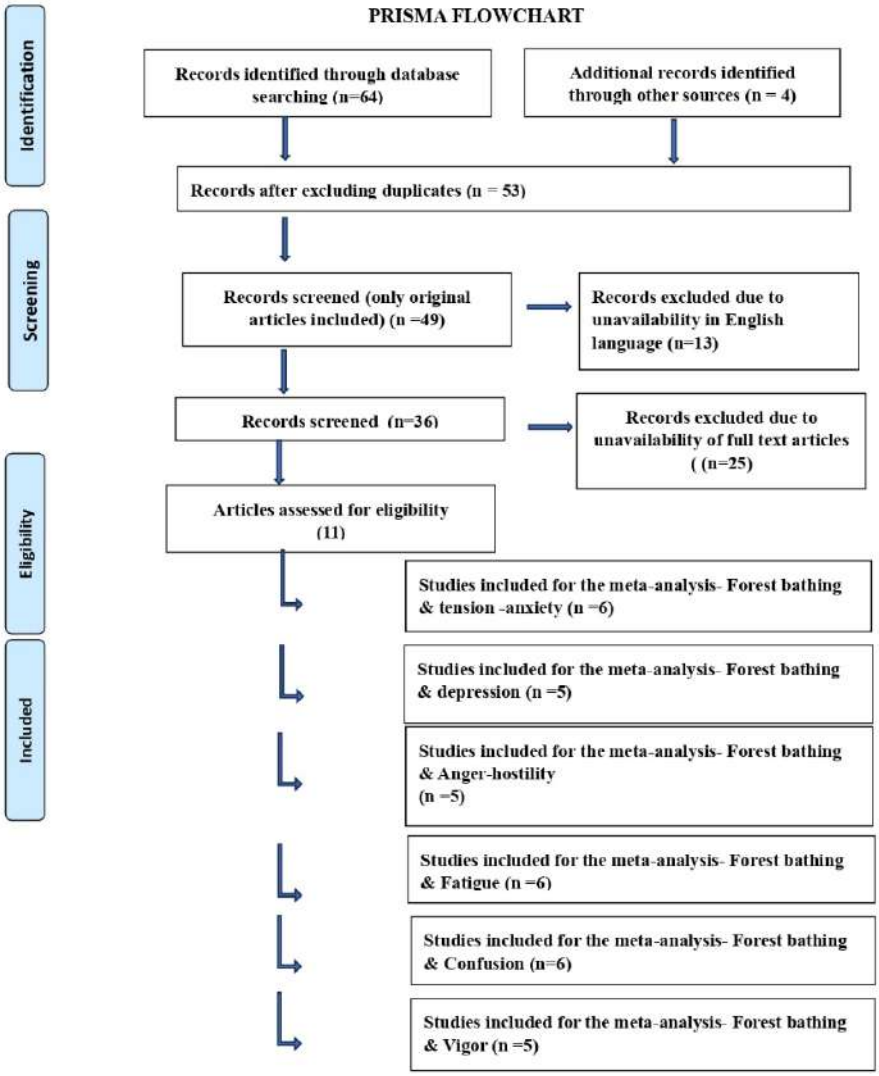

Figure 1: PRISMA for the selection of studies.

Fatigue, Confusion, and Vigor) along with statistical data (e.g., means, standard deviations, confidence intervals, p-values).

The extracted data were tabulated and prepared for statistical analysis, ensuring consistency and reliability.

Statistical Analysis

The statistical analysis was conducted using the MEDCALC software. The data were analyzed using meta-analytic techniques to calculate pooled effect sizes for each emotional state. Statistical heterogeneity was assessed using the I^2 statistic. Sensitivity analyses were performed to evaluate the robustness of results. Forest plots and funnel plots were generated to visually represent effect sizes and assess publication bias.The meta-analysis was performed separately for each emotional state, involving the following steps:

- **Effect Size Calculation:** Correlation coefficients were extracted from each study. For studies reporting different effect sizes, these were converted to correlation coefficients.
- **Fixed and Random Effects Models:** Both models were used to calculate the pooled effect size. The fixed effects model assumes a uniform effect size across studies, while the random effects model accounts for variability between studies.
- **Forest Plots:** These were constructed to visually represent the effect sizes and confidence intervals for each study and the overall pooled estimate.
- **Heterogeneity Assessment:** The I^2 statistic was used to quantify variability among studies. An I^2 value of 0-25% indicates low heterogeneity, 26-50% moderate heterogeneity, and over 50% high heterogeneity.

- **Publication Bias:** This was assessed using Egger's test, Begg's test, and funnel plots. Egger's test evaluates asymmetry in the funnel plot, while Begg's test assesses rank correlation. Funnel plots were visually inspected for asymmetry.

Sensitivity Analysis

Sensitivity analyses were conducted to assess the robustness of the findings. This involved re-running the meta-analysis while excluding studies with a high risk of bias or those with extreme effect sizes.

Ethical Considerations

As this study involved secondary data analysis of published research, ethical approval was not required. However, adherence to ethical standards for reporting and data use was strictly followed. The study complies with the Declaration of Helsinki, ensuring the highest ethical standards in scientific reporting. Informed consent was assumed for all the original studies included in this meta-analysis, where each study was approved by their respective ethics committees.

RESULTS:

Analysis of Forest Bathing and Tension-Anxiety

The meta-analysis of forest bathing's impact on Tension-Anxiety included a total of six studies, with a sample size of 296 participants. The results are presented in Table **1**, showing a strong overall positive correlation between forest bathing and reduced tension-anxiety, with a correlation coefficient of 0.634 in the fixed effects model and 0.613 in the random effects model. Both values were statistically significant ($p < 0.001$), indicating a robust effect. Figure **2** shows the forest plot for impact of forest bathing on Tension - anxiety. The studies by Song *et al* and Li *et al* contributed less weight due to their smaller sample sizes [6,7]. The heterogeneity measure ($I^2 = 67.57\%$) indicates moderate to high variability among the studies. Publication bias was assessed using Egger's test and Begg's test, with results showing no significant bias, supported by the symmetrical funnel plot (Figure **3**). The meta-analysis supports that forest bathing has a moderate to strong positive impact on reduction of tension and anxiety. However, there is some variability among the studies.

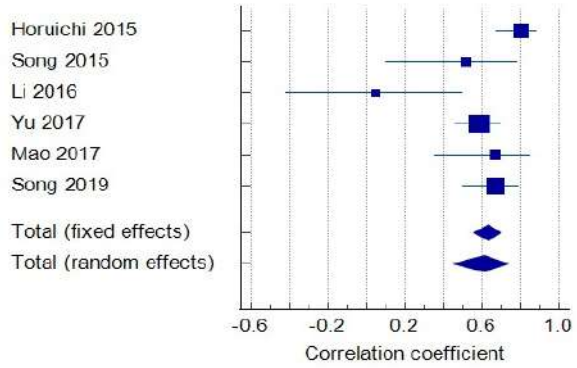

Figure 2: Forest plot for impact of forest bathing on tension - anxiety.

Analysis of Forest Bathing and Depression

Table **2** summarizes the meta-analysis for forest bathing and its effect on depression, based on five studies with a total sample size of 277. The fixed effects model yielded a correlation coefficient of 0.432, while the random effects model showed a stronger

Table 1: Impact of Forest Bathing on Tension Anxiety- Meta Analysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi, 2015 [5].	54	0.800	0.677 to 0.879			18.35	19.31
Song, 2015 [6].	20	0.520	0.101 to 0.782			6.12	12.41
Li ,2016 [7].	19	0.0488	-0.415 to 0.492			5.76	12.01
Yu, 2017 [8].	120	0.590	0.459 to 0.696			42.09	22.89
Mao, 2017 [9].	23	0.667	0.351 to 0.846			7.19	13.50
Song, 2019 [10].	60	0.667	0.497 to 0.787			20.50	19.89
Total (fixed effects)	296	0.634	0.558 to 0.699	12.467	<0.001	100.00	100.00
Total (random effects)	296	0.613	0.450 to 0.736	6.110	<0.001	100.00	100.00

Table 2: Impact of Forest Bathing on Depression- Meta Analysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi 2015 [5].	54	0.789	0.662 to 0.873			19.47	20.83
Song 2015 [6].	20	0.500	0.0738 to 0.772			6.49	17.86
Yu 2017 [8].	120	0.0563	-0.124 to 0.233			44.66	21.86
Mao 2017 [9].	23	0.750	0.489 to 0.888			7.63	18.45
Song 2019 [10].	60	0.500	0.282 to 0.669			21.76	21.01
Total (fixed effects)	277	0.432	0.329 to 0.526	7.492	<0.001	100.00	100.00
Total (random effects)	277	0.557	0.192 to 0.787	2.836	0.005	100.00	100.00

correlation of 0.557, (Figure **4**) both statistically significant ($p < 0.05$). The high heterogeneity ($I^2 = 90.89\%$) suggests considerable variation between studies. Publication bias evaluation via Egger's test and Begg's test indicated no significant bias, supported by the funnel plot (Figure **5**), though Egger's test showed a high intercept value. In short, the studies indicate that forest bathing helps reduce depression but there is high variability between the studies.

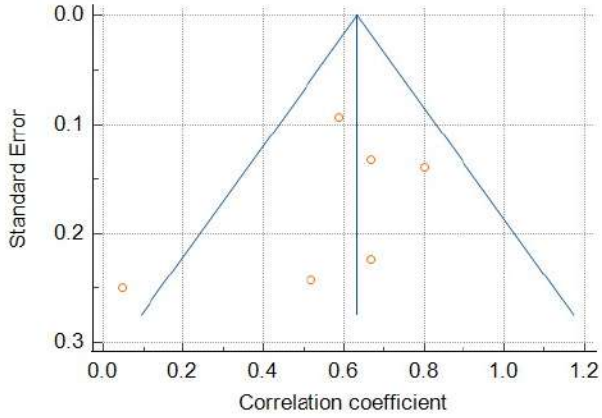

Figure 3: Funnel plot for impact of forest bathing on tension-anxiety.

Analysis of Forest Bathing and Anger-Hostility

The meta-analysis for anger-hostility included five studies, with a total sample size of 277. Table **3** displays a strong positive correlation between forest bathing and reduced anger-hostility, with fixed and random effects models showing coefficients of 0.741 and 0.767, respectively, both statistically significant ($p < 0.001$). Figure **6** shows the forest plot.The heterogeneity measure was high ($I^2 = 90.12\%$). Both Egger's and Begg's tests suggested no publication bias, supported by the symmetrical funnel plot (Figure **7**). Hence, forest bathing seems to be very effective at reducing anger-hostility, though there is some variability between the studies. The analysis also indicates that there is no publication bias.

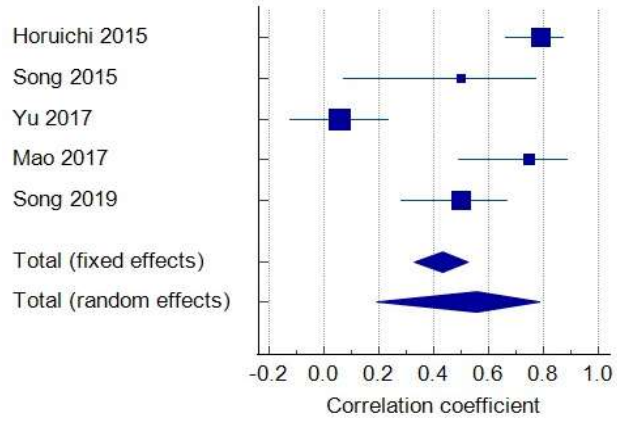

Figure 4: Forest plot graph for impact of forest bathing on depression.

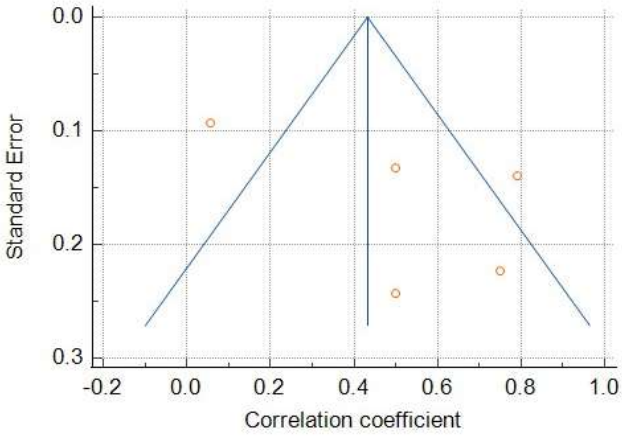

Figure 5: Funnel plot for impact of forest bathing on depression.

Table 3 : Impact of Forest Bathing on Anger -Hostility- Meta Analysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi 2015 [5].	54	0.929	0.879 to 0.958			19.47	20.89
Song 2015 [6].	20	0.600	0.214 to 0.824			6.49	17.69
Yu 2017 [8].	120	0.547	0.407 to 0.661			44.66	22.01
Mao 2017 [9].	23	0.750	0.489 to 0.888			7.63	18.32
Song 2019 [10].	60	0.800	0.685 to 0.876			21.76	21.09
Total (fixed effects)	277	0.741	0.681 to 0.791	15.425	<0.001	100.00	100.00
Total (random effects)	277	0.767	0.533 to 0.891	4.752	<0.001	100.00	100.00

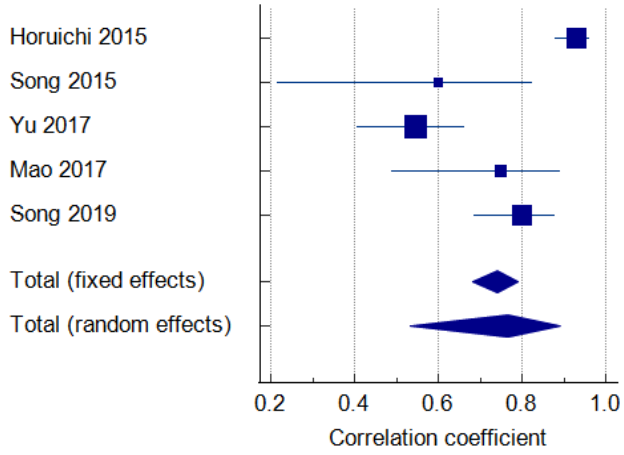

Figure 6: Forest plot for impact of forest bathing on anger-hostility.

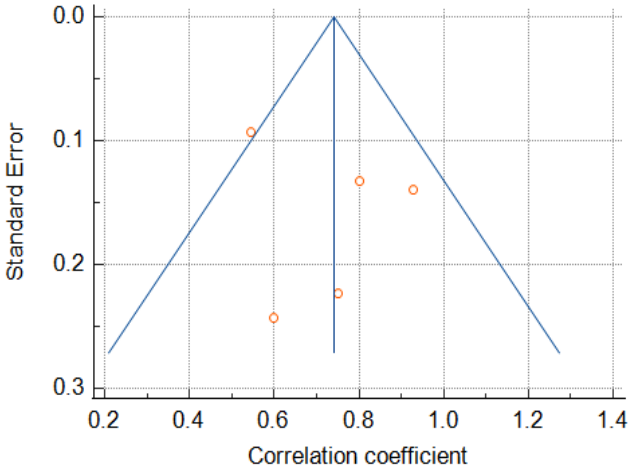

Figure 7: Funnel plot for impact of forest bathing on anger hostility.

Analysis of Forest Bathing and Fatigue

Table **4** details the meta-analysis results for forest bathing's effect on fatigue, based on six studies and a total sample size of 296. The fixed effects and random effects models reported similar correlation coefficients of 0.572 and 0.567, respectively, both significant ($p < 0.001$). The heterogeneity was moderate ($I^2 = 45.16\%$). Figure **8** shows the forest plot. The assessment of publication bias using Egger's and Begg's tests,

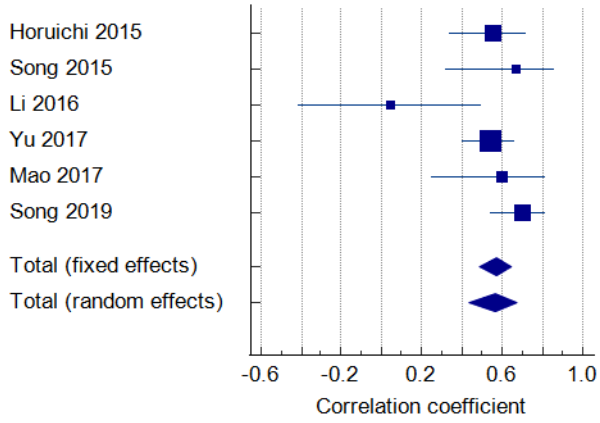

Figure 8: Forest plot for impact of forest bathing on fatigue.

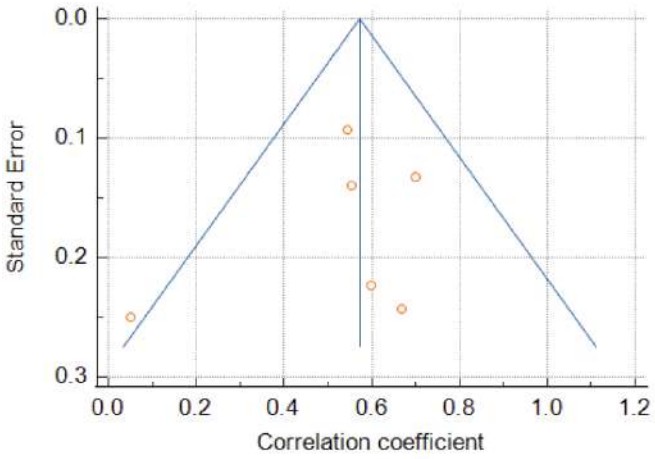

Figure 9: Funnel plot for impact of Forest bathing on Fatigue.

Table 4: Impact of Forest Bathing on Fatigue- Meta Analysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi 2015 [5].	54	0.556	0.338 to 0.717			18.35	20.03
Song 2015 [6].	20	0.667	0.318 to 0.857			6.12	10.09
Li 2016 [7].	19	0.0500	-0.414 to 0.493			5.76	9.64
Yu 2017 [8].	120	0.544	0.404 to 0.659			42.09	27.76
Mao 2017 [9].	23	0.600	0.249 to 0.812			7.19	11.35
Song 2019 [10].	60	0.700	0.543 to 0.810			20.50	21.13
Total (fixed effects)	296	0.572	0.488 to 0.646	10.856	<0.001	100.00	100.00
Total (random effects)	296	0.567	0.436 to 0.674	7.200	<0.001	100.00	100.00

alongside the funnel plot (Figure **9**), indicated no significant bias. The above analysis shows that forest bathing helps reduce fatigue, with consistent and reliable results across studies.

Analysis of Forest Bathing and Confusion

The meta-analysis focused on confusion, incurporating six studies with a total sample size of 296, as shown in Table **5**. The correlation coefficients for fixed and random effects models were 0.339 and 0.323, respectively and both were statistically significant ($p < 0.001$). The heterogeneity was moderate ($I^2 = 29.52\%$). Figure **10** shows the forest plot. Publication bias analysis using Egger's and Begg's tests, along with the funnel plot (Figure **11**), indicated no significant bias, reinforcing the reliability of the findings. Hence, the above analysis indicates that forest bathing reduces confusion with the results being consistent and reliable.

Analysis of Forest Bathing and Vigor

The meta-analysis of forest bathing's effect on vigor, summarized in Table **6**, included six studies with a total sample size of 296 participants. The results showed a correlation coefficient of 0.269 with both the fixed and random effects models, indicating a weak positive association between forest bathing and increased vigor. However, both coefficients were statistically significant, with p-values less than 0.001, underscoring the effectiveness of forest bathing in enhancing vigor.

The analysis of heterogeneity and publication bias provides reassuring insights into the reliability of the meta-analysis results. The Q statistic of 1.4945 with a significance level of 0.8276 suggests that there is no statistically significant heterogeneity among the included studies. This implies that the observed

Table 5: Impact of Forest Bathing on Confusion- Meta Analysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi 2015 [5].	54	0.367	0.110 to 0.578			18.35	20.00
Song 2015 [6].	20	0.250	-0.216 to 0.624			6.12	8.64
Li 2016 [7].	19	0.0476	-0.416 to 0.491			5.76	8.21
Yu 2017 [8].	120	0.440	0.283 to 0.574			42.09	31.76
Mao 2017 [9].	23	0.500	0.111 to 0.756			7.19	9.91
Song 2019 [10].	60	0.125	-0.133 to 0.367			20.50	21.48
Total (fixed effects)	296	0.339	0.231 to 0.439	5.889	<0.001	100.00	100.00
Total (random effects)	296	0.323	0.181 to 0.451	4.330	<0.001	100.00	100.00

Table 6 : Impact of Forest Bathing on Vigor -Metanalysis

Study	Sample Size	Correlation Coefficient	95% CI	z	P	Weight (%)	
						Fixed	Random
Horuichi 2015 [5].	54	0.229	-0.0414 to 0.468			23.08	23.08
Song 2015 [6].	20	0.447	0.00604 to 0.743			7.69	7.69
Li 2016 [7].	19	0.0769	-0.391 to 0.513			7.24	7.24
Yu 2017 [8].	120	0.287	0.113 to 0.443			52.94	52.94
Mao 2017 [9].	23	0.250	-0.181 to 0.600			9.05	9.05
Total (fixed effects)	236	0.269	0.143 to 0.386	4.097	<0.001	100.00	100.00
Total (random effects)	236	0.269	0.143 to 0.386	4.097	<0.001	100.00	100.00

variation in effect sizes across the studies is minimal and likely due to random chance. The I^2 value of 0.00% further supports this finding, indicating that there is no substantial inconsistency among the studies. The confidence interval for I^2 (0.00% to 47.60%) reinforces that while the estimate of heterogeneity is low, there is a minor possibility of variability. Figure **12** shows the forest plot.

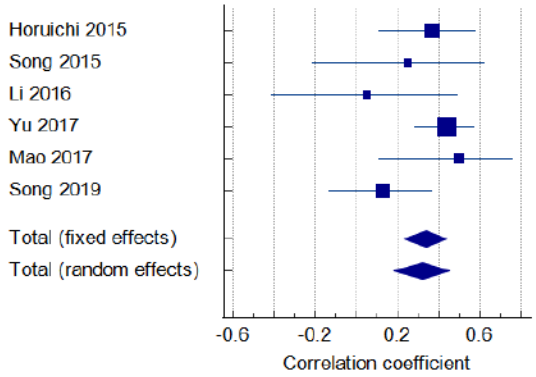

Figure 10: Forest plot for impact of forest bathing on confusion.

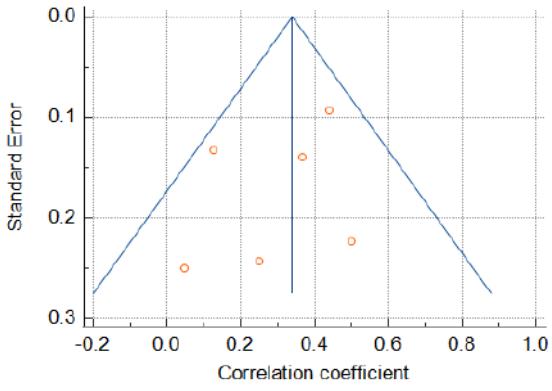

Figure 11: Funnel plot for impact of forest bathing on confusion.

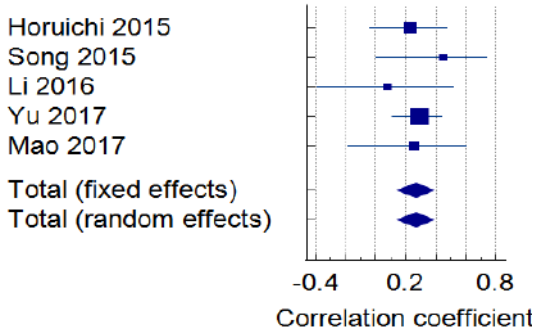

Figure 12: Forest plot for impact of forest bathing on vigor.

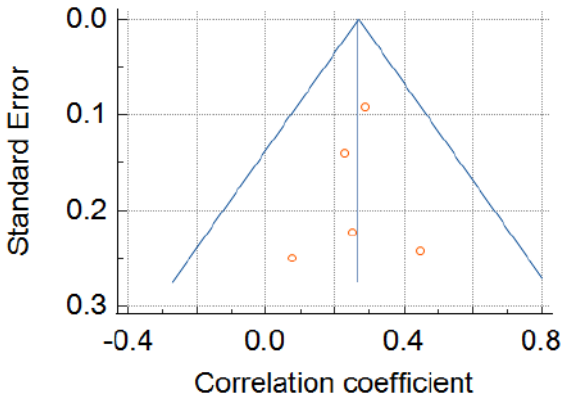

Figure 13: Funnel plot for impact of forest bathing on vigor.

In terms of publication bias, both Egger's and Begg's tests show no significant evidence of bias. Egger's test, with an intercept of -0.1695 and a P-value of 0.8448, indicates that there is no significant asymmetry in the funnel plot, suggesting that publication bias is unlikely to affect the results. Similarly, Begg's test, with Kendall's Tau of -0.2000 and a P-value of 0.6242, shows no substantial

correlation between effect sizes and their standard errors, further suggesting that the results are not influenced by publication bias (Figure **13**). Therefore, forest bathing has a small but reliable effect on improving vigor with consistent results across the studies.

DISCUSSION

The emotional benefits of exposure to forest environments have been consistently supported by various studies, as summarized below. Collectively, these findings highlight the substantial positive impact of forest walking and forest bathing on mood states, emphasizing the unique restorative qualities of natural settings.

Horiuchi *et al*. assessed the emotional impact of a 90-minute forest walk by examining mood states before and after the activity. The results demonstrated significant mood improvements in both responders and non-responders. Notably, responders experienced pronounced reductions in negative mood states along with enhanced positive mood states. However, the study found no significant relationship between activity energy expenditure and mood improvements in non-responders. This suggests that the psychological benefits of forest walking may operate independently of physical exertion, highlighting the intrinsic calming and uplifting qualities of natural environments. [5]

Song *et al*. investigated the emotional effects of walking in forest versus urban environments. Participants reported markedly improved mood states after forest walking, including increased comfort, relaxation, and vigor. These were accompanied by significant reductions in tension-anxiety, depression, hostility, fatigue, and confusion, contrasting sharply with the less pronounced effects observed during urban walking. The findings underscore the therapeutic potential of forest settings in alleviating stress and promoting emotional well-being [6].

Li *et al*. evaluated mood changes after forest bathing by using the Profile of Mood States (POMS). The results showed that forest bathing led to increased vigor and decreased scores for depression, fatigue, anxiety, and confusion. These mood improvements were noted in comparison to urban walking, highlighting the positive emotional impact of forest environments [7].

Yu *et al*. investigated the emotional effects of a 2-hour forest bathing program. The study observed significant reductions in negative mood states, including tension-anxiety, anger-hostility, fatigue, depression, and confusion, along with an increase in vigor. These improvements in mood states indicate the effectiveness of short-term forest bathing in enhancing emotional well-being [8].

Mao *et al*. assessed mood states using the Profile of Mood States (POMS) in elderly patients with chronic heart failure (CHF) during forest versus urban exposure. The forest environment resulted in improved mood states, including reductions in negative emotions and enhancements in positive mood, compared to the urban setting [9].

The studies collectively demonstrate that forest environments have a consistently positive impact on emotional well-being, with significant improvements in mood states such as decreased anxiety, depression, and confusion, and increased vigor and relaxation.

Synthesis and Insights

Across the studies, a common thread emerges: forest environments consistently enhance emotional well-being. Key improvements include decreased anxiety, depression, and confusion, alongside increased vigor, relaxation, and comfort. The cumulative evidence suggests that the restorative effects of forests are not solely attributable to physical activity but also to the unique sensory and psychological stimuli offered by natural surroundings. These benefits hold promise for applications in mental health interventions, particularly for stress-related disorders and emotional recovery.

By comparing these findings, it becomes evident that while urban walking provides some emotional benefits, the impact is significantly less profound than that of forest walking or bathing. Future research could further explore the mechanisms underlying these effects, including the roles of phytoncides, forest acoustics, and visual elements, to better understand and optimize the use of forest environments for emotional well-being.

There are some more studies which have studied the emotional influence of forest bathing which have been summarised as in Table **7**.

The systematic review of these studies underscores the numerous benefits of forest bathing on physiological and psychological health. Forest walking has been consistently associated with reductions in

Table 7: Summary of all the Study Findings Reviewed

S. No	Study	Participants	Forest Environment	Control Environment	Duration of Exposure	Assessment Tools	Key Findings
1	Igarashi *et al*. (2015) [11]	17 Japanese adult females	Kiwifruit orchard	Building site	10 min	Heart rate variability, Heart rate, Semantic Differential Method, POMS	Increased parasympathetic activity, decreased heart rate, and improved mood states after viewing the kiwifruit orchard.
2	Song *et al*. (2015)[6]	20 middle-aged hypertensive participant	Forest	Urban environment	17 min	HRV, heart rate, mood states	Forest walking increased HRV and decreased heart rate; improved mood in forest vs urban setting.
3	Horiuchi *et al*. (2015) [5]	54 middle-aged and elderly individuals	Forest	Urban environment	90 min	Blood pressure, salivary amylase, mood states, activity energy expenditure	Forest walking reduced mean arterial pressure and improved mood states. Greater walking-related energy expenditure might enhance physiological benefits.
4	Li *et al*. (2016) [7]	19 middle-aged males	Forest	Urban environment	Not specified	Blood pressure, pulse rate, mood states, biological samples	Forest bathing reduced pulse rate, improved vigor, and decreased negative mood states.
5	Jia *et al*. (2016) [8]	Elderly COPD patients	Forest	Urban area	Not specified	Flow cytometry, ELISA, POMS	Reduced inflammation and stress levels; decreased negative subscales of POMS after forest exposure.
6	Song *et al*. (2018) [13]	585 participants	Forest areas	City areas	15 min	POMS, State-Trait Anxiety Inventory	Reduced negative moods and improved positive moods; greater reduction in depression for participants with high trait anxiety.
7	Takayama *et al*. (2017) [14]	Respondents not specified	Managed and unmanaged coniferous forests	Not specified	15 min per environment	POMS, PANAS, ROS, Semantic Differential Scale, Perceived Restorativeness Scale	Managed forests evaluated more positively; both forest types had restorative effects, with enhanced effects in managed forests.
8	Mao *et al*. (2017) [9]	Elderly CHF patients	Forest	Urban environment	4 days	BNP, cardiovascular factors, mood states, air quality	Forest group showed reduced BNP, lower cardiovascular risk factors, improved antioxidant function, and better mood states.
9	Yu *et al*. (2017) [8]	128 middle-aged and elderly individuals	Forest	Urban environment	2 hours	Physiological responses, mood states, anxiety levels	Lower pulse rate, blood pressure, and negative mood states; higher vigor.
10	Song *et al*. (2019) [10]	60 young women	Forest	City area	15 min	Heart rate variability, Heart rate, Blood pressure, Pulse rate, POMS, STAI	Higher parasympathetic activity, lower sympathetic activity and heart rate, improved mood states, and reduced negative feelings after forest walk.
11	Bielinis *et al*. (2018) [15]	62 young Polish adults	City forest	Urban area	15 min	POMS, PANAS, SVS, ROS	Significant decrease in negative moods and increase in positive moods; highest scores in SVS and ROS after forest exposure.

blood pressure, improvements in mood, and enhancements in autonomic nervous system function. The findings from Horuichi *et al*. and Li *et al*. highlight that both the physical activity involved and the natural environment contribute to these benefits, although the strength of these effects can vary among individuals [5,7].

The positive impact on mood states, including reduced anxiety, depression, and fatigue, is corroborated by Song *et al*. and Yu *et al*. These studies demonstrate that forest bathing can provide significant psychological relief and improve overall well-being. The improvement in cardiovascular parameters, as reported by Mao *et al*., emphasizes the potential of forest bathing as a complementary therapy for managing

chronic conditions such as Congestive heart Failure [6-9].

The reviewed studies collectively support the therapeutic potential of forest bathing, particularly in enhancing mood and reducing physiological stress responses. The evidence suggests that forest environments offer a valuable intervention for improving both mental and physical health. Future research should focus on standardizing forest bathing protocols, exploring long-term effects, and further elucidating the mechanisms underlying its benefits.

The findings of this meta-analysis provide valuable insights into the impact of forest bathing on various emotional states, including tension-anxiety, depression, anger-hostility, fatigue, confusion, and vigor. The analysis highlights the overall positive effects of forest bathing, suggesting that immersion in natural environments can significantly influence emotional well-being.

Our analysis revealed a strong positive correlation between forest bathing and reduced tension-anxiety, with a combined correlation coefficient of 0.634 (fixed effects) and 0.613 (random effects). This finding is consistent with previous studies demonstrating the stress-relieving benefits of nature exposure. For instance, a study by Park *et al*. found that exposure to natural environments significantly reduced cortisol levels and improved mood states. The high correlation in our study suggests that forest bathing can be a valuable intervention for managing anxiety, potentially offering an alternative to traditional stress-reduction techniques [16].

The meta-analysis indicated a moderate positive correlation between forest bathing and decreased depression, with correlation coefficients of 0.432 (fixed effects) and 0.557 (random effects). This aligns with research by Bratman *et al*., which showed that exposure to natural environment can alleviate symptoms of depression by enhancing mood and reducing rumination. The variability in the strength of the correlation across studies could be attributed to differences in study design and the duration of forest exposure, highlighting the need for standardized practices in future research [17].

The analysis found a substantial positive correlation between forest bathing and reduced anger-hostility, with fixed and random effects coefficients of 0.741 and 0.767, respectively. These findings support the work of Berman *et al*., who demonstrated that natural environments can lower aggressive responses and enhance emotional regulation. The high level of heterogeneity in this domain suggests that individual study characteristics, such as participant demographics and forest bathing protocols, may influence outcomes [18].

Forest bathing was also associated with a moderate reduction in fatigue, with fixed and random effects correlation coefficients of 0.572 and 0.567. This finding corroborates the research by Lee *et al*., which highlighted that time spent in nature can improve energy levels and reduce feelings of exhaustion. The relatively lower heterogeneity in this domain suggests a more consistent effect of forest bathing on fatigue, although further research is needed to explore optimal exposure durations and settings [19].

The impact of forest bathing on confusion was less pronounced, with correlation coefficients of 0.339 (fixed effects) and 0.323 (random effects). While these values are statistically significant, they suggest a weaker effect compared to other emotional states. This finding is in line with studies such as that by Hartig *et al*., which indicated that while nature exposure benefits many emotional states, its effects on cognitive functions like confusion may be less robust [20].

The analysis of vigor showed a low correlation coefficient with 0.269 ,both by fixed and random effect models. But previous research indicates that nature exposure can enhance positive feelings and overall vitality. A study by Maller *et al*. found that green space exposure is positively associated with increased vigor and well-being. However, the inconsistent results in our study may reflect variations in the methods used to measure vigor or the intensity of forest bathing experiences [21].

The study found moderate to high heterogeneity in several emotional states, suggesting variability in the effects of forest bathing across different studies. This variability may be influenced by differences in study design, participant characteristics, and forest bathing protocols. Publication bias was assessed using Egger's and Begg's tests, with results indicating no significant bias. The funnel plots also supported the absence of publication bias, suggesting that the results of this meta-analysis are robust and reliable.

The results of this meta-analysis provide compelling evidence that forest bathing significantly enhances

psychological well-being, reduces stress, and improves mood. The consistency of positive outcomes across the studies analyzed underscores the therapeutic potential of forest environments. This discussion explores the mechanisms behind these benefits, the implications for mental health interventions, and the limitations of the current research.

Forest bathing, like the effects observed with serum acetyl-carnitine in depression episodes [22] and blue light interventions on physiological parameters and circadian rhythms [23], has a profound psychological influence, potentially reducing stress and promoting mental well-being. Similar to how constant romantic experiences may protect against neurodegeneration through neurochemical pathways [24], immersion in nature may trigger positive emotional and cognitive responses, offering a non-pharmacological intervention for mental health [25,26].

Mechanisms of Psychological Benefits

Forest environments offer a unique combination of sensory stimuli that can profoundly impact psychological well-being. The presence of natural elements such as trees, water bodies, and wildlife creates a calming atmosphere that may reduce the physiological markers of stress, such as cortisol levels and blood pressure. The phenomenon of "biophilia," which suggests that humans have an innate affinity for nature, could explain why forest bathing has such a pronounced effect on mental health. Exposure to natural environments has been linked to increased activity in the parasympathetic nervous system, which promotes relaxation and recovery from stress.

Additionally, forest bathing can be seen as a form of mindfulness, where individuals are fully engaged in their surroundings, promoting present-moment awareness and reducing rumination. This mindfulness component may play a critical role in alleviating symptoms of mood disorders, as it encourages a break from the cycle of negative thoughts often associated with anxiety and depression.

Implications for Mental Health Interventions

The findings of this meta-analysis suggest that forest bathing could be a valuable addition to existing mental health interventions. It offers a non-invasive, low-cost, and accessible option for individuals seeking to improve their mental well-being. Healthcare providers and therapists could consider incorporating forest therapy into treatment plans, especially for patients with anxiety, depression, or chronic stress.

Moreover, the benefits of forest bathing are not limited to individuals with mental health conditions. As a preventive measure, regular engagement with natural environments could promote resilience to stress and improve overall quality of life. This could be particularly beneficial in urban areas, where access to natural spaces is limited, and stress levels are typically higher.

Future Research

Future research should aim to standardize the methodology for studying forest bathing, including consistent outcome measures and longer follow-up periods to assess the sustainability of the benefits. There is also a need for more research into the specific components of forest environments that contribute to psychological well-being. Understanding whether certain types of forests (e.g., coniferous vs. deciduous) or specific features (e.g., water bodies, biodiversity) are more beneficial could help optimize forest therapy practices.

Furthermore, the role of individual differences, such as age, gender, and baseline mental health status, in the effectiveness of forest bathing should be explored. Personalizing forest therapy based on these factors could enhance its efficacy.

CONCLUSION

The findings of this meta-analysis confirm the therapeutic potential of forest environments in promoting mental health. The study demonstrated significant reductions in psychological parameters such as tension-anxiety, depression, anger-hostility, fatigue, and confusion. These effects were robust across different models, despite some variability between studies. Moreover, the weak positive association with vigor highlights that forest bathing can enhance emotional well-being in a holistic manner. Given the observed positive effects, forest bathing could be integrated into public health strategies as a non-pharmacological intervention for stress and mood disorders.

Outcomes of the Study

This meta-analysis provides strong evidence that forest bathing significantly reduces negative emotional states, particularly tension-anxiety, depression, and anger-hostility. The pooled results from six studies

suggest that forest immersion can lead to measurable improvements in mental health. Additionally, fatigue and confusion were moderately reduced, while vigor showed a weaker, yet positive association.

Rationale of the Study

The rationale for this study stemmed from increasing interest in non-pharmacological interventions for managing stress and mood disorders. Forest bathing, as a practice that emphasizes connection with nature, has gained global attention for its potential mental health benefits. However, there was a need to systematically analyze the evidence to provide conclusive insights into its psychological impacts. This study fills that gap by quantitatively assessing the effect of forest environments on six distinct emotional states, helping to guide future public health policies and interventions.

Limitations of the Study

This meta-analysis has some limitations. First, the number of included studies was relatively small, with only six studies meeting the inclusion criteria, which may affect the generalizability of the results. Second, there was significant heterogeneity in some of the psychological parameters, such as anger-hostility (I^2 = 90.12%) and tension-anxiety (I^2 = 67.57%), which suggests variability in how forest bathing was implemented and measured across studies. Third, the analysis was restricted to studies published in English, potentially excluding relevant research in other languages. Lastly, while the study provides evidence of forest bathing's psychological benefits, it does not fully explore long-term effects or the optimal frequency and duration of forest immersion for sustained improvements.

AUTHOR CONTRIBUTIONS

Jyoti Brahmaiah: Conceptualization, Methodology, Writing – Original Draft Preparation.

Alfred J Augustine: Supervision, Project Administration, critical insights and feedback to study

Ramya Ramakrishnan: Supervision, Project Administration, critical insights and feedback to study

Kishore A: Review of literature

Usha Adiga: statistical analysis

Praveen Hoogar: Review of literature

CONFLICTS OF INTEREST

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REFERENCES

[1] Li Q. Effects of forest environment (Shinrin-yoku/Forest bathing) on health promotion and disease prevention -the Establishment of “Forest Medicine”. Environ Health Prev Med 2022; 27: 43. https://doi.org/10.1265/ehpm.22-00160

[2] Bang KS, Lee I, Kim S, *et al.* The Effects of a Campus Forest-Walking Program on Undergraduate and Graduate Students' Physical and Psychological Health. Int J Environ Res Public Health 2017; 14(7): 728. https://doi.org/10.3390/ijerph14070728

[3] a. Chen H-T, Yu C-P, Lee H-Y. The Effects of Forest Bathing on Stress Recovery: Evidence from Middle-Aged Females of Taiwan. Forests 2018; 9(7): 403. https://doi.org/10.3390/f9070403

[3] b. Berman MG, Jonides J, Kaplan S. The cognitive benefits of interacting with nature. Psychological Science 2008; 19(12): 1207-1212. https://doi.org/10.1111/j.1467-9280.2008.02225.x

[4] Keller J, Kayira J, Chawla L, Rhoades JL. Forest Bathing Increases Adolescents' Mental Well-Being: A Mixed-Methods Study. Int J Environ Res Public Health 2023; 21(1): 8. https://doi.org/10.3390/ijerph21010008

[5] Horiuchi M, Endo J, Akatsuka S, *et al.* An effective strategy to reduce blood pressure after forest walking in middle-aged and aged people. J Phys Ther Sci 2015; 27(12): 3711-3716. https://doi.org/10.1589/jpts.27.3711

[6] Song C, Ikei H, Kobayashi M, *et al.* Effect of forest walking on autonomic nervous system activity in middle-aged hypertensive individuals: a pilot study. Int J Environ Res Public Health 2015; 12(3): 2687-2699. https://doi.org/10.3390/ijerph120302687

[7] Li Q, Kobayashi M, Kumeda S, *et al.* Effects of Forest Bathing on Cardiovascular and Metabolic Parameters in Middle-Aged Males. Evid Based Complement Alternat Med 2016; 2016: 2587381. https://doi.org/10.1155/2016/2587381

[8] Yu CP, Lin CM, Tsai MJ, Tsai YC, Chen CY. Effects of Short Forest Bathing Program on Autonomic Nervous System Activity and Mood States in Middle-Aged and Elderly Individuals. Int J Environ Res Public Health 2017; 14(8): 897. https://doi.org/10.3390/ijerph14080897

[9] Mao G, Cao Y, Wang B, *et al.* The Salutary Influence of Forest Bathing on Elderly Patients with Chronic Heart Failure. Int J Environ Res Public Health 2017; 14(4): 368. https://doi.org/10.3390/ijerph14040368

[10] Song C, Ikei H, Kagawa T, Miyazaki Y. Effects of Walking in a Forest on Young Women. Int J Environ Res Public Health 2019; 16(2): 229. https://doi.org/10.3390/ijerph16020229

[11] Igarashi M, Miwa M, Ikei H, Song C, Takagaki M, Miyazaki Y. Physiological and Psychological Effects of Viewing a Kiwifruit (Actinidia deliciosa 'Hayward') Orchard Landscape in Summer in Japan. Int J Environ Res Public Health 2015; 12(6): 6657-6668. https://doi.org/10.3390/ijerph120606657

[12] Jia BB, Yang ZX, Mao GX, *et al.* Health Effect of Forest Bathing Trip on Elderly Patients with Chronic Obstructive Pulmonary Disease. Biomed Environ Sci 2016; 29(3): 212-218.

[13] Song C, Ikei H, Park BJ, Lee J, Kagawa T, Miyazaki Y. Psychological Benefits of Walking through Forest Areas published correction appears in Int J Environ Res Public Health 2020; 17(4): E1316. Int J Environ Res Public Health 2018; 15(12): 2804. https://doi.org/10.3390/ijerph15122804

[14] Takayama N, Fujiwara A, Saito H, Horiuchi M. Management Effectiveness of a Secondary Coniferous Forest for Landscape Appreciation and Psychological Restoration. Int J Environ Res Public Health 2017; 14(7): 800. https://doi.org/10.3390/ijerph14070800

[15] Bielinis E, Takayama N, Boiko S, Omelan A, Bielinis L. The effect of winter forest bathing on psychological relaxation of young Polish adults. Urban For Urban Gree 2018; 29: 276-83. https://doi.org/10.1016/j.ufug.2017.12.006

[16] Park BJ, Tsunetsugu Y, Kasetani T, Kagawa T. The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): Evidence from field experiments in 24 forests across Japan. Environmental Health and Preventive Medicine 2010; 15(1): 18-26. https://doi.org/10.1007/s12199-009-0086-9

[17] Bratman GN, Hamilton JP, Daily GC. The impacts of nature experience on human health and cognition. Annual Review of Psychology 2015; 66: 601-630.

[18] Berman MG, Jonides J, Kaplan S. The cognitive benefits of interacting with nature. Psychol Sci 2008; 19(12): 1207-1212. https://doi.org/10.1111/j.1467-9280.2008.02225.x

[19] Lee J, Jordan M, Horsley J. Contact with nature and mental health: A review of the evidence. European Journal of Public Health 2015; 25(4): 769-776.

[20] Hartig T, Mang M, Evans GW. Restorative effects of natural environment experiences. Environment and Behavior 1991; 23(1): 3-26. https://doi.org/10.1177/0013916591231001

[21] Maller C, Townsend M, Pryor A, Brown P, St Leger L. Healthy nature healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. Health Promotion International 2006; 21(1): 45-54. https://doi.org/10.1093/heapro/dai032

[22] Varma RS, Kumar BGP, Krishna CSM. Serum acetylcarnitine as a diagnostic marker in depression episodes. Biomedical and Biotechnology Research Journal 2024; 8(2): 194-199. https://doi.org/10.4103/bbrj.bbrj_132_24

[23] Ahmed I, Bernhardt GV, Shivappa P. Prevalence of academic procrastination and its negative impact on students. Biomedical and Biotechnology Research Journal 2023; 7(3): 363-370.

[24] Gholami M, Emanuele E, Motaghinejad M. Constant romantic feelings and experiences can protect against neurodegeneration: Potential role of oxytocin-induced nerve growth factor/protein kinase B/cyclic response element-binding protein and nerve growth factor/protein kinase B/phospholipase C-gamma signaling pathways. Biomedical and Biotechnology Research Journal 2023; 7(1): 24-31. https://doi.org/10.4103/bbrj.bbrj_28_23

[25] Fatima N, Sonkar GK, Singh S, Sonkar SK, Mahdi AA. Impact of blue light intervention on physiological parameters and circadian rhythms: Insights from a Wistar rat model study. Biomedical and Biotechnology Research Journal 2024; 8(2): 160-165. https://doi.org/10.4103/bbrj.bbrj_117_24

[26] Libyan Pharmacy Professionals' Knowledge, Attitudes, and Practices Regarding Generic Substitution for Prescribed Brand Medications. Biomedical and Biotechnology Research Journal 2024; 8(Abstract Supplement): S2. https://doi.org/10.4103/bbrj.bbrj_59_24

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