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The Effects of Forest Bathing on Anxiety in Adults: A Systematic Review

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Abstract

Background: Adult anxiety is a global health concern. This systematic review examined the effects of forest bathing on adult anxiety levels. Management of anxiety levels aligns with the United Nations Goal 3: Ensure healthy lives and promote well-being.

Methods: Inclusion criteria were full-text English articles from 1999 to 2023, of systematic reviews, meta-analyses, qualitative, quantitative, and mixed-method studies. Researchers searched eight databases for full-text peer-reviewed research articles about the effects of forest bathing on adults 18 years and older with an anxiety measure. Exclusion criteria were non-English, non-full-text, non-research, animal subjects, humans under the age of 18 years, and laboratory/video watching studies. Through Academic Search Premier, Biomedical Central, Cumulative Index of Nursing and Allied Health Literature Ultimate, Health Source: Nursing, Medline, PubMed, Science Direct, and Sigma Nursing databases, 1,340 articles were retrieved.

Results: Thirteen studies met the final inclusion criteria after four screening phases. The total number of primary adult study participants was 906, with a mean age of 41.25. Review studies included 7,513 participants. Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines steered the screening/reporting of this mixed-methods study. Synthesis Without Meta-analysis guidelines also drove the reporting of study data. The quality assessment with diverse studies tool was used to assess reporting and transparency. Researchers independently reviewed studies via extraction tables, comparing analyses for discussion and decisions. Thirteen reviewed studies found that forest bathing as an intervention reduces adult anxiety levels.

Conclusions: Forest bathing in adults reduced anxiety levels. Limitations include sample non-generalizability to broad populations and measurement concerns. Future rigorous methods and generalizable sampling would progress the effects of forest bathing on anxiety research. Implications include forest bathing to decrease anxiety levels, which aligns with the United Nations Sustainable Development Goal 3: Ensure healthy lives and promote well-being.

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Introduction

Researchers have studied the mental health benefits, specifically the anxiety level effects of spending time in forest settings. Stress and anxiety are both public health concerns. All people experience anxiety in life, such as schoolwork, employment, or paying bills. Increased levels of anxiety and depression are associated with reduced healthy life expectancy in the 2025 global data [1]. Anxiety disorders and depressive disorders are the most common mental health conditions occurring globally in both females and males [2]. Impacts of the rising global burden of anxiety in adolescents and young adults relate to socioeconomic factors and COVID-19 experiences [3]. The United Nations Sustainable Development Goals Report includes Goal 3: Ensure healthy lives and promote well-being for all ages [4]. Goal 3 includes target 3.4, preventing and treating mental health and well-being [5]. Forest bathing is a globally available intervention that aligns with the United Nations (UN) Sustainable Development Goal 3: to ensure healthy lives and promote well-being.

Forest bathing (FB) is a translation of the Japanese term "Shinrin-yoku," which means spending time in forests [6]. Forest bathing is spending time in forests or wooded areas, viewing/watching the landscape, walking, or combining both. The literature includes numerous holistic health benefits of forest bathing, from physical, psychological, and spiritual health promotion [7]. Various health benefits from forest bathing include increased cytotoxic T lymphocyte cell counts related to breathing in phytoncides [8,9], lowered systolic and diastolic blood pressure [10], and improvements in mental health (depression and stress levels) [11]. This systematic review aimed to evaluate and synthesize research studies to examine the effects of forest bathing, a globally available intervention, on anxiety levels in adults.

Attention Restoration Theory

Attention Restoration Theory (ART) proposes that spending time in natural settings allows for unstructured attention periods, promoting recovery from mental fatigue, stress, and negative moods [12]. ART includes four cognition states that people experience:

1. Clearer concentration or clearer head,
2. Recovery of mental fatigue,
3. Soft fascination allowing space for reflection (such as watching clouds and listening to nature sounds) and
4. Reflection and restoration

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Being in natural environments promotes restoration from mental fatigue [13]. Participants significantly improved their attention performance after ten minutes of walking in a natural setting [14]. Improving attention control may diminish the development of anxiety [15]. Drivers on freeways with green landscapes were more mentally alert than drivers on freeways without green landscapes [16]. Humans who walked on forested and park trails contributed more to perceived restoration and positive affect or state of mind [17], and a positive affect that reduces the effect of anxiety [18]. The restoration and recovery of spending time within nature or forests promotes restoration. For this systematic review study, the research questions were:

1. What are the effects of forest bathing (walking and being in the woods) on anxiety levels in adults aged 18 years and older? (Primary question)
2. What is the methodology rigor of the forest bathing studies reviewed?

Methodology

This study used a systematic review without a meta-analysis approach because of varying study designs and was exempt from institutional review for ethics. The study adhered to the Cochrane Handbook for Systematic Reviews of Interventions [19,20], Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [21], and the Synthesis Without Meta-analysis (SWiM) guidelines for reporting [22].

Eligibility criteria

The studies were full-text articles in English published from 1999 to 2023. They included systematic reviews, meta-analyses, and qualitative, quantitative, and mixed-methods studies. The population examined was human adults aged 18 years and older. An anxiety measure and a forest setting for the intervention were a requirement for inclusion. We excluded studies with humans less than 18 years of age, animal subjects, laboratory-setting studies, or research on watching videos of forests. Partial-text articles, non-research, or studies in languages other than English were excluded

Literature search strategy

A search of eight databases for research articles included Academic Search Premier, Biomedical Central, Cumulative Index of Nursing and Allied Health Literature (CINAHL) Ultimate, Health Source: Nursing, Medline, PubMed, Science Direct, and Sigma Nursing Repository. The key search terms included “forest bathing” AND “anxiety” (OR) “forest bathing” AND “anxiety levels in adults” (OR) “forest therapy” AND “anxiety” (OR) “forest environment” AND “anxiety.” The search ranged in publications from January 1999 to November 2023.

Study selection

Four phases of article selection processing were present for this study. The first phase assessed matching for the search terms forest bathing/therapy and anxiety. The second phase involved title and abstract screening of articles with the words forest bathing and anxiety. The third phase involved removing duplicates and sorting articles for inclusion with an anxiety measure. Both researchers assessed all study settings for the time duration of the intervention and a natural forest environment, and excluded any study using a laboratory setting during the fourth phase. Each study was identified as qualitative, quantitative, or mixed methods.

Quality assessment

The studies included diverse methodological approaches and measures. Two researchers independently assessed the risk of quality bias using the quality assessment with diverse studies (QuADS) tool, an updated appraisal for use with studies of various methodologies (inter-rater reliability Cohen's Kappa of 0.66) [23]. Any disparities between the two researchers' quality assessments were deliberated in a meeting to discuss the findings and reach a final agreement.

Data collection process and measures

The two researchers set up data extraction worksheets categorized by Level of Evidence (LOE), Quality Rigor and Bias Assessment, and Study Summary. The seven levels of evidence model [24] was used to analyze each study and determine the level of evidence. The QuADS tool, a recent evidence-based version of the Quality Assessment Tool for Studies with Diverse Designs (QATSDD) [23], was applied to assess the risk of quality bias and sensitivity analysis. Each researcher independently completed the data extraction worksheets, and any differences were discussed and resolved through shared decision-making in a meeting. One summary table of the data was then prepared from the extraction tables. Both researchers independently analyzed and reviewed the final summary table, and then finalized it together.

The PRISMA search process will evolve into a figure from a PRISMA worksheet the researchers created to document the search process, databases used, the number of articles, and the four review phases guided by the inclusion/exclusion criteria.

Data analysis methods and synthesis

The studies in this review include a variety of measures and methodological approaches, so meta-analysis was not feasible. The analysis and reporting include the studies' Levels of Evidence [24]. The study adhered to the SWiM guidelines for data analysis and reporting. Based on study evidence, each study sample was assessed for subgroup analysis (age, gender, race, clinical diseases) of heterogeneity.

Results

Literature search strategy and study selection

A search of eight databases (Academic Search Premier, Biomedical Central [CINAHL] Ultimate, Health Source: Nursing, Medline, PubMed, Science Direct, and Sigma Nursing) found 1,340 records that were then screened for search terms of forest bathing/therapy and anxiety in the titles and abstracts, resulting in 1,308 articles left (Figure 1). Next, researchers removed duplicates and reviewed the full-text articles to include only studies with an anxiety measure. The final phase was a deep full-text review of each article for inclusion of only those studies with a natural forest setting. Studies of forest videos, digital images of forests, or a laboratory setting were excluded. The final number of studies included was 13, quantitative or mixed methods.

Study characteristics

Table 1 summarizes the characteristics of the studies included. Eleven studies were quantitative, and two were mixed methods. Three

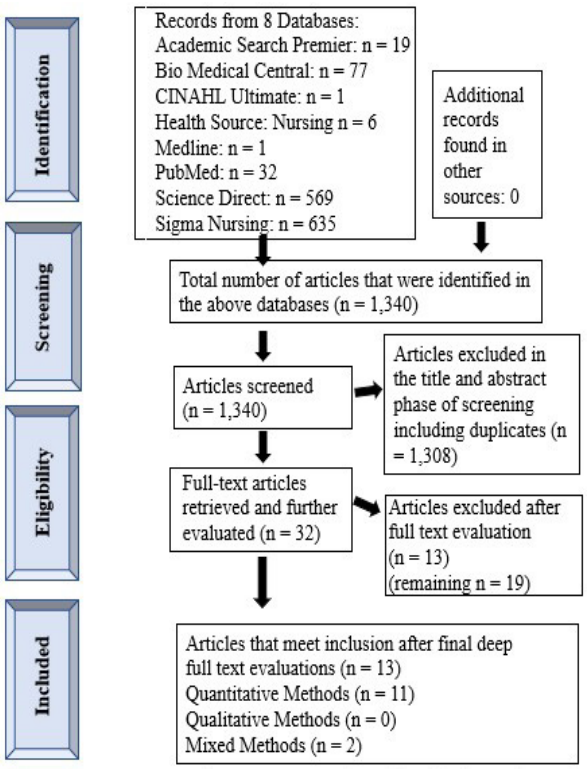


Figure 1: PRISMA literature search and inclusion flow chart.

studies studied the geographic locations of the forests in Japan [25-27]. Five studies reviewed the literature [28-32]. Three studies collected data after forest bathing in China [6,33-34]. One study used forest settings in Germany [35], and one forest bathing study location was Canada [36].

Data extraction

The researchers completed all data extraction independently and then compared it. They held meetings to discuss any discrepancies and reach final agreements. Researchers grouped the thirteen studies using the research questions. Outcomes were grouped into two major categories based on the effect of forest bathing on anxiety levels in adults and the quality of studies. After sensitivity analysis of sampling, for a high risk of bias, missing reporting, comparison to the full dataset, and conclusions, thirteen studies remained in the review.

Forest bathing outcomes in adults

The anxiety measures that were used, State-Trait Anxiety Inventory (STAI) [6,26,33] and Profile of Mood States (POMS) tension-anxiety measure [25,27,35-36], showed all decreased anxiety levels after forest bathing. One systematic review reported the Hospital Depression Anxiety (HADS), STAI, and POMS tension-anxiety measures, all of which decreased in adults after forest bathing [30]. An anxiety level survey related to financial state, exam-pass pressure, and love-affair relationships reported decreased anxiety from the financial state but not exam-pass or love-affair relationship stress [34]. Review studies using the STAI and POMS measures reported decreased anxiety levels after forest bathing [28-29,31-32]. In all thirteen studies, adults experienced decreased anxiety levels after forest bathing (Table 1 for summary). One study compared a forest bathing setting intervention in which participants had reduced anxiety levels to a cultivated field setting intervention where the participants had significantly decreased anxiety levels [35].

Quality assessment

The second research question was: What is the methodology rigor of the forest bathing studies reviewed? The data extraction, sensitivity analysis, synthesis summary, and quality rigor and bias assessment worksheet were then re-formatted to an ordering table according to the LOE of the studies for deeper evaluation using the QuADS tool. After the independent reviews and meetings to discuss discrepancies, the researchers evaluated the strengths and limitations of each study design and bias agreement as noted in the ordering table (see Table 1). The framework elucidated the risk of bias concerns in all studies, irrespective of the LOE. Groups (control, intervention), methods, design, sampling, measures (reliability/validity), procedures, generalizations, and analyses were analyzed. Two researchers independently scored each study, using the 0-3 scoring for the thirteen criteria. Researchers held discussions and reached a consensus on any score differences.

Eleven studies were quantitative, zero were qualitative, and two were of mixed-method design. Three studies were LOE I; six studies were LOE II; two studies were LOE III, one study was LOE IV, and one study was LOE V. The research designs of the studies were systematic reviews (n = 3), randomized control trials (n = 6), quasi-experimental (n = 2), integrative review (n = 1), and one broad literature review (Table 2).

Eight primary studies used convenience sampling [6,25-26,33-36]. Two studies reported following PRISMA for reporting article search strategies [30,32]. One systematic review reported some selection criteria, paper search, screening, and data extraction [31]. One integrative review used PRISMA guidelines adapted for integrative reviews [29]. One broad review reported numbers, date ranges, databases, keywords, and inclusion criteria for articles selected [28]. Two studies did not report reliability or validity information of POMS or STAI measures [6,33]. The reliability of the STAI measure ranges from 0.81 to 0.89 [26]. One study reported the POMS reliability in the study sample between 0.62 and 0.71, but did not report STAI measure reliability [36]. Another study reported using negative-score questions for every fourth question for the anti-anxiety measure, but it did not report reliability [34]. One study reported a high level of reliability and validity but did not report a reliability coefficient [27]. One study reported the validity of the study design of setting locations but did not report the reliability of the German POMS measure [35]. QuADS scores ranged from 16 to 36 (Table 1 for details).

The total number of primary adult study participants was 906, ages 19 to 80 years [6,25-27,33-36] with a mean age of 41.25. Six of the eight primary studies accounted for 369 participants who were all university students [6,25,27,33-34,36]. One study reported a mean age of participants at 45 [35]. One primary study with 498 participants had an average age of 56.2 years [26]. There were 509 male and 397 female participants in the primary studies reviewed [6,25-27,33-36].

Participants in six primary studies were reported as healthy adults [6,26-27,33-34,36], or healthy highly sensitive persons of adult age [35]. Participants in one study were screened for mental disorders and cardiovascular or allergic diseases, and excluded those with habitual

Table 1: Ordering table of included research summaries.

Authors Year	Purpose & Forest type & description	Methodology, Design & Sampling	Results, Conclusions specific to anxiety, QuADS
Level of Evidence I, n = 3			
Wen et al. (2019) [31]	Health efficacy of FB to improve health in humans; reviewed studies and reported restorative measures but did not discuss ART	Mixed methods systematic Review of 28 quantitative studies (11 NRCT and 17 RCT) published from January 2015 to April 2019 and found using three databases; used a qualitative approach; used the quantitative Downs and Black checklist to guide analysis; measures in the studies included POMS tension-anxiety, STAI, and homemade anti-anxiety scores; the total number of participants = 924	Six studies reviewed found a significant decrease in anxiety after forest bathing (POMS tension-anxiety, STAI, homemade anti-anxiety score measures); forest bathing may improve health by reducing anxiety levels; QuADS score = 36
Yau & Loke (2020) [32]	To review the effects of FB on blood pressure and anxiety levels; wrote that forest settings promote healing, health, and well-being, but did not specify Restorative Theory	Quantitative systematic Literature Review; 14 research articles included; dates for inclusion were the inception of the database Full-text Database (CNKI) through April 2019; 5 databases searched for many studies used POMS and STAI measures; studies had middle and older aged adult participants; PRISMA; used the quality assessment tool for studies with diverse designs (QATSDD); the total number of participants = 125	Reduction in anxiety levels in middle to older-aged adults (POMS, tension-anxiety, and STAI scores); forest bathing reduces anxiety in middle and older-aged adults; QuADS score = 27
Siah et al. (2022) [30]	Studied psychological benefits of FB; Forest or natural settings; Used Restorative Theory Framework	Quantitative systematic review and meta-analysis; 36 peer-reviewed studies published from January 2020 to March 2021; studies were RCT (22), quasi-experimental (7), crossover (7); PRISMA guidelines for reporting; six studies used the STAI measure; two studies used the Hospital Anxiety Depression Scale measure; seven studies used the POMS tension-anxiety measure; total number of participants = 3554	Anxiety measures in studies under review found statistically significant decreases in anxiety levels after forest bathing in the intervention groups for the meta-analysis; benefits of reduction of anxiety from forest bathing with caution to lessen selection bias in future studies; QuADS score = 27
Level of Evidence II, n = 6			
Lee et al. (2011) [25]	Studied physiological and psychological benefits of FB; Urban versus Rural FB; restorative not included in the article	Quantitative RCT; within-group comparisons of rural versus forest groups; convenience sample of 12 young Japanese male university adult participants; those with habitual drinking and smoking were excluded; random selection of 6 participants for the experiment for random sampling within a non-probability sample; mean age of 21.2 years; 3-day, 2-night field experiment; Forest Time 15 min for three days in a row; four data collection points; semantic differential measures of comfortable and soothed; feeling of refreshed survey measure; POMS tension and anxiety measure; POMS reliability not reported; study took place in Japan; total number of participants = 12	POMS tension-anxiety level was significantly decreased after the forest setting, but increased after the urban setting; participants reported comfortable, soothed, and refreshed feelings significantly lower in the forest setting than in the urban setting; forests likely play a role in preventative medicine; QuADS score = 21
Oomen-Welke et al. (2022) [35]	Studied psychological benefits of FB; Forest and field settings; did not use restorative framework or effects	Facebook posts and screened via telephone interviews; convenience sample; 39 participants; healthy, highly sensitized participants with a mean age of 45 years; 4 males; 35 females; German version of POMS tension and anxiety measure; German POMS reliability for sample not reported; did design data collection settings to be similar and geographically close for internal validity; study took place in Germany; time in forest one hour (control group time one hour in field); one hour = 3600 seconds International System	POMS tension-anxiety measure decreased after forest bathing but was significantly decreased after being in a cultivated field; QuADS score = 21
Hassan & Deshun (2023) [33]	Studied FB effects of quality of sleeping and anxiety levels; bamboo forest park (intervention) versus indoor room (control); no restorative comments	Quantitative RCT; convenience sample; 50 young university adults; mean age 19.8 years; 25 healthy males and 25 healthy females; participants allocated to group I and group II but does not include if assignment was random; control group = 25; intervention group = 25; four hours from 9 am to 1 pm; before and after STAI measures; did not report statistical reliability of STAI measure; study took place in China; time in forest four hours of sleeping; recruitment details not included, but said used healthy volunteers and screened by checking for a normal EEG	Both groups had reductions STAI anxiety measure, but the intervention group had a significantly more reduction in anxiety levels; concluded that young adults sleeping in bamboo forest had anxiety reduction; QuADS score = 20

Continued...

Authors Year	Purpose & Forest type & description	Methodology, Design & Sampling	Results, Conclusions specific to anxiety, QuADS
Hassan et al. (2018) [6]	Studied the physiological and psychological relaxation effects of FB; Bamboo forests versus City Environments; did not mention restorative	Quantitative RCT; 60 University Student Participants; posted posters to recruit sample at University; 30 participants were male and 30 participants were female; convenience sampling; control group = 30, intervention group = 30; age range of participants 19-24 years with a mean age of 19.6; STAI measure; reliability of STAI measure not reported; On the first day of study, the intervention group was in a bamboo forest setting and walked for 15 minutes, the control group was in an urban setting and walked for 15 minutes; On day two of study, The intervention and control group switched settings; average temperatures in settings ranged from 22 to 27 degrees C.; study took place in China; time in forest 15 minutes each day	STAI measure had significant reductions in anxiety after walking in a bamboo forest over a city park; concludes that walking in a bamboo forest reduces anxiety levels; generalized data to adults; QuADS score = 20
Park et al. (2011) [27]	Studied psychological benefits of FB; Rural versus urban forests; discussed restorative effects of forest setting	Quantitative RCT; Therapeutic Effects of Forest project compared 14 forest settings and 14 urban areas with randomized groups; groups were then further assigned to viewing and walking of the settings; recruited 168 male participants (university students) with a mean age of 20.4 years; POMS tension and anxiety measure; reported a "high level of reliability and validity" (p. 25); took place in Japan; 15 minute view/15-minute walk	Before and after measures of urban viewing and urban walking had significant increases in POMS tension and anxiety measure, whereas before and after measures of forest viewing and walking had significant decreases in POMS tension and anxiety measure; QuADS score = 17
Zhou et al. (2019) [34]	To examine FB effects on anxiety levels; Rural and urban forest settings; discussed the restorative effect of forest bathing	Quantitative RCT; 43 university student participants with forest ecology major with a mean age of 20.74 years (range 19-23); 24 participants in the intervention group and 19 participants in the control group; 8 males and 35 females; compared anxiety in groups in before and after urban forest area bathing and rural forest area bathing during the winter season; study lasted for two days; used anti-anxiety measure with scores 1-10 to quantify their perceived anxiety level—referred to as anti-anxiety scores; did report the measure was reliable, but did not report reliability statistics for the 12 question measure; used negative-score questions every fourth question; specifically studied anxiety from financial state, exam-pass pressure, and love-affair relationship; took place in China;	After the urban forest setting, participants reported decreased anxiety from financial state, exam-pass pressure, and love-affair relationship stress; After the rural forest setting, participants reported decreased anxiety from financial state, but not exam-pass or love affair relationship stress; the researchers concluded university students benefit from urban forests to reduce anxiety from exam-pass rates and love/affair stress; the rural and urban settings were similar; QuADS score = 16
Level of Evidence III, n = 2			
He et al. (2023) [36]	Studied physical and psychological effects of FB; Forest setting; discussed restorative theory but did not find supporting evidence	Quantitative pre-test/post-test randomization of subjects for data analysis; did not have a control group (quasi-experimental); 36 healthy graduating college students with mean age of 24.4; 18 male and 18 female participants; convenience sample, POMS tension and anxiety; reported sample reliability of POMS as 0.62-0.71; STAI measures; no report of STAI reliability; 2 hours forest immersion program; 2-hour time in a forest setting; study took place in Canada; total number of participants = 36	After the forest immersion program, participants had a decrease in anxiety measures per STAI and decreased POMS tension-anxiety measure after forest immersion program; a two-hour time in a forest setting is promising for decreasing anxiety; QuADS score = 22

Continued...

Authors Year	Purpose & Forest type & description	Methodology, Design & Sampling	Results, Conclusions specific to anxiety, QuADS
Morita et al. (2007) [26]	Studied psychological benefits of FB; University Forest (vague); no mention of restorative Studied psychological benefits of FB; University Forest (vague); no mention of restorative	Quantitative; quasi-experimental (not randomized); control and intervention groups; convenience sample of 498; 254 healthy females; 244 healthy males; 20 years age or over (mean age 56.2); STAI measure with reliability of 0.81-0.89; 2-way ANOVA; time in forest 2 hours, 20 minutes; study took place in Japan; total number of participants = 498	STAI measure had significantly decreased anxiety levels in the forest group, but not in the control group; concludes forest environments contribute to health and well-being; QuADS score = 22
Level of Evidence IV, n = 1			
Leibold (2021) [29]	Studied FB effects on anxiety in adults Forest; did not include restorative	Mixed Methods Integrative Review of 2015-2020 years; six databases: CINAHL, Health and Medical Collection, OVID, Pub Med, Public Health Database, and Science Direct; PRISMA; 11 quantitative research articles reviewed; examined forest; watching and walking, as well as study rigor; studies reviewed used POMS tension-anxiety and STAI measures; total number of participants = 1,243	Decrease in anxiety levels in adults per POMS tension-anxiety and STAI in studies reviewed; Stressed the importance of the descriptions of forest settings as found this may impact reductions in anxiety levels; QuADS score = 25
Level of Evidence V, n = 1			
Farrow & Washburn (2019) [28]	Studied benefits of FB on heart rate variability, activation of PNS, effects on anxiety; Rural and Urban forest settings for 2-4 hours; restorative not mentioned	Quantitative, broad literature review of 2008-2018 years; PubMed, Science Direct databases used; in the methods section, the article reads that nine articles were chosen for the review, but the table of review result includes ten articles; adult participants with the most between ages 30-69 years; POMS tension-anxiety (Did not report reliability/validity); Time in the forest: 2-4 hours; total number of participants = 1,667	POMS tension-anxiety and STAI measures decreased after forest bathing in all studies; concluded that time in the forest may be linked to the amount of anxiety reduction; QuADS score = 24

Table 2: Primary Studies Comparisons of Sampling Analysis

Study Author(s)	Mean Age in Years	Participant Number	Gender Number	Health Status of Adult Participants	Type of Sampling
Lee et al. (2011) [25]	21.2	12	0 females 12 males	Screened for mental disorders and cardiovascular or allergic diseases; excluded those with habitual smoking and drinking alcohol	Random sampling within a non-probability sample
Oomen-Welke et al. (2022) [35]	45	39	35 females 4 males	Healthy highly sensitive	Convenience
Hassan & Deshun (2023) [33]	19.8	50	25 females 25 males	Healthy	Convenience
Hassan et al. (2018) [6]	19.6	60	30 females 30 males	Healthy	Convenience
Park et al. (2011) [27]	20.4	168	0 females 168 males	Healthy	Convenience
Zhou et al. (2019) [34]	20.74	43	35 females 8 males	Healthy	Convenience
He et al. (2023) [36]	24.4	36	18 females 18 males	Healthy	Convenience
Morita et al. (2007) [26]	56.2	498	254 females 244 males	Healthy	Convenience
	Total Mean 41.25 years	Total 906	Total 397 females 509 males		

smoking and drinking alcohol [25]. Six of the eight primary study participants were university-educated. Two primary studies included mostly middle-aged to older adults and did not include education level information [26,35].

The research review studies included in this study had 7,513 participants [28,29,30,31,32]. The education status of participants was unknown in review studies [28,29,30,31,32]. The total number of participants in this study from primary and review studies was 8,417 [35].

Discussion and Implications

Primary research question

This systematic review had one primary and one secondary outcome finding. The primary question of the effects of forest bathing on anxiety levels in adults aged 18 years and older found consistent evidence of decreased anxiety levels after forest bathing in all thirteen of the reviewed studies [6,25-36]. However, one study quantified by the POMS tension-anxiety measure found that anxiety decreased after forest bathing but significantly decreased after time in the cultivated field [35]. Previous studies [7-11] about desirable physical, psychological, and spiritual health improvement, phagocyte immune response to produce cytotoxic T lymphocytes, and lowered blood pressure effects after forest bathing may vary in a cultivated field. Further examination of the forest versus cultivated field settings is warranted in future studies.

Secondary research question: quality assessment

A secondary finding was the quality assessment of the reviewed studies. Use of the PRISMA [21], SWiM reporting guidelines [22], and QuADS appraisal tool [23] illuminated the reporting process for the narrative and Table 1. A wide range of bias risks was present in the studies. Most studies used nonprobability convenience sampling, which may contribute to selection bias as researchers recruited participants at their university [6,25-27,34,36]. One article did not report how researchers recruited and assigned participants to Groups I and II [33]. One study reported recruiting university students who were forest ecology majors, which may contribute to positivity bias [34]. The primary studies included more male subjects than female subjects. Increased study population sampling of the general population and probability sampling of equitable genders, varied ages, health status, and education could improve generalizability in future studies. Furthermore, studying the differences in the sample characteristics in the effect of forest bathing on anxiety levels is worthy of examination.

One study included a homemade survey measure of anxiety with a focus on financial state, exam-pass pressure, and love-affair relationship anxiety [34]. The same study also uses an urban forest setting as the control and a rural forest setting as the intervention [34]. Although anxiety levels decreased, the rural forest setting participants reported reduced anxiety from the financial state, but not exam-pass or love affair relationship stress [34]. Further validity and reliability testing of the homemade measure of anxiety factors is necessary to continue testing the forest bathing effects of various anxiety factors.

In the studies reviewed, the participants consistently reported decreased [32,34-35] and significantly reduced anxiety levels after forest bathing [6,25-27,29-28,30-31,33,36]. However, to assume cause and effect, randomization, sufficient and equitable sampling (ages, gender, health status, education), and inclusion of control and intervention groups are necessary. Six of the eight primary studies used experimental design [6,25-27,33-35]. Although study data findings decrease anxiety levels after time in the forest, more studies with an experimental design and equitable samples are best for cause and effect. The identified areas for quality improvement could improve global confidence in study findings.

Combining the various adult ages in the study did contribute to generalizability. However, concerns about selection bias limit generalizability. Since most participants were healthy, this may contribute to forest bathing appearing more effective than it actually is. The generalizability would be improved by designing a study that includes an equitable number of healthy and unhealthy participants. Generalizing the findings requires further studies focusing on the design of participant sampling and sampling strategies, specifically, equitable adult ages, genders, health status, and education status.

The QuADS appraisal tool recognizes mixed methods as a valuable methodology [23]. Two studies used mixed methods [29,31], while the remaining were quantitative [6,25-28,30,32-36]. Using mixed methods is a strategy to control bias by integrating qualitative and quantitative data and triangulation [23].

The length of time for forest bathing varied from two days [34] to 15 minutes of viewing/walking [27]; 15 minutes of walking [6]; one hour in a forest [35];15 minutes in forest for three days in a row [25]; two hours in a forest setting [36]; four hours of sleeping time in a forest [33]; and two hours and 20 minutes in a forest setting [26]. The study's implications are relevant to researchers, practitioners, and educators in health promotion. The findings support using forest bathing as an effective integrative therapy for reducing anxiety levels in healthy adults. Although most measures were reliable, researchers' improved reporting about measure reliability is an implication for future studies. Time in forest settings and the amount of anxiety reduction are valid aspects for future studies.

Nursing research and practice within the UN Sustainable Development Goals [4] are worthy of Global Nursing time in contribution to the goals. The study furthers evidence in the literature related to Goal 3: Good Health and Well-Being of the United Nations Sustainable Development Goals. The findings contribute to the global efforts to ensure healthy lives and promote well-being by addressing a natural way to reduce anxiety levels. Integrating these findings into education and practice contributes to health and well-being worldwide. Although the study focuses on the adult population, further research about the effects of forest bathing for families and people of all ages is recommended.

Practice implications include the promotion of forest bathing as self-care to decrease anxiety levels in adults. Health practitioners and educators can incorporate forest bathing into their programs and curricula to enhance mental health outcomes. Integrating forest bathing into health promotion strategies promotes a natural, accessible, and cost-effective method for anxiety management. While promoting forest bathing to lessen anxiety, it is essential to include safety education precautions to ensure participants' well-being. Preparation of appropriate clothing and shoe attire, checking the weather, awareness of potential hazards, and education promote safety in forest bathing.

Attention restoration therapy

ART theorizes that spending time in natural settings [12,13], such as forests, improves concentration and restores energy. Various levels of restoration discussion and ART were reviewed in the studies. One of the thirteen research studies described ART related to forest bathing [30]. One study discussed designing restorative forest environments within a natural urban environment [27]. One study described the restorative effects of the forest, known as 'Shinrin-yoku' in Japan [34]. One study found decreased anxiety levels in participants after forest bathing, but significant decreased anxiety levels after time in a cultivated field [35]. The green space [6] and time in the cultivated field [35] are worthy of future study. Previous studies of ART report improvement in attention [14] and feeling restored and a positive affect/state of mind [17]. A positive affect attenuates anxiety levels [18], while improved attention (but not hyperattentive) may serve to diminish the development of anxiety pathophysiology [15]. Two studies included the impact of spending time in a natural forest environment for healing, promoting health, and well-being, but did not name Restorative Theory as a guiding framework [31-32]. A discussion of restorative theory and evidence about heart rate and ART was included without discussing it in the context of affect or anxiety-related attention levels [36]. One systematic review reported research studies with increased restorative measure scores (Restorative Scale Compatibility scores, Restorative Outcomes Scale scores) but did not name Restorative Theory as the theoretical framework [31]. Other studies did not include the Restorative Theory of effects [6,28-29,25,26,33,35]. Future studies should deepen the focus on the impacts of Attention Restorative Theory and forest bathing to reduce anxiety. Using a theoretical or conceptual framework when reporting in future studies is recommended to further theory scholarship and obtain data specific to frameworks and forest bathing.

Strengths and Limitations

The study's strengths include the use of PRISMA [21], SWiM [22], and QuADS [23] to improve reporting and the reliability of quality assessment, along with the Risk of Bias and Cochrane Handbook [19,20]. Another strength is using two researchers to double-validate the analysis of items and synthesis of findings. Using an ordering table with SWiM is also a strength because it improves data display and enhances transparency [22]. The ordering table is in order of level of evidence. The ordering table elucidated the comparisons of the level of evidence [24] in relation to the QuADS score.

Another strength of the study is the compilation of studies evaluating different samples of participants across adulthood ages, education levels, and genders for the effect of forest bathing on anxiety levels. Although the exact time in the forest, settings, and anxiety measures vary, a reduction in anxiety remains the outcome. A limitation was that not all studies reported education level data for comparison.

The topic of anxiety and forest bathing as an intervention to reduce anxiety levels is a strength of this review. Anxiety is a global [1,2] problem worthy of study. A previous study reported rising anxiety disorders among adolescents and young adults worldwide [3], with an urgent need to address effective interventions. Likewise, the study is relevant to UN Sustainable Development Goals 3 [4,5] to improve health and well-being for all.

The study includes six RCTs and three systematic reviews, which are LOE I and II studies, and the detailed appraisal of the study qualities using QuADS ranges from 16 to 36. The QuADS appraisal process illuminates the quality of studies as an area for improving design and sampling. Quantitative and qualitative data increase methodological quality by including comprehensive perspectives through multiple lenses. Reporting of data and procedures to enhance transparency in future studies allows for better quality appraisals.

Although including review studies in the current review contributes to the effects of forest bathing on anxiety, it limits the ability to analyze detailed information about the participant samples. For example, most review articles did not include information about participants' education levels [28,30-32]. Quality education is a protective factor that strengthens resilience against a mental health condition [2]. The significance of this study lies in compiling data from 13 studies in a mixed-method approach to examine the effects of forest bathing on anxiety levels in adults. The quality assessment identifies key areas within sampling to increase generalizability.

Conclusion

This systematic review highlights the potential benefits of forest bathing as an effective intervention for reducing adult anxiety levels. The findings from the 13 reviewed studies were evaluated using PRISMA and SWiM guidelines and assessed with the QuADS appraisal tool. The findings consistently demonstrated decreased anxiety levels in adults following time spent in forest settings. However, the variance in the risk of bias across studies suggests a need for improved reporting and more rigorous sampling and study methodologies. Future research that includes experimental designs, equitable samples of adults of various ages, genders, health status, and education levels, and focuses on time in the forest for anxiety reduction is worthy.

While some studies utilized the Attention Restoration Theory (ART) framework or discussed restorative effects, the inconsistent application indicates an area for further exploration. Future research should consider diverse populations to enhance the generalizability of results. Using forest bathing to reduce anxiety represents a perspective of the valued whole person's perception and life expectancy from anxiety [1]. Overall, forest bathing presents a promising, natural approach to anxiety reduction, warranting further investigation, such as the time spent in the forest and equitable sampling of ages, gender, health status, and education.

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Ethical Approval and Informed Consent Statements

The study was a systematic review and did not include humans, so an Institutional Review Board approval was not required.

Author Contributions

Both authors contributed substantially to the planning, methodology, data extraction, analysis, and interpretation of data. Both authors were 100% involved in writing and final approval of the manuscript.

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