

Shinrin-Yoku 森林浴 (Forest Bathing): A Scoping Review of the Global Research on the Effects of Spending Time in Nature

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Abstract

Background: This Scoping review (ScR) builds upon the 2017 review conducted by Hansen et al which contributed to evidence base shinrin-yoku (SY), also known as forest bathing (FB), has many positive health effects and is becoming a prescribed dose (specific time spent in nature) by health care providers. Practice and research regarding SY, has been historically based in Asian countries with a recent increase in Europe. The need and call for more research worldwide continues to further the evidence of SY as a health promotion modality. Through this ScR the authors identified programmatic components, health information monitored and screened, time spent in nature, geographical regions, trends, and themes in SY research worldwide.

Methods: Following PRISMA-ScR guidelines we searched across 7 electronic databases for SY or FB research articles from 2017 through 2022. PubMed, CINAHL, PsycInfo, ScienceDirect, SCOPUS, Embase, JSTOR were included due to the interdisciplinary nature of SY or FB research. Each database provided unique strengths ensuring a capture of a wide range of articles. The resulting articles were screened and extracted through Covidence.

Results: Database searches returned 241 results, with 110 references removed during the deduplication process, 131 were initially screened in the title and abstract review stage. Resulting in 82 unique results deemed relevant and screened in full text. During the final stage of the review, 63 articles met all inclusion criteria and were extracted for data.

Conclusions: The practice of SY has physiological (PHYS) and psychological (PSYCH) benefits across age groups. Research findings indicate either the natural or the virtual environment (VV) has significant health benefits. Continued research is encouraged globally for short- and long-term health outcomes for all individuals. The connection with nature benefits the mind, body and soul and is supported by Henry David Thoreau's philosophy: "Our lives need the relief of where the pine flourishes and the jay still scream."

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Keywords

shinrin-yoku, forest bathing, forest therapy, nature therapy, scoping review, health benefits of nature

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Introduction

Rationale

The rationale for this ScR is primarily driven by the need to identify existing knowledge gaps that have developed in the past 5 years,¹ to clarify concepts, and to investigate new SY research. While we recover from the COVID-19 pandemic² the rates of PHYS health morbidities³ rise, suicide and mental health issues escalate,⁴ and health promotion becomes even more paramount worldwide. The causes of cardiovascular disease, cancer, obesity, and liver disease are associated with sedentary lifestyles, exposure to carcinogenic agents, and the overuse of alcohol and recreational drugs.⁵⁻⁷ Health promotion programs are needed to mitigate the health care crisis. Research⁸ shows SY decreases incidences of PHYS and PSYCH disorders and is an inexpensive health promotion intervention.

The practice of SY, also known as Forest Bathing (FB), is a “traditional Japanese practice of immersing oneself in nature by mindfully using all 5 senses.”⁸ Originally, SY was initiated by the Japanese government in the 1980s to provide a mindfulness practice for individuals who lived in urban or city areas⁹ to combat work-related stress. Arisugawa-no-miya memorial park¹⁰ is an example in Tokyo where citizens may immerse themselves in densely forested areas with waterfalls to alleviate work-related stress.

Many PHYS and PSYCH health benefits are highlighted throughout the literature.^{9,11} The PHYS benefits include improved immune function/cancer prevention,¹² decreased pulse rate and BP, protection of the respiratory system, and decreased stress responses.¹¹ The PSYCH impacts include an increase in mental relaxation and a decrease in depression, anxiety disorders, grief, isolation¹³ and anger.^{8,9} Furthermore, SY practice may allow one to experience a “higher power¹⁴” and lead to understand the spiritual connection¹⁵ with nature through the concepts of *awe* and *wonder*.^{15,16} SY as a therapeutic modality¹⁷ may increase energy and happiness levels, improve sleep quality, reduce the inflammation response, reduce chances of obesity and accelerate surgical recovery time.

Investing time mindfully connecting with nature promotes health and alleviates sub-optimal health states¹⁸ (SHS). A cross-sectional¹⁸ study found a significant relationship between low physical activity and SHS among college freshmen in China. Xu et al¹⁹ conducted a large sample (N = 48,978 Chinese adults) survey study and determined lifestyle behaviors to be improved to ameliorate SHS incidence due to short sleep duration, lack of exercise, unhealthy nutrition, alcohol consumption, smoking tobacco, and irregular meal-times. The increasing incidence of health care providers prescribing nature-based programs²⁰ is promising. Many

advantages are associated with viewing forests, varied species of trees, mountains, plants, flowers, urban green spaces, rivers, and parks. As Ralph Waldo Emerson (1858) reminds us: “Cities of mortals woe begone, Fantastic care derides, but in the serious landscape lone, Stern benefit abides” (p. 9).²¹

Objectives

The objective of this ScR was to identify existing knowledge gaps that have developed in the past 5 years, to clarify concepts, and to investigate new research in SY. The research on this topic has increased over the past 5 years, with primary research continuing to be conducted in Japan and South Korea.

Conceptual Framework

The Forest Therapy Conceptual Model (FTCM), as defined by Gobster et al (2022), is a valuable tool for a ScR building upon the 2017 review by Hansen et al. It provides a comprehensive framework to understand the process of human-forest interaction, therefore enhancing the methodological quality of studies. The model’s global relevance makes it suitable for SY research, because SY involves the interaction of the forest and human individuals. It aids in identifying programmatic components, health information, time spent in nature, geographical regions, and trends in SY. The model also helps identify the specific components of SY that contribute to health outcomes, such as the types of interactions with the forest that are most beneficial. The FTCM (see Figure 1) provides insights into how cultural, geographical, and individual factors influence the practice and outcomes of SY. In conclusion, the Forest Therapy Conceptual Model is highly relevant for a systematic review, providing valuable insights into SY worldwide.

According to Gobster et al (2022),²² Forest Therapy (FT) is an overarching term encompassing an individual’s mindful connection with nature while using a multi-sensory approach in natural and semi-natural environments to improve physical wellbeing and mental health. Gobster and associates conducted a ScR of the FT research and created a conceptual framework. These FT interactions are demonstrated in this model (see Figure 1) as 4 components: *human, forest, interaction, and outcomes*.

The *human* factor concerns *who* is the research participant and *how* the research sample may engage in or enjoy FT. Gobster et al (2022)²² include human sub-components, such as socio-demographics, human needs and motivations, target groups and, individual group differences. The *forest* factor represents the features and qualities of the forest environment that may provide therapeutic effects and positive health outcomes. The framework’s authors include within the *forest*

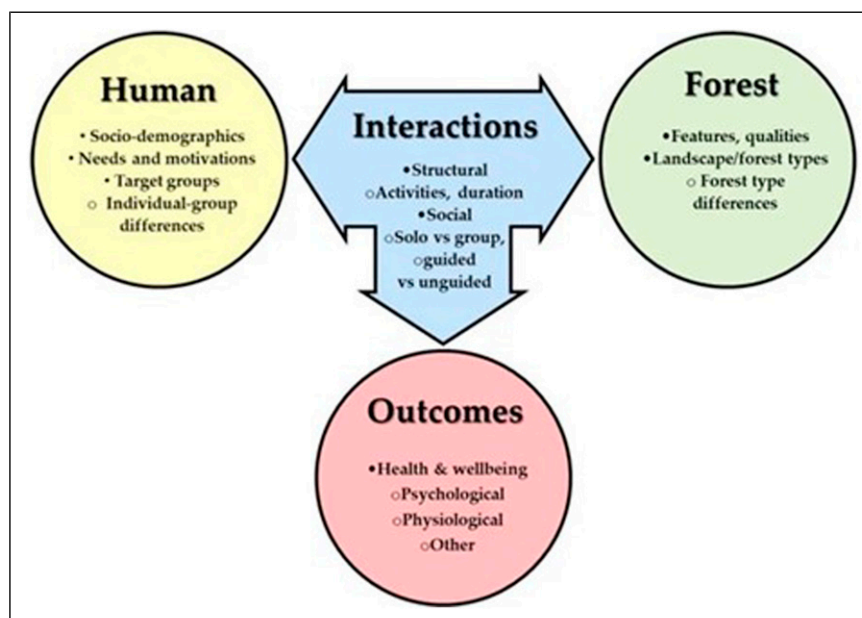


Figure 1. The forest therapy conceptual model

component landscape/forest types and the forest type differences. Regarding the model's *interaction* component, Gobster et al (2022)²² demonstrate an interest in what kinds of activities individuals participated in and the time spent engaging with nature. The *interactions* component demonstrates an interest in the social aspects in nature and the size of the groups and whether guided vs unguided engagements significantly differ. The model component, *outcomes*, includes the aspects.

This ScR included, but was not limited to, components illustrated in the conceptual model by Gobster and co-authors (2022).²²

Materials and Methods

Protocol and Registration

The review protocol does not exist outside of this manuscript for this scoping review.

Search Strategy

This ScR was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines²³. The review was conducted using 6 databases: PubMed, SCOPUS, ScienceDirect, Embase, JSTOR, CINAHL to identify relevant studies published in English language from 2017 through January 30, 2022. Search keywords were "SY", OR "FB" OR "FT." [Figure 2](#) shows our PRISMA-ScR flow chart. *Eligibility Criteria for Inclusion and Exclusion*

This study is a ScR exploring programmatic components, health information monitored and screened, time spent in nature, geographical regions, and trends and themes in SY worldwide. To be eligible for analysis, primary studies needed

to (1) report an empirical intervention study, using pre- and post-intervention measures, (2) use SY, FB, FT defined under the concept of (mindfulness; immersion in nature, sensory experience; slow walk; sitting intentional) and a measurement of PSYCH, PHYS, and/or spiritual health or wellbeing, (3) Can include an overnight or residential SY programs, (4) can include Virtual sensory nature immersion, and (5) published in English.

Exclusion criteria were (1) review articles, (2) studies not including humans, (3) case studies or qualitative studies, (4) studies involving horticulture, green prescriptions, green gym, blue therapy, blue gym, brown therapy, wilderness therapy, forest schools, an outdoor hiking or exercise program, or interventions to change the environment because these activities are not based in SY principles.

Article Screening

Article screening was conducted in 3 phases: title and abstract, full-text review and data extraction. All 131 articles were screened for inclusion and exclusion by 2 review team members. Once an article was voted to be included it was moved to the data extraction phase of the review.

Article Extraction

All articles included in the final phase of data extraction were reviewed by 2 team members (see [Table 1](#)). Any researchers' disagreements were solved through team discussion during all stages.

Risk of Bias

Due to such as lack of resources and expertise a Risk of Bias assessment was not feasible.

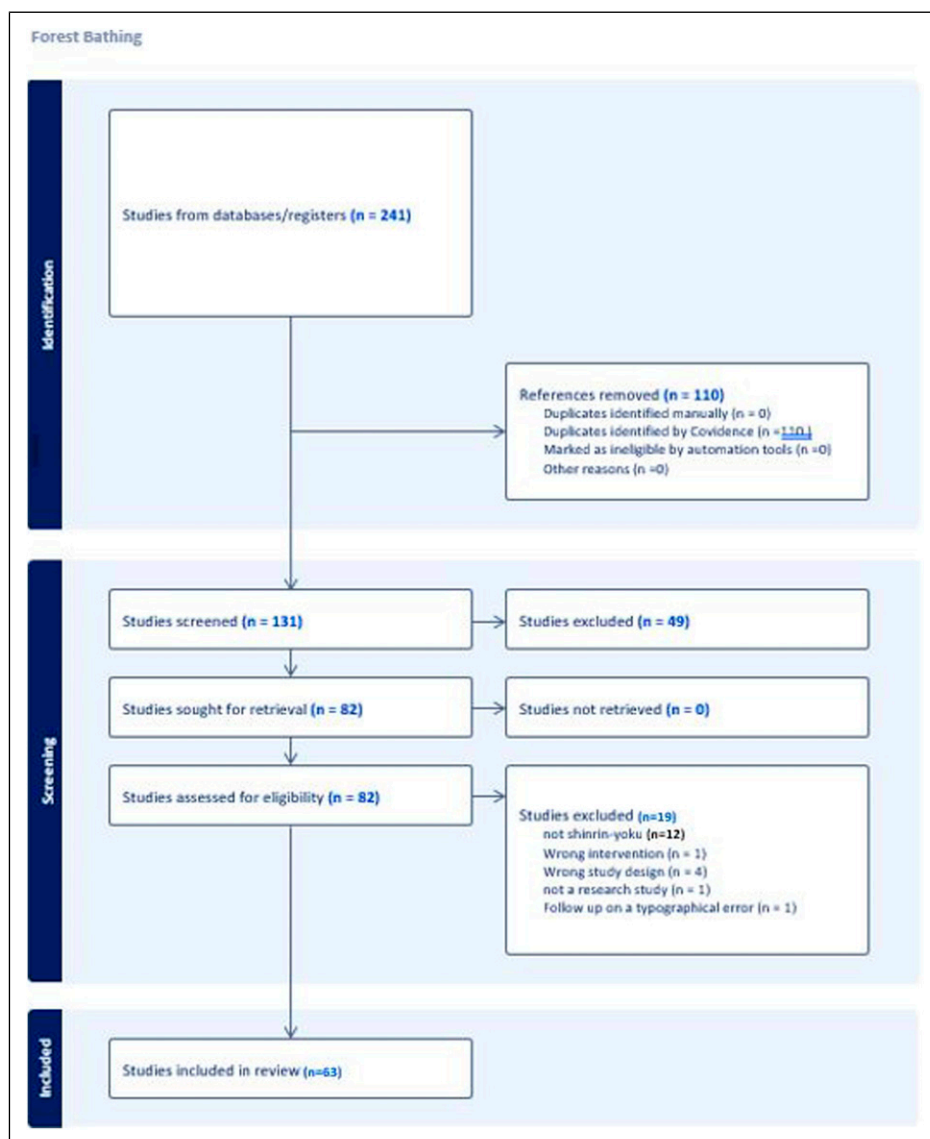


Figure 2. PRISMA- ScR flowchart.

Findings

Results

Searching across the 6 bibliographic databases (PubMed, SCOPUS, ScienceDirect, Embase, JSTOR, CINAHL) 241 results were returned. Deduplication in Covidence removed 110 references. A total of 131 research articles were initially screened with first stage resulting in 82 unique research articles screened for full text. After which, 13 articles were not relevant and excluded. During the final review stage, 63 articles met all inclusion criteria and were extracted, with 1 article included as a typographical correction to an already included article.

Table 2 in-Situ and Virtual Study Characteristics. Studies are Presented Alphabetically by First Author's Last Name and Then by Country of Study. Included Studies Represented Varied

Study Designs From Randomized Control Trials (RCTs), Quasi-Experimental, Longitudinal, and Cross Sectional. The Most Common Study Designs Were Non-randomized (NR) Experimental Studies (25) and RCTs (20).

The countries with the most included articles were Japan (18), South Korea (17), and China (10). A total of 10 of the research articles included for data extraction involved a virtual environment, with 1 based on a cross-sectional survey design. The method of virtual forest or nature exposure varied across studies with most relying on a computer program or virtual reality and 1 study utilizing auditory stimulation of forest and nature sounds.

Physiological and Psychological Effects

The 63 articles extracted for data, meeting all inclusion criteria, focused on the PHYS and PSYCH effects of SY.

Table 1. Data Extraction Tool Template.

Article Citation	Study Population	Sample	Aim and Design	Participants	Outcomes	Findings
Authors, journal name, Publication year, Volume, issue number, pages, DOI	Population description, country of study, health status	Overall N number, intervention table, control table	Aim of study, Programmatic component, Activity, framework used, individual or group activity, sensory direction/activities, study design	Inclusion criteria, exclusion criteria, method of recruitment	Physiological measures; tools/citations, psychological measures tools/citations, sensory metrics; tools/citations, spiritual metrics tools/citations	Physiological results, psychological measures results, sensory metrics results, Significant associations, comments/caveats, conclusions, spiritual metrics results

Most measured the PHYS effects through circulatory function of systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate. PSYCH effects were primarily measured through the Profile of Mood States (POMS). Other measurement tools included the Warwick–Edinburgh Mental Well-Being Scale (WEMWBS), Subjective Vitality Scale (SVS) and the Restorative Outcome Scale (ROS).

The PHYS results of SY indicate reduced blood pressure, decreased heart rate, increased relaxation, and decreased stress among the 63 research studies reviewed. Another study²⁴ found PHYS effects on brain activity and autonomic nervous activity.

The study participants' PSYCH results from the POMS questionnaire following SY indicate decreased tension-anxiety, depression, anger, and fatigue with an increase in positive emotions and a sense of well-being. *Connection to nature* was an outcome of interest for a single portion of the included papers. *Connection to nature*²⁵ and the *time spent in nature* may increase participants' well-being, health status and emotional states [Figure 3](#). Our current review articles have noted the same.

A synopsis of the studies is alphabetically presented by country.

Australia

Australian research included (1)²⁶ multi-site longitudinal stepped-wedge cluster randomized trial of adults with mental illness. The intervention was a FT session with time of observation (DOS) of 10 weekly 90-minute sessions. Outcomes are still pending.²⁷

Canada

Canadian research included (1)²⁸ pre- and post-intervention study of healthy adults who completed a forest walk (FW) observation. The intervention was 120 minutes. There was a significant decrease in negative affect and a significant increase in positive affect.²⁸

China

The studies (10)²⁸⁻³⁸ conducted in China included both NR (5) and RCTs (5). Populations included university students, elderly patients with congestive heart failure (CHF), healthy adults and people with hypertension. Interventions varied between a sitting nature observation (SO), a walking nature observation (WO), and a combination of both sitting and walking observations (SAWO). Settings included bamboo forests, coniferous forests, mixed forest, and city/urban settings. Patients with cardiovascular disease were often accompanied by a health care professional. University students were often unaccompanied or provided FT guides.³³ DOS varied between studies including short exposure and elongated exposures: 15min (SO), 30 (SO, WO), 1.5 (SO), 1.5hr (WO), 2hr (SO). Biological measurements included Endothelin-1 (ET-1), activities of renin, B-type natriuretic peptide (BNP) and levels of inflammatory cytokines and oxidative stress levels and inflammatory measures. They included natural killer (NK) cell activity and perforin, granzysin, and granzymes A/B in peripheral blood lymphocytes (PBLs) levels. PHYS measurements included BP, heart rate (HR), diastolic BP (DBP) and oxygen saturation (SpO2). PSYCH measurements explored outcomes around mental health, mood states and subjective vitality. They used PSYCH measurement tools including the ROS and WEMWBS. All authors reported positive effects of FT interventions on biological, physiological and PSYCH parameters. Research includes an expansive evaluation of biological markers. In 1 study, patients with CHF who walked in forests demonstrated decreased ET-1, renin activities, B-type natriuretic peptide (BNP) and reduced levels of inflammatory cytokines and oxidative stress. Male university students improved in biological, PHYS measurements, such as increased NK activity, number, perforin, granzysin and granzymes A/B levels; decreased BP, HR, SpO2 and PSYCH results: enhanced positive mood states.

Finland

Finland research included (2)^{39,40} a cross-over research study and 1 RCT of undergraduate students who participated in a

Table 2. In-Situ and Virtual Study Characteristics. Studies are Presented Alphabetically by First Author's Last Name and Then by Country of Study.

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Thomas 2020	Australia	Other: Multi-site longitudinal stepped-wedge cluster randomized trial	(n = 140) Adults with a mental illness	10 weekly 90-min forest therapy sessions facilitated by a certified forest therapy guide and accompanying PCCS health workers	Study proposal ^b awaiting outcomes
Fu 2022	Canada	Other: Pre- and post-intervention study	(n = 58) Healthy adult participants	120 minute guided nature break activity	The nature break showed a significant decrease in participants' negative affect and a significant increase in participants' positive affect, psychologically Physiological differences were also present upon completion of the activity
Hassan 2018	China	Randomized controlled trial	(n = 60) University students	Independent forest walking	The current study found that bamboo forest walking had positive effects on brain activity
Liu 2021	China	Randomized controlled trial	(n = 30) University students	Sit for 30 minutes in a forest site (3 sites and 1 urban site) then after a 10 minute break, walk 30 minutes at a moderate energy expenditure	All types of forests had a stronger restorative effect than the urban environment provided. Decreased blood pressure and heart rate and increases in the subjective vitality scale (SVS) in the mixed forest, whereas restorative outcome scale (ROS) and warwick-Edinburgh mental well-being scale (WEMWBS) significantly improved in the coniferous forest
Lyu 2019	China	Non-randomized experimental study	(n = 60) University students	3 day bamboo therapy; 3 day city environment	Bamboo forest therapy enhanced positive mood states and reduced negative mood states in male university students. The blood pressure and heart rate of the male participants were decreased and SpO ₂ (blood oxygen) levels were increased bamboo forest significantly increased the NK (natural killer cell) activity, number of NK cells and levels of perforin, granulysin, and granzymes A/B in peripheral blood lymphocytes (PBLs) in the participants
Mao 2017	China	Randomized controlled trial	(n = 36) Participants had experienced chronic heart failure (CHF)	Walking twice a day along a flat walking path at the forest site for about 1.5 hours accompanied by a nurse or physician for 4 days	Decreased B-type natriuretic peptide (BNP) and levels of inflammatory cytokines and oxidative stress levels in CHF participants
Mao 2018	China	Randomized controlled trial	(n = 36) Adults with chronic heart failure (CHF)	Forest and urban walking accompanied by a nurse of a physician	The current study found a decline in B-type natriuretic peptide (BNP) levels and the attenuated inflammatory response and oxidative stress in participants
Wang 2019	China	Non-randomized experimental study	College students and social workers (n = 96)	Virtual reality	The current study results showed that the artificial environment was not as effective in relieving the stress of the participants. However, physiologically, the artificial environment had restorative effects
Wu 2017	China	Non-randomized experimental study	(n = 36) Elderly participants with chronic heart failure (CHF)	Two walks with breaks in between. No future information was provided	The current study showed a decrease in the level of Endothelin-1 (ET-1) and inhibited the activities of renin, which suggests a benefit in CHF participants

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Wu 2019	China	Non-randomized experimental study	(n = 31) Participants were healthy or had hypertension	Two groups were activated according to this procedure Day 1 subjects walked along a predetermined course in each area at an unhurried pace for about 1.5 hours Day 2 subjects walked the same as the first day, at afternoon, the subjects were arranged to sit quietly for 1.5 hours	The current study found that walking in: Yaolin national forest park, in tonglu Hangzhou city, Zhejiang province, could provide many benefits to the elderly patients with HTN.
Wu 2020	China	Randomized controlled trial	(n = 31) Participants had a mean age of 73.5	Multi-day intervention: After breakfast, 1 group was sent to the forest site, the other to the suburban site. In the afternoon, after taking lunch and noon break in their resting room, the subjects were arranged to sit quietly for 2 hours	Decreased level of diastolic blood pressure; increased the levels of SpO2%; boosted the heart and autonomic nerve system; reduced the inflammation response; and promoted the mood state of participants
Zeng 2020	China	Non-randomized experimental study	(n = 120) University students	Sat in chairs and viewed the landscape for 15 min. Then walked around the terrain; then walked around an urban environment	The results support the concept that forest therapy has positive effects on physical and mental health, indicating that it can be effective for health promotion
Bielinis 2020	Finland	Randomized controlled trial	University students (n = 42)	Videos were used as experimental stimulation	This study's results indicate watching a video showing a walk in a forest environment can effectively reduce 'pessimistic attitude to do work' among university students. This video can also be implemented for lowering negative mood states, such as tension, fatigue, forgetfulness, irritation or raising a level of human restoration
Bielinis 2021	Finland	Other: Crossover research study	(n = 22) Undergraduate college students	Each participant was involved in each measurement 4 times. Each setting was contemplated for 15 minutes in a sitting or standing position	The level of negative mood significantly decreased after their brief exposure to the snow-covered forest environment and a positive indicator of "vigor" did not change
Reese 2022	Germany	Randomized controlled trial	(n = 50) University students	Participants either took a self-paced physical forest walk or in a self-paced self-controlled moving VR forest walk viewing a 360° footage	The current study found that a short virtual forest walk increases indicators of well-being similarly to a walk in a comparable physical forest
Peterfalvi 2021	Hungary	Non-randomized experimental study	(n = 12) Working age adults	Slow walking with 5 rest periods. Two viewpoints for watching scenery (quietly listening to nature sounds and viewing remote items in the forest); experimental walk was conducted by 1 of the researchers	Lowered blood pressure; immune function-enhancing effect as a result of forest walking
Meneguzzo 2021	Italy	Non-randomized experimental study	(n = 134) Healthy adults age 41-60	Independent forest walking; guided forest walking; guided urban walking	The current study found that forest therapy sessions in remote forest areas are effective in improving psychological mood states

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Pichler 2022	Italy	Non-randomized experimental study	(n = 78) Participants were adults who were also couples	Two intervention groups: a Hiking group participated in a daily moderate hiking program, except for 1 rest day in the middle of the week; and the nature group/Forest therapy participated each day in standardized forest therapy sessions assisted by a psychologist	Health related quality of life and nature connection were outcomes of interest in the forest group. This study also presents a health related quality of life tool validation
Kobayashi 2018	Japan	Randomized controlled trial	(n = 485) Healthy Japanese males	Forest walk or urban walk dependent on group assigned	Autonomic relaxation (increases in parasympathetic indicators and or decreases in sympathetic indicators) for forest environments was confirmed in this study. In addition, negative emotions were identified providing an interest in conducting further research on the existence of negative responses
Kobayashi 2019	Japan	Randomized controlled trial	(n = 74) Male participants with a mean age of 22.4	Group 1 first walked in the forest area prior to walking in the urban area. Group 2 walked the urban area before the forest area	The current study could not determine whether forest-walking is more therapeutic than viewing a forest landscape
Kobayashi 2021	Japan	Randomized controlled trial	(n = 57) Participants had a mean age of 42.44	Independent forest walking and viewing and independent urban walking and viewing. Two types of intervention conducted at each experimental site. The walking experiment was conducted in the morning and the viewing experiment was conducted in the afternoon on the same day	Walking in both forest and urban environments had a positive effect on the mood state of participants
Kotera 2021	Japan	Other: Pre- post- and 2- week follow-up study	(n = 25) University students	3-day shinrin-yoku retreat, and 2-weeks after the completion of the retreat participants responded to the same 3 scales prepared online by the retreat coordinator	The current study found a heightened rating of self-compassion among Japanese undergraduate students who had a history of high rates of mental health problems
Ochiai 2020	Japan	Other: Within individual - each individual received both forest and city auditory stimulus	Japanese men with gambling disorders (n = 12)	Participants were seated with closed eyes. Wore headphones and listened to the sound of ocean waves for dummy auditory stimulus. Then, they listened to forest and city auditory stimuli for 1 min each	The current study showed that forest auditory stimulation created physiological and psychological relaxation. Since participants were suffering from gambling disorders, the authors also noted that exposure to virtual forest therapy may help to stop the progression of the gambling disorder
Ohe 2017	Japan	Non-randomized experimental study	(n = 43) Healthy adults aged 20-60	Forest therapy program, from the forest therapy promotion council	The current study found positive relaxation, physiological, and psychological effects from forest therapy
Song 2017	Japan	Randomized controlled trial	(n = 20) Participants were males with hypertension	Rest on a chair (provided) for 5 min then view the landscape (forest or urban as assigned for that day) environments for 10 min Conversation among participants was prohibited	Significant increase in parasympathetic nervous activity; significant decrease in heart rate, and a significant increase in feeling comfortable, relaxed; and natural

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Song 2017	Japan	Non-randomized experimental study	(n = 26) Middle aged hypertensive men	Forest walking and other multisensory experience activities to help increase the participants' connection to nature	Blood pressure decreased during the forest therapy program and the decrease was sustained 5 days post program
Song 2018	Japan	Non-randomized experimental study	(n = 17) University students	On the first day, 1 group performed the experiment in the forest area, and the other performed the same experiment in the city area. On the second day, participants switched field sites to eliminate order effects	This study found that participants had a decrease in negative mood measures. The participants' vigor increased after forest walking
Song 2018	Japan	Non-randomized experimental study	17	After a rest period of 60 seconds, participants viewed a gray background for the same amount of time. After which, participants viewed forest and city (control) images for 90 seconds, while seated	The current study found that the visual stimulation of the forest images had a significant physiological effect on brain activity and autonomic nervous activity
Song 2019	Japan	Non-randomized experimental study	(n = 72) Participants were office workers	The participants viewed the landscape for 15 min. While sitting	Higher parasympathetic nervous activity; lower sympathetic nervous activity; lower heart rate; feeling more comfortable; relaxed; improved mood state; and lower anxiety levels
Song 2019	Japan	Randomized controlled trial	(n = 60) Female university students	Walk 1 km in an urban area and 1 km in a forest	Findings indicate participants' had a higher parasympathetic nervous activity while walking in a forest, as well as a lower sympathetic nervous activity. Participants also demonstrated lower heart rates, expressed feeling more "comfortable," "relaxed" and "natural" while walking in the forest. In addition to an improvement in mood states and lower anxiety levels for the participants who walked in the forest vs those who walked in the city
Song 2019	Japan	Non-randomized experimental study	Female, Japanese university students (n = 21)	Participants viewed a gray background for 60 seconds (rest period) followed by visual, olfactory, combined visual and olfactory stimuli for 30 seconds in a soundproof chamber	The forest-related stimuli promoted physiological and psychological relaxation effects, and the combined visual and olfactory stimuli demonstrated an additive effect
Song 2020	Japan	Non-randomized experimental study	Male university students (n = 650)	"Upon arrival in a city or forest areas, the participants waited for their turn inside a room and each of them was eventually taken to the experimental site. They stayed in 2 environments and viewed the landscape for 15 min while resting in a chair	The current study showed that psychological relaxation occurred in participants upon viewing forest landscape, relaxation rates were more prevalent in participants who measured high trait anxiety levels before the viewing

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Takayama 2017	Japan	Randomized controlled trial	(n = 18) Participants were males with a full-time job	Participants viewed the scenery in either the crowding forest or the thinned forest for 15 min	The impressions and evaluations of the restorative traits for the crowding vs thinned forest environments differed greatly, and the thinned forest were evaluated more positively than the crowding I
Takayama 2019	Japan	Randomized controlled trial	(n = 46) Male graduate and undergraduate students	Day 1: View forest/urban sites Day 2: View forest/urban sites then remain in a waiting room and complete questionnaires; leave waiting room and walk a forest course independently for about 15 min	Although the forest setting had a higher restorative effect than the urban setting, the influence of differences in individual traits was minimal
Takayama 2022	Japan	Non-randomized experimental study	Adults 20-40 years of age who are, "busy working and generally have few opportunities to experience forests and nature." (n = 25)	Experimental room: Designed to incorporate elements of the forest environment focusing on sight, hearing, and smell	The current study results showed that a digital forest bathing environment resulted in restorative traits and psychological effects similar to those of the real forest environment
Tsutsumi 2017	Japan	Non-randomized experimental study	Healthy men in their 20s (n = 12)	Viewed sea and forest videos on different days	The current study found that watching preferred DVDs with natural views and sounds decreased heart rates and increased the parasympathetic nerve activity
Bielinis 2019	Poland	Non-randomized experimental study	(n = 21) University students	Independent forest walking with sensory direction given every 15 minutes	Completion of the intervention led to lower physiological stress markers and lower negative psychological markers
Bielinis 2019	Poland	Randomized controlled trial	(n = 32) University students and employees	Participants walked around 1 km/for 20 min. Over flat roads to pre-selected point; stand in a line 1 meter apart and view environment for 15 min; no talking	Levels of negative mood indicators (tension/anxiety/anger/hostility, depression/dejection, confusion, and fatigue) decreased after participation
Bielinis 2019	Poland	Non-randomized experimental study	(n = 50) Adults with affective and psychotic disorders	1 hour 45 minute forest walk with additional exercises (walking, stretching, watching landscapes) under the supervision of a qualified therapist	Patients with affective disorders-forest therapy had a positive effect on nearly all profile of mood state (POMS) subscales. Anxiety levels decreased but fatigue did not have a significant change
Bielinis 2020	Poland	Non-randomized experimental study	(n = 50) University students	Forest walks with additional exercises in the forest environment (walking, stretching, watching landscapes)	Forest therapy had a positive effect on nearly all profile of mood states (POMS) subscales, with the exception of anger and hostility
Lim 2020	Singapore	Other: Pre-post-nature immersion for mood, nature connectedness and heart rate	(n = 51) University students and community members	Guided and unguided forest (garden) walks	Nature connectedness, mood state, and heart rate improved regardless of whether the walk was guided or not
Bang 2018	South Korea	Non-randomized experimental study	(n = 52) Elementary school students in grades 4-6	60 min of activity after 30 min of lecture; 2 hours total of program duration, once weekly for 10 weeks	The current study showed a partially effective improvement in children's psychological health
Joung 2020	South Korea	Other: Single-group crossover design	(n = 24) College students in their 20s	15 min. Walking in the forest. Three minute rest, 5 minutes to complete questionnaires, 2 minutes collecting saliva for samples	Relaxing effects were noted upon completion of a short walk in a rural forest area

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Kang 2021	South Korea	Randomized controlled trial	(n = 29) School aged children between 7-13 years of age	Art therapy in the forest Each session 10 min.; find a place to work 40 min.; find materials from their surroundings to create an artwork 10-15 min.; discuss projects with group	Increased children's resistance to disease, alleviated stress, and increased self-esteem
Kang 2021	South Korea	Non-randomized experimental study	(n = 54) Non-disabled siblings of children with disabilities	15 minute sessions/3 times per week for 4 weeks	The current study found that participation in art therapy in a forest positively affected changes in brain waves
Kil 2021	South Korea	Other: Survey	(n = 247) Adult participants	Forest walking	The current study found that forest bathing can increase many markers of positive well-being
Kim 2019	South Korea	Other: Pre-post-test experimental	(n = 9) Cancer patients	Independent forest walking	Forest therapy was shown to be beneficial for the improvement of sleep quality in cancer patients
Kim 2020	South Korea	Other: Pretest-posttest control group design	(n = 38) University students	Forest dance, forest meditation, forest exercise, walking, and other activities under the instruction of the therapist	Campus forest therapy interventions provide significant psychological effects
Kim 2020	South Korea	Other: Prospective, single-arm, single center trial	(n = 35) Postmenopausal insomnia patients	6 days/6 participants per each group	This small sample prospective clinical study suggests forest therapy may be an effective treatment for insomnia
Kim 2021	South Korea	Randomized controlled trial	(n = 38) Healthy adults	Voluntary forest activities (stretching, respiration, walking, meditation and exercise) for 8 sessions; 1 hour long session/week	There were significant positive changes in the research participants' emotional states, stress responses and happiness levels
Lee 2018	South Korea	Randomized controlled trial	(n = 79) Female participants age 40-70	Groups walked in the forest; while also engaging in five-sense feeling; playing folk games; and meditation over 2 hours	The current study reduced oxidative stress and improved insulin resistance
Park 2020	South Korea	Non-randomized experimental study	(n = 53) Women who live in a city between the ages of 40-64	Program consisted of lying-down meditation, seon yoga, serotonin walking, healing touch, stress relief meditation, and natural meditation Guided by a professional instructor	The current study found that forest therapy increased serotonin levels
Park 2021	South Korea	Non-randomized experimental study	(n = 88) Adolescents aged 13-18 years	Self guided activities; including forest walking; and woodworking	46 of the 87 health-related indicators, resulted in significant impacts observed
Yi 2019	South Korea	Non-randomized experimental study	(n = 84) Elderly adults	Breathing program 30 min. Of a preparatory session, 30 min. Of guided-breathing meditation; 20 min. Of slow forest walking; 20 min. Of muscle training with a stretchable band; and 20 min of closing activities Walking program; 30 min. Of preparatory activities, 50 min. Of forest walking; 20 min. Of muscle training; and 20 min. Of closing activities	Both programs improved neurophysiology; HRV, and bioimpedance

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Yi 2021	South Korea	Non-randomized experimental study	(n = 69) Older adults	12 sessions/2 sessions per week (6 weeks in total) and 2 hours. Active forest walking in addition to: 10 min. Of warm up exercises; 50 min. Of guided qigong exercises; 20 min. Of band gymnastics; 30 min. Of physio-cognitive play; and 10 min. Of cooldown exercises	This study showed an increase in cognition, a decrease in depression, and significant differences were noted in electrophysiology (such as bioimpedance, electroencephalogram (EEG) and heart rate variability (HRV))
Bach 2021	Spain	Non-randomized experimental study	(n = 31) University students	Baseline saliva; then 1,2,4,8 hour collection of human saliva after exposure to the forest	Decrease in cortisol saliva concentrations during an 8 h exposure to forest. Time spent in the forest may be an important factor when considering stress biomarkers and response to these environments
Bach 2021	Spain	Randomized controlled trial	(n = 10) Female university students	2-hour walk in holm oak forest (intervention) 2-hour walk in an urban area	Higher absorptions of alpha-pinene were found in the forest group participants with lower baseline monoterpene blood concentrations
Serrat 2020	Spain	Randomized controlled trial	(n = 169) Adults with fibromyalgia	The TAU + NAT-FM protocol integrates the FIBROWALK protocol, replacing the exercise therapy described there for activities carried out in nature such as yoga, nordic walking, photography, and shinrin yoku	The results of this study suggest that the TAU + NAT-FM intervention (added to TAU) could emerge as an add-on therapy that improves the core symptoms of this prevalent and costly disease
Yu 2017	Taiwan	Non-randomized experimental study	(n = 128) Some participants had chronic diseases and some were otherwise healthy	Guided 2 hour forest bathing program to stimulate the senses (visual, auditory, olfactory, tactile)	Decrease in pulse rate and systolic and diastolic blood pressure in the participants
Tsao 2022	Taiwan	Non-randomized experimental study	(n = 25) Healthy adults	Group 1: 6-day/5-night forest walking exercise program (1.5 hr. In a <i>Phyllostachys edulis</i>) forest. Group 2: Participants in urban parks in taipei city	The study participants showed an increase in cardiovascular functions after walking in the forest environment
Yu 2021	Taiwan	Other: A between-subject, pretest-posttest field experiment design (single-blind)	(n = 99) Physically capable adults age 20 or older	Forest walking with a small group	The walk alone group exhibited a significant systolic blood pressure (SBP) decrease and a significant increase in sympathetic nervous system (SNS) activity, the self-guided group exhibited a significant increase in heart rate (HR) values and significant decreases in SBP and diastolic blood pressure (DBP), and the guided group showed a significant decrease in SBP the 3 forest therapy programs had positive effects on improving mood states
Markwell 2020	United Kingdom	Other: Mixed-methods experimental	(n = 22) Group was mixed with students and adults employed full-time	Shinrin-yoku group: 4-hour long forest walking sessions, once a week for 4 consecutive weeks. Digital shinrin-yoku group: Watched an hour-long forest video session once a week for 4 consecutive weeks	The current study found shinrin-yoku can reduce stress and increase the positive affect and well-being more so than digital shinrin-yoku

(continued)

Table 2. (continued)

Author, Publication Year	Country of Study	Study Design	Study Population ^a	SY or FB Intervention	Outcomes
Alyan 2021	Other: Not mentioned by the authors	Randomized controlled trial	University students (n = 20)	Letter detection test; touch bubbles on a computer 'touchpad' to capture participants' attention and motivate them to complete the task	Two virtual (realistic and dreamlike) forest environments on participants' moods and psychophysiological responses through the measurement of heart rate, skin conductance level, and profile of mood states (POMS) measures and sub scales. The realistic group demonstrated a greater relief in physiological states than the dreamlike group

Included studies represented varied study designs from Randomized Control Trials (RCTs), quasi-experimental, longitudinal, and cross sectional. The most common study designs were non-randomized experimental studies (25) and RCTs (20).

^aGender was included in the description when the study included a sample of 1 gender type.

sitting/standing observation of snow-covered forests lasting 15-minute while during the RCT students watched 15-minute (each) forest and urban videos. Researchers reported a significant decrease in negative mood; however, positive vigor did not change. The videos demonstrated a reduction in 'pessimistic attitude to do work' among students.

Germany

German research included 1 RCT (1)⁴¹ involving university students who participated in a self-paced forest walk or in a self-paced virtual reality (VR) walk with 360-degree viewing. Researchers reported on PSYCH outcomes and found short virtual forest walks increased well-being similarly to physical forest walks.

Hungary

Hungarian research included a NR study (1)⁴² evaluating a forest program in adults. Participants completed intermittent slow walking with 5 rest periods where they had 2 viewpoints for watching scenery. Biological and PHYS results included decreased BP and enhanced immune function.

Italy

Italian research included (2)^{43,44} NR studies of healthy adults. Interventions varied between independent forest walk (FW), urban walking, hiking group and a nature group. Walks were either self-guided or by guided instructors. Results indicated FT sessions in remote forest areas are effective in improving PSYCH mood states.

Japan

Japanese research included studies (18)^{24,45,46,46-58} that were NR (9) and RCTs (7) and other pre- and post-study designs (2).

Research populations: hypertensive males, employed males, office workers, university students, undergraduates (male/female) and healthy male adults. Interventions varied between SO, WO, walking observation and other sensory (WOAOS), FT, Viewing Landscape (VL), View Landscape Sitting (VLS) and a SY retreat. Settings included forest, urban, city, crowded and thinned forests. Interventions were self-guided or conducted by guides. DOS varied between studies including short exposure and elongated exposures: 15min and 10min (VL), 30 (SO, WO), 1.5 (SO), 1.5hr (WO), 2hr (SO). PHYS measurement included parasympathetic nervous system (PNS), sympathetic nervous system (SNS), HR and BP. PSYCH assessment included comfortability, relaxation, mood, anxiety, self-compassion, and restorative effect. FT interventions on PHYS and PSYCH parameters resulted in positive effects.

Poland

Polish research included (4)⁵⁹⁻⁶¹ studies that were NR (3) and RCTs (1). Research populations: adults, university students and employees. Interventions varied between FWWAE, FWWSD and WO. Interventions were carried out in the forest and were self-guided, however, adults with affective and psychotic disorders were supervised by qualified therapists. DOS varied between studies including short- and extended-exposures: 20 min (WO), 15 min (FWWSD) and 1hr 45 min (FWWAE). PHYS measurement included stress while PSYCH measurements included POM subscales, depression/dejection, confusion, fatigue, anger, and hostility. Authors reported positive effects of FT interventions on PHYS and PSYCH parameters. Polish researchers have an expansive evaluation of PSYCH markers not found in other reported studies. Adults with affective and psychotic disorders who were exposed to FWWAE and accompanied by therapists showed positive effects on the POMS subscales, decreased anxiety, but fatigue had no significant change. University students exposed to 15-minute of FT showed improved PHYS stress and lowered negative

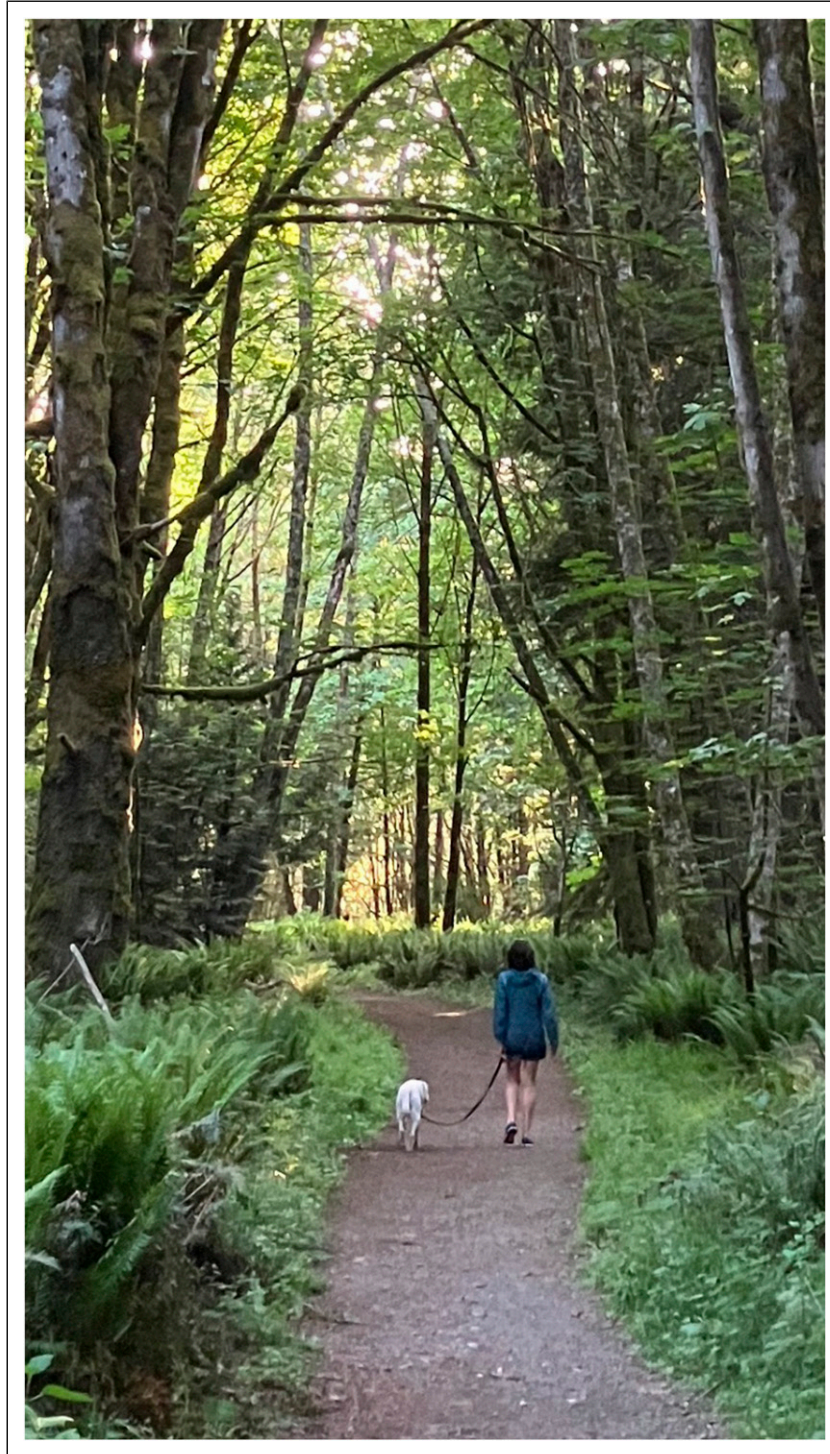


Figure 3. A SY experience at Gazzam Lake Nature Preserve, Bainbridge Island, Washington, June 2023. Photo credit Joe Richards.

PSYCH markers. Comparatively, university students exposed to 1hr and 45 minutes of FWWAE had a positive effect on the POMS subscales, however, there was no change in anger or hostility. The DOS did not influence outcomes whether participants had a 15-minute walk with sensory direction or a 1 hour 45-minute FWWAE.

Singapore

Singapore research included (1)⁶² a study on university students and community members evaluating forest (garden) walks. Outcomes included HR and mood states. Researchers reported improved nature connectedness (not reported in

other studies), mood state and HR regardless of whether the walk was guided or not.

South Korea

South Korean research included (14)⁶³⁻⁷⁹ studies that were NR (6 and RCTs (3) and other trials (5). Populations cited: stroke survivor, female, adult, elementary school aged, cancer patients, siblings of disabled children, elderly, university students, postmenopausal insomnia, juvenile offenders. Interventions varied between walking only, walking while engaging 5 senses, art therapy in forest, FW, and wood working, breathing program, voluntary forest activities, band gymnastics, physio-cognitive play, cool down exercise, seon yoga, serotonin walking, healing touch, urban group, Qigong, forest dance, forest meditation and walking meditation. Settings included various forest locations. Interventions were self-guided or guided. DOS varied between studies including short- and extended-exposures. Biological measurements included serotonin, insulin, oxidative stress, sleep quality and resistance to disease. PHYS measurements included neurophysiology, bioimpedance, serotonin, electroencephalogram, heart rate variability (HRV) and bioimpedance. While PSYCH measurements included positive well-being, depressive mood, anxiety, self-esteem, alleviated stress, emotional state, stress response, happiness levels, well-being, mental balance, social involvement, sociability, and self-control. All reported positive effects of FT interventions on biological, PHYS and PSYCH parameters. South Korean researchers included several contemplative practices in their forest programs including FW, WO, warm-up exercises, Qigong, band gymnastics, physio-cognitive play, cool down exercises, lying down meditation, seon yoga, serotonin walking, healing touch, stress-relief, and natural-meditation. South Korean researchers were the only group to evaluate the influence of *forest cognition* in older adults. Outcomes were positive regardless of the intervention setting, type (traditional forest therapy or mixed with contemplative practices), administration (self- or guided), and length (10 minutes or 6 weeks).

Patients with cancer who completed a FW intervention reported improved sleep quality. Non-disabled siblings of children with disabilities experienced positive effects on brain waves and elderly participants who completed a forest breathing program had improved neurophysiology, improved HRV and improved bioimpedance. University students showed a significant improvement in PSYCH effects. Moreover, juvenile offenders reported improvement in PSYCH well-being, self-esteem, mental balance, social involvement, sociability, self-control, and happiness. The type and time of exposure did not appear to matter as results were positive whether participants had a 15-minute 3 times per-week for 4 weeks or a 2-hour session.

Spain

Spanish research included (3)⁸⁰⁻⁸² studies included NR (1) or RCTs (2). Populations cited: university students and adults with fibromyalgia. Interventions varied between WO and non-specified exposure. Interventions were carried out in forests and were self-guided. DOS varied between studies including a 2-hour WO and unspecified exposure. Biological measurements included alpha-pinene, monoterpene, cortisol, stress biomarkers and core symptoms. While PHYS measurements reported on core symptoms. All authors reported positive effects of FT interventions on biological and PHYS parameters. Spanish researchers have an expansive evaluation of biological markers not found in other reported studies. Female university students completing a walking program in an oak forest and urban setting showed increased absorption of alpha-pinene in the forest with lower baseline monoterpene blood concentrations. Time spent in the forest may be an important factor when considering stress biomarkers. While forest programs showed more benefits vs urban programs, the DOS did not appear to matter as results were positive whether participants did a 2-hour walking only program or otherwise.

Taiwan

Taiwanese research included (3)⁸³⁻⁸⁵ studies that were NR (2) or RCTs (1). Populations cited: healthy adults and survivors of chronic disease. Interventions varied between WO, exercise programs, and FB. Settings included forests, *Phyllostachys edulis* (forest) and urban settings. Interventions were guided and self-guided. DOS varied between studies including short- and extended-exposures: 2-hour FB, 6 days, and 5 nights WO. Researchers explored PHYS samples including SBP and DBP, SNS activity, HR, and pulse. PSYCH measurements included mood states. Results were positive whether participants had a 2-hour or a 6-day 5-night SY program. *Phyllostachys edulis* forests showed benefits in participants' cardiovascular functions following a walking exercise program. Healthy adults exhibited a decrease in SBP and increase in SNS activity.⁸⁵ The self-guided group exhibited an increase in HR values and decreases in SBP and DBP. The 3 FT programs had positive effects on improving mood states.⁸⁵

Tsao (2022)⁸³ conducted a 6-day/5-night FW exercise program (1.5 hr. in a *Phyllostachys edulis*) compared to an urban park in Taipei city. The FW program results indicate an increase in cardiovascular function. Yu (2017)⁸⁴ investigated a 2-hour FB program to stimulate the senses in healthy adults and survivors of chronic disease. Results showed a decrease in pulse rate and SBP and DBP in the participants.

United Kingdom (UK)

British research included (1)²⁷ a mixed-methods study of students and adults. This study population received either a

walking or video setting only intervention. Settings included a SY or a SY video setting with 4-hour exposure times. Researchers explored PSYCH responses and reported SY reduces stress and increases positive affect and well-being more than the digital SY.

Discussion

The evidence suggests, from a PHYS perspective, blood pressure and heart rate decreased in participants of SY along with increased relaxation for each of the empirical studies. Psychologically, participants reported a decrease in anxiety along with an improved state of well-being. Gender, culture, education, marital status, economic status, nor age had an impact on the outcomes for each of the studies. The time the participants engaged in the SY activities ranged from 15 minutes to 90 minutes. Based on the studies reviewed, the findings provided evidence, SY may be of benefit PHYS and PSYCH even if exposure is as little as 15 minutes.

Summary of Findings

This ScR expands on the 2017 review by Hansen and colleagues, which looked at program elements, health data tracked and screened, time spent outdoors, geographical areas, and ScR trends and themes. A total of 63 studies (21 randomized, 29 non-randomized, and 13 other), with 4359 participants, met all the criteria for a detailed review and evaluation. Although some studies showed strong design and reporting, the findings are moderated by several shortcomings related to study design and outcomes. As a result, we highlight several areas for ongoing research and enhancement in this discussion.

Limitations

There are limitations of this study. First, many primary studies had moderate to high bias in participants and researchers are aware of the interventions. Blinded SY interventions are practically impossible to apply. Additionally, self-reported questionnaires for PSYCH reported outcomes can lead to errors, weakening the link between SY and intended outcomes. Future studies could include well-designed interventions and reliable psychological measures to explore SY effects.

Second, although SY may include a spiritual component,⁸⁶ none of the authors included spiritual metrics in the research designs. However, meditation was included as an independent variable of multiple studies. Qualitative papers were excluded in this review and perhaps spiritual measures were not found due to this exclusion.

Third, these studies were carried out internationally. Therefore, awareness of this fact in interpreting the results is suggested, and the need for broader geographic application, including the United States (US), is emphasized in SY review effects. Fourth, this ScR may have missed

unpublished or non-English studies as only English studies from the past 5 years were reviewed. Literature searches using international databases were not conducted, however, it appears our method identified many for this ScR. This ScR's conceptualization was based on Hansen et al (2017) State-of-the-Art review. There is background information regarding the practice of SY in the US, however, the authors did not find research conducted in the US during the 2017 to 2022 time period. Hence, a renewed call for empirical research in the US is evidenced by the results of this paper.

Fifth, the chosen studies lacked follow-up evaluations, potentially affecting effectiveness of reported outcomes. It's uncertain if SYs impact persists over time. Hence, future research could include follow-ups to assess long-term effects on PHYS and PSYCH health. In addition, a spiritual connection may be a researched outcome in the future.

Despite its limitations, this study highlights SYs therapeutic benefits. Its use as a non-pharmacologic method to manage and treat PHYS and PSYCH health conditions are advocated for while aligning with the increasing endorsement of nature-based therapeutic activities for maintaining physical and mental health.

Conclusion

The evidence from this review of 63 papers support the practice of SY as a health promotion modality. Compelling data suggests even brief exposures to SY are beneficial. The 63 studies conclude SY, is a powerful modality for improving both PHYS and PSYCH health and well-being. Whether spending a few minutes or a few days, whether in the heart of the forest or experiencing it virtually, SY has been shown to alleviate negative mental and physiological health symptoms.

While these findings are promising, the potential for bias in these studies are acknowledged. Furthermore, there are aspects of well-being, such as our connection to nature as a spiritual component, that have yet to be fully explored in SY research. The exact mechanisms and underlying processes through which SY works remain the subject of ongoing investigation.

An evaluation of SY's long-term efficacy in comparison to other established therapeutic contemplative approaches is necessary before SY can enter mainstream treatment modalities. While the potential is promising, we acknowledge there is still a significant amount of research to be conducted. However, with each progressive study, there is an advancement towards a profound understanding of the therapeutic index intrinsic to SY.

Humans intuitively know the innate PHYS, PSYCH and spiritual benefits⁸⁷ associated with being in nature due to our long history (99.9% time) living in/with and as a part of nature. Today, as evidenced by this review, health care providers, scientists, psychologists, and environmental advocates worldwide are unveiling the remarkable holistic-

health benefits associated with SY. This review of 63 studies and supporting background information demonstrates the heightened interest in SY worldwide. The practice of slowly moving through nature in an awareness/awakened/mindful state profound effects on the PHYS and PSYCH systems. Nature connects us with our spirituality through such concepts as *awe*, *wonder* and *gratitude*. This ScR has illuminated the health-promotion benefits of spending time in nature and added to the evidence-based literature. Let us continue to research, reflect, promote and document, as well as learn from the experiences associated with SY. As Santosa and colleagues (2022) mention: *Nature reminds us to rest when tired, enjoy every breath, and be grateful for everything that happens* (p.1165).⁸⁸

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