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REVIEW ARTICLE

The effects of forest bathing on psychological well-being: A systematic review and meta-analysis

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Abstract

Globally, around half (55%) of the population live in fast-paced urban settings where many people find it challenging to manage their stress and respond to crises with a positive mindset. This resulted in prolonged distress where anxiety and fatigue caused physical and mental health concerns. Nature walks involving immersive exposure in the forest, and green spaces have been posited to offer physiological and psychological benefits. Therefore, in this systematic review, we evaluated the effects of forest bathing on psychological and physiological outcomes. We searched four English and five non-English databases (Chinese and Korean) for peer-reviewed studies published between January 2000 and March 2021. This review adhered to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-analysis Statement 2020. The primary outcomes explored in this review were mainly psychological, including anxiety, depression, mood and quality of life. The secondary outcomes were physiological outcomes such as blood pressure and heart rate. We conducted a meta-analysis on each outcome using the random-effects model. Heterogeneity was assessed by the I^2 statistic. Thirty-six articles (21 in English, 3 in Chinese and 12 in Korean) with 3554 participants were included in this review. Our meta-analysis suggested that forest bathing can significantly reduce symptoms of depression and anxiety. However, we did not observe as many benefits in physiological outcomes. Against the background of the negative effects of urbanization on mental well-being, this review highlighted the potential therapeutic role of forests in the contemporary world, lending further evidence-based support for forest conservation.

KEYWORDS
forest bathing, meta-analysis, psychological well-being, systematic review

INTRODUCTION

Humans have been theorized to possess a psychological sense of closeness and connection to nature, as characterized by an emotional bond that can extend into a sense of identity with nature as a whole (Lim et al., 2020). Theories that offered explanations for human relationship with nature primarily focused on the restorative effects of the natural environment on humans. For example, the biophilia hypothesis by Wilson (1992) has posited that it is an innate human tendency to engage with nature positively, a legacy from our forest-dwelling past. Whereas, Attention restoration theory (ART), suggested by Kaplan and Kaplan (1989), focused on the cognitive improvement associated with restoration. And finally, the Psycho-evolutionary stress reduction theory (PET) by Ulrich (1984) argued that restoration can be achieved through stress reduction and acknowledges affective or emotional changes related to nature's involvement. However, all three theories appeared to

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suggest salubrious or therapeutic effects on mental health, mental development and personal fulfilment when individuals are reconnected to a natural environment (Grassini, 2022).

In 1982, the Japanese government introduced 'Shinrin-yoku', which translates as forest bathing, as a form of therapy for city dwellers through exposure to forested areas in the cities (Lim et al., 2020; Wen et al., 2019). As its name suggests, forest bathing involves immersion in forested areas and mindful attention to all five senses (Lim et al., 2020), through which the physical and psychological healing of the body occurs (Wen et al., 2019). This total sensory experience of nature stems from mindfulness, which intentionally focuses on the present without judgement (Lim et al., 2020) through activities such as walking or meditation in nature (Wen et al., 2019).

In this regard, the concept of salutogenesis defined by Antonovsky encapsulates the benefits of an individual's exposure to nature on their health and well-being (Antonovsky, 1996). Salutogenesis stems from the perspective that health and illness are not seen as contrasting entities but as two ends of the same continuum (Stoltz & Schaffer, 2018). Just as stressors represent factors that lead an individual from optimal health to diseases, 'salutogens' represent personal and environmental factors that improve health and well-being (Stoltz & Schaffer, 2018). Salutogens enhance an individual's ability to elicit and sustain a 'sense of coherence and meaning' towards life, thus bolstering their coping resources against stress (Stoltz & Schaffer, 2018). The sense of coherence between humans and the natural environment stemming from the concept of salutogenesis has been widely researched worldwide (Mayer et al., 2019). This strong sense of coherence is said to affect individuals' performance and success positively and relate to their social situations and network structures (Nosheen et al., 2014). Nurses can therefore play an active role in using the salutogenic model of health and with health promotion efforts, implement disease prevention measures (Mittelmark & Bull, 2013), such as forest bathing. Studies have shown that an individual's physical and psychological health can improve through the salutogenic effects of the natural environment (Stoltz & Schaffer, 2018).

The benefits of forest bathing on psycho-physiological health are manifold. It has been demonstrated to improve immunity, aid mood regulation, and reduce anxiety and depression among young and old adults (Bang et al., 2017; Lim et al., 2020; Wen et al., 2019). Additionally, walking in the forest has been reported to exert significantly more positive effects on physical and mental health than walking in the city (Bang et al., 2017). A meta-analysis by Roberts et al. (2019) showed an improvement in an individual's depressive mood after walking in green spaces and built green environments such as parks, where the frequencies for the walks ranged from daily to weekly, and the duration ranged from 50 to 90 min.

Apart from improved self-reported stress and anxiety levels, objective measures of stress such as saliva cortisol levels and pulse rates have also decreased due to forest bathing (Ochiai et al., 2015). In addition, significant decreases in systolic and diastolic blood pressure and heart rate were reported among Chinese students who had completed a bamboo forest walk compared to those who walked in an urban environment (Zeng et al., 2020).

These psycho-physiological benefits of forest bathing have been demonstrated among older adults too. For example, middle-aged males undergoing forest bathing have reported significantly decreased blood pressure and serum cortisol levels (Li et al., 2016; Ochiai et al., 2015). Furthermore, one study on 24 elderly participants also found significantly enhanced vigour and decreased cardiovascular disease-associated factors among those participants who completed a 7-day forest-walking programme (Mao et al., 2012). It can be seen that the benefits from forest bathing go beyond alleviating stress-related physical and mental health issues, improving physiological outcomes and also potentially enhancing the body's immune system. Although a recent meta-analysis by Roberts et al. (2019) showed a positive impact on depressive symptoms after walking in green spaces and built green environments, the review remains limited in terms of its language inclusion and the absence of other psychological outcomes such as anxiety. Therefore, this systematic review and meta-analysis was timely as it aimed to evaluate the effectiveness of forest bathing on individual well-being.

AIMS

This systematic review aimed to systematically identify and synthesize evidence on forest bathing and its impacts on individual well-being.

METHODS

This systematic review adhered to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2020 statement (Page et al., 2021) to ensure the methodological rigour of the systematic review (Tam et al., 2019).

Eligibility criteria

Types of studies

This review included randomized controlled trials (RCTs), cluster-randomized trials, crossover trials and quasi-experimental studies with an independent control group published in Chinese, English or Korean from 2000 onwards to ensure that the findings are up-to-date.

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Types of participants

Participants from the selected studies were included if they were adults older than or equal to 18 years (there were no restrictions by gender) but excluded if they had been diagnosed with psychological conditions or cognitive impairment.

Types of interventions

We included interventions involving any type of activities conducted physically in the forest or natural settings.

Types of comparators

The review included studies that contrasted an intervention group with an independent control group that either (i) did not receive any intervention or (ii) received the same activity as that in the intervention group but not in the forest or natural settings (e.g. in an urban setting).

Types of outcomes

Primary outcomes for this review were mainly psychological outcomes, including anxiety, depression, mood and quality of life, measured by validated instruments. Secondary outcomes were physiological outcomes such as blood pressure and heart rate.

Information sources

Four databases, that is, PubMed, EMBASE, CINAHL and PsycInfo, were searched for potential articles in English published between January 2000 and March 2021. Additionally, searches were conducted also conducted on China National Knowledge Infrastructure (CNKI) for Chinese publications and Korean Medical Database (KMbase), Research Information Sharing Service (RISS), DBpia and National Digital Science Library (NDSL) for Korean publications.

Search strategy

A search strategy was developed to identify studies used in this review. An initial pilot search on PubMed was performed with the following keywords: 'Forest therapy', 'Forest walking', Forest hiking', Forest bathing', 'Shinrin-yoku', 'Salim yok', 'Forest environment', 'Wood-lands', 'Greenwood', 'Green Space', 'Green environment', 'Wildness experience', 'Nature therapy', 'Nature walk', 'Trees', 'Forest air bathing', 'Wood' and 'Parks'. To ensure the sensitivity and specificity of the strategy, advice was sought from an experienced medical librarian from the university. Titles, abstracts and subject descriptors containing the relevant keywords were then retrieved to modify the searches on various electronic databases for a more comprehensive search. The search strategy used in PUBMED is shown in File S1. The results were exported to MS Excel for evaluation upon completion of the searches.

Selection process

Both publications before 2000 and duplicate records were identified and removed. For the remaining publications, the reviewers (Authors 2 and 6 for the Chinese database, Authors 1 and 4 for the English database and Authors 3 and 4 for the Korean databases) independently screened the titles and abstracts; studies not meeting the inclusion and exclusion criteria were removed at this stage. The kappa statistic was used to assess the agreement between the reviewers. Following this, two independent reviewers retrieved the full texts of those publications fitting the eligibility criteria for further assessment. Publications from the same research studies were identified and linked in this stage. To avoid including data from the same study in different publications in the meta-analysis, the reviewers checked the demographic characteristics of different publications from the same group of authors. If the data were confirmed to have come from the same study, only one data set would be used; otherwise, both data sets will be included in the meta-analysis. Finally, the reference lists of the identified publications were hand-searched and reviewed to determine any additional relevant literature (Whittemore & Knafl, 2005). Any disagreements throughout the study selection were resolved through discussion or by seeking the opinion of a third reviewer in the team.

Data collection process

A Microsoft Excel template for data extraction was created with reference to a previous review (Tam et al., 2021). The reviewers (Authors 2 and 6 for the Chinese database, Authors 1 and 4 for the English database and Authors 3 and 4 for the Korean databases) independently extracted information on the publication, participants, intervention and control groups, and outcomes. The mean, standard deviation and sample size of the intervention and control groups in each study were extracted as outcomes. For publications reporting only medians and interquartile ranges, such data were extracted and converted to means and standard deviations (Wan et al., 2014). For publications reporting means and standard deviations in a graphical format, such data were extracted from the graphical plots where possible (Higgins et al., 2021).

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Study risk of bias assessment

The reviewers independently assessed the quality of the included studies using the JBI Critical Appraisal Checklist for randomized controlled trials and the JBI Critical Appraisal Checklist for quasi-experimental studies (Joanna Briggs Institute, 2017). Each of the questions was assigned a rating of 'Yes', 'No' or 'Unclear'. The score on the Critical Appraisal checklist was based on the total number of 'Yes' obtained for each included study. Two independent reviewers performed these quality appraisals. All disagreements between the two reviewers were discussed until a unanimous consensus was reached.

Synthesis methods

A meta-analysis was conducted on each outcome for which usable data were reported in at least five studies. Mean differences (MD) were used for continuous outcomes measured with the same scales; otherwise, standardized mean differences (SMD) were used. Results were considered statistically significant when $p<0.05$. A random-effects model was used in the analysis; it assumed that different studies estimated different but related effects and would be more likely to fit an actual sampling distribution. Heterogeneity was assessed by the I^2 statistic and accordingly stratified as small ($I^2<30\%$), moderate ($30\% \leq I^2<70\%$) and substantial ($70\% \leq I$). Predefined subgroup analysis was conducted based on (i) the control group—active control (e.g. urban walking or activity) versus no intervention and (ii) quality—≤50% versus >50%.

RESULTS

Study selection

Of the 20 364 publications identified from the databases (16 519 from English, 2659 from Chinese and 1149 from Korean), 743 duplicates were removed. For the remaining 19 621 publications, the titles and abstracts were screened; 19 527 were thus found ineligible. Following this, 94 publications were retrieved, from which 47 were removed with reasons and 36 were included herein. The kappa statistic for the articles from the English databases was 0.70, indicating substantial agreement between the reviewers. The selection flow is presented in Figure 1.

Study characteristics

Thirty-six articles (21 in English, 3 in Chinese, and 12 in Korean) were included, which reported 34 research studies; five articles in this review reported results from two similar studies (de Brito et al., 2019; de Brito et al., 2020) and (Sin et al., 2018; Sin & Lee, 2018a; Sin & Lee, 2018b) (See File S2). Published between 2008 (Cho et al., 2008) and 2020 (Zeng et al., 2020), the studies ranged in sample size from 12 (Ji et al., 2012) to 585 (Song et al., 2018), totalling 3354 participants (See Table 1). The reported mean age of the participants ranged from 21.7 (Kobayashi et al., 2018) to 70.6 (Lee et al., 2014), while Lim et al. (2014) reported that the median age of the participants was between 80 and 90. The reported percentages of females ranged from 0.0% to 100%, with a median of 51.25%.

There were 19 studies from Korea, seven from China, four from Japan, three from the United States of America (USA), two conducted in the Scandinavian countries (Norway and Sweden) and one in the United Kingdom. The design used in the studies included in this review were mainly randomized control trials (22), followed by quasi-experimental design (7) and crossover design (7). The intervention groups involved activities undertaken in the forest or natural environments, such as exercise, walking, meditation or a combination. Conversely, the control groups involved either no intervention (i.e. daily routine for healthy participants and usual care for patients) or similar activities undertaken in an urban setting.

Quality assessment of the included studies

The results of the assessments are depicted in Tables S3 and S4. The median quality score for the 29 randomized controlled studies was 8 (out of 13), ranging from 6 to 10. Remarkably, blinding participants and the personnel delivering the intervention were impossible in these studies; hence, the two items were all rated 'No'. Furthermore, most studies did not clearly mention the randomization and allocation concealment methods. Finally, the seven studies with a quasi-experimental design had a quality score of 8 or 9 (out of 9).

Synthesis results

Depression

Twelve studies reported depression as an outcome, of which seven used the Beck Depression Inventory (Bang et al., 2016, 2017; Cho et al., 2008; Chun et al., 2017; Han et al., 2016), two used Zung's Depression Scale (Choi & Ha, 2014; You et al., 2014), two used Hospital Anxiety and Depression Scale (Kim et al., 2015; Pálsdóttir et al., 2020) and one used Geriatric Depression Scale—Korea Version (Lim et al., 2014). Data from 10 studies were included in the meta-analysis, providing no intervention in the control group. The pooled SMD was −0.67 (95% CI −0.99, −0.35, $p<0.001$), and moderate heterogeneity was observed ($\chi^2 = 29.31$, $p<0.001$, $I^2 = 69\%$)

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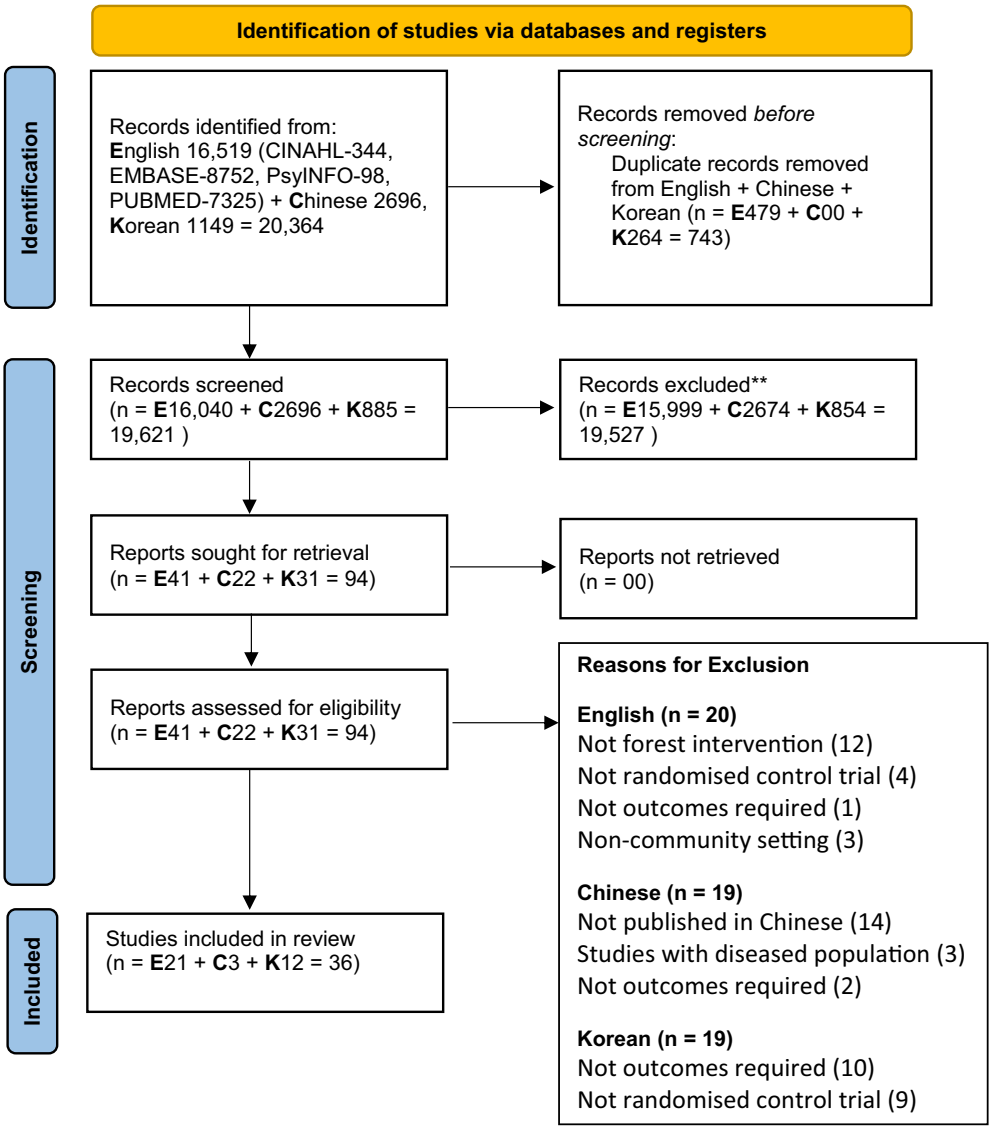

FIGURE 1 PRISMA 2020 flow diagram. E, English; C, Chinese; K, Korean.

(See Figure 2). Two studies (Pálsdóttir et al., 2020; Shin et al., 2012) were not included in the meta-analysis since no standard deviations were reported, but both studies reported significantly lower scores for those in their intervention groups.

Anxiety

Nine studies reported anxiety as an outcome, of which six used the State–Trait Anxiety Inventory (Cho et al., 2008; Chun et al., 2017; de Brito et al., 2019; Koselka et al., 2019; Sin & Lee, 2018b; Song et al., 2019) and two used Hospital Anxiety and Depression Scale (Kim et al., 2015; Pálsdóttir et al., 2020). Data from the seven studies (Cho et al., 2008; Chun et al., 2017; de Brito et al., 2019; Kim et al., 2015; Park et al., 2015; Sin et al., 2018; Song et al., 2019) were included in the meta-analysis. The pooled SMD was −0.84 (95% CI −1.42, −0.25, $p = 0.005$), and substantial heterogeneity was observed ($\chi^2 = 31.39$, $p < 0.001$, $I^2 = 84\%$). No subgroup differences were detected ($p = 0.87$). Three studies (Koselka et al., 2019; Pálsdóttir et al., 2020; Song et al., 2018) were not included in the meta-analysis since no standard deviations were reported, but all three reported lower mean anxiety scores for their intervention groups (See Figure 3).

Mood

Eight studies reported mood as an outcome, of which seven used the Profile of Mood States (POMS), and one used the Positive and Negative Affect Schedule (PANAS) (de Brito et al., 2019). The POMS comprised six domains: depression and dejection, tension and anxiety, anger and hostility, fatigue, confusion and vigour. All the included studies adopting the POMS

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TABLE 1 Characteristics of the included studies. (All the numbers were round to 1 decimal place).

Author (Year)	Country; Setting; Design	Sample size (% female)	Mean age (SD)	Intervention; Duration & Frequency	Control	Assessment time points	Outcome (measures)
Bang et al. (2016)	South Korea; University; RCT	45 (93.3%)	Int: 42.2 (11.4); Ctrl: 37.4 (9.3)	Urban forest-walking exercise based on Information-Motivation-Behavioural skills Model; 40 min each session; twice a week; 5 weeks	Daily routine	BL, 5th wk	1. Physical activity level (MET); 2. Health promoting behaviour (HPLP-II); 3. Quality of life (*GHQ-12*); 4. Depression (BDI); 5. Waist size; 6. BMI; 7. BP; 8. Bone density
Bang et al. (2017)	South Korea; University; Quasi	99 (52.5%)	OA: 24.3 (4.2)	Campus forest-walking program; once a week for 6 weeks	Daily routine	BL, 6th wk, 3 mth	1. Health promoting behaviour (HPLP-II); 2. Physical activity (IPAQ-SF); 3. Depression (BDI); 4. HRV; 5. BP; 6. Cholesterol; 7. Bone density; 8. Body mass index (BMI); 9. Parasympathetic nerve activity
Brown et al. (2014)	UK; Workplace; RCT	94 (21.3%)	OA: 42.0 (10.6)	Walks 4 Work intervention which involves walking in a natural environment; 8 weeks	Daily routine	BL, 8th wk	1. HR; 2. Natural *log of high frequency* (lnHF); 3. BP; 4. Cardiovascular disease (CVD) risk score 5. Quality of life (SF-8)
Calogiuri (2016)	Norway; Workplace; RCT	14 (50.0%)	OA: 49.0 (8.0)	Green-exercise intervention which involves exercising in the natural environment; over 2 consecutive days	Indoor exercise	BL, 2nd wk, 10th wk	1. Perceived potential for restoration (PRS) 2. Affective state (PAAS); 3. BP; 4. Cortisol levels
Cho et al. (2008)	South Korea; Alcohol counselling centre; Quasi	107 Alcohol dependence patients group (7.1%) 91 Family group (100%)	Alcohol dependence patients group Int: 44.7 (7.5); Ctrl: 47.0 (9.3) Family group Int: 49.0 (13.3); Ctrl: 54.3 (11.3)	Forest-healing program; 2 nights and 3 consecutive days	Daily routine	BL, after the program, 3rd day	1. Anxiety (STAI-KYZ) 2. Depression (BDI) 3. Self-esteem (SES) 4. Positive and negative affect (PANAS); 5. Psycho-sociological well-being inventory (PWI-SF); 6. Quality of life (GHQ-12); 7. Life experience (HUS); 8. Psychological Flexibility (AAQ)
Choi and Ha (2014)	South Korea; Community health centre; Quasi	53 (76.9%)	50–59 years Int: 38.5%; Ctrl: 37% ≥60 years Int: 48.5%; Ctrl: 51.5%	Forest-experience-integration intervention; 2 h per session; Once a week for 8 weeks	Daily routine	BL, 8th wk	1. Depression (ZSDS) 2. Resilience (KRQ-53)
Chun et al. (2017)	South Korea; Stroke welfare centre; RCT	59 (32.2%)	OA: 60.8 (9.1)	Forest program which involves meditation and walking in the forest; 4 consecutive days	Stayed in the hotel	BL, 4th day	1. Depression (BDI/HAM-D 17); 2. Anxiety (STAI); 3. Oxidative stress (d-ROMs test/BAP)

(Continues)

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TABLE 1 (Continued)

Author (Year)	Country; Setting; Design	Sample size (% female)	Mean age (SD)	Intervention; Duration & Frequency	Control	Assessment time points	Outcome (measures)
Dang et al. (2020)	China; Nursing home; RCT	26 (46.2%)	Int: 69.2 (4.8); Ctrl: 69.2 (4.8)	Doing exercise in the forest + Respiratory Muscle Training (RMT); 15 days	RMT	BL, 15th day	1. Pulmonary function (Forced expiratory volume/Forced vital capacity) 2. Quality of life (SGRQ)
de Brito et al. (2019)	USA; Community; Non-randomised Crossover	23 (82.6%)	OA: 49.3 (6.7)	Green walking, 50-min session; once a week; 3 consecutive weeks	Suburban walking	BL, 3rd wk	1. Anxiety (STAI-S); 2. Mood (PANAS) 3. Directed-attention (Backwards Digit Span: BDS)
de Brito et al. (2020)	USA; Community; Non-randomised Crossover	24 (83.3%)	49.7 (6.5)	Green walking, 50-min session; once a week; 3 consecutive weeks	Suburban walking	BL, 3rd wk	1. HRV; 2. BP
Han et al. (2016)	South Korea; Workplace; Quasi	61 (57.4%)	Int: 41.6 (6.5); Ctrl: 37.5 (8.4)	Forest therapy camp which involves meditation and exercising in the forest; 2 consecutive days	Daily routine	BL, 2nd day	1. HRV; 2. Natural Killer cell activity; 3. Depression (BDI); 4. Self-reported pain (VAS); 5. Health-related Quality of life (EQ-VAS)
Ji et al. (2012)	South Korea; Community; RCT	12 (0%)	OA: 35.7 (NA)	Viewing and walking in the forest; 3 consecutive days	Viewing and walking in the urban area	BL, 3rd day	1. BP; 2. HR; 3. Amylase concentration (Endocrine system activity); 4. Mood (POMS)
Jia et al. (2016)	China; Hospital; RCT	18 (33.3%)	Int: 70.1 (67–77); Ctrl: 70 (61–79)	Forest bathing trip which involves walking in the forest area; 4 consecutive days	Walking in the city area	BL, 4th day	1. Flow cytometry; 2. Cytokines Production; 3. Mood (POMS)
Kim et al. (2015)	South Korea: Care hospital; RCT	53 (84.9%)	OA: 21–70 Int: Median 41–50 Ctrl: Median 41–50	Forest activity intervention; 4 h per day; 3 consecutive days	Daily routine	BL, 3rd day	1. Anxiety & Depression; (HADS); 2. Mood (POMS-B); 3. Hope (DHS)
Kim et al. (2021)	South Korea: Community health centre; RCT	24 (70.8%)	OA: 40–79	Forest healing program; 3 h per session; once a week for 8 weeks	Daily routine	BL, 8th wk	1. Cholesterol; 2. BP; 3. Blood Glucose; 4. Self-esteem (RSES); 5. Meaning in Life Questionnaire
Kobayashi et al. (2018)	Japan; University; Crossover	485 (0%)	OA: 21.7 (1.6)	Forest bathing which involves walking through a forest; 15 min; 1 day	Walking in the urban area for 15 min	During the intervention	1. HRV

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TABLE 1 (Continued)

Author (Year)	Country; Setting; Design	Sample size (% female)	Mean age (SD)	Intervention; Duration & Frequency	Control	Assessment time points	Outcome (measures)
Koselka et al. (2019)	USA; University; Crossover	38 (52.63)	OA: 22.9 (4.6)	Walking on a forest path; 50 min walk; 3 separate days	Activities of Daily Living	BL, post-intervention	1. Positive and negative affect (PANAS); 2. Anxiety (STAI); 3. Stress (PSS-10); 4. Working memory (vBDS)
Lee et al. (2014)	South Korea; Senior Welfare Centre; RCT	70 (100%)	Int: 70.2 (4.7); Ctrl: 71.1 (5.8)	Forest bathing which involves walking around a forested area; 1 h; 1 day	Walking in the city area	BL, 30 min post-intervention	1. BP; 2. Arterial stiffness (Cardio-Ankle Vascular Index); 3. Pulmonary function (Forced expiratory volume/ Forced vital capacity)
Lei et al. (2020)	China; Community; RCT	18 (NA)	OA: 60–70	Forest therapy which involves exercising in the forest; 5 consecutive days	Exercising in the hotel	BL, 5th day	1. BP; 2. Cardiovascular factors
Lim et al. (2014)	South Korea; Nursing home; RCT	64 (70.3%)	OA: Median 80–90	Forest therapy program; 1.5 h per session; once a week for 11 weeks	Daily routine	BL, 11th wk	1. Self-esteem (RSES); 2. Depression (GDSSF-K)
Mao et al. (2012)	China; NA; RCT	24 (NA)	Int: 67.7 (4.2); Ctrl: 66.8 (3.5)	Forest bathing trip which involves walking in the forest area; 7 consecutive days	Walking in the city area	BL, 7th day	1. BP; 2. Cardiovascular disease-related pathological factors; 3. Serum pro-inflammatory cytokine levels; 4. Mood (POMS)
Mao et al. (2012)	China; University; RCT	20 (0%)	OA: 20.8 (0.5)	Forest bathing trip which involves walking in the forest area; 2 consecutive days	Walking in the city area	BL, 2nd day	1. Serum cytokine levels; 2. Oxidative stress status; 3. Distribution of Leukocyte Subsets; 4. Factors Associated with Cardiovascular Disease; 5. Stress response; 6. Mood (POMS)
Pálsdóttir et al. (2020)	Sweden; Hospital; RCT	101 (59.4%)	OA: 67 (47–80)	Nature-based rehabilitation (NBR) which involves exercising in the nature environment + standard care; 3.5 h session; twice a week; 10 weeks	Standard care	BL, 8th mth, 14th mth	1. Post-stroke fatigue (Mental Fatigue Scale); 2. Perceived Occupation Value (Oval-pd); 3. Disability (Modified Rankin Scale); 4. Health-related Quality of Life (EQ-5D); 5. Anxiety (HADS); 6. Depression (HADS)
Park et al. (2015)	South Korea; Community; Quasi	70 (62.9%)	OA: Median 40–50	Forest therapy program; 90 min; 1 day	Control 1 (Hiking & forest bathing) Control 2 (Aerobic)	BL, post-intervention	1. Physical stress; 2. Mental stress; 3. Stress resistance; 4. Stress index; 5. BP

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TABLE 1 (Continued)

Author (Year)	Country; Setting; Design	Sample size (% female)	Mean age (SD)	Intervention; Duration & Frequency	Control	Assessment time points	Outcome (measures)
Shin et al. (2012)	South Korea; Alcohol Research Centre; RCT	92 (8.7%)	45.3 (3.9)	Forest healing camp which involves meditation and exercising in the forest; 9 consecutive days	Daily routine	BL, 9th day	1. Depression (BDI)
Sin et al. (2018)	South Korea; Health association; RCT	63 (38.1%)	Int: Median 50–60 Ctrl: Median 50–60	Forest bathing which involves walking around a forest; 2 h; 1 day	Daily routine	BL, post-intervention	1. The activity of the autonomic nervous system; 2. Pulse; Heart rate deviation
Sin and Lee (2018a)	South Korea; Health association; RCT	63 (38.1%)	Int: Median 50–60 Ctrl: Median 50–60	Forest bathing which involves walking around a forest; 2 h; 1 day	Daily routine	BL, post-intervention	1. Vascular age types; 2. Vascular age index; 3. Heart beating
Sin and Lee (2018b)	South Korea; Health association; RCT	63 (38.1%)	Int: Median 50–60 Ctrl: Median 50–60	Forest bathing which involves walking around a forest; 2 h; 1 day	Daily routine	BL, post-intervention	1. Pulse; 2. Anxiety (STAI-Y) 3. Psychological stress (SF-PWI)
Song et al. (2019)	South Korea; Unmarried mothers' house; RCT	70 (100%)	OA Median 20–30	Forest therapeutic program; twice a week for four weeks (8 sessions)	Daily routine	BL, 4th wk post-intervention	1. Depression (BDI); 2. Self-esteem (RSES)
Song et al. (2013)	Japan; University; Crossover	485 (0%)	OA: 21.8 (1.6)	Forest bathing which involves visiting the forest, sitting on a chair and viewing the landscape; 15 min	Exposure to the urban area	BL, post-intervention	1. BP; 2. Pulse rate
Song et al. (2019)	Japan; University; Crossover	585 (0%)	OA: 21.7 (1.6)	Forest bathing which involves walking through a forest; 15 min; 1 day	Walking in the city for 15 min	Post-intervention	1. Mood (POMS); 2. Anxiety (STAI)
Song et al. (2019)	Japan; University; Crossover	60 (100%)	OA: 21.0 (1.3)	Forest bathing which involves walking through a forest; 15 min	Walking in the city	BL, during intervention (HRV), post-intervention	1. HRV; 2. HR; 3. BP; 4. Pulse rate; 5. Mood (POMS); 6. Anxiety (STAI)

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TABLE 1 (Continued)

Author (Year)	Country; Setting; Design	Sample size (% female)	Mean age (SD)	Intervention; Duration & Frequency	Control	Assessment time points	Outcome (measures)
Yi et al. (2019)	South Korea; Community; Quasi	90 (77.8%)	Int 1 (Breathing Program): 78.5 (6.9); Int 2 (Walking Program): 72.9 (6.2); Ctrl: 74.4 (4.9)	Two forest therapy programs 1. Walking Program (WP) - 50 mins of forest walking 2. Guided-breathing meditation program (BP) - 30 mins of guided-breathing meditation and 20 mins of slow forest walking; 11 sessions; 11 weeks	Daily routine	BL, 11th wk	1. Neural activity (Electroencephalography); 2. Bioimpedance; 3. HRV
You et al. (2014)	South Korea; Community; Quasi	20 (100%)	OA: ≥50	Forest therapy (Sallimyok program) which involves meditation, forest therapy, stretching exercise, wrapping-up and sharing feelings in the forest; 5 h; 1 day	Daily routine	BL, post-intervention	1. Depression (ZSDS); 2. Psychological wellbeing (PWB)
Zeng et al. (2020)Zeng (2020)	China; University; RCT	120 (50%)	OA: 19–24	Forest therapy which involves walking in the bamboo forest for 15 min and viewing the landscape for 15 min each day; 3 days	Walking in the urban site	BL, 3rd day	1. BP; 2. HR; 3. Peripheral oxygen saturation (SpO2); 4. Environmental satisfaction evaluation (SDM)
Zheng et al. (2017)	China; Sanatorium; RCT	190 (0%)	OA: 50 (NA)	Forest bathing which involves speed walking for 2 km in the forest; once per day; 20 days	Speed walk along the highway	BL, 20th day	1. BP; 2. Blood lipid; 3. Cardiac function

Abbreviations: AAQ: Acceptance & action questionnaire-16; BAI: Beck Anxiety Inventory; BAP: biological antioxidant potential; BDI: Beck Depression Inventory; BL: Baseline; BMI: Body Mass Index; BP: Blood Pressure; COMOSWB: A Concise Measure of Subjective Well-Being; Ctrl: Control; DHS Dispositional Hope Scale; d-ROMs test: The reactive oxygen metabolites test; EQ-5D: EuroQol scale – 5 Dimensions; EQ-VAS: EuroQol Visual Analogue Scale; GDSSF-K: Geriatric Depression Scale Short Form- Korea Version; GHQ-12: General Health Questionnaire 12-item; HADS: Hospital Anxiety and Depression Scale; HAM-D: Hamilton Depression Rating Scale; HBSC-SCL: Health Behaviour in School-Aged Children (HBSC) Symptom Check List; HPLP-II: Health-Promoting Lifestyle Profile II; HR: Heart Rate; HRV: Heart Rate Variability; HUS: Hassles and Uplifts Scale; Int: Intervention; IPAQ-SF: International Physical Activity Questionnaire Short-form; KRQ-53: Korean Resilience Questionnaire-53; MAACL: Multiple Affect Adjective Checklist; MET: Metabolic Equivalent Minutes; MMSE: Mini–Mental State Examination; Mth: Month; OA: Overall; Oval-pd: Occupational Value Assessment with predefined items; PAAS: Physical Activity Affect Scale; PANAS: Positive Affect Negative Affect Scale; PGWBI: Psychological General Well Being Index; POMS: Profile of Mood States; PSQI: Pittsburgh Sleep Quality Index; PSS-10 Perceived Stress Scale; PWI-SF: Psychosocial Well-being Index Short Form; Quasi: Quasi-experimental; RCT: Randomized Controlled Trial; RSES: Rosenberg Self-Esteem Scale; RSS: Restorative State Scale; SACQ: Student Adaptation to College Questionnaire; SES: Self-esteem Scale; SF-36/SF-8: 36-/8-Item Short Form Survey; SGRQ: St George's Respiratory Questionnaire; STAI: The State-Trait Anxiety Inventory; SWLS: Satisfaction With Life Scale; vBDS test: Backward Digit Span test; wk: Week; ZSAS: Zung Self-Rating Anxiety Scale; ZSDS: Zung Self-Rating Depression Scale.

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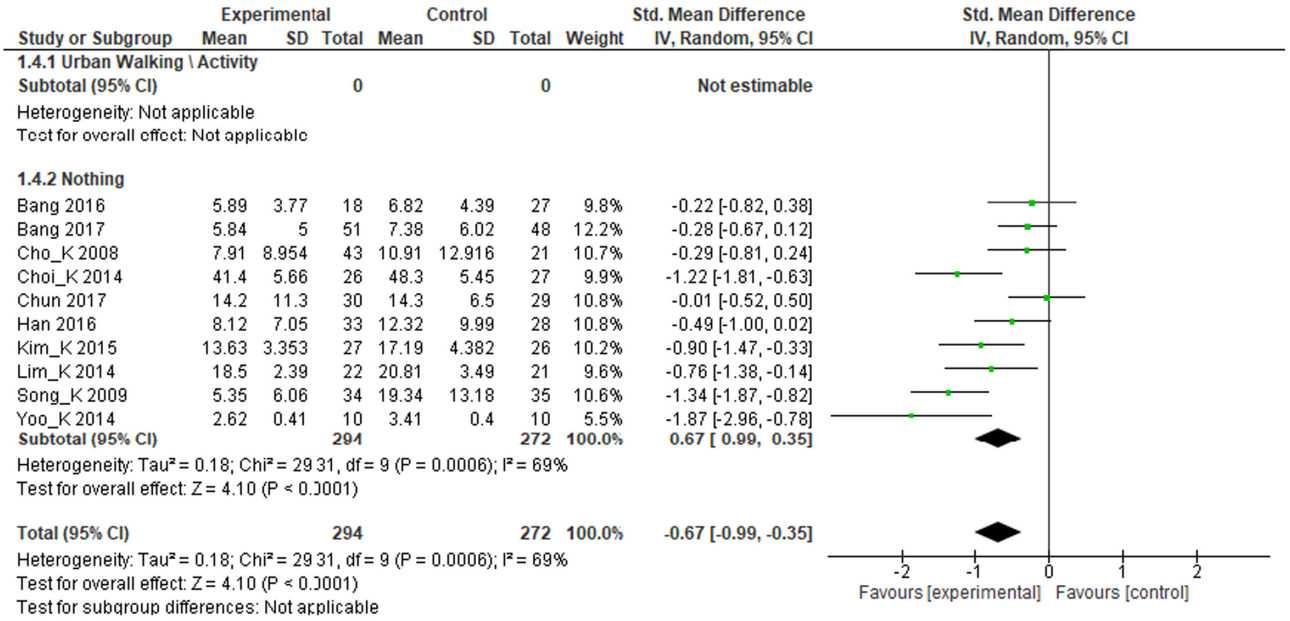

FIGURE 2 Depression.

reported superior scores for the intervention groups for most domains. However, data extraction was infeasible as the results were reported as bar charts. The study by de Brito et al. (2019) adopting the PANAS reported an insignificant mean difference between the intervention and control groups.

Quality of life

Six studies (Bang et al., 2016; Brown et al., 2014; Cho et al., 2008; Dang et al., 2020; Han et al., 2016 and Pálsdóttir et al., 2020) reported quality of life as an outcome. Two studies used the General Health Questionnaire (GHQ-12) (Bang et al., 2016; Cho et al., 2008). The others used EuroQol-5D (EQ-5D) (Pálsdóttir et al., 2020), EuroQol Visual Analogue Scale (EQ-VAS) (Han et al., 2016), 8-Short form health survey (SF-8) (Brown et al., 2014) and St. George's Respiratory Questionnaire (SGRQ) (Dang et al., 2020). Meta-analysis was not conducted since only four studies provided sufficient data. All six studies reported improved quality of life in the intervention group, but only four detected statistically significant differences (Bang et al., 2016; Cho et al., 2008; Dang et al., 2020 and Han et al., 2016).

Systolic blood pressure

Fifteen studies reported systolic blood pressure as an outcome, and data from 13 studies were included in the meta-analysis. The pooled MD was −1.66 (95% CI −4.30, 0.97, $p = 0.22$), and moderate heterogeneity was observed ($\chi^2 = 24.72$, $p = 0.02$, $I^2 = 52\%$). No subgroup differences were detected ($p = 0.57$). Two studies (Song et al., 2013; Zeng et al., 2020) were not included due to their lack of data, but both reported reduced blood pressure in the intervention group (See Figure 4).

Diastolic blood pressure

Fifteen studies reported diastolic blood pressure as an outcome, and data from 13 studies were included in the meta-analysis. The pooled MD was −3.09 (95% CI −7.52, 1.34, $p = 0.17$), and substantial heterogeneity was observed ($\chi^2 = 159.33$, $p < 0.0001$, $I^2 = 92\%$). In addition, a significant difference between subgroups was detected ($p = 0.03$). Two studies (Song et al., 2013; Zeng et al., 2020) were not included due to their lack of data, but both reported reduced blood pressure in the intervention group (See Figure 5).

Heart rate

Seven studies reported heart rate as an outcome, and data from five studies were included in the meta-analysis. The pooled MD was −0.42 (95% CI −3.32, 2.49, $p = 0.78$), and substantial heterogeneity was observed ($\chi^2 = 9.33$, $p = 0.05$, $I^2 = 57\%$). No subgroup difference was detected ($p = 0.55$). Two studies (Song et al., 2013; Zeng et al., 2020) were not included, and they reported lower heart rates in the intervention group (See Figure 6).

Variability of heart rate

Six studies (Bang et al., 2017; de Brito et al., 2020; Han et al., 2016; Kobayashi et al., 2018; Song et al., 2019 and Yi

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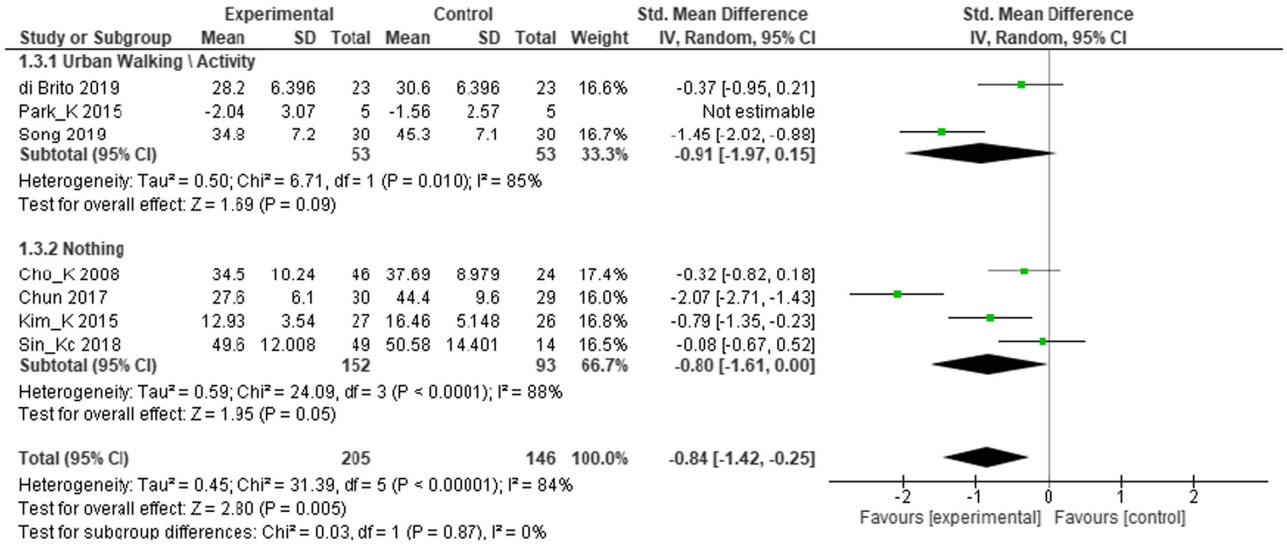

FIGURE 3 Anxiety.

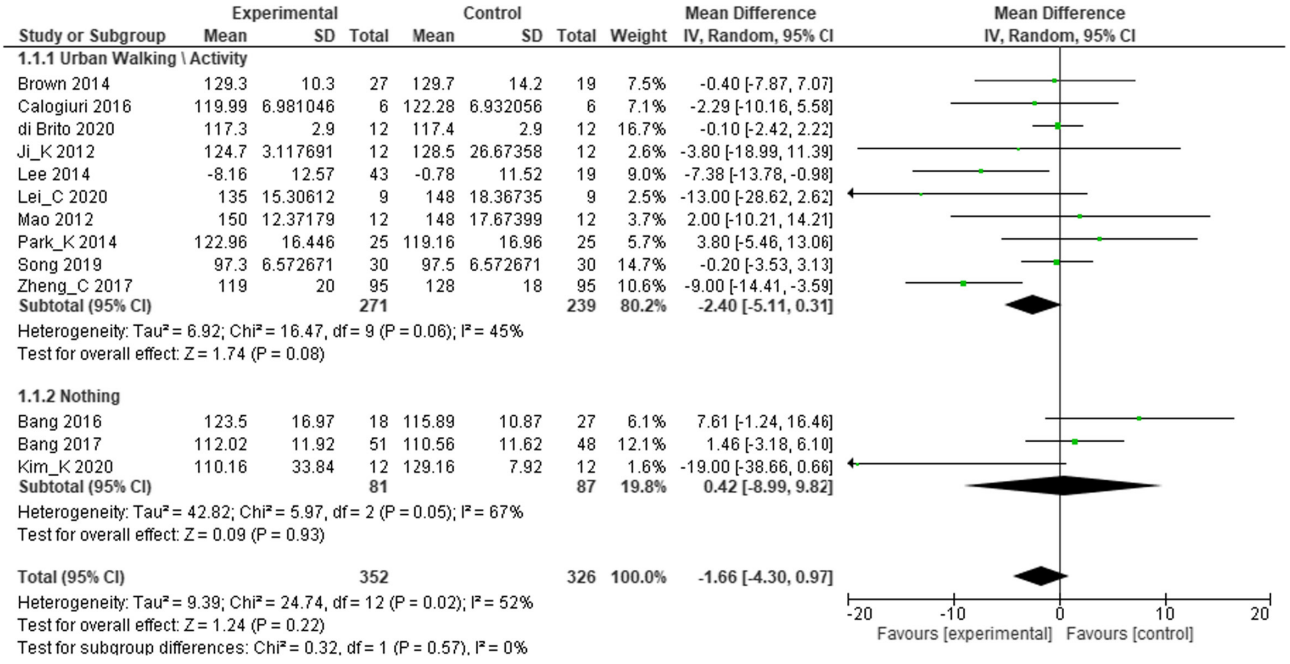

FIGURE 4 Systolic blood pressure.

et al., 2019) reported variability of heart rate as an outcome, of which two (de Brito et al., 2020; Han et al., 2016) used the Standard Deviations of Normal-to-Normal RR intervals (SDNN) in milliseconds (ms) while four (Bang et al., 2017; Kobayashi et al., 2018; Song et al., 2019 and Yi et al., 2019) used the spectrum method with high- and low- frequency component. Since fewer than five studies provided sufficient data, a meta-analysis was not conducted. However, all but one study (Song et al., 2019) reported an insignificant difference between the intervention and control groups.

DISCUSSION

Our review comprised 36 articles with an aggregate of 3554 participants from nine databases in three languages (21 in English, 3 in Chinese and 12 in Korean). The studies included quasi-experimental designs, non-randomized crossovers and randomized control trials. Our findings provided evidence that forest bathing demonstrates a statistically significant improvement in the symptoms of both depression and anxiety compared to the control groups. However, forest bathing appeared

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to be less beneficial due to the small sample size involving studies that examined the effects of forest bathing on physiological outcomes such as blood pressure and heart rate. It is noteworthy that meta-analysis could not be conducted for the outcomes of quality of life and variability of heart rate outcomes because of insufficient data. Likewise, a meta-analysis could not be conducted for mood outcome because the presentation of results as bar charts in those studies rendered data extraction infeasible, despite evidence on the role of forest bathing in improving mood.

In line with previous reviews, our findings demonstrated the beneficial effects of forest bathing in improving stress (Antonelli et al., 2019), well-being (Corazon et al., 2019) and depressive symptoms (Grassini, 2022; Lee et al., 2017). While it might be useful to compare outcomes of interest between reviews, the heterogeneity in the operationalization of 'forest bathing' translated into methodological challenges. For instance, while our review and Corazon et al. (2019) considered studies conducted in any natural green environments, Antonelli et al. (2019) excluded studies conducted in parks or urban green areas. Additionally, moderation analysis by Roberts et al. (2019) suggested that factors such as the specific elements of a given natural environment (e.g. type of environment) exerted moderating effects on the relationship between the natural environment and depressive mood. Hence, effect sizes might differ due to variations in the operationalization of 'forest bathing' between reviews and direct comparisons' infeasibility. Nonetheless, the totality of evidence suggested the beneficial effects of forest bathing on psychological outcomes.

The past decade has witnessed an increase in research on the use of forest bathing in improving the overall well-being of various populations (Tsunetsugu et al., 2010). The benefit of forest bathing includes the reduction of anxiety (Chen et al., 2018), depression (Maund et al., 2019), negative emotions (Janeczko et al., 2020), stress responses (Kim et al., 2021) and physiological responses such as heart rate and blood pressure (Zeng et al., 2020). A timely review of the effectiveness of forest bathing is paramount as the modern world undergoes a mental health crisis, with consistently high rates of mental health conditions (Richter et al., 2019) alongside a further exacerbation by the COVID-19 pandemic (Costa et al., 2020; Grassini, 2022; Hamada & Fan, 2020). As demonstrated by our findings, individuals might derive psychological benefits from engaging in forest bathing during this period.

Activities conducted during forest bathing examined in the reviewed studies typically included meditation, walking or landscape viewing. The low-intensity nature of these activities meant that individuals from all populations could embrace forest bathing, regardless of physical limitations. However, it is important to note that the accessibility of forested areas, especially in cities, can affect individuals' motivation to participate in forest bathing programmes (Lee et al., 2019). The importance of such accessibility has also been highlighted in the World Health Organization's brief for action (World Health Organization, 2017) and in the Green, Active, Prosocial, and Safe places (GAPS) framework by the Centre of Urban Design and Mental Health (Hosang, 2016). As urban green spaces garner increasing global attention (Siah et al., 2022) and the effects of urbanization

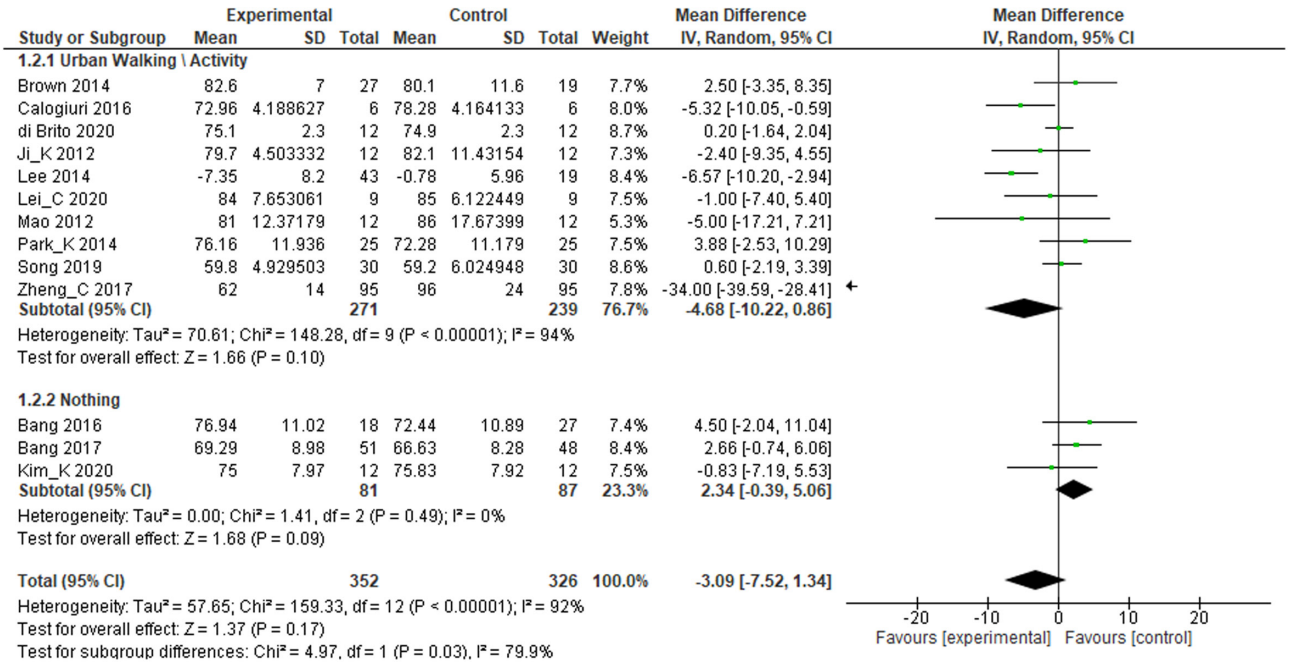

FIGURE 5 Diastolic blood pressure.

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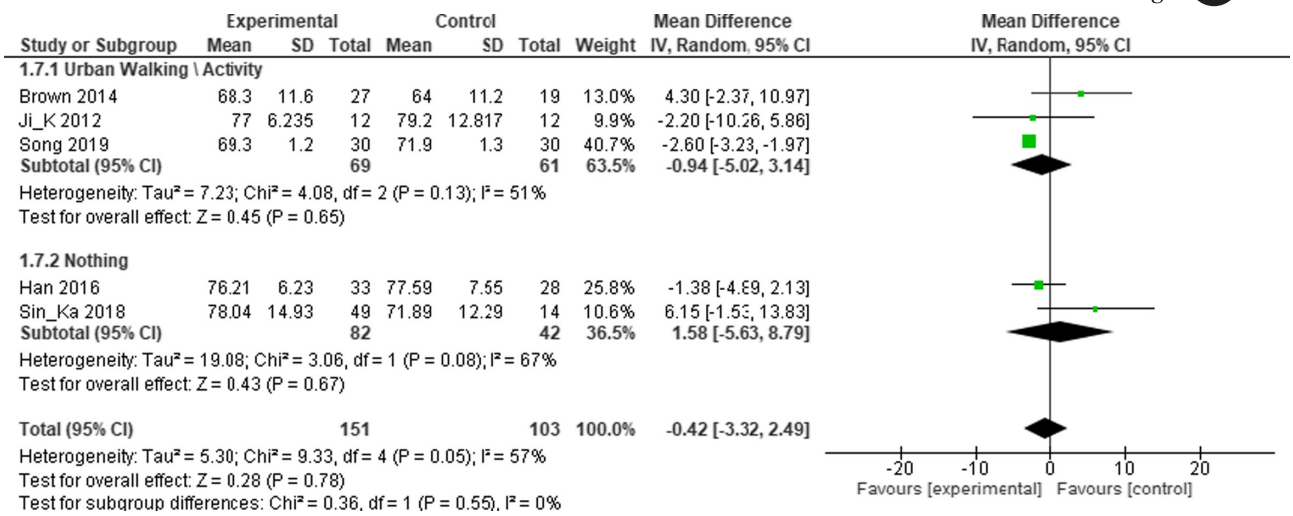

FIGURE 6 Heart rate.

on mental health become more apparent (Ventriglio et al., 2021), this review contributes to the growing body of research on the positive impacts of forests and green spaces in the contemporary world and lends further evidence-based support for urban forest conservation.

The reviewed studies were conducted in various countries, including South Korea, China, Japan, the United Kingdom (UK), the United States of America (USA), Norway and Sweden. While most provided details on experimental field sites, such as the geographical location, terrain and time of day, other potential confounding factors, such as the weather, temperature, season, greenness composition and distance from urban areas, were not considered. These factors have been acknowledged in previous research as variables potentially affecting the impacts of forest bathing. For instance, Chen et al. (2018) concluded that conducting forest bathing during winters with cloudy weather and intermittent rain was not ideal, considering the relationship between depression and limited sunshine exposure (American Psychiatric Association, 2020). Hence, future research on forest bathing may consider exploring these factors.

Some included studies adopted a crossover design, which has typically been used for studies involving intermittent exposure or investigating transient acute effects (Mittleman & Mostofsky, 2014). However, it is unknown whether the effects of forest bathing were transient or long-lasting since many included studies utilized a cross-sectional design. Hence, future research may consider undertaking a longitudinal approach to explore the long-term effects of forest bathing. Additionally, studies with a crossover design entailed the risk of carry-over effects from previous exposure (Mittleman & Mostofsky, 2014), thus warranting a sufficient intervening wash out period (Wellek & Blettner, 2012).

Strengths and limitations

This review has provided an updated synthesis of the current understanding of forest bathing based on evidence from the past two decades. The main strength of the review lies in its comprehensive inclusion of nine databases spanning three different languages, which has yielded a more global coverage and thorough understanding of the impacts of forest bathing. Nonetheless, several limitations should be acknowledged. Firstly, implementing blinding was difficult in many studies, given the nature of the experiments, thus introducing selection bias. Secondly, the small number of studies for each outcome of interest limited the exploration of subgroup analyses in this review. Finally, high heterogeneity was observed in the meta-analysis, and it may be due to the variations of the intervention in the included studies. Nonetheless, no substantial differences were observed between participants engaged in urban walking or activities and those involved in their daily routines.

CONCLUSION

This review has provided evidence for the beneficial effects of forest bathing on psychological well-being. However, caution should be exercised in interpreting the results due to several risks of biases in the reviewed studies. Future research may consider exploring environmental variables (e.g. weather, temperature, season, greenness composition and distance from urban areas) and controlling for methodological variables (e.g. sufficient wash out periods) that could influence effect sizes or even confounders. The standardized operationalization of forest bathing and its constituents may also provide a more structured approach for comparative studies.

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RELEVANCE TO RESEARCH AND CLINICAL PRACTICE

Against the rising importance of the forest environment's role in preventing the harmful effects of global warming, human interference in Earth's life support systems (the forest) has also negatively impacted individuals' mental health. Results from this review reinforced mental health nurses' important role in championing the need for forest preservation as expressed in the United Nations Sustainable Development Goal 11.7 for sustainable cities and communities. Furthermore, mental health nurses can advocate forest bathing as an intervention to prevent and control non-communicable diseases and improve the quality of life and well-being of people and societies as mentioned in the WHO Action Plan for the implementation of the European Strategy for the Prevention and Control of Noncommunicable Diseases in 2012–2016 (World Health Organization, 2012).

Although this review focused on the physical and psychological effects of using forest bathing, one can extrapolate its benefits to those staying in urban cities as well. Government, city planners and policymakers are often faced with conflicting demands on the need to provide for the differing needs of the city population while balancing the need to have green space and improve urban ecosystem services. The importance of having green spaces for health was further emphasized in the Parma Declaration (World Health Organization, 2010), where a commitment was made then, 'to provide each child by 2020 with access to healthy and safe environment…. and to green spaces in which to play and undertake physical activity'. Mental health nurses should therefore work with such agencies as they contribute their professional expertize to ensuring the availability of green spaces in future cities.

Furthermore, with the beneficial effects of forest bathing, mental health nurses should prescribe it as a cost-effective intervention for the individual's mental health outcomes (Koselka et al., 2019), as it goes beyond pharmacological prescription and psychotherapy. Finally, nurse researchers interested in conducting studies on forest bathing should consider having a structured programme within the intervention. A structured intervention programme will improve the study's rigour and allow a more robust comparison across different arms within the trial. Nurse researchers should also consider incorporating biomarkers (e.g. stress and inflammatory biomarkers) when investigating the effects of forest bathing. This will provide additional objective measurement, which could further prove its beneficial effects.

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CONFLICT OF INTEREST STATEMENT

None declared by the authors.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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