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ADMINISTRATIVE INFORMATION**Support** - This research received no external funding.**Review Stage at time of this submission** - Completed but not published.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202650156**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 28 May 2026 and was last updated on 28 May 2026.**INTRODUCTION**

Review question / Objective This systematic review and meta-analysis aims to evaluate the effectiveness of forest therapy programs on psychological and physiological health outcomes in middle-aged women.

PICOS framework:

- P (Population): Middle-aged women (aged 40–64 years)
- I (Intervention): Forest therapy programs, including forest bathing (shinrin-yoku), guided forest walks, and nature-based healing programs conducted in forest environments
- C (Comparator): Control groups (no treatment, waitlist control, or indoor activity control)
- O (Outcomes): Psychological outcomes (depression, anxiety, stress, sleep quality, quality of life) and physiological outcomes (salivary cortisol, heart rate variability, blood pressure)
- S (Study design): Randomized controlled trials, quasi-experimental studies, and pre-post studies.

Rationale Middle-aged women face unique biopsychosocial challenges, including menopausal transition, chronic stress, depression, anxiety, and sleep disturbances, which significantly impair quality of life. Forest therapy, grounded in Attention Restoration Theory (ART) and Stress Recovery Theory (SRT), has garnered increasing empirical support as a nature-based therapeutic intervention. However, the evidence base remains fragmented, and no comprehensive meta-analysis has quantitatively synthesized the effects of forest therapy specifically targeting middle-aged women. This review addresses this gap by providing pooled effect size estimates and identifying moderating factors to inform evidence-based forest therapy program development.

Condition being studied This review focuses on psychological and physiological health conditions prevalent in middle-aged women (aged 40–64), including depressive symptoms, anxiety, perceived stress, sleep disturbance, and reduced quality of life. These conditions are often associated with

hormonal changes during perimenopause and menopause, occupational stress, and social role burden, collectively contributing to deterioration of overall well-being in this population.

METHODS

Search strategy Electronic databases searched: PubMed, Web of Science, Scopus, Cochrane Library (international); RISS, KISS, DBpia, NDSL (Korean).

Search terms (English): "forest therapy" OR "forest bathing" OR "shinrin-yoku" OR "forest healing" OR "nature-based therapy" AND "middle-aged women" OR "women" OR "female" AND "mental health" OR "stress" OR "depression" OR "anxiety" OR "sleep" OR "quality of life" OR "cortisol" OR "heart rate variability"

Search terms (Korean): 산림치유, 산림욕, 자연기반치유, 중년여성, 우울, 불안, 스트레스, 수면, 삶의 질, 코르티솔, 심박변이도

Time period: January 2000 – December 2024.

Participant or population Middle-aged women aged 40–64 years without restriction on nationality, ethnicity, or health condition. Studies enrolling mixed-sex samples were included only if sex-disaggregated data for women were available or the majority ($\geq 70\%$) of participants were women.

Intervention Forest therapy programs conducted in natural forest environments, including forest bathing (shinrin-yoku), guided forest walks, forest healing programs, and structured nature-based therapeutic activities. Interventions could be single-session or multi-session, facilitated or self-directed.

Comparator No-treatment control, waitlist control, or active control (e.g., indoor relaxation, urban walking). Studies with pre-post designs without a control group were also included for sensitivity analysis.

Study designs to be included Randomized controlled trials (RCTs), quasi-experimental studies, and pre-post (single-group) studies reporting quantitative outcomes.

Eligibility criteria Inclusion criteria:

- Participants: middle-aged women (40–64 years)
- Intervention: forest therapy in natural forest settings

- Quantitative health outcomes reported
- Published in peer-reviewed journals (Korean or English)
- Published between 2000 and 2024

Exclusion criteria:

- Animal studies, case reports, reviews, editorials
- Interventions conducted in indoor or non-forest settings
- No extractable quantitative data
- Duplicate publications.

Information sources PubMed, Web of Science, Scopus, Cochrane Library, RISS, KISS, DBpia, NDSL, Google Scholar. Additional records identified through manual reference screening of included studies and relevant systematic reviews.

Main outcome(s) Primary outcomes:

1. Psychological: depressive symptoms (BDI, CES-D, PHQ-9), anxiety (STAI), perceived stress (PSS, VAS-stress)
2. Physiological: salivary cortisol, heart rate variability (HRV: SDNN, LF/HF ratio, ln[HF]), blood pressure
3. Sleep quality (PSQI)
4. Health-related quality of life (WHOQOL-BREF, SF-36)

Effect size measure: Cohen's d / Hedges' g.

Additional outcome(s) Self-efficacy, nature connectedness, immune function markers (NK cell activity, immunoglobulin A), fatigue (MFS), and positive/negative affect (PANAS).

Data management Study records managed using Microsoft Excel and Rayyan (web-based systematic review tool). Two independent reviewers screened titles, abstracts, and full texts. Discrepancies resolved by consensus or third-party arbitration. Data extraction performed using a standardized form.

Quality assessment / Risk of bias analysis RCTs assessed using the Cochrane Risk of Bias Tool 2.0 (RoB 2). Quasi-experimental and pre-post studies assessed using the Newcastle-Ottawa Scale (NOS). Overall evidence quality evaluated using the GRADE framework.

Strategy of data synthesis Random-effects meta-analysis using the DerSimonian-Laird method. Effect sizes expressed as Cohen's d (Hedges' g for small samples). Heterogeneity assessed via Cochran's Q statistic and I^2 index ($I^2 > 75\%$ considered substantial). Publication bias evaluated

using Egger's regression test and Begg's rank correlation test, supplemented by funnel plot visual inspection. Analyses conducted using Comprehensive Meta-Analysis (CMA) version 3.0.

Subgroup analysis Subgroup analyses planned for:

1. Intervention type (forest bathing vs. structured program)
2. Intervention duration (single-session vs. multi-session)
3. Outcome domain (psychological vs. physiological)
4. Age range (40–49 vs. 50–64 years)
5. Study design (RCT vs. non-RCT)
6. Geographic region (Korea vs. other countries).

Sensitivity analysis Leave-one-out analysis to assess the influence of individual studies on pooled estimates. Additional sensitivity analyses restricted to

- (1) high-quality studies (low risk of bias), (2) RCTs only, and
- (3) studies with active control groups, to evaluate the robustness of overall findings.

Language restriction Korean and English only.

Country(ies) involved Republic of Korea (primary); international collaborations if applicable.

Keywords forest therapy; forest bathing; shinrin-yoku; middle-aged women; meta-analysis; systematic review; mental health; stress; depression; anxiety; heart rate variability; cortisol.

Dissemination plans The findings of this systematic review and meta-analysis will be published in a peer-reviewed international journal.

Contributions of each author

Author 1 - Young-Ho Lee - Author 1 drafted the manuscript, developed the search strategy, and conducted the data extraction and statistical analysis.

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Author 2 - Gyeong-Min Min - Author 2 contributed to screening the studies, assessing the risk of bias, and reviewing the manuscript.

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