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Establishing the evidence base for forest-based health promotion programs in Korea

한국의 녹지이용 건강증진 프로그램 근거기반 구축 연구

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ABSTRACT

Establishing the evidence base for forest-based health promotion programs in Korea

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In accordance with entering aged society, modernization and growing interest in health, attempts are increasing to restore health conditions and improve quality of life by utilizing nature and forests. The natural environment offers a variety of benefits in terms of psychological, social, educational and physiological aspects. Green spaces such as forests, parks, trees, and gardens are known to have a direct and indirect impact on people's health and well-being in various ways. There are three main mechanisms by which green space exposure affects health: providing opportunities for physical activity, promoting and developing social activities, and improving health conditions through green space exposure itself. Researches into the link between health and green spaces are ongoing, and evidence is accumulating from diverse perspectives.

This study was conducted to provide scientific evidences for the effects of the use of green space, which is expanding beyond public service functions to prevent diseases and promote health, on the human body psychologically and physiologically. The current status of prior researches on health levels according to forest exposure was analyzed, and psychological and physiological effects of

participation in forest-based health promotion programs were reviewed through systematic literature review. The current status of forest healing programs conducted in Korea was investigated, and the composition of the programs and the level of health-related evidence were evaluated. In addition, various interventions of forest exposure levels were carried out and the results of change in health indicators were identified.

Based on previous studies, 33 literature were analyzed and the activities performed in forest-based interventions were typified as staying, walking, exercising, and indirect exposure. In fact, walking in forests has consistently shown health improvement in the overall psychological and physiological domains. Forest-based activity programs have been shown to be effective such as depression, anxiety, cognitive function, stress hormones, and inflammatory relief, but lack evidence to assess differences in health effects according to activity types.

According to an analysis of 75 representative forest healing programs developed and operated in Korea, more than 90% of the programs were designed for the normal with the aim of promoting health. The participants in the program were teenagers and adults at a high rate. For detailed factors of forest healing programs, dynamic activities using plants or stimulating touch were the most common. In addition, the forest healing program consisted mainly of walking activities, and it was revealed that the program mostly consisted of one-day or accommodation-type forest healing programs, including more than 60 minutes of outdoor programs in spring and summer. As a result of classifying the level of effectiveness of forest healing programs according to the results of Chapter 2, on the psychological side, less than an hour of walking was found to have the greatest effect while less than an hour of staying and exercising was found to have the most

considerable levels of effectiveness on the physiological aspect. However, current forest healing programs were mainly concentrated on walking and exercising for more than an hour. Therefore, it is necessary to consider activities in areas with high levels of evidence when developing forest healing programs in the future.

To verify the health effects of forests, various health-related indicators were observed to analyze how the experience of participating in forest healing programs for two nights and three days causes changes in health conditions before, right after and after a certain period of time from the program participation. Short exposure times and activities alone had positive health effects such as immunity and cardiovascular conditions, and showed significant changes after the program.

This study examined the possibility of forest-based health promotion programs as a way to promote public health by objectively and quantitatively evaluating the health effects on forest exposure. The significance of this study is to establish basis necessary for designing forest healing programs in the future, and to arrange a foundation for big data base related to the effectiveness verification of green-space use.

Keywords: Forest-based health promotion programs, Forest healing, Forest therapy, Forest healing programs, Health effect, Nature environment

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Chapter 1. Introduction

The Significance of Nature and Green Space

As interest in entering an aged society, modernization, and health increases, efforts are increasing to restore health and improve quality of life by utilizing nature and forests. Modern urbanites are looking for green spaces to harmonize with urban life and other balances in their lives. The natural environment benefits from psychological, social, educational and physiological aspects [1]. The natural environment is sometimes described as ‘a great health machine’[1], providing preventive aspects and therapeutic health benefits[2]. Green spaces such as forests, parks, trees, and gardens are known to directly and indirectly affect people’s health and well-being, and provide benefits like psychological relaxation, reduced stress, enhanced physical activity, and other harmful factors[3]

Definition of spatial extent

Natural environment is the widest and most extensive spatial concept that is defined as “environment with physical features (i.e. flora and fauna) and processes (i.e. climatic and geological process) of non-human origin that people can ordinarily perceive”[41]. Natural environment can be categorized into green space and blue space[42, 43]. Green space is defined as “outdoor area with greenery and other natural features”[44-46]. For example, spaces like garden, park, forest, wilderness area can be included in green space[46-48]. Forest is defined by certain area and tree crown cover. A green space with 10-30% of tree crown cover and area over 0.05-1.0ha can be defined as forest[49-51]. Recently, street trees, parks, and green spaces within or nearby urban areas are referred to urban forest or forest due to increase of public health and recreational use of forest[52, 53].

Table. 1.1. Concept of natural environment, green space and forest

Concept	Definition	Spatial extent	Reference
Natural environment	Environment with physical features (i.e. flora and fauna) and processes (i.e. climatic and geological process) of non-human origin that people ordinarily can perceive. *Interchangeable to “Nature”	Green space Blue space	[41-43]
Green Space	Outdoor area with greenery and other natural features	garden, park, forest, wilderness area	[44-48]
Urban Green Space	Publicly accessible areas with natural vegetation, such as grass, plants or trees.	urban tree, urban park, urban forest, neighborhood wilderness, woodland and nature reserve in peri-urban area	[54]
Forest	Land with tree crown cover (or equivalent stocking level) of more than 10 % and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ.		[49]
	A minimum area of land of 0.05~1.0 ha with tree crown cover (or equivalent stocking level) of more than 10~30 % with trees with the potential to reach a minimum height of 2~5 m at maturity in situ.		[51]
	A land area with a minimum 10 % tree crown coverage (or equivalent stocking level), or formerly having such tree cover and that is being naturally or artificially regenerated or that is being afforested		[50]
Urban Forest	systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas	forests, street trees, trees in parks and gardens, and trees in derelict corners	[52]
	trees, forests, greenspace and related abiotic, biotic and cultural components in areas extending from the urban core to the urban-rural fringe.		[53]

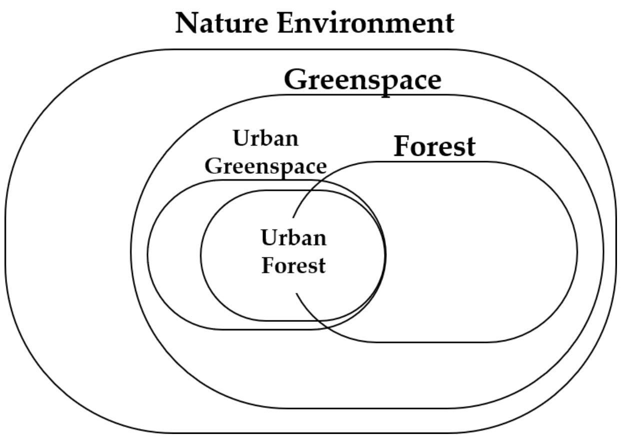

Figure 1.1. Diagram of natural environment, green space and forest by classification of spatial Extent

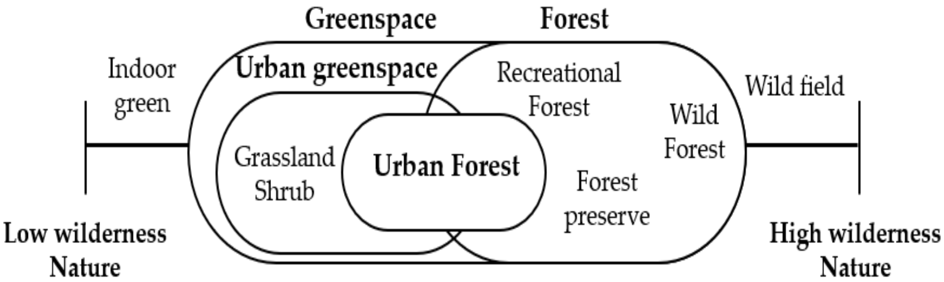

Figure 1.2. Diagram of natural environment, green space and forest by level of wilderness

Theory of Preference for The Natural Environment

The effects of the natural environment on health are explained by various theories. The Savanna theory has evolved over time in the African savannah, where humans have lived through forest gathering and hunting, and are fond of the environment by relying on the environment for forests near savannah grasslands, mixed forests, rivers and lakes. Humans are more positive about the specific environment of Savannah as a result of their harvesting and hunting lives, and they miss and prefer environments with genetic trees[4]. Wilson defined the human mind and genes as biophilia, which has an inherent attachment to nature and regressions instinct. Stress increases negative emotions and excites the autonomic nerves with physiological responses to all situations that threaten a healthy life. Psycho-evolutionary theory explains that the natural environment creates interest and positive emotions, which in turn causes stress recovery[5, 6]. Attention Restoration Theory (Action Restoration Theory) states that the natural environment recovers the state of attention and fatigue that falls due to excessive external environmental factors or internal psychological factors in modern life[2]. As such, the natural environment itself is found to be fundamentally preferred by humans, and just being in nature reduces stress or gives stability.

Green Space and Health Impact Mechanisms

Green space affects health through various channels. Green exposure reduces stress, restores cognitive function, increases exercise volume, increases social interaction, promotes solidarity, improves air quality, mitigates heat island phenomena, and reduces noise. These various factors and pathways affect mental illness, obesity, cardiovascular disease, and mortality[7]. As a result, exposure to the natural environment leads to improvement of human health and happiness.

There are three main mechanism for natural environment to affect health: providing opportunities for green spaces to engage in physical activity, promoting and developing social activities, and exposing green spaces themselves to health[8]. Currently, the relationship between health and green space has been continuously studied and evidence has been accumulated. However, the amount of evidence for mechanism and pathways for the health effects of green space is insufficient. Based on the evidence so far, whether or not the actual nature itself affects human health as an independent cause and the causal relationship between nature and health have not yet been clarified.

Various Health Promotion Effects of Green Space

The direct and indirect health effects of green space are being investigated in terms of psychological and physiological aspects. Green space controls climate environmental factors that can potentially be harmful. Recent meta-analysis shows that all green spaces relieve heat stress, urban heat island phenomena, and air pollution reduction[9]. Studies using modeling techniques have also demonstrated that trees have potential to eliminate significant amounts of air pollution, resulting in improved air quality[10, 11]. It also plays an important role in noise mitigation[12], water quality management and purification[13].

Since the early 1900s, studies related to green spaces have been conducted, and activities in forests have been studied from various perspectives on their health effects. Indeed, there is a strong connection between green space and mentality[14-16]. It has been confirmed that the natural environment can provide health benefits and serve as a buffer against the harmful effects of stress through stress reduction processes[17-19].

Improving human cognitive and emotional resilience[20], plants have been shown to have a positive effect on the recovery of inpatients[21]. Watching natural video tapes rather than watching urban video tapes[6], or exposure to the natural environment gave psychological satisfaction and stability, which also improved concentration and attention and reduced stress and increased immunity[22].

Viewing green spaces or being in green spaces alone has reduced blood pressure [6, 23, 24], skin conductivity, and muscle tension[6]. Visit in nature also affects immune responses[25]. Sensitive symptom relief was also shown in the respiratory tract and the allergic system[26]. Furthermore, it has been reported that exposure to green spaces improves cognitive performance [27, 28], as well as the attention of low-income urban children[29], and breast cancer patients [30]. Exposure to green space is effective in crime prevention[31], less aggression or violence in the home [32]and better job satisfaction for workers[33]. Green spaces strengthened their bond with neighbors[34], and in case of poor children, their control improved[35].

Current Status of Forest Utilization for Health promotion

Forest healing projects are actively underway in advanced countries such as

Germany and Japan to maintain and heal the people by using forests, and in the United States, New Zealand, and Britain, they are trying to prescribe nature for stress relief or simple treatment.

Korea is a representative forest country with 64% of its land made up of forests, and its forest resources have increased 15 times over the past40 years. Therefore, the government introduced the concept of forest healing to actively use forests as a tool for promoting the health of the people, and operated healing forests, a space that differentiates green environment and functions.

According to Korea Forest Service Forestry Yearbook statistics, the annual number of visitors to healing forests reached 1.7 million as of 2018, of which 270,000 (15%) participated in forest healing programs run in healing forests[36]. Forest healing programs are developed and operated for various target purposes by utilizing forest resources such as phytoncide, anion, sunlight, natural scenery, and sound to prevent diseases and promote health of the people.

Even though the program is being managed for various groups in age and disease, satisfaction about the program and space that the participants experienced is only counted for evaluation as a means of verifying the effects. Medical verification based on big data also has not been established.

Definition of the Concepts

Japan Forestry Agency, developed a certain concept called ‘Shinrin-yoku’ in 1982. Shinrin-yoku means ‘forest bathing’ or ‘green shower’ in Japanese, which is defined as staying in the forest atmosphere, or taking in the forest through our senses. Since then, forest bathing has widely known as health improving activity utilizing forest environment[37, 38]. The scientists continued researching in order to prove the scientific effects of Shinrin-yoku and finally defined ‘forest therapy’ as a forest healing activity based on scientific data[39]

Korea Forest Service, with ‘Forest Culture and Recreation Act’ of 2011, has defined forest healing as “an activity to improve health and strengthen immunity utilizing various elements of nature such as aroma or view.” It is noted that KFS used ‘healing’ instead of ‘therapy’, for ‘therapy’ is generally recognized as term of which is solely used in medical field. However, the both terms are used in fields[40].

Extent of Nature-based Programs

Nature experience can be conducted via various activities such as window-viewing of natural scenes, being in natural settings, encountering plants and animals, participating in recreational activities, undertaking environmental conservation work, and participating in nature-based programs[55].

Nature-based Interventions (NBIs) refer to more structured programs, activities, or strategies that aim to engage people in nature-based experiences with the specific goal of achieving improved health and wellbeing[56]. NBIs are primarily designed to increase the level of exposure to the natural environment (e.g., green space, brown space, and blue space). NBIs are conducted by creating an environment and by providing programs for prevention, promotion, and treatment purpose[56-58].

Nature-based therapy is a bespoke form of NBIs, defined as “treatment or interventions specifically designed, structured and facilitated for individuals with a defined need”[59]. When designing an NBT, it is important to choose the landscape type and treatment options that are appropriate for the specific individual needs[59].

Some nature-based programs are grouped according to the landscape in which they are performed, such as park prescription[56, 60, 61], forest therapy[62, 63], and wilderness therapy[64, 65]. Those nature-based programs can be conducted for various therapeutic purposes.

Table 1.2. Concept of nature experience, NBIs, NBTs

Concept	Definition	Practice	Reference
Nature Experience	All activities to experience and interact with nature	1) viewing natural scenes 2) being in natural settings 3) encountering plants and animals 4) participating in recreational activities 5) undertaking environmental conservation work and 5) participating in nature-based therapy programs	[55]
Nature-based Intervention (NBI)	programs, activities or strategies that aim to engage people in nature-based experiences with the specific goal of achieving improved health and wellbeing Structured to increase the level of exposure to the natural environment	e.g. structured promotion of nature-based experiences in green space, brown space, and blue space	[56]
Intervention Goals	*Intervention*		
Prevention of chronic health conditions	Creation of environment to promote nature interactions	e.g. Increasing provision of public parks and gardens, streetscape enhancement with vegetation, community garden, greening school grounds, provision of accessible natural environment	
Promotion of general wellbeing	Provide programs for education or nature engagement	e.g. Nature play, wild play, Forest schools, children's' kitchen garden, outdoor education, promotion and facilitation campaigns, blue gyms	
Treatment of specific physical and mental or social health and well-being issues	Creation of healing environment to promote nature interactions	e.g. Healing garden in hospitals or residential care homes	
	Provide treatments that engage patients with nature or change behavior	e.g. Green/nature/park/garden prescription, forest therapy, horticultural therapy, Wilderness therapy, wilderness program, care-farming, pet therapy, pet-assisted therapy, green gym, green exercise, environmental volunteer work	
Nature-based therapy	Treatment or interventions specifically designed, structured and facilitated for individuals with a defined need	Choose landscape type and treatment option suitable for specific individual needs	[57-59]
Green/nature/park/ garden prescription	Doctors' or professionals' prescription of outdoor activities to patients or clients with specific need	Increase exercise and the associated benefits, stress reduction, reduce blood pressure, improve healing times, reduce depression, increase resilience and other mental health benefits. Some are targeted towards children for purposes such as prevention or treatment of obesity, cancer and diabetes. Some also target quality of life, wellbeing and social support.	[56, 60, 61]

Forest therapy	Immune-strengthening and health-promoting activities utilizing various elements of the forest often with emphasis on attention to breathing, sensory stimuli, and other meditative techniques	Consists of structured activities and interventions utilizing forest features (landscape, smell, sound, terpene, negative ion, sunlight, terrain, etc) that stimulate the five senses of humans and have a positive effect on human body	[62, 63]
Wilderness therapy	Programs designed to challenge participants in remoted natural environments.	Personal growth, social skills through immersion in nature	[64, 65]

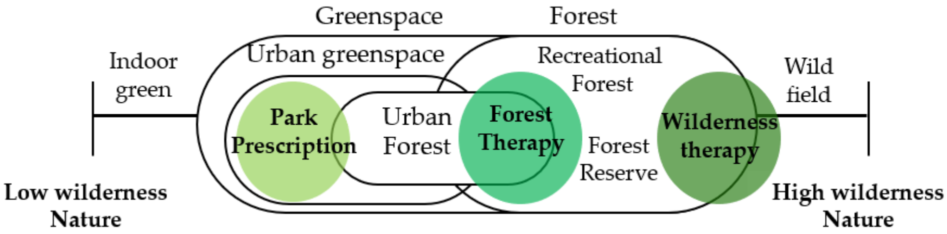

Figure 1.3. Diagram of NBTs in different natural environment: Green space, forest and wild field

Objective of This Study

As such, the use of green space, especially forests, has expanded beyond its public interest function to prevent disease and promote health, but there is a lack of insight into the medical effects on the psychological and physiological effects of green space on the human body. In addition, forest healing programs are operated using a variety of forest resources, but the level of healing effects of forest healing programs is not evident. Although relevant studies have been continuously reported on the positive health effects of forest healing programs, there is a lack of evidence to support the positive health effects, and specific mechanisms for these positive effects have not yet been verified. Furthermore, various metrics are used and observed in several studies to verify immediate physiological changes due to exposure of forest environments, however, there are limitations in terms of the number of subjects and methodology since they are still in the early stages. Therefore, scientific evidences are needed through continuous researches to expand the formation of forests, develop forest healing programs, and enhance medical validity. The main purposes of this study are as follows:

(1) Analyze the current status of prior studies on health levels according to forest exposure and evaluate psychological and physiological health conditions according to forest-based health promotion programs through systematic literature review.

(2) Investigate the current status of forest healing programs conducted in Korea, and evaluate the composition of the programs and the level of health-related evidence.

(3) Review the changes in health levels resulting from various interventions of forest exposure in order to provide evidence and forest-based health promotion programs.

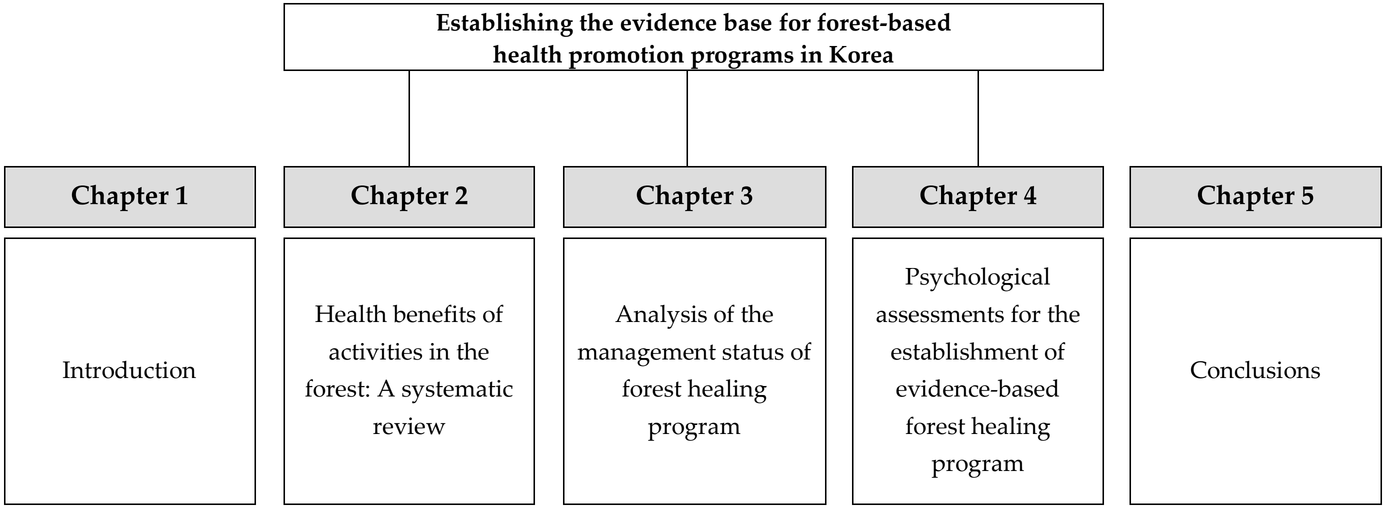

Fig 1.4. Schematic diagram of the overall composition in the dissertation.

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Chapter 2

Health Benefits of Activities in the Forest: A systematic Review

1. Introduction

The benefits of forests on human health have long been discussed. In particular, clinical trials of the health benefits of forest-based activities have increased rapidly over the past decade. With respect to PubMed searches, research on health effects of forest-based activities has been increasing since the 1990s, with 830 studies per year in the 2000s and more than 3000 studies per year more recently. Overall, there has been a sharp increase in research since 2012. The effects of forest-based activities have been reported in various health domains such as cardiovascular function [1-7], immune system[1, 3, 8-10], endocrine system[11, 12], and mental health[5, 7, 13-15]. With the increasing amount of empirical evidence, forests' preventive medical potential is gradually being recognized, leading to medical and societal acceptance of forest therapy in some countries[16].

East Asian countries, such as Korea and Japan, are representative countries that have actively utilized forest therapy under the name of "forest healing" or "forest bathing." In Japan, forest bathing has emerged as a therapeutic method during the 1980s and, since the 1990s, the physiological effects of forest environments have been investigated [17, 18]. Since 2000, the Japanese Forest Therapy Association started to examine therapeutic effects in the field and certified forest areas for therapeutic use. The certified forests are called Forest Therapy Bases and, today, their number has increased to a total of 62 bases around Japan, attracting approximately 2.5 to 5 million visitors annually [19].

In Korea, numerous efforts have been made to utilize forests as preventive medicine. In 2005, the Korean government enacted the “Forestry Culture and Recreational Act and Forest Welfare Promotion Act,” which recognizes the health promotion and therapeutic effect of forests. In 2010, the government defined the terms “forest healing” and “healing forest” in their law and promoted the systematic use of forests for immune-strengthening and health-promoting activities [20]. Furthermore, in 2010, the first official healing forest—Saneum Healing Forest—opened. Since then, forests for therapeutic use have been continuously constructed. Recently, 34 healing forests have been in service, and 29 additional forests are under construction. While establishing these facilities, the national qualification system for a forest healing instructor has been implemented to train professionals to develop forest healing programs and provide forest healing services [20]. Consequently, the number of healing forest visitors has consistently increased from 157,000 in 2011 to 1.861 million in 2019[21].

With the expansion of forest healing, participant groups—unmarried mothers, alcoholics, children with atopic dermatitis, adolescents, seniors with dementia—and their purpose for participating has varied. According to the current investigation on forest healing programs in Korea, most programs have abstract therapeutic goals rather than specific expected health effects [22]. In order to provide reliable and effective forest healing programs in the field, programs should be organized according to the purpose of participation. Thus, a study is needed to evaluate the effectiveness of forest healing programs for each component of the program.

Therefore, I conducted a systematic review—a research method that provides the latest summary of previous studies relevant to a specific research question—

and summarized the most recent research evidence on forest therapy programs. By following a well-established procedure to search, include, synthesize, and evaluate primary studies, a systematic review provides a credible evidential basis and enables beneficial suggestions for future research by discovering existing knowledge gaps. Previous systematic reviews have often focused on the overall health benefits of spending time in forests [23] or the clinical results of forest therapy programs [24, 25]. Others have focused on one specific health effect, such as blood pressure[26, 27], diabetes[27], stress recovery[28], and depression[29]. The current line of research provides an overall assessment of health benefits at the participation level, rather than assessing different effects for different program compositions. Reviews on specific forest-based programs—immersive nature experiences[30] and green exercise[31]—have been conducted; however, are fragmentary reviews on a single type of intervention. Recently, a study evaluated the differences in health effects according to the forest environment characteristics [32]. However, little is known about the differences in health effects based on the activity components of forest programs.

Thus, I focused on the effectiveness of individual activities in forest therapy programs. To this end, I collected empirical studies on forest therapy, divided the studies according to their activity components, and evaluated the comprehensive health effects of each type of activity. The purpose of this review was to answer three questions: (1) what kind of activities were performed during the forest therapy program in empirical studies, (2) what kind of health effects were associated with each activity component, and (3) whether there were any differences in the health effects according to activity components. By answering these questions, I expect to contribute to the advancement of evidence-based designs for forest therapy programs.

2. Materials and Methods

To provide credible evidence, I followed standardized procedures for conducting systematic reviews [33]. I set study question by specifying the Population, Intervention, Comparison, Outcome, and Study design (PICOS). I attempted to gather all relevant studies and reported our search strategy for obtaining reproducible search results. Moreover, I included studies that met eligibility criteria and synthesized their results. The quality of each study was evaluated using the Cochrane risk-of-bias tool version 2 (RoB 2).

2.1. PICOS and Eligibility criteria

The current review was written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis checklist [34]. To classify the related studies, I established the study question based on eligibility criteria following the PICOS framework, displayed in Table 1, as follows:

P: All the participants (both healthy and unhealthy).

I: All interventions designed to utilize green spaces—park, urban forest, forest—as individual health-promoting tools.

C: Studies that included control groups to verify the effect (e.g., extant intervention, urban environment, daily routine, waitlist group).

O: The studies that contained psychological or physiological outcomes of the participants related to health and well-being.

S: Randomized controlled trials (RCT) or randomized cross-over studies

Table 2.1. Eligibility criteria for the study selection

PICOS element	Inclusion criteria	Exclusion criteria
Population	Studies with humans, healthy or not	Studies not including human participants.
Intervention	Studies reporting any intervention that matched our definition of "Designed and structured activities which utilize a defined green space—park, urban forest, and forest—as a health promotion tool."	Studies not including designed or structured interventions. Studies not providing a description of the green space where the intervention was held.
Comparison	Studies with a comparison group (e.g., waitlist group, urban group, normal daily routines, other comparative intervention).	NA
Outcome	Any quantitative psychological and physiological outcome at an individual level related to health and well-being.	Studies not including health and well-being outcomes. Studies not including quantitative outcomes. Studies including only population-level or community-level outcomes.
Study Design	Randomized controlled trials and randomized cross-over studies.	Reviews, qualitative studies, nonrandomized controlled trials, uncontrolled before and after, with no comparator groups relevant for the current review, and quasi experiments.

2.2. Search strategy

In order to develop keywords for searching relevant studies, I referred to previous systematic reviews on the greenspace-based intervention that could be considered as forest-based intervention[19, 21, 23, 24, 26, 27]. Furthermore, I limited the scope of study design to randomized controlled trials and randomized cross-over, as I found enough clinical controlled trials through pilot searches. Finally, I selected the search keywords about the undertaken place, activity, participants, and outcomes. The search keywords are shown in Table 2. I searched four different databases: PubMed, PsycINFO, Web of Science, Scopus. All the studies were published in English from Jan. 2000 to Feb. 2021

Table 2.2. Search keyword

	Keywords
P	("people" OR "volunteers" OR "participants" OR "subjects" OR "individuals")
I	("natural environment" OR "green space" OR "nature space" OR "green nature" OR "forest") AND ("intervention" OR "program" OR "programme" OR "exposure" OR "therapy" OR "recreation" OR "physical activity" OR "exercise" OR "activities" OR "walking" OR "meditation" OR "staying")
C	-
O	("health" OR "well being" OR "well-being" OR "health promotion" OR "physiological" OR "psychological" OR "mental health" OR "physical health" OR therapeutic)
S	("randomized controlled" OR "RCT")

2.3. Study Selection Process

From the database search, I found a total of 1903 studies with 1288 on PubMed, 25 on PsycINFO, 81 on Web of Science, and 509 on Scopus. The results were exported to EndNote Citation Manager software (version Endnote X9.3.3). After removing 209 duplicates, the titles and abstracts of the 1694 publications were reviewed. Two reviewers independently screened the full text for 265 documents based on the eligibility criteria after removing 1429 nonrandomized studies or explicitly unrelated documents. The discrepancy during the screening process was resolved through discussion. By reviewing the references of the searched systematic reviews, I found and included four additional studies that met the eligibility criteria. Overall, 33 studies were included in the review (Figure 1).

2. 4. Data Items and Extraction Process

Data were extracted from the document by a single investigator using the same data extraction form. The extracted data included study information (e.g., year of publication and author), samples (e.g., sample size, gender, participant characteristics, and age), intervention design (e.g., undertaken area, activity duration, and frequency), study design (study design and comparator), and outcome measurements.

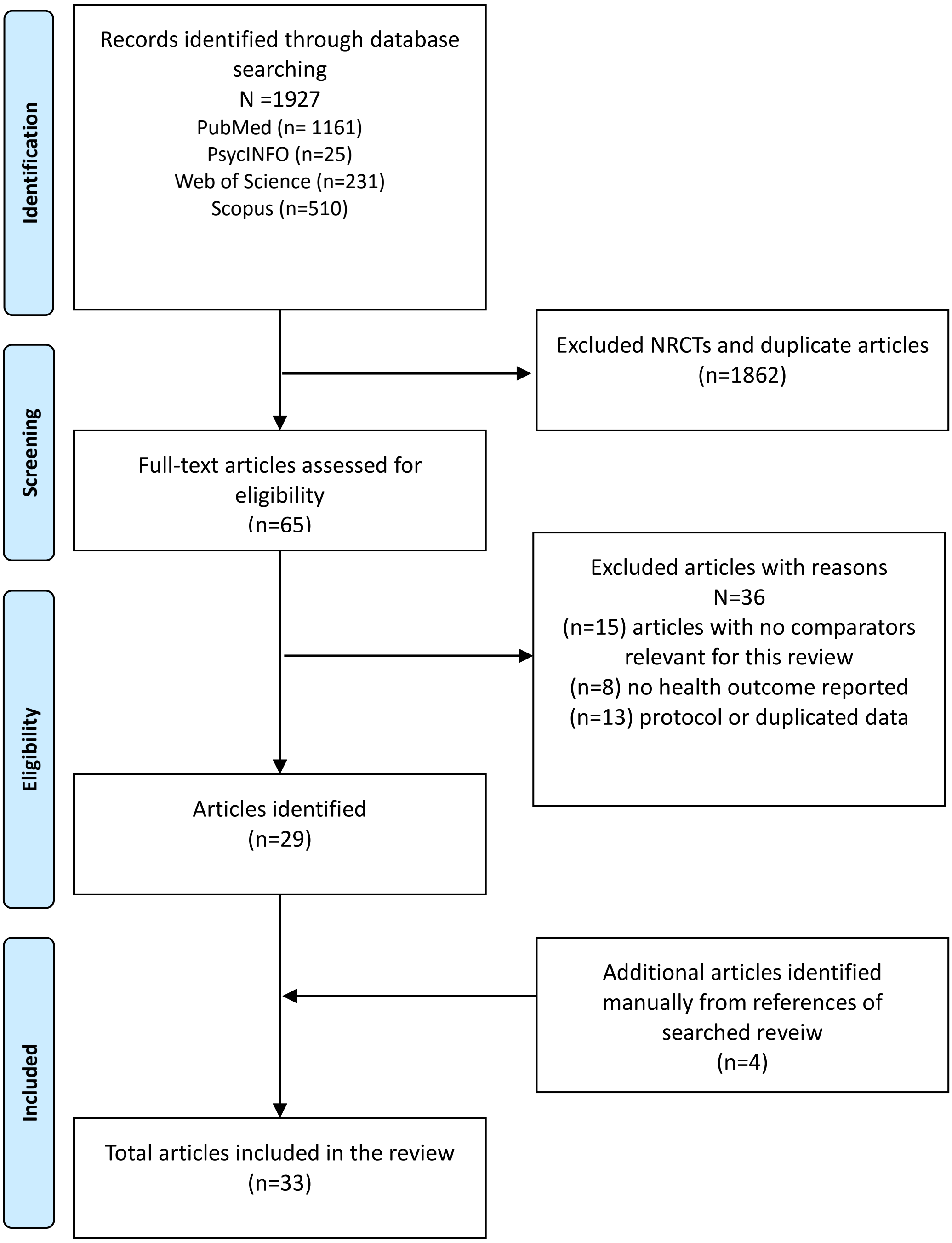

Figure 2.1. Flow diagram illustrating the selection process

2.5. Narrative synthesis

In the current review, a narrative synthesis of the empirical evidence was conducted. Inspired by the reporting method of Mygind et al. [30]—one of the previous systematic reviews—we assessed the consistency of significant results of studies according to the activities conducted. The 33 included studies were divided into homogeneous groups according to the activity performed in the intervention, and the ratio of significant outcomes in each group was calculated. The results of the included studies were classified as having a significant positive effect on the health outcome (+), a mixed effect including both significant and nonsignificant effects on the positive health outcome (+/), a nonsignificant effect on the positive health outcome (/), or any negative health outcome (-). I calculated the percentage of the significant positive effect(%p) and of both the positive and mixed effects (%p+m). Subsequently, I compared the results of each group based on the different health domains.

2.6. Risk of Bias assessment

Along with synthesizing the empirical evidence, I assessed the quality of the included studies by assessing the risk of bias in the individual studies using the Cochrane RoB 2 tool in accordance with the latest version of the Cochrane Handbook for Systematic Reviews of Interventions version 6.2[33]. The RoB 2 tool was adopted because it is the most comprehensive tool that can evaluate the risk of bias in both RCT and randomized cross-over studies. Furthermore, the RoB 2 can evaluate all forms of bias that may occur in randomization, experimental design, study conduction process, and reporting. There are five areas of bias covered in the RoB 2 tool which assesses bias that occurred during randomization(D1) by dropout(D2), due to missing data (D3), during measurement (D4), and by selecting results (D5). The overall risk of bias has the highest risk across the five domains. The evaluation in each domain was proposed as being “low risk,” “some concerns,” and “high risk” by algorithms with answers to signaling questions.

3. Results

3.1. Study Characteristics

A total of 6285 participants were reported in the 33 included studies, with the number of samples ranging from 12 to 585. Twenty-two studies reported results with small samples (≤60), and 11 studies reported results including samples ranging from 67 to 585. The age of participants ranged from 6 to 98 years, with 17 children in one study, 1069 young adults in 12 studies, 164 middle-aged adults in two studies, and 232 older adults in seven studies. In 11 studies, 744 adults participated in without age restrictions.

Eleven of the included studies were conducted in urban forests, such as urban green spaces, city parks, and forests within walking distance. Eighteen studies were conducted in remote forest areas, such as recreational forests, forest reserves, and wild forests. Moreover, four studies were conducted mainly indoors by indirect exposure using natural or audiovisual materials. The included studies reported quantified psychological (29 studies) or physiological (25 studies) health outcomes. Psychological outcomes included mood (n=17), affect (n=9), anxiety (n=7), depression (n=4), cognitive function (n=9), well-being, and quality of life (n=6). Physiological outcomes included nervous system (n=19), stress hormone (n=12), blood pressure (n=12), cardiovascular disease (n=6), inflammation (n=7), oxidative stress and antioxidant (n=9), immune function(n=4), and pulmonary function(n=1).

The activities conducted in the interventions were categorized into four activities: staying, walking, exercise, and indirect exposure. Staying (n=7) referred to static activities in the forest, including sitting, viewing, watching, and relaxation sessions. Walking (n=20) referred to walking and exploring given places such as unhurried pace walks, leisurely walking, walking along a given course, instructed walking, and walking and observing surroundings. Exercise (n=3) referred to activities composed of physical activity with a higher intensity, such as hiking and workout sessions. Indirect exposure (n=4) referred to activities in which interventions were performed mainly indoors, utilizing audiovisual and natural materials. Two studies conducted both staying and walking in their intervention and reported the effects separately. One study reported a single result of walking, staying, and exercising. The duration of the interventions ranged from 10 min to 240 min. The main characteristics of the studies included in this review are displayed in Table 3. The Psychological and physiological outcomes according to the activities conducted in included studies are shown in Table 4.

3.2. Psychological outcomes

3.2.1. Mood

Five studies investigated the effect of staying on mood states [35], subjective feeling [36], stress response symptoms[37], and burnout[38, 39]. One study conducted a 15 min relaxation session in an urban forest and compared changes in mood state with the urban group. Mood states were measured using the Profile and Mood State Questionnaire (POMS). Consequently, negative moods—depression, anxiety, anger, fatigue, and confusion—significantly decreased while there were no significant changes in vigor[35]. One study demonstrated that sitting in forests for 15 min and looking at landscapes significantly improved subjective feelings, including comfort, calm, and feeling refreshed compared to the urban environment [36]. One study conducted staying activities in cities or forests for 2 h and reported that staying in the forest partially mitigated psychological stress response symptoms[37]. Two studies assessed burnout symptoms using the Shirom Melamed Burnout Questionnaire (SMBQ)[38, 39]. One study assessed 10 weeks of natural-based therapy in comparison with cognitive behavioral therapy. Both interventions showed a significant reduction in burnout (SMBQ) scores, indicating that natural-based therapy could be as effective as conventional treatments[39]. Other studies reported no significant difference in burnout (SMBQ), stress, and fatigue between the waitlist control and intervention group, where participants regularly spent time alone in the forest for 11 weeks[38].

Ten studies investigated the effect of walking on mood states[1, 40-44], distress [45], perceived stress levels[46], and subjective feelings [36]. In two studies, walking for 15 min in a well-managed artificial forest and walking in an urban environment were conducted, and the mood state (POMS) changes were compared. Consequently, a significant decrease in negative mood—depression, anxiety, anger, fatigue, confusion—and a significant increase in positive mood was reported[42, 44]. Similarly, another study conducted a 17 min walk in forests and cities and compared the effects on mood states (POMS). Significant reductions in negative mood—depression, anxiety, anger, fatigue, and confusion—and significant increases in positive mood and vigor were reported [43]. In three studies, the degree of improvement of mood states (POMS) in an urban walking group and forest walking group were measured and compared [1, 40, 41]. One study identified significant improvements in depression, anxiety, anger, and confusion, but did not observe significant changes in fatigue and vigor [1]. Another study identified significant improvements in depression, anxiety, anger, fatigue, and vigor, but did not confirm significant results in confusion [41]. Another study identified significant improvements in depression, anger, confusion, and fatigue, but no significant changes were observed in anxiety and vigor [40]. In one study, the distress level was measured and compared after 20 min of forest garden walking and urban road walking. Consequently, distress decreased significantly after walking in the forest garden, and mindful awareness improved significantly[45]. In another study, the same subjects were assigned to walk across a forest and an urban roadside for 50 min on different dates, and the most consistent reduction in perceived stress level was observed when walking in the forest[46]. One study found that walking in a forest for 15 min had a positive effect on subjective feelings—comfort, calm, and feeling refreshed—rather than walking in an urban environment [36].

Two studies investigated the effects of exercise on distress[47], tranquility, and fatigue[48]. One study compared the changes in distress levels of a six-month park prescription group with an indoor standard physical activity group; no significant difference was found [47]. Another study assessed the effect of 45 min of exercise for three days in the park and indoors; no significant difference in the improvement of tranquility and fatigue was found [48].

3.2.2. Affect

Two studies assessed the effect of staying on affective states with the Positive and Negative Effect Schedule (PANAS). One study conducted a 15 min relaxation session in an urban forest and compared changes in affective states with the urban group. A significant improvement in positive affect was observed, while there was no significant effect on negative affect[35]. Another study reported that staying in an outdoor garden for 2.5 h increased positive affect and reduced negative affect[49].

In three studies, the effect of walking on affective states was investigated using the PANAS measurement. One study compared the affective states of a treadmill walking group with a forest walking group and a forest walking video. The results demonstrated that forest walking significantly promoted positive affect and significantly improved negative affect[50]. One study assigned the same participants to 50 min walks across forest and urban roadsides on different dates and compared the affective states. It was reported that walking in the forest had a significant effect on reducing negative affect, but did not have a significant effect on positive affect[46]. Another study found that walking in urban parks for 30 min for seven days was especially effective in reducing negative affect than walking on urban streets, but reported no significant change in positive affect[51].

In one study, the effect of exercise on affective states was investigated using the PANAS measurement. According to this study, after 45 min of the same exercise over three days indoors or at parks, a significant improvement in positive affect was observed in the park movement group; however, no significant difference in the improvement of negative affect was evident [48].

In three studies, the effects of indirect exposure to forests through audiovisual materials on affective states were investigated by using the PANAS. One study conducted 2.5 min of an intervention on forest video viewing groups, urban forest video viewing groups, and controls; it was reported that watching forest videos significantly improved positive and negative affect, but in some urban forest landscapes, only positive affect increased[52]. One study conducted forest or abstract observation activities through virtual reality (VR) for 10 min and confirmed the significant effect of forest observation through VR on positive emotions, but did not confirm a significant effect on negative emotions[53]. One study conducted an intervention including viewing a slide show and reflecting for 11 min. Two intervention groups watched forest scenery or urban scenery; affective states after the intervention were measured and compared with the control group. Results showed that watching the slide show in the forest did not show any significant change in positive affect; however, it showed some negative effects on negative affect[54].

3.2.3. Anxiety and Depression

Two studies investigated the effects of staying on improving anxiety and depression. In one of the studies, observations were conducted indoors or in horticultural gardens for 2.5 h, and the variation in the Spielberger State-Trait Anxiety Inventory (STAI) score—a measure of anxiety state—was compared. It was reported that the effect of observing in the horticultural garden was not significant but tended to relieve anxiety[49]. Another study compared the results of the Hospital Anxiety and Depression Scale measurements—a measure of anxiety and depression—in groups of waitlist control with groups that regularly spent time in solitude in the forest for 11 weeks. The report showed no significant differences in depression and tension between the two groups[38].

Four studies examined the effects of walking on anxiety and depression. One study compared the change in scores of the STAI after a 15 min walk in a city or an artificial forest. Walking in artificial forests was reported to significantly lower anxiety levels than walking in an urban environment[42]. A similar study also reported that walking in a forest was effective in mitigating anxiety, as the STAI score was significantly lower than walking in the same city for 15 min[55]. One study allowed the same subjects to walk across a forest and urban roadside for 50 min on different dates and compared changes in STAI scores; walking in the forest improved anxiety symptoms [46]. One study performed walking in a four-day program in forests and cities and compared the STAI scores. Significant improvement was observed in all indicators by walking in a forest, especially the anxiety state reduction effect[56].

One study investigated the effect of indirect exposure, using natural materials, on anxiety and depression. In this study, gardening was performed for three months using natural materials, and the Self-rating Anxiety Scale and Self-rating Depression Scale scores were compared. Horticulture treatment showed no significant effect on anxiety or depression compared to the waitlist control group[57].

3.2.4. Cognitive function

One study investigated the effect of staying on cognitive function. This study performed relaxation sessions in urban areas and urban forests and compared the results of the persisted restorativeness schedule (PRS) measurement, which is a measure related to attention restoration. Significantly higher PRS values were reported in urban forests [35].

Three studies investigated the effect of walking on cognitive function. One study provided instructed walking to children in the park, downtown, and in the neighborhood on different days and assessed their concentration by using Digit Span Backwards scores. It was confirmed that walking in the park significantly improved attention and working memory, rather than walking downtown or in the neighborhood[58]. Another study found that groups walking in bamboo forests showed significantly higher attention mean scores than those walking in cities[55]. In another study, the same subjects walked across a forest and an urban roadside for 50 min on different dates, and the Visual Backward Digit Span Test (vBDS) was performed. There were no significant differences in vBDS scores between urban and forest walks[46].

One study investigated the effects of exercise on cognitive function. This study performed the same exercise indoors and at parks for 45 min for three days and compared the results of the PRS measurements. Significant improvements in the PRS scores were reported in park movement groups[48].

In four studies, indirect exposure utilizing natural and audiovisual materials was investigated to determine the effect on cognitive function. One study conducted 2.5 min of an intervention whereby participants watched a forest video or urban forest video and compared the results with the controls. The groups that watched the wild forest and urban forest images showed significantly higher PRS scores than the control group, indicating that viewing images of forests can also mitigate cognitive fatigue[52]. In one study, 11 min watching a slideshow of still images of the forest increased the PRS scores significantly compared to a slideshow of the city's roads or groups that saw nothing[54]. One study measured the score of the Montreal Cognitive Assessment (MoCA)—an indicator of cognitive function—before and after horticulture sessions for three months and compared the results with those of the waitlist group. No significant improvements in the MoCA scores were observed by horticulture sessions [57]. One study measured the mental-arithmetical score as an indicator of focus using mathematical quizzes in groups that observed forests or abstract painting through VR for 10 min. No significant difference in the scores between the two groups was found[53].

3.2.5. Well-being and quality of life

Two studies investigated the effect of staying on psychological and social well-being. One study conducted nature-based therapy in a forest garden for 10 weeks, comparing the intervention effects with a group of controls that received an existing treatment, namely cognitive behavioral therapy. A more significant improvement in the Psychological General Well-Being Index in the group that performed nature-based therapy was found[39]. Another study conducted interventions for 11 weeks and compared the results with those of the waitlist control group. Comparing Self-Concept Questionnaire (SCQ) scores—a measure of self-esteem—no significant difference between the two groups was found[38].

One study investigated the effects of walking on general well-being. This study measured the general well-being of green land walking groups and the waitlist control group using the SF-8 scales. It was reported that significant improvements in mental health were observed when walking in green areas, but no significant differences were observed in other elements of well-being, such as physical or general health[59].

Another study investigated the effect of exercise on quality of life and psychological well-being. One study performed a park presentation and standard physical activity for six months; exercise in the park improved quality of life but not at a significant level[47].

One study investigated the effect of indirect exposure using natural materials on psychological and social well-being. In one study, gardening was performed for three months using natural materials, and the results were compared with those of the waitlist control group. No significant changes were observed in psychological well-being or life satisfaction. In addition, relationships with others significantly improved compared to the waitlist control group, but the friendship scale reported no significant changes[57].

3.3. Physiological outcomes

3.3.1. Nervous system

In two studies, the effect of staying on the physical response to stress and the indicators of relaxation, heart rate variability, pulse rate, and cerebral activity were investigated. One study conducted a 15 min view of a landscape sitting in a city or forest. Pulse rates were significantly lowered when looking at the landscape from the forest. Furthermore, a relaxation effect in the autonomic nervous system was evident, with ln HF values showing an overall high and increasing tendency, and ln (LF/(LF+HF) values showing an overall low tendency[36]. Another study also reported results of 20 min of sitting in a city or forest and looking at a landscape. Urban environments have shown a tendency to increase cerebral activity (t-Hb concentration) while decreasing cerebral activity (t-Hb concentration) in forest environments, indicating that staying in forests is more suitable [60].

Nine studies investigated the effects of walking on improving and relaxing body responses to stress. One study conducted a 15 min walk in urban or artificially constructed forests. It was reported that the average values of heart rate and ln (LF/HF) when walking in the forest were significantly lower than when walking in the city, while the average value of ln HF was significantly higher[42]. Another study reported hourly heart rate and ln HF measurements, taking 17 min to walk in a city or forest. It was found that ln HF significantly increased only when walking in the forest, and heart rate (HR) significantly decreased. In addition, the ln HF average was significantly higher in the forest, and the HR average of the forest was significantly lower than in the city[43]. Another similar study compared urban or forest walking interventions of 15 min. The average value of ln (LF/(LF+HF) when walking in the forest was lower than that of the city, and the average value of ln HF was higher than that of the city; however, no obvious trend was found. In addition, there were no noticeable changes in HR[36]. In one study, a 20 min walk in an urban forest was performed twice a week for eight weeks. The pre- and post-intervention results of the experimental group were compared with those of the built environment walking group and the waitlist control group. No significant differences in ln HF and HR values were found[59]. In one study, walking in a city or forest was performed twice a day, 1.5 h per day for seven nights and seven days. In both forests and cities, no significant changes in HR values before and after walking were reported[40]. One study conducted interventions of walking for 15 min every day for two nights and three days in a city or bamboo grove. The effect of relaxation was confirmed by observing significantly lower HR levels and significantly higher peripheral oxygen saturation (SpO2) in the group that walked through the bamboo grove[61]. A study conducted forest walking, gym walking, and watching forest walking for 40 min each in three groups and examined the acute and chronic stress responses of each group. They observed an increase in HR and a decrease in ln HF values as a result of walking in nature, which is thought to be due to physical efforts required to walk in nature[50]. A different study conducted urban or forest walking interventions for 20 min and found that walking in the forest significantly mitigated against cerebral activity (t-Hb coordination)[60]. Finally, one study repeatedly measured the high alpha wave of groups walking in bamboo groves and urban environments for 15 min. The high alpha wave was significantly higher in the group walking in the bamboo grove than the city with an increasing trend indicating that walking in the forest has a positive effect on brain activity and relaxation[55].

One study investigated the effect of exercise on physical responses and relaxation on stress. In one study, three groups of participants were compared before and after exercising in the forest, indoor treadmill walking, and sedentary control for 3 h each. It was reported that exercise in forests did not cause significant changes in HR values before and after the intervention compared to sedentary controls [62].

One study investigated the effects of indirect experience through audiovisual materials on stress response and relaxation indoors. In one study, they investigated the effect of observing forests or abstraction through VR for 10 min on stress reduction. After the stress-inducing task was performed, the forest or abstraction was observed through VR, and the stress (skin conductivity response) was significantly lowered when the forest was observed. However, there was no significant change in HR[53].

3.3.2. Stress hormone

Three studies examined the effect of staying on stress hormone reduction. One study conducted a 15 min view of a landscape sitting in a city or forest. The salivary cortisol level was significantly lowered when looking at the landscape from the forest[36]. Another study also reported 20 min of sitting in a city or forest and looking at a landscape. Salivary cortisol increased in urban environments, while salivary cortisol levels were maintained in forest environments, suggesting that staying in forests was more suitable for rest[60]. One study found that observations at the horticultural garden or indoors, for 2.5 h each, were performed without significant movement, suggesting that observations at the horticultural garden further significantly reduced salivary cortisol levels[49].

Five studies examined the effects of walking on stress hormone reduction. One study conducted forest walking, gym walking, and watching forest walking for 40 min each in three groups and examined the acute and chronic stress responses of each group. Walking in nature was shown to reduce stress by significantly lowering salivary cortisol levels under chronic stress conditions, such as the test period[50]. A study conducted two leisurely walks for 1.5 h a day for two nights and three days in a city or forest. Walking in forests significantly lowered cortisol and epinephrine levels rather than walking in cities[8]. In other similar studies, the same intervention was carried out twice daily by walking for 1.5 h in cities or forests for two nights and three days. Serum cortisol levels decreased significantly in the forest walking group, but no significant decrease was found in testosterone levels [41]. In one study, interventions were conducted that took 30 min to walk through an urban park or a city street for seven days. A significant decrease in salivary cortisol levels during the early stages of walking in urban parks was observed. However, there was no significant effect of walking on urban streets[51]. In one study, interventions were conducted to walk through cities or forests for 20 min and no significant reduction in salivary cortisol was observed during walking in the forest [60].

Two studies examined the effect of exercise on stress hormone reduction. In one study, three groups of participants performed 3 h of forest exercise, indoor treadmill walking, and sedentary control. It was reported that exercise in the forest significantly reduced salivary cortisol compared to the sedentary control group, but showed no significant difference compared to indoor exercise[62]. A study compared the effects of executing the same exercise in a park or indoors for three days for 45 min per day. No significant difference was found in serum cortisol when exercising in the park, but some positive improvements were observed in the cortisol wakening response[48].

One study investigated the effects of indirect indoor and outdoor exposure on stress hormone reduction, including the use of natural materials. One study reported that after three months of horticulture sessions in indoor facilities and outdoor gardens, there was no significant difference in serum cortisol and dehydroepiandrosterone compared to the waitlist control group[57].

3.3.3. Blood pressure

One study investigated the effect of staying on blood pressure stability. Sitting in a city or forest, looking at a landscape for 15 min showed significantly lower diastolic blood pressure (DBP) than a city when spending time in the forest, and no significant difference was seen in systolic blood pressure (SBP)[36].

Eight studies examined the effect of walking on blood pressure stability. One study conducted interventions that included walking 3 h a day on a broad leaved evergreen road at an unhurried pace for seven nights and seven days, and found a significant decrease in SBP and DBP compared to walking in a city[40]. One study compared the blood pressure of the waitlist group—a group that walked along the path with trees and greenery for 20 min, twice a week for eight weeks—and a group that walked through a built environment. They observed a significant decrease in DBP in the group that walked on the green space, but no significant decrease in SBP was found [59]. One study showed significantly lower SBP in groups that performed 30 min of bamboo grove walking over three days than in groups that performed urban walking, but DBP did not show significant differences [61]. One study conducted a 30 min supervised walk in an urban park or on an urban street for seven days. A significant reduction in DBP in the urban park walking group compared to walking in an urban street was found; however, a significant decrease in SBP was not observed [51]. One study conducted a 15 min walk in a bamboo grove or city. Both SBP and DBP significantly decreased when walking in the city, while DBP and SBP increased while walking in the bamboo grove[55]. A study reported that walking in artificial forests for 15 min did not cause significant changes in blood pressure compared to walking in cities[42]. Another similar study reported that walking in a forest for 15 min did not cause significant changes compared to walking in a city[36].

Three studies investigated the effect of exercise on blood pressure stability. One study reported that groups that performed green exercise in parks showed a significant decrease in DBP compared to indoor exercise groups, but showed no significant change in SBP[48]. One study reported that exercise in urban parks had no significant effect on SBP and DBP compared to standard indoor exercise[47]. Another study reported that exercise in forests caused an increase in DBP and SBP, compared to indoor exercise or sedentary groups.[62]

3.3.4. Cardiovascular disease risk biomarkers

Four studies investigated the effects of walking on cardiovascular disease prevention. In one study, an hour of urban and forest walking showed a positive effect on cardiovascular disease prevention, with no change observed in the cardio-ankle vascular index (CAVI)—a biomarker of arterial stiffness—in the urban walk group, but a significant reduction in CAVI in the forest walking group.[63] Three studies investigated the positive effects of forest walking on the renin-angiotensin system and identified a significant decrease in ET-1 after forest walking[1, 40, 41]. Mao et al. [1] also identified significant increases in angiotensin II type 2 receptor and brain natriuretic peptide levels during forest walking. Mao et al.[40] also identified significant positive effects in angiotensinogen, homocysteine, angiotensin II type 1 receptor, and angiotensin II type 2 receptor, but did not observe significant changes in renin and angiotensin II.

In one study, the results were compared after a six-month park prescription and standard physical activity. It was reported that exercise in the park did not cause significant changes in blood glucose and blood lipids [47].

3.3.5. Inflammation

One study investigated the effect of staying on the mitigation of inflammation. A study reported that 2 h of staying in urban and forest areas resulted in a significant decrease in interleukin-8 (IL-2) and tumor necrosis factor α (TNF-α) levels compared to city stayings; no significant change in interleukin-6 (IL-6) was reported[37].

Five studies investigated the effects of walking on the relief of inflammation. All five studies compared the results of forest walking and urban walking and confirmed positive effects for forest walking; however, different indicators showed significant changes in each study. One study reported a significant decrease in IL-6 and TNF-α levels after walking in forests[41]. One study observed a significant decrease in TNF-α levels after forest walking, but did not observe significant changes in IL-6 levels [64]. Three other studies observed significant reductions in IL-6 levels, but did not observe significant results for TNF-α[1, 8, 40]. Among the three studies, Jia et al. [8] also reported significant reductions in interferon gamma, interleukin-8, interleukin-1β, and C-reactive protein levels through forest walking, while Mao et al. [1] reported no significant reduction in high sensitive-reactive protein levels during forest walking.

3.3.6. Oxidative stress and Antioxidant

One study investigated the effect of staying on enhancing antioxidant power. In one study, 2 h of staying in a forest reported significantly improved antioxidant power (GPx) compared to the urban environment[37].

Four studies investigated the effect of walking on relieving oxidative stress and improving antioxidant power. Three studies showed that walking in forests reduces malondialdehyde (MDA), an indicator of oxidative stress, more significantly than walking in cities[1, 41, 64]. Three studies also measured the total superoxide dismutase(T-SOD) activity, an indicator of antioxidant power. One study confirmed a significant increase in T-SOD activity[1], while the other two studies did not[41, 64]. One study observed a significant increase in BAP, an indicator of antioxidant power, in the forest walking group rather than in the urban walking group [56].

3.3.7. Immune function

One study investigated the effect of staying on promoting immune function. This study assessed the effect of sitting and viewing a landscape for 15 min in a forest, and the results showed that sitting in the forest did not cause significant changes in Ig(A)[36].

Three studies investigated the effects of walking on immune promotion. Jia et al. [8] conducted three-hour daily walking interventions in cities and forests for patients with chronic obstructive pulmonary disease (COPS). There were significant reductions in perforin levels (NK cells, NK-like cells, and CD8+ T-cells) in the forest walking group, confirming the improved health status of patients with COPS. Mao et al. [41] conducted three-hour daily walking interventions in a city or forest for three days for healthy college men. A significant increase in total B cells in the population performing forest walking was found, but no significant effect was found on the indicators of total T cells, lymphocytes, lymphocytes, NK cells, and CD4/CD8. Tsunetsugu et al. [36] reported that walking in a forest for 15 min had no significant effect on Ig(A) compared to walking in a city.

3.3.8. Pulmonary Function

One study investigated the effect of walking on improving the exhale function. This study conducted an hour-long urban or forest walking intervention. Significant positive changes in cardiopulmonary functions were confirmed in the forest walking groups—significantly increasing FEV1 and FEV6 after forest-based intervention—than in the urban walking groups[63].

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Intervention undertaken in the urban forest										
Ameli 2021 [45]	Participants form military facility	12	25%	35.00	Instructed walking	Woodland road	20 min	Urban road	Distress: DT (+); Mindfulness awareness: MAAS (+)	Randomized cross over
Bielinis 2019 [35]	Young women	32	100%	20.97	Relaxation session	Urban Forest	15 min	(N=16) Urban	Mood States: POMS (anxiety (+), depression (+), anger (+), fatigue (+/), confusion (+), vigor (/); Affective states: PANAS (PA (+), NA (/)); restorativeness: ROS (+); Vitality: SVS (+)	RCT
Brown 2014[59]	Healthy office workers(18–65)	73	21%	42.00	Walking	Nature walking route (trees, grassland, public footpath, country lane)	Twice 20 min/week (for 8 weeks)	(N=27) Built walking route group (N=19) Waitlist control group	Mental health: SF-8(general health (/), physical health (/), mental health (+)) HRV: ln HF (/); Heart rate (/); Blood pressure: Systolic (-), Diastolic (+); Cardiovascular disease risk biomarker: Framingham CVD risk score (/);	RCT

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Calogiuri 2015**[48]**	Office workers	14	50%	49.00	Green exercise session (biking bout and a circuit-strength sequence)	Urban forest	45min (3-day)	Indoor	Affective state: PAAS(PA(+), NA(/) Tranquility(/), fatigue(/)); Restorativeness: PRS(Being Away(+); Fascination(+)); Blood pressure: SBP(/), DBP(+); cortisol awakening response: CAR AUC_G(/), CAR AUC_I(+); Serum cortisol(/)	RCT
Faber 2009[58]	Children with ADHD	17	88%	9.23	Carefully controlled, individual, guided walks	park	20min	(N=7) Downtown (N=4) Neighborhood	Attention and working memory: DSB(+)	RCT (single blind controlled trials)
Grazuleviciene 2016[51]	Coronary artery disease patients (45-75)	20	35%	62.30	Supervised 30min walking	City park (70% of land covered with pine)	30min (7 days)	(N=10) Urban street	Mood states: PANAS(PA(+/), NA(/); Blood pressure: SBP(/), DBP(+); Salivary cortisol(/)	RCT
Müller-Riemenschneider 2020[47]	Healthy middle-aged Adults	145 (91 %)	79%	51.10	Face to Face park prescription and invitation to weekly green exercise session	Urban park	150min/week (6-month)	(N=80) Standard physical activity material	General well-being: SF-12(/), WHO5(/); Distress: K-10(/); Quality of life: WHOQoL(+/); Cardio-metabolic health: blood glucose(/), blood liquids(+/); Blood pressure: SBP(/), DBP(/)	RCT

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Ng 2018[57]	Aged Adults (61-77)	59	78%	67.10	Horticultural therapy weekly session	Indoor, garden	Once a week (3-month)	(N=30) waitlist control	Psychological Well-being: Ryff's Scales of psychological well-being(/); Depression: SDS(/); Anxiety: SAS(/); Social connectedness: Positive Relations with Others(+),Friendship Scale(/); Satisfaction with Life Scale(/); Inflammatory cytokine: IL-6(+), IL-1β (/), HCRP(/), Sgp-130(/); Stress: cortisol(/), DHEA(/); Cognitive function: MoCA(/)	RCT
Rodiek 2002[49]	Aged adults (71-98)	16	100%	84.70	Single instructed session(observing surrounding)	Outdoor horticultural garden	2.5hr	(N=10) Indoor	Mood states: Philadelphia Geriatric Center Positive and Negative Affect Rating Scale(PA(/) NA(/)); Anxiety: STAI(/); Salivary cortisol(+);	RCT
Song 2019[42]	Healthy female university students	60	100%	21.00	Walking along a given course (1km)	Secondary forest od artificial forest	15min	City area	Mood States: POMS(anxiety(+),depression(+), anger(+), fatigue(+), confusion(+), vigor(+)) Anxiety: STAI(+) HRV((lnHF(+), ln(LF/HF)(+)); Heart Rate (+); Blood Pressure (/)	Randomized cross over

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Song 2018[44]	Male university students of Japan	585	0%	21.70	15min walking along a given course	Well-maintained forest area (52sites)	15min	City area	Mood states: POMS(Depression(+), Anxiety(+),Anger(+) Fatigue(+), Confusion(+),Vigor(+))	Randomized cross over
Stigsdotter 2018 [39]	Patients with stress-related illness	76	76%	46.40	Nature-based Therapy sessions (awareness exercise, nature-based activities, reflection relaxation)	Forest garden (1.4ha)	3hr*3day/week (10-week)	Cognitive Behavioral Therapy	Psychological well-being: PGWBI(+); Burnout: SMBQ(+)	RCT
Intervention undertaken in the forest										
Chun 2017[65]	Patients with chronic stroke (36-79)	59	32%	60.80	Staying at a recreational forest site (meditation, experiencing forest through five senses, walking)	Forest	4-day program	(N=29) Urban hotel	Depression: BDI(+), HAM-D17(+); Anxiety: STAI(+); Oxidative stress: d-ROMs(/); Antioxidant: BAP(+)	RCT
Hassan 2018[55]	Healthy university students (19-24)	60	50%	19.60	Walking along a given track	Bamboo forest	15min	(N=30) City area	Anxiety: STAI(+); Attention: meditation and attention mean scores(+); Blood pressure: SBP(+),DBP(+); EEG(+)	Randomized cross over

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Im 2016[37]	Young adults (18-35)	41	65%	22.76	Exposure to forest environment	Pine tree forest	2hr	Urban environment	Stress response: SRI-MF(Somatic symptoms(+) depressive symptoms(+) Anger symptom(/) Total (+)); Inflammatory cytokine: IL-6(/), IL-8(+), TNF-α(+); Antioxidant: GPx(+)	Randomized cross over
Jia 2016[8]	Elderly patients with chronic obstructive pulmonary disease(COPD)	18	33%	70.06	Forest bathing trip (short, leisurely walk in forest)	Forest	1.5hr*2/day (3-day)	(N=8) Urban	Mood states: POMS(anxiety(+), depression(+), anger(+), vigor(/), Fatigue(/), confusion(/)); Inflammatory cytokine: IFN-γ(+), IL-6(+), IL-8(+), IL-1β(+), TNF-α(/), CRP(+); Lymphocytes and subsets: NK cell(+), NK-like cell(+), CD8+ T-cell(+); Stress hormones: cortisol(+), epinephrine(+)	RCT
Koselka 2019	University students	38	52%	22.90	Walking along forest	Forest Preserve	50min	Urban roadside	Affective states: PANAS(PA(/); NA(+)); Anxiety: STAI(+); Stress: PSS-10(+); Attention and Working memory: vBDS(/)	Randomized cross over

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Lee 2014[63]	Women aged from 60 to 80	62	100%	70.50	Forest walking	Forest	1hr	(N=19) City	Blood pressure: SBP(+), DBP(+); Cardiovascular disease risk biomarker(Arterial stiffness): CAVI (+); Pulmonary function: FEV1(+), FEV6(+);	RCT
Mao 2018[66]	Elderly patients with chronic heart failure who have participated in forest trip 4 weeks ago	20	56%	72.20	Forest bathing trip (twice 1.5hr walk)	Broad-leaved evergreen forest	3hr /day 4-day trip	(N=10) City	Cardiovascular disease risk biomarkers: BNP(+); Inflammatory cytokine: IL-6(/), TNF-α(+); Oxidative stress: MDA(+),TSOD(/)	RCT
Mao 2017[1]	Elderly patients with chronic heart failure	33	42%	72.20	Forest trip (3hr walking/day)	Forest (Huangyan forest)	4-day trip	(N=10) City	Mood states: POMS(Anxiety(+), depression(+), anger(+), confusion(+), vigor(/), Fatigue(/)); Cardiovascular disease risk biomarkers: BNP(+), ET-1 (+), AGT(/), ANG2(/), AT1(/), AT2(+); Inflammatory cytokine: IL-6(+), TNF-α(/), HCRP(/); Oxidative stress: Serum MDA(+), T-SOD(+)	RCT

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Mao 2012a[41]	Healthy male university students	20	0%	20.80	3-day trip including short term forest walking (twice 1.5hr walk)	*Chamaecyparis obtuse* Forest	3hr/ day (3-day	(N=10) Urban	Mood States: POMS(Anxiety(+), depression(+), anger(+), confusion(/), vigor(+), Fatigue(+)); Inflammatory cytokine: IL-6(+), TNF-α(+); Oxidative stress: T-SOD(/), MDA(+); Cardiovascular disease risk biomarkers: ET-1(+), Platelet activation(/); Immunocytes: Total T cell(/), Total B cell(+), Thlymphocyte(/), Tslymphocyte(/), NK cell(/), CD4/CD8(/); Serum cortisol(+), Testosterone(/)	RCT
Mao 2012b[40]	Elderly Patients with essential hypertension BP (60 to 75)	24	NA	67.23	Walking at an unhurried pace for 1.5hr*2/day	Broad leave evergreen Forest	3hr/day (7-day)	(N=12) urban area	Mood states: POMS(anxiety(/), depression(+), anger(+), vigor(/), Fatigue(+), confusion(+)); Blood pressure: SBP(+), DBP(+); Heart rate(/) Inflammatory cytokines: IL-6(+), TNF-α(/); Cardiovascular disease risk biomarkers: ET-1 (+), AGT(+), Hcy(+), AT1(+), AT2(+), Renin(/), Ang2(/)	RCT

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Niedermeier 2017[62]	Healthy Adults (18-70)	42	48%	32.00	Green exercise (mountain hiking)	Forest (Innsbruck region)	3hr	(N=) Indoor treadmill walking (N=) Sedentary control	Blood pressure: SBP(-), DBP(-); HRV(/); Salivary cortisol(+/)	Randomized cross over
Olafsdottir 2020[67]	Healthy university students	67	69%	24.39	Forest walk	Recreational forest area of Reykjavík city	40min	(N=30) watching forest-walk video (N=30) Trade mill walk	Affective states: PANAS(PA(+), NA(+)); Salivary cortisol(+); Heart rate(-/); HRV(-/)	RCT
Park 2007[60]	Male university students	12	0%	22.80	Forest bathing (20min walk around the given area, 20min sit and watch the landscape)	Forest area (Seiwa Prefectural Forest)	40min	City area	Cerebral activity(relaxation): t-Hb concentration(+); Salivary cortisol(+/);	Randomized cross over
Shin 2012[68]	Alcoholics	92	9%	45.25	Forest therapy camp in recreational forest (Nature–game, nature–interpretation, Mountain-climbing, tracking, orienteering, Nature-meditation, Counseling in forest environment)	Forest (Saneum Recreational Forest)	9-day forest healing camp	(N=45) Normal daily routines	Depression: BDI(+)	RCT

Table 2.3. Main characteristics of included studies *(Continued)*

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Song 2015[43]	Middle-aged hypertensive males	19	0%	58.00	Instructed walk along a given course	Forest environment	17min	Urban environment	Mood States: POMS(anxiety(+), depression(+), anger(+), vigor(+), Fatigue(+), confusion(+)); Heart rate(+); HRV: lnHF(+)	Randomized cross over
Sonntag-Öström 2015[38]	Patients with exhaustion disorder (24-60)	78	86%	44.60	Spend the time solitude in peace and quietness	Boreal forests	Twice 4hr/week (11-week)	(N=43) waiting list control group	Burnout: SMBQ(/); stress: PRQ(/); Fatigue: CIS(/); Self-esteem: SCQ(/); Anxiety and depression: HAD-S(anxiety(/), depression(/))	RCT
Tsunetsugu 2007[36]	Male University Students	12	0%	22.00	Walking and chair watching	Forest (60 min by car)	15min	Urban	Subjective feeling(Mackay et al): Comfortable(+), Calm(+), Refreshed(+); HRV: HF(+/), LF/(LF+HF)(+/); Blood Pressure: SBP(+/), DBP(+); Pulse Rate(+/); Salivary cortisol(+); IgA(S)(/)	RCT Cross over
Zeng 2020[61]	University students (19-24)	120	50%	21.46	Viewing landscape(15min) Walking(15min)	(N=60) Bamboo forest (N=30) Bamboo forest park	30min (3-day)	(N=30) urban environment	Blood pressure: SBP(+), DBP(+/); Heart Rate(+); Oxygen Saturation: SpO2(+);	RCT

Table 2.3. Main characteristics of included studies

First author and Year	participants	N	Female (%)	Mean age	Activities	Undertaken area	Duration	Comparison group	Outcome measurement	Study design
Intervention undertaken indoor (indirect exposure)										
Golding 2018 [54]	Adults	58	78%	21 to 73	Watching slideshows of still images and reflection	woodland and heathland in Southern England	11min	(N=20) Urban street; (N=20) Control	Affective states: PANAS(PA(-/); NA(/)); Restorativeness: PRS(Being Away(+); Fascination(+);	RCT
McAllister 2017[52]	Adults of Australia (18-75)	220	72%	49.07	Watching a video film	(N=72) Wild Forest (N=76) Urban park	2.5 min	(N=72) Control	Affective states: PANAS(PA(+ only forest), NA(+ both)); Restorativeness: PRS(+ both)	RCT
Valtchanov 2010 [53]	Undergraduate students	22	54%	17-26	Observing forest via virtual reality	Forest	10min	(N=10) Observing abstract paintings via VR	Affective states: ZIPERS(PA(+), NA(/)); Stress: SCL(+), heart rate(/); Cognitive function: mental-arithmetic score(/)	RCT

AGT angiotensinogen, *ANG II* angiotensin II, *AT1* angiotensin II type 1 receptor, *AT2* angiotensin II type 2 receptor, *BDI* Beck Depression Inventory, *BDNF* Brain-derived neurotrophic factor, *BNP* brain natriuretic peptide, *CAR* cortisol awakening response, *CAVI* cardio-ankle vascular index, *CIS* Checklist Individual Strength questionnaire, *CRP* C-reactive protein, *DHEA* dehydroepiandrosterone, *DBP* diastolic blood pressure, *DSB* Digit Span Backwards, *DT* distress thermometer, *ET-1* endothelin-1, *GPx* glutathione peroxidase, *HAD-S* Hospital Anxiety and Depression Scale, *HAM-D17* Hamilton Depression Rating Scale, *HCRP* high sensitive-reactive protein, *Hcy* homocysteine, *HRV* heart rate variability, *IFN-γ* interferon gamma, *IL-1β* interleukin-1β, *IL-6* interleukin-6, *IL-8* interleukin-8, *K-10* Kessler Psychological Distress Scale, *MAAS* Mindful Attention Awareness Scale, *MDA* malondialdehyde, *MoCA* Montreal Cognitive Assessment, *NA* negative affect, *NK cell* (CD56+/CD3-), *NK-like cell* (CD56+/CD3-), *CD8+ T-cell* (CD3+/CD8+), *PA* positive affect, *PAAS* Physical Activity Affective Scale, *PANAS* Positive and Negative Affect Schedule, *PGWBI* Psychological General Well-being Index, *POMS* Profile and Mood State Questionnaire, *PRQ* Perceived Stress Questionnaire, *PRS* Perceived Restorativeness Scale, *PSS-10* Cohen's Perceived Stress Scale, *RAS* Renin-angiotensin system *SAS* Self-Rating Anxiety Scale, *SCR* skin conductance response, *SBP* systolic blood pressure, *SCQ* Self-Concept Questionnaire, *SDS* Self-Rating Depression Scale, *SMBQ* Shirom-Melamed Burnout Questionnaire, *SpO2* peripheral oxygen saturation, *SRI-MF* Stress Response Inventory-Modified Form, *STAI* Spielberger State-Trait Anxiety Inventory, *TMD* total mood disturbance, *TNF-α* tumor necrosis factor α, *T-SOD* total superoxide dismutase, *TSOD* total superoxide dismutase, *vBDS* Visual Backward Digit Span Test, *vBDS* Visual Backward Digit Span Test, *WHO-5* Five well-being Index, *WHOQoL* WHO Quality of life

Table 2.4. Psychological and physiological outcomes according to the activities conducted in included studies

	Direct Exposure																		**Indirect Exposure**					
	Staying						**Walking**						**Exercise**						**Nature/Audiovisual Material**					
	+	**+/**	**/**	**-**	**%p**	**%p+m**	**+**	**+/**	**/**	**-**	**%p**	**%p+m**	**+**	**+/**	**/**	**-**	**%p**	**%p+m**	**+**	**+/**	**/**	**-**	**%p**	**%p+m**
Psychological outcome	**5**	**5**	**6**	**-**	**31.3**	**62.5**	**16**	**8**	**-**	**-**	**66.7**	**100.0**	**1**	**2**	**5**	**-**	**12.5**	**25.0**	**3**	**2**	**7**	**1**	**23.1**	**38.5**
Mood	3	2	3	-	37.5	62.5	7	4	-	-	63.6	100.0	-	-	3	-	0.0	0.0	-	-	-	-	*0.0*	*0.0*
Affect	-	2	-	-	0.0	100.0	1	2	-	-	33.3	100.0	-	1	-	-	0.0	100.0	1	1	-	1	33.3	66.7
Anxiety	-	1	1	-	0.0	50.0	4	-	-	-	100.0	100.0	-	-	-	-	0.0	0.0	-	-	1	-	0.0	0.0
Depression	-	-	1	-	0.0	0.0	2	-	-	-	100.0	100.0	-	-	-	-	0.0	0.0	-	-	1	-	0.0	0.0
Cognitive function	1	-	-	-	100.0	100.0	2	1	-	-	66.7	100.0	1	-	-	-	100.0	0.0	2	-	2	-	50.0	50.0
Well-being/quality of life	1	-	1	-	50.0	50.0	-	1	-	-	0.0	100.0	-	1	2	-	0.0	33.3	-	1	3	-	0.0	25.0
Physiological outcome	**6**	**2**	**4**	**-**	**50.0**	**66.7**	**42**	**7**	**22**	**1**	**58.3**	**68.1**	**0**	**4**	**3**	**1**	**0**	**50.0**	**1**	**0**	**3**	**0**	**25.0**	**25.0**
Nervous system	1	-	2	-	33.3	33.3	8	1	4	1	57.1	64.3	-	1	1	-	0.0	50.0	1	-	1	-	50.0	50.0
Stress hormone	2	1	-	-	66.7	100.0	5	2	1	-	62.5	87.5	-	1	1	-	0.0	50.0	-	-	2	-	0.0	0.0
Blood pressure	-	1	-	-	0.0	100.0	3	3	2	-	37.5	75.0	-	1	1	1	0.0	33.3	-	-	-	-	-	-
Cardiovascular disease	-	-	-	-	0.0	0.0	7	-	7	-	50.0	50.0	-	1	-	-	0.0	100.0	-	-	-	-	-	-
Inflammation	2	-	1	-	66.7	66.7	11	-	5	-	68.8	68.8	-	-	-	-	-	-	-	-	-	-	-	-
Oxidative stress/antioxidant	1	-	-	-	100.0	100.0	5	-	3	-	75.0	75.0	-	-	-	-	-	-	-	-	-	-	-	-
Immune function	-	-	1	-	0.0	0.0	1	1	-	-	50.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-
Pulmonary function	-	-	-	-	-	-	2	-	-	-	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-

+: significant effect on positive outcome; +/: including both significant and nonsignificant effect on positive outcome; /: nonsignificant effect; -: negative outcome; %p : ratio of significant effect on positive outcome (count of "+"/total count); %p+m: ratio of positive outcome including both significant and nonsignificant (sum of "+"and "+/"/total count).

The numbers listed in the table are calculated and aggregated individual indicators reported in the study.

3.4. Risk of Bias

As a result of the risk of bias assessment of the 33 included studies using RoB 2, three studies were evaluated as being of some concern, and 30 studies were at high risk. The overall evaluation results are listed in Table 5.

Regarding the randomized process (D1), most studies reported baseline differences, proving no problems were caused by randomization. Ten studies reported a detailed randomization process, while 23 studies did not explain the process. In addition, nine studies reported allocation concealment in detail, while 24 studies did not report the processes. Thus, 24 studies were evaluated as having some concerns or high risk in the randomized process.

Regarding dropout during an intervention (D2), participants and research attendants in most studies were aware of the assigned intervention. Only two of the 33 included studies were double-blind. Ten studies were single-blind, including three studies with participant being blinded and seven studies with research attendants being blinded. Furthermore, 21 studies did not use blinding. In addition, 14 studies reported that dropout occurred in the middle of the intervention. Seven studies proved that dropout was irrelevant to the trial context or took appropriate analyses to estimate the effect of assignments, while six studies did not. Therefore, 23 studies were evaluated as having some concerns.

Regarding missing outcomes (D3), 19 studies reported data from all or almost all participants and were evaluated as low risk. Seven studies were evaluated as low risk by providing evidence, performing corrections, or proving that no bias occurred due to the missing outcome. Seven studies without explanation of potential bias were evaluated as having some concerns as there was uncertainty whether the missing value was affected by its true value.

Regarding outcome measurement (D4), 31 studies pre-specified measurements or provided evidence for high validity or high sensitivity of the measurement, while two studies did not provide sufficient evidence supporting their measurement. In all studies, there was no difference between the intervention and control groups. Five studies that included blinding were evaluated as low risk as assessors did not know about the intervention. Five studies without blinding were evaluated as having some concerns as, even though the assessor knew of the intervention, it was unlikely to affect the result. Twenty-three studies were evaluated as high risk, including self-reported measurements without participant blinding.

Regarding selecting results (D5), one of the 33 studies was evaluated as low risk as it provided a protocol that confirmed the result analysis method before unblinding the outcome data. In 12 studies, all results were reported but were evaluated as having some concerns as they did not provide a sufficient basis for selecting an analysis method. Twenty studies that reported part of the results were evaluated as high risk.

Table 2.5. Risk of bias of included studies using the RoB 2 tool.

First Author and year	D1	D2	D3	D4	D5	Overall
Ameli 2021	-	!	+	-	-	-
Bielinis 2019	+	!	+	-	!	-
Brown 2014	+	+	+	+	!	!
Calogiuri 2015	-	!	!	-	-	-
Chun 2017	+	!	+	-	!	-
Faber 2009	!	+	+	!	-	-
Golding 2018	+	!	+	-	-	-
Grazuleviciene 2016	-	!	+	-	-	-
Hassan 2018	-	!	+	-	!	-
Im 2016	+	!	+	-	-	-
Jia 2016	-	!	!	-	!	-
Koselka 2019	-	!	+	-	-	-
Lee 2014	+	!	+	+	!	!
Mao 2012a	-	!	+	-	!	-
Mao 2012b	-	!	+	-	!	-
Mao 2017	-	+	+	-	-	-
Mao 2018	-	!	!	!	-	-
McAllister 2017	!	+	+	+	-	-
Müller-Riemenschneider 2020	!	+	+	+	+	!
Ng 2018	-	+	+	-	-	-
Niedermeier 2017	-	+	+	!	-	-
Olafsdottir 2020	-	+	!	-	-	-
Park 2007	-	!	!	!	!	-
Rodiek 2002	-	!	!	-	-	-
Shin 2012	-	+	+	-	!	-
Song 2015	-	!	+	-	-	-
Song 2018	-	!	+	-	-	-
Song 2019	-	!	+	-	-	-
Sonntag-Öström 2015	+	!	+	-	!	-
Stigsdotter 2018	+	!	+	-	-	-
Tsunetsugu 2007	-	!	+	-	!	-
Valtchanov 2010	+	+	!	+	-	-
Zeng 2020	-	!	+	!	-	-

+ Low risk

! Some concerns

- High risk

D1: Randomization process

D2: Deviations from the intended interventions

D3: Missing outcome data

D4: Measurement of the outcome

D5: Selection of the reported result

4. Discussion

In the recent decade, many studies have demonstrated the health benefits of forest-based activities. As scientific evidence has accumulated, forest therapy has been recognized as a new option to prevent disease and improve health in some East Asian countries, European regions, and North American countries [16, 69]. Korea, a pioneer country that actively utilizes forest therapy, has expanded therapeutic forest sites, trained specialists, and tried to integrate scientific evidence into forest therapy services. In Korea, the demand for forest therapy is consistently increasing, and evidence-based designs of forest therapy programs is required to meet the diverse therapeutic needs [41]. It is thus necessary to derive program components suitable for the purpose of forest therapy; however, studies evaluating the therapeutic effect of each individual program component of these programs are limited.

Extant reviews have identified comprehensive health effects of forest therapy [23-25] and have provided reviews that assessed the effectiveness of forest therapy in specific health domains or the effectiveness of specific types of programs [26-28, 30, 31]. These reviews took approaches at the level of participation, which evaluated the overall effect of participating in forest therapy programs. That is, a systematic review of health effects according to the characteristics of the forests where programs were undertaken [32]. However, I could not find any review evaluating the effectiveness of forest therapy programs according to behavioral components, such as type of activities, duration, and frequency. Thus, I focused on the activity components of forest therapy programs and attempted to identify the health effects according to the different activities conducted in the programs.

The 33 RCTs included in this study reported the health-promoting effects of forest therapy programs and were categorized according to four activity components: staying, walking, exercise, and indirect exposure. Overall, walking showed the most consistent health effect while staying, exercise, and indirect exposure showed mixed effects, including both significant and nonsignificant results. Regarding psychological outcomes, walking showed a consistent effect in relieving depression and anxiety. Although there were a limited number of studies on cognitive function, all activities showed a significant effect in enhancing cognitive function. Regarding physiological outcomes, walking and staying showed consistent effects on reducing stress hormones and relieving inflammation. In summary, walking in the forest had the most consistent health-promoting effects.

I also adopted the RoB 2—a reliable tool to assess both RCTs and randomized cross-over studies—tool for quality assessment of the included studies. However, our results were more conservative than the actual level of quality of each included study. That is, the included studies were assessed as being high risk, especially in the randomization process (D1), measurement of outcome (D4), and selection of the reported results (D5). Forest therapy requires exposure and immersion in the forest; therefore, in some cases, visiting a therapeutic forest or the instruction of forest therapy specialists is required. Furthermore, accommodation facilities are required. This inevitably makes the allocation of concealments and participant blinding even more difficult, which may result in a higher risk of bias during the randomization process (D1). In addition, the effect of forest therapy on mood, depression, anxiety, and affective states is usually measured using a self-report method. This type of measurement without participant blinding may have been the main cause of the higher risk of bias evident in the measurement of outcomes (D4). Furthermore, in our review, 12 studies reported the overall results without justifying their analysis method used. This may have led to a higher risk of bias in the reported results (D5). Thus, regarding D1 or D4, some clinical trials on forest therapy inevitably have higher risk. Taking this into account, our RoB2 assessment may not fully reflect actual quality of included studies. In other words, higher risk of bias on D1 and D4 may be partly due to the innate characteristics of forest therapy rather than shortcomings in research designs. Regarding D5, a fundamental way to lower the risk of bias is to release a protocol that states the analysis method in advance. In addition, establishing a standardized monitoring system or institutional guideline for forest therapy programs is required to lower the risk of bias and strengthen the evidence of future studies.

Although several important findings arose from the review, there were some limitations. First, most of the included studies had a high risk of bias with only two studies being double-blind. Ten studies utilized single blinding, and 21 studies did not conduct blinding. Moreover, most studies included self-report measurements without blinding participants, resulting in a higher risk of bias. In addition, only two of the 10 studies that used cross-over designs included a wash-out period to prevent carry-over effects; the remaining eight studies did not. This also leads to a higher risk of bias. Second, there was a gap between conducted activities. In other words, most studies focused on walking (61%) and staying (21%) with insufficient studies on exercise and indirect experiences. Therefore, it was not possible to compare the health-promoting effects of activities in some indicators and to identify differences between activities. Third, there was a gap in duration and frequency. Most studies performed interventions in the short-term in 60 min or less (63%). There little research on one-day interventions for more than an hour while most of the day and night interventions focused on duration of 180 min.

Furthermore, there was little research on the physiological effects of regular interventions. Finally, most studies conducted the same activity in urban and forest environments. Although the effects of forest-based interventions can be examined by adopting an urban comparator, it may be more suitable to assess environmental effects rather than differences in activities. Thus, it was difficult to assess the differences between the individual activities performed in the forest.

These limitations can be addressed by implementing the following recommendations. First, future research can lower the risk of bias in several ways. Participant blinding can be conducted by providing limited information until the results have been collected (e.g., walking speed evaluation research, research for determining the appropriate time of exercise, and research for performance evaluation of VR equipment). Research assistant blinding can also be implemented by conducting measurements by separate institutions based on concealed identification numbers. In addition, pre-registration protocols including research analysis methods and providing a valid basis for study measurement and analysis method selection can also lower the risk of bias. Second, future research should diversify these activities. In particular, RCTs on activities with moderate or greater intensity is needed. Furthermore, activities can be diversified based on not only the strength of physical activity but also sensory use[70], features of the forest environment[71], and the degree of social interaction[30, 72]. Third, RCTs on diverse duration and frequency are needed. In particular, little research on interventions that take 1 to 3 h, more than 4 h, and regular interventions exist. As duration and frequency are essential features when constructing forest-based activities, addressing this literature gap is essential. Finally, as most studies have compared these effects in urban and forest environments, a proper control design is needed. For example, some studies have compared the effects of other activities in the forest[36, 60], while others have investigated the effects of the environment and activity separately by setting more than one comparator[50, 59, 62]. In addition, other recent studies have evaluated the therapeutic effect of forest-based activities by comparing the effect with verified therapy[39, 47]. For instance, Stigsdotter et al. [39] tested the efficacy of forest-based interventions on stress-related diseases by comparing the effects of specialized cognitive behabioral therapy for bodily distress syndromes.

Staying, walking, and exercising are physical activities that can bring health benefits even if they are not necessarily carried out in the natural environment. Therefore, it is needed to verify whether the reported health effects can be considered as effects of nature-based healing programs rather than physical activity. Of the 33 included studies, 26 performed the same activity in comparative and natural settings, and multiple comparisons confirmed the effectiveness of nature-based healing programs.

The two of the included studies reported no significant differences in performing nature activities compared to indoor activities [62, 67]. When performing simple activities such as walking or staying, participants can focus primarily on their surroundings. However, when engaging in complex activities such as high-intensity exercise or learning, participants have difficulty concentrating on their surroundings and there would be a risk of compromising the restorative mechanisms from nature exposure. Taking this into account, when the physical or cognitive demands of a program are high, it would be beneficial to examine long-term outcomes (e.g., probability of activity continuing, long-term stress relief, and increased resilience) rather than short-term effects of activities[48].

Besides, one of the included studies found that passive nature exposure conducted in comfortable indoor condition, is more effective for acute stress reduction [67]. Activities in nature generally require more physical effort than indoors[73, 74] and the restorative experience can be hampered in uncomfortable, dangerous, cold, or humid conditions. Therefore, depending on the target effect and the participant, indirect exposure may be more effective. Further studies on the effects of indirect natural exposure (e.g. window view, VR, etc.) are needed.

5. Conclusion

The purpose of this review was to evaluate health benefits according to the activity components of forest therapy programs. This review synthesized 33 studies and categorized activities into staying, walking, exercise, and indirect exposure. Walking showed the most consistent effects, whereas other activities showed mixed effects of both significant and nonsignificant results. In the psychological results, walking showed a stable effect on relieving depression and anxiety symptoms. Moreover, walking, staying, and exercise had a positive effect on improving cognitive function. Physiological results showed that staying and walking consistently reduced stress hormone levels, and walking and staying had a relatively consistent effect on relieving inflammation. However, most of the included studies were at high risk of bias, with studies being biased toward specific activities, duration, and frequency. Therefore, appropriate blinding methods and standardized monitoring systems should be developed to strengthen the evidence level of future RCTs. Furthermore, future RCTs should diversify the activities, duration, and frequency of interventions to fill gaps in the literature. In addition, a suitable control-group design should be considered in future studies.

Today, the health benefits of forests have started to expand from empirical knowledge to preventive medicine in practice. Therefore, along with an increasing public demand for recreation and health use of forests, it is necessary to provide reliable and effective forest therapy programs. Although this review had some limitations, I expect that the findings highlighted here will contribute to future evidence-based designs for forest therapy.

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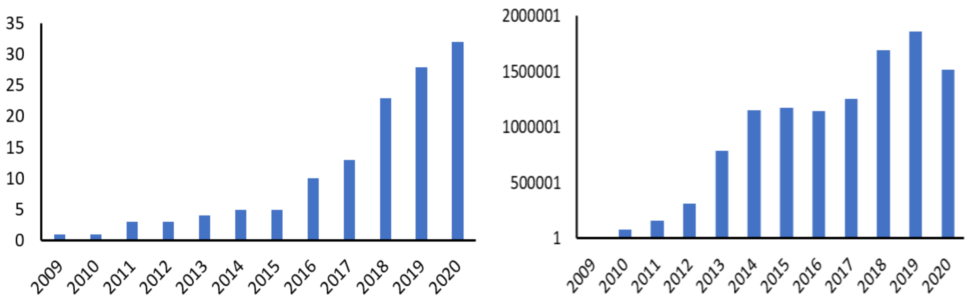
Chapter 3

Analysis of the management status of forest healing program

1. Introduction

In 2018, the public value of forests in Korea reached $221 billion, of which forest recreation function was the fourth highest at $18 billion (8.3%). This increased by 6.8 billion compared to $17 billion in 2014, whereas “forest healing” increased to $51 billion in 2018 from $24 billion in 2014 [1]. With the ongoing increase in public interest in forest recreation and forest healing, the number of operational therapeutic forests with forest healing programs increasing. These therapeutic forests are defined as forests (including natural and man-made facilities) designed for enhancing health, wellness, and happiness—i.e., healing [2].

The Korea Forest Service has been creating and operating therapeutic forests in Korea since opening the first therapeutic forest in 200. Since then, the number of national and public therapeutic forests have steadily increased to 5 by 2015 and 32 by 2020 (Figure 1). In line with this increasing number of therapeutic forests to experience forest healing, the number of visitors to therapeutic forests are also increasing rapidly. For example, the number of visitors to therapeutic forests was merely 1,067 in 2009, but increased to 1.7 million in 2015, 1.8 million in 2019, and 1.5 million in 2020 (global pandemic year), indicating that more and more people are visiting therapeutic forests to experience the effects of forest healing.



(**a**) (**b**)

Figure 3.1. (a) The number of healing Forests; (b) The number of visitors to healing forests.

Forest healing is not an act of treating diseases, but a healing activity that helps maintain health and increases immunity, which reduces stress [3-12], recovers cognitive functions [13-18], and reduces depression [5, 12, 14-19] and cardiovascular disease [20-26]. As more people visit therapeutic forests to enjoy the benefits and participate in forest healing programs, the number of qualified healing forest guides (instructors) are also increasing (Figure 2).

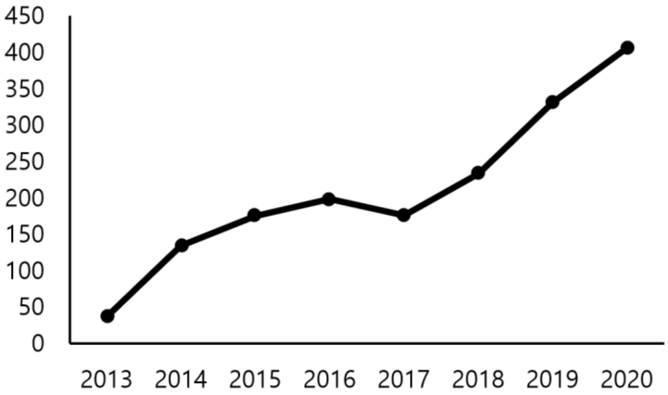


Figure 3.2. The Number of new forest healing guidance certificates (Levels 1 and 2)

The forest healing program was developed based on the gender, age, occupational characteristics, diseases of the participants, and their purpose for visiting. After examining the therapeutic potential and spatial aspects of a site, programs are designed based on different healing factors and treatments. Forest healing factors include the landscape, phytoncides, anions, sounds, sunlight, and oxygen levels [28], whereas the six major therapies of forest healing include plant therapy, water therapy, diet therapy, psychotherapy, climate therapy, and exercise therapy [29].

Generally, a performance assessment determines the success of a forest healing programs, and also assesses any underlining reasons for changes to the program [30]. However, since there is not yet a standard for forest healing, this assessment is based on its healing efficacy during the program development phase, although the program is initially run without any verification required.

To reduce cases of poor implementation, the Korea Forest Service is validating the forest healing program based on the criteria for the forest education program. However, as the purpose of the forest education and forest healing differs, using this certification system for verification is limited. Therefore, to provide high-quality forest healing programs, a basis for evaluating the composition and effectiveness of the forest healing program is needed. Prior studies that analyzed the activities of forest healing programs have already been carried out several times, but these studies did not solely target certified programs and the number of programs analyzed were few [31-33].

To address previous limitations, this study aimed to analyze 75 forest healing programs certified by the Korea Forest Service and the Korea Forest Welfare Promotion Agency (as of December 2020) to validate their activities. This study utilized the certification system of forest education programs conducted by the Korea Forest Service, the Ministry of Gender Equality and Family, and the Ministry of Environment (Table 1). Furthermore, the purpose of the project was to provide a basic dataset (representative criteria) to serve as guidance for future foundation-based forest healing programs by the Korea Forest Welfare Promotion Agency.

Table 3.1. Certification criteria of each institution for forest healing program

Category	**Korea Forest Service**	**Ministry of Gender Equality and Family**	**Ministry of Environment**
Certification System	Forest Education Program	Adolescent Training Activity	Selection of Outstanding Environmental Education Program
Purpose	Providing opportunities to understand the necessity and role of forest and value of forest environment system.	Providing superior programs to help adolescents to participate by choosing beneficial and safe activities	Providing the environmental education programs that are eco-friendly, high-quality, and safe
Criteria	-Total 5 index, 9 items - Education program: Composition, Management, Evaluation, Faculty members, Education environment (Place and equipment, Safety control, Hygienics), Activity records, Accommodations	- Common Criteria, 6 items -Individual Criteria: 3 items with accommodation, 5 Without accommodation. -Special Criteria: 2 items for high risk, 1 for accommodation as groups, and 3 for non-face-to-face (real time, contents, task performance)	-3 index, 5 items -Program (quality, management, evaluation), instructors (certification and arrangement), education activity environment (safety control)
Process	-Documentation review -Field survey and evaluation report of consulting -examination of item and review -Consideration and decision -Issue of Certification	-Verification consulting -Applying for Verification -Verification Examination -Consideration to verify -Issue of Verification	-Pre-consulting(optional) -Appointed application -Appointed Examination -Appointed Consideration -Selection as Outstanding Program

2. Materials and Methods

2.1 Research Methods

To determine the current status of forest healing programs, 75 forest healing programs operated by the main body of forest welfare, the Korea Forest Welfare Institute, were analyzed. The 75 programs are certified as quality programs by the Korea Forest Service, Ministry of Gender Equality and Family, and Ministry of Environment, and consist of 39 programs by the Korea Forest Service, 21 programs by the Ministry of Gender Equality and Family, and 15 programs by the Ministry of Environment.

A total of 278 detailed forest healing program were identified from 75 qualified forest healing programs. Of the 278 programs that consisted of forest healing programs, 268 were included, excluding overlapping programs. The 268 programs were analyzed in six categories (participants, six major methods, seasons, sensory activities, physical activities, and locations) referring to the contents written by the forest healing instructor who developed the programs (Table 2).

Table 3.2. Classifying criteria of activities for 268 detailed forest healing programs

Classification Criteria	**Classification**	**Detailed Items**
Participants	Disease	Normal, Chronic, Addictive, Environmental
	Targets	Infant, , Adolescent, Aged, Pregnant, Health-Impaired
The Six Methods		Plant Therapy, Water Therapy, Diet, Psychotherapy, Climate Therapy, Exercise
Season		All of them, Spring, Summer, Fall, Winter
Sensory Activities		Visual, Olfactory, Auditory, Tactile, Palate
Activities		Dynamic activities, Static activities, Both
Locations		Indoor, Indoor/Outdoor, Outdoor

The classification of the six major therapeutic approaches is based on the areas of forest healing programs from a previous study [29], and is divided into plant therapy, water therapy, diet, psychotherapy, climate therapy, and exercise therapy. Briefly, these activities were categorized as: walking and hanging around in the forest to improve health (plant therapy); water activities such as walking in the valley or immersing one's arms and legs in water (water therapy); eating activities such as drinking tea (diet); meditation and contemplation in forests (psychotherapy); activities that utilize the microclimate elements of forests, such as morning and night walks (climate therapy); and activities that include forest scenery and terrain such as forest sports events and trekking (exercise therapy).

Activities for the senses are divided into five categories according to visual, olfactory, auditory, tactile, and palate. These subdivisions can be understood as: programs that utilize color perception (visual); programs that utilize fragrances such as herbs, flowers, and fruits (olfactory); programs where participants listen to the wind and leaf swaying sounds from nature (auditory); programs where participants touch petals, leaves, branches, and seeds (tactile); and programs that eat food and drink tea (palate) [32].

The activities, seasons, and locations classifications were based on the contents written by the forest healing instructors. For instance, activities were divided into dynamic, static, and dynamic-static activities; seasons were divided into the seasons (four seasons, spring, summer, fall, and winter) or simply all of them if year-round; and lastly, locations were divided into indoor, outdoor, and both indoor-outdoor.

In addition, the classification of forest healing programs included activity types (one day, day and night, or regular), education personnel, and participation fees, whereas the classification criteria were selected based on prior research. When classifying types, if there were one or more characteristics of the activity contents, all of them were included in the type, whereas a frequency analysis of the 268 detailed program activities was conducted according to the six major classifications.

After the frequency analysis, a systematic review (SR) was performed to determine the strength of evidence for forest healing program effects. The detailed programs were then classified according to activity, type, and duration categories.

2.2 Effectiveness of Forest Healing Program through SR and Meta-Analyses

2.2.1. 'Health Benefits of Forests to People' through SR

An SR was conducted to analyze the activity-specific effects in forests. When selecting each case, the keywords were followed by Table 3 according to PICOS, and the keywords were searched in four electronic databases: PubMed, PsycINFO, Web of Science, and Scopus. This includes studies published in English between January 2000 and February 2021.

A total of 1,903 search results were exported to the EndNote Citation Manager software (version EndNote X9.3.3) with 1,288 electronic database searches in PubMed, 25 in PsycINFO, 81 in Web of Science, and 509 in Scopus searches. After removing 209 duplicates, the titles and abstracts of the 1,694 publications were reviewed. Two reviewers independently screened the full text for 265 articles, after removing 1,429 non-randomized studies or explicitly unrelated subjects, to identify the studies to be included in the systematic literature review. This discrepancy was resolved through discussion. In addition, the final 33 studies were included by reviewing references from existing systematic literature reviews retrieved, adding four qualified studies that were not identified through searches (Figure 3).

To understand the effectiveness of activities in the forest, I also looked at how consistent or mixed positive results have been reported throughout the first round of research, including using the 33 selected studies [35]. The 33 studies were divided into homogeneous groups according to the activities conducted in the intervention. As an indicator for the overall performance for each group, I used an index called %p+m, which is the ratio of positive outcomes with significant or mixed reports (non-significant) compared to the total number of reports (× 100 for percentage). In this study, the p+m ratio was considered to be the effectiveness of activities, and the current status and effectiveness of activities and time by applying the categories of activities classified through frequency analysis and the number of detailed programs over time.

2.2.2. Search for Meta-Analyses on forest healing programs

To understand the effectiveness of forest healing programs, meta-analyses on existing forest healing programs were selected using the SR process. When selecting the paper, the keywords were searched in three electronic databases: PubMed, Cochrane Library, and Scopus, as shown in Table 3, according to the PICOS used by SR. This includes studies published in English until May 2021.

A total of 616 searches were exported to the EndNote Citation Manager software (version Endnote 20) with 254 from PubMed, 113 from the Cochrane Library, and 249 from Scopus searches. After removing 13 duplicates, the titles and abstracts of 603 publications were reviewed. Two reviewers independently screened the full text of 13 studies, after eliminating 589 non-meta-research or apparently unrelated subjects, to identify the studies to be included in the systematic literature review. Disagreements were resolved through discussion, and the final three studies were included (Figure 3).

In order to understand the effectiveness of forest healing programs, the analysis was based on the confidence interval (95% CI) using the results of the last three selected studies. If the CI value included zero, it was regarded as "No Effect," whereas if it did not include zero, it was regarded as an "Effect." This was intended to determine whether the activities carried out in the forest were effective.

Table 3.3. Keywords used to search for relevant studies

Keywords	'Health Benefits of Forests to People' through SR	Search for Meta Literatures on forest healing programs
P	(people OR volunteers OR participants OR subjects OR individuals)	(people OR infant OR adolescent OR adult OR elderly OR pregnant women OR disabled)
I	("natural environment" OR "green space" OR "nature space" OR "green nature" OR "forest") AND (Intervention OR program OR programme OR exposure OR therapy OR recreation OR "physical activity" OR exercise OR activities OR walking OR meditation OR staying)	("green space" OR "forest") AND (Healing OR therapy OR program)
C	-	
O	"health" OR "well being" OR "well-being" OR "health promotion" OR "physiological" OR "psychological" OR "mental health" OR "physical health" OR therapeutic	
S	"randomized controlled" OR “RCT”	"Meta"

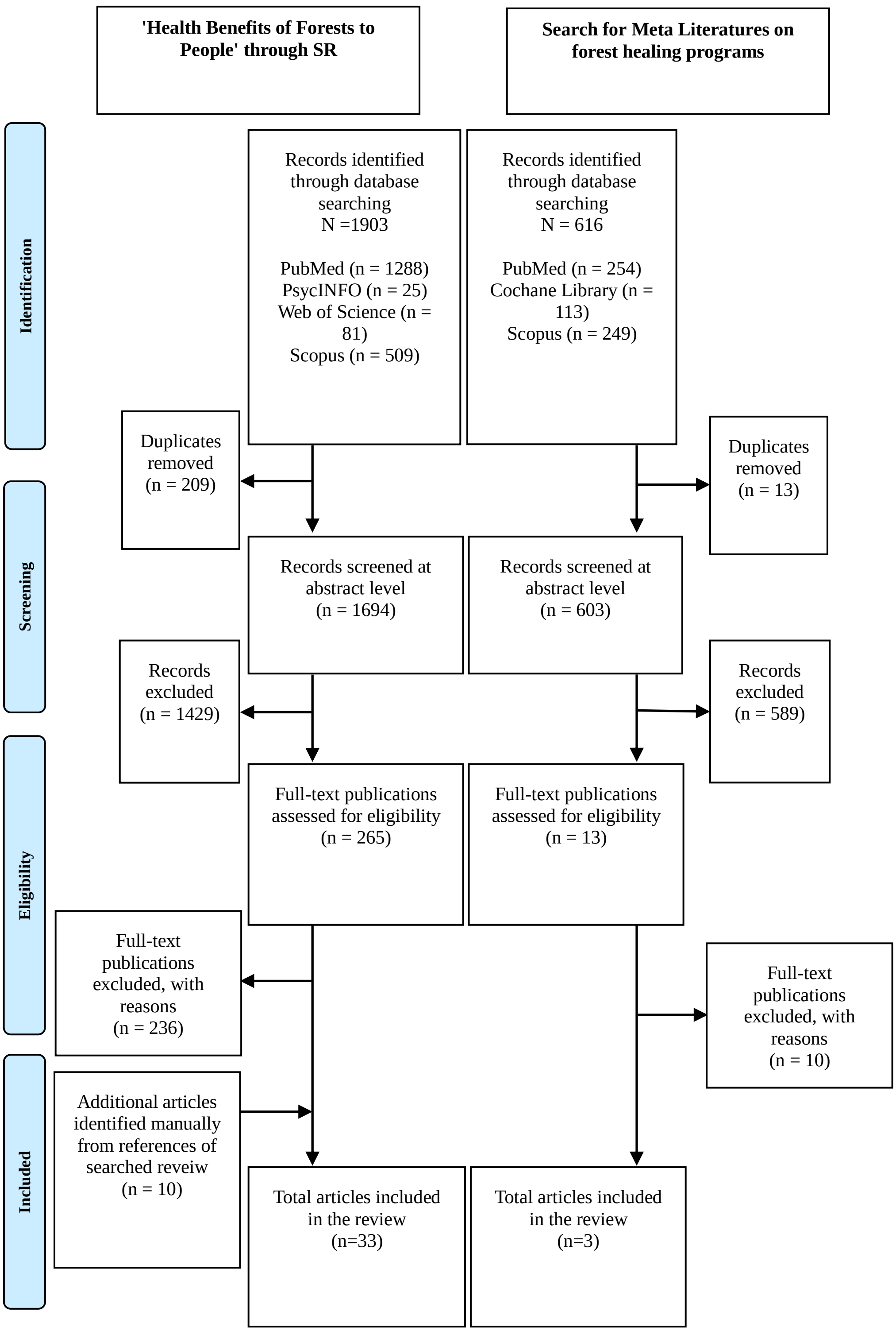


Figure 3.3. Flow diagram Illustrating the selection process

3. Results

3.1.1. Target Groups for Forest Healing Program Development

Since the purpose and details of the program vary depending on who participates in the forest healing program, the selection of subjects is an important part of program development. A total of 75 forest healing programs were analyzed for their activities to classify the target items based on the accounts made by the developer and forest healing instructor (Table 4).

First, an analysis of the frequency of subjects according to the disease-states confirmed the following hierarchy: normal > addictive > chronic = environmental diseases; with normal disease-states accounting for 90.67% of program activities. Therefore, this can generally be seen as a program activity that considers most (nearly all) possible subjects.

Second, an analysis of the frequency of the target groups confirmed the following hierarchy: teenagers > adults > families > infants = the elderly = the disabled > pregnant women; with 54.67% of teenagers participating in more than half of the program activities.

Table 3.4. Classification of the participants for the forest healing programs

Section	Subsection	Participation Frequency	Rate (%)
Disease	Normal	68	90.67
	Chronic disease	2	2.67
	Addictive disease	3	4.00
	Environmental disease	2	2.67
Target	Infant	5	6.67%
	Adolescent	41	54.67%
	Adult	15	20.00%
	Elderly	3	4.00%
	Pregnant women	1	1.33%
	Disabled	3	4.00%

3.1.2 Healing factors and activity evaluation

The forest healing program aims to maximize the effectiveness of forest healing by utilizing the landscape, phytoncides, anions, sounds, temperature, humidity, light, and terrain, which are the physical environmental elements of forests. Detailed programs are planned to provide the desired positive effects by organizing healing factors and activities according to the effects and purposes of the participants.

Activity items are selected by referring to prior research, and static activities include items that move the body while sitting or standing in one place without lying or moving. The activities of moving and stopping, moving while walking slowly, running, and jumping are classified as dynamic activities. In addition, if both dynamic and static activities are performed in the detailed program, they are classified as dynamic-static activities [29].

Based on these distinctions, 268 detailed programs were used to classify healing factors and activity items to analyze the activities of the forest healing programs. When classifying activity items, it was based on the accounts made by the program developer and forest healing instructor. In some instances, more than one type of therapeutic approach or activity was used to classify activity items; hence, the total frequency was higher than the number of detailed programs (Table 5).

First, according to the frequency analysis of the six major methods, the order of most to least frequent were plant therapy > psychotherapy > exercise therapy > water therapy > climate therapy > diet therapy; plant therapy accounted for 67.63%, whereas diet only accounted for 0.72%. When classifying detailed programs, there were instances where no specific therapeutic approach was used, whereas others that constituted multiple therapies simultaneously.

Second, according to the frequency analysis results for the five sensory activities, the of most to least frequent were tactile > olfactory > auditory > visual = palate, with tactile sense activities accounting for 34.22% of the detailed program composition. Furthermore, there were also programs that did not include sensory activities in the composition of detailed programs, while others utilized all five senses.

Third, the results of the frequency analysis of activities show that more than half of the activities were dynamic activities, accounting for 59.70%, and the frequency order given as dynamic activities > static activities > dynamic-static activities.

3.1.3 Season and training time

To determine the season when the forest healing program was operated and the duration of each session, it was analyzed using schedules prepared by the forest healing instructor (Table 5).

First, according to the frequency analysis of the seasons, the order of highest to lowest frequency by season were summer > spring = fall > winter. There were 45 activities (61.64%) available in spring, summer, and fall, whereas 23 activities (31.51%) were available for all four seasons. This indicates that fewer programs are operated in winter than in other seasons due to environmental restrictions on outdoor activities.

Second, the frequency of forest healing programs for sessions >60 min was higher than <60 min, with 74.25% of the detailed programs running for more than 60 min. Among the detailed programs, the minimum program duration was 10 min for one-day programs, and the maximum program duration was 240 min for two-day and one-night programs.

3.1.4 Location for forest healing program, type of activities, number of educations, Participation fee

When planning a forest healing program, the effect of the forest healing program may vary depending on where the program is conducted and the type of activity. Accordingly, 268 detailed programs were used to analyze the contents of the program's activities and 75 forest healing programs were used to analyze the types of activities (Table 5).

First, the results of the frequency analysis of the venue showed that the outdoor area accounted for 57.09% of activities, by order of outdoor > indoor > outdoor-indoor, which indicates that the forest healing program actively utilized the places created in the healing forest.

Second, according to the frequency analysis of the visit characteristics, the order was one day visit = day- and night visits > regular visit. Within the day- and night visits type, it was higher in the order of one night and two days (34.67%) than two nights and three days (12.00%). This is the largest number of one-day visits, with the total program time of one-day programs consisting of 2–6 h, and regular visit programs consisting of 3–15 sessions.

In addition, I analyzed the number of education personnel and participation fee items using 75 programs to analyze the content of forest healing program activities. Education personnel in the forest healing program consist of 5–300. Furthermore, 17 programs were free of charge with green subsidies, and besides free programs, the cost was 1,000~165,000 KRW.

Table 3.5. Characteristics of the session types for forest healing programs

Section	Detailed Contents	Frequency (Cnt)	Rate (%)
Therapeutic approach	Phytotherapy	188	67.63
	Hydrotherapy	16	5.76
	Dietary therapy	2	0.72
	Psychotherapy	35	12.59
	Climate therapy	6	2.16
	Kinesiology	31	11.15
5sense activities	Visual	36	11.96
5sense activities Activity	Olfactory	74	24.58
	Auditory	52	17.28
	Tactile	103	34.22
	Gustatory	36	11.96
	Static activities	81	28.62
Activity Contents	Dynamic activities	169	59.72
	Both	33	11.66
	Staying	31	10.44%
Contents Season	Walking	132	44.44%
	Exercise	48	16.16%
	Indirect(Natural Materials, Audiovisual Materials)	86	28.96%
	Spring	70	95.89
Season Hours of operation (minute)	Summer	73	100.00
	Fall	70	95.89
	Winter	25	34.25
	< 60mins	76	26.95
Hours of operation (minute) Location	> 60mins	206	73.05
	Outdoor	160	55.56
Location Visit characteristic	Indoor	88	30.56
	Both	40	13.89

	One day visit		35	46.67
Visit characteristic	Day and nights visit	1N2D		26
	Day and nights visit	2N3D	9	34.67
	Regular visit	5	6.67	12.00

3.2.1. Effectiveness of forest healing programs on activities and time

An SR was conducted to determine the effectiveness of forest healing activities and to support the level of evidence for forest healing program effects. The duration of sessions was divided into more or less than 1 h, and activities were divided into staying, walking, exercise, and indirect. Staying included viewing, watching, and meditation in one place, and walking included activities such as walking around and observing the surroundings. Exercise included trekking and forest sports. Finally, indirect included natural materials, audiovisual materials, programs that utilize natural materials, and programs that include audio-visual materials (Table 6).

To determine the current status and effectiveness of the forest healing programs currently implemented, it was divided into static and dynamic activities and further detailed activities, and the criteria were the same as those used by SR. According to the analysis, it was higher in the order of walking > indirect > exercise > staying, with walking accounting for 46.27% (Table 7).

Table 3.6. Health outcomes across activities

	Mental Health						Physical Health					
	+	**+/**	**/**	**-**	**%p**	**%p+m**	**+**	**+/**	**/**	**-**	**%p**	**%p+m**
Staying												
<1 h	**6**	**3**	**2**	**-**	**54.5%**	**81.8%**	**-**	**1**	**1**	**-**	**0.0%**	**50.0%**
>1 h	**3**	**1**	**8**	**-**	**25.0%**	**33.3%**	**3**	**-**	**1**	**-**	**75.0%**	**75.0%**
Walking												
<1 h	**23**	**5**	**5**	**2**	**65.7%**	**80.0%**	**5**	**3**	**4**		**41.7%**	**66.7%**
More than 1hr	**5**	**5**	**1**	**-**	**45.5%**	**90.9%**	**27**	**-**	**18**	**-**	**60.0%**	**60.0%**
Exercise												
<1 h	**2**	**2**	**3**	**-**	**28.6%**	**57.1%**	**-**	**1**	**-**	**-**	**0.0%**	**100.0%**
More than 1hr	**-**	**2**	**4**	**-**	**0.0%**	**33.3%**	**-**	**1**	**2**	**1**	**0.0%**	**25.0%**
Indirect												
<1 h	**3**	**2**	**8**	**1**	**21.4%**	**35.7%**	**1**	**-**	**3**	**-**	**25.0%**	**25.0%**
>1 h	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

+: significant effect on positive outcome; +/: including both significant and nonsignificant effect on positive outcome; /: non-significant effect; -: negative outcome; %p = ratio of significant effect on positive outcome (count of "+"/total count); %p+m = ratio of positive outcome including both significant and nonsignificant (sum of "+"and "+/"/total count)

+: significant effect on positive outcome; +/: including both significant and nonsignificant effect on positive outcome; /: non-significant effect; -: negative outcome; %p = ratio of significant effect on positive outcome (count of "+"/total count); %p+m = ratio of positive outcome including both significant and nonsignificant (sum of "+"and "+/"/total count)

Table 3.7. Detailed activity type

Categories	**Detailed Contents**	**Frequency**	**Ratio(%)**
Activities	Staying	24	8.96
	Walking	124	46.27
	Exercise	41	15.30
	Indirect (Natural Materials, Audiovisual Materials)	79	29.48
Total		268	100.00

To understand the level of evidence for the effectiveness of forest healing programs, I applied the activity category and time effectiveness of the SR, as well as the activity frequency of programs to illustrate the activity, time, and effectiveness of the ongoing forest healing programs (Figure 4 and 5). The background color represents the activity and time effect (%p+m) after SR, with darker colors having a greater effect on forest healing, and gray dots indicating the frequency of detailed forest healing programs—the more gray dots, the more time and activity were logged.

According to the results, the most psychologically beneficial activity was walking: with 80.0% of sessions <1 h and 90.9% of session >1 h showing positive outcomes (which was also the most frequent activity). Physiological activities are considered to be highly effective exercise for both >1 h and <1 h, each showing great physical effects. However, detailed programs were not actively implemented.

Furthermore, walking activities are both psychologically and physically >60.0% effective, indicating that the level of detailed programming is more active than other activities.

In the case of indirect activities, no studies were available for activities >1 h. Therefore, detailed forest haling programs are currently underway with the effectiveness yet to be evaluated.

These results indicate that for psychological benefits, walking activities work regardless of duration, whereas staying activities is 48.5% more effective for shorter durations than >1 h. This can be explained by a sense of boredom when a static program is run for >1 h. Also, %p+m showed that the physiological benefit of 1> h of walking activity is >60% effective, whereas <1 h of exercise is 100% effective. However, the main measurement tool of staying is heart rate variability, which is determined by movement, and this indicator may vary depending on the design of the study because there is a significant difference between measurements with or without sufficient rest.

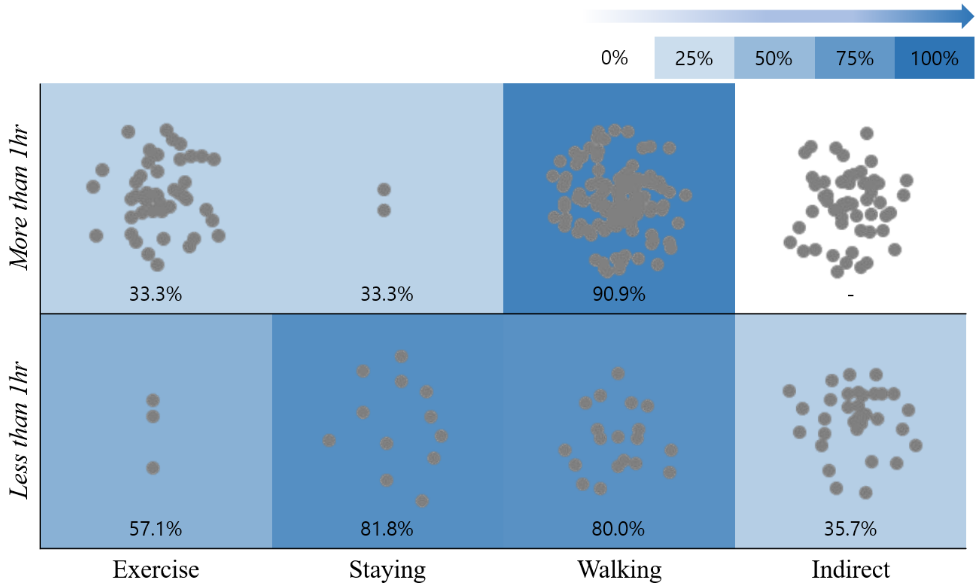


Figure 3.4. Effect of forest healing program activities and duration on mental health (Psychological).

*Background color : The forest healing effect size (%p+m) is expressed as 0~100%, indicating that darker colors have a greater effect on forest healing; *Gray dots: The detailed forest healing program was classified by activity and time, and expressed as a single gray dot for each program.

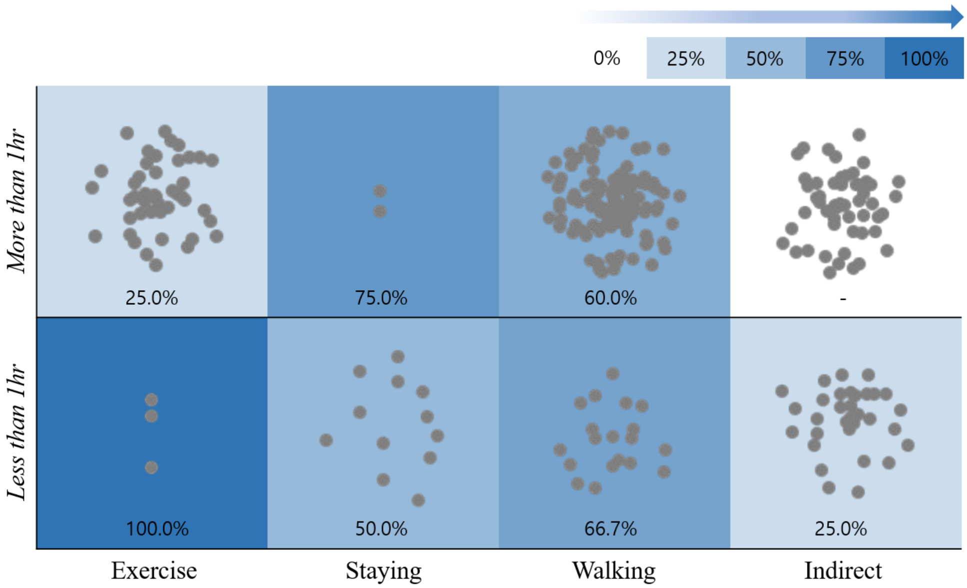


Figure 3.5. Effect of forest healing program activities and duration on phisical health (physiological)

*Background color : The forest healing effect size (%p+m) is expressed as 0~100%, indicating that darker colors have a greater effect on forest healing; *Gray dots: The detailed forest healing program was classified by activity and time, and expressed as a single gray dot for each program.

3.2.2. Evidence for effectiveness of forest healing programs

To understand the effectiveness of the forest healing program, the final three META studies aimed to determine whether activities carried out in the forest were effective with 95% CI. First, the papers used for META analysis were divided into either effect or no effect through the CI index. Then, the activities used in the study were also divided according to effect and no effect. Duplicate papers were excluded at this point as significant overlap occurred during the forest healing META analysis. Forest healing program activities were divided into the same criteria used earlier, and a total of 63 activities were effective, whereas 5 activities were ineffective in the META paper (Table 8).

I compared the activities of detailed forest healing programs used after certification and the composition of forest healing programs supported by META. Walking (132 cases, 44.44%) accounted for most of the activities of detailed forest healing programs being used after certification, with 31 cases also accounting for the most activities confirmed through the META paper. Most activities have been shown to be effective when forest healing occurs, but a total of five studies related to walking showed no effect.

Table 3.8. Numbers of references providing evidences of forest healing activities

Activities		**Numbers of references**	
		Effect	No Effect
Staying	31(10.44%)	27	-
Walking	132(44.44%)	31	5
Exercise	48(16.16%)	1	-
Indirect	86(28.96%)	4	-
Total	297(100%)	63	5

3.2.3. Psychological and physiological effects of forest healing programs

In the final three selected META studies, the results were divided into either effect or no effect through the CI index, and the effectiveness of the forest healing program was identified through research methods conducted in each paper (Figure 6). Most of the experimental sites were forests, but three were conducted in places other than the forest. Among the studies that showed forest healing effects, blood pressure had the highest number of therapeutic effects in the study, with 32 cases, followed by 24 cases for depression, 17 cases for anxiety, 16 cases for anger, and 10 cases related to cortisol. Furthermore, five studies involving cortisol, a stress biomarker, showed no forest healing effects.

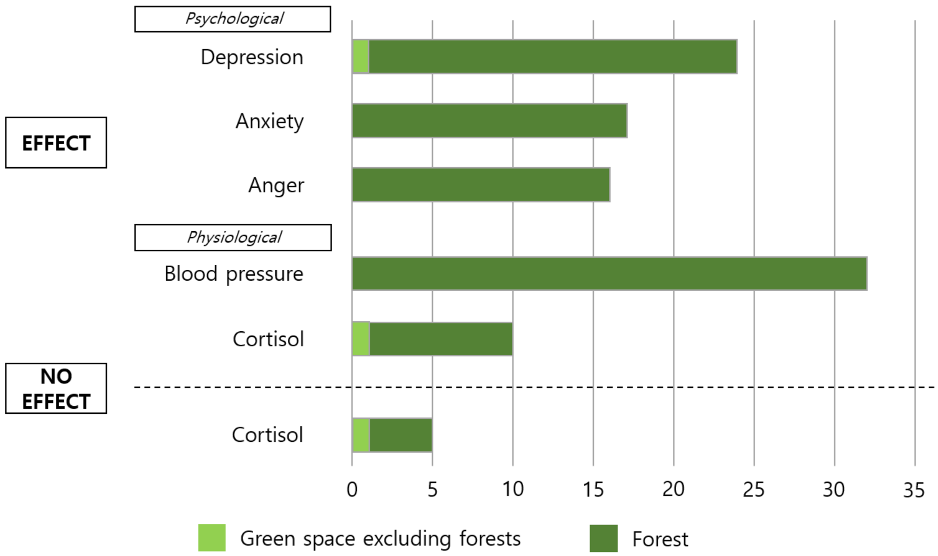


Figure 3.6. Overview of outcomes from psychological and physiological studies of forest healing programs

4. Discussion

Forest healing programs is not only helpful for people who aim to improve their lifestyle, but can also be therapeutic in recovering, rehabilitating, treating, and preventing diseases. These government-run facilities play a supplementary role in improving health by utilizing nature as a means of facilitating therapeutic purposes. Currently, primary outcomes (effects) is verified by assessing the purpose for a specific target group in developing forest healing programs; however, the number of verification studies are limited and biased toward fragmentary effects. In addition, efforts have been made to evaluate the effectiveness of the program by utilizing program satisfaction surveys in the field, but this is insufficient to evaluate health outcomes, or overall facility and operational effectiveness. Therefore, in this study performed a meta-analysis of previous research to evaluate the level of quantitative and qualitative evidence for the programs currently in operation in Korea. As there has not been an established basis for evaluating forest healing programs, I analyzed forest healing programs in detail to identify the most common characteristics and variables which determine forest healing effects through systematic review and meta-analysis.

Currently, 90.67% of those who participate in the forest healing programs form part of planned programs for the general public. It can be said that forest healing programs have broader implications considering all subjects rather than only targeting individuals with a specific disease or conducting professional activities only required by a specific target group. This does however mean that specialization and advancement of forest healing programs are needed [34]. However, this showed that certified forest healing programs are mainly characterized by youth education, and that the forest healing program is significant in educational activities beyond the meaning of "healing" aimed at. Among the various therapies used in forest healing, many programs were used to utilize plants, improve mindfulness, and promote health by physical activity, with programs comprising tactile activities most prominent. In addition, detailed programs were operated using dynamic activities, with walking by far the most common activity. This was the same as the results of the existing study, and the activities conducted in the field or research showed that the verified activities were skewed to one side.

It has been reported previously that a program operated over multiple sessions is more effective than having a single session for one day [36]. However, recurring (continuous) visitations are often difficult and would need to be addressed in future research to improve the benefit of forest healing programs. Forest healing instructors who plan and develop programs have to organize them based on the desired outcomes; however, they still face the difficulties of having insufficient evidence and data to design the best informed program, and even if the subjects receive the best program for their situation, they are usually reluctant (have to be urged) to participate in regular programs.

The documents have shown that most walking and staying activities, such as meditation for >1 h, are most effective psychologically and physiologically; however, there are far more indoor activities that are less effective because of operational convenience (easier). A review of the quantitative distribution of the ground by disease and activity showed that some studies did not actually show the expected physical changes or did not utilize appropriate indicators, timing, and duration to measure the changes. In addition, if forest healing activities currently conducted for the public become certified for certain diseases (such as depression and blood pressure) it will improve the professionalism of these forest healing program in the future.

This study was intended to examine the forest healing program certified in Korea through systematic review and meta-analysis. I determined the current status of certified forest healing programs and divided them into duration and activities to determine the effectiveness of forest healing. Through rigorous analysis, I identified the criteria for effectiveness and potential complications of domestic forest healing programs. To date, the criteria for forest healing programs are diverse and have not been standardized; thereby allowing independent forest healing programs to be established using other certification systems. However, by classifying forest healing programs based on the results from previous studies, our results are able to accomplish the following: establishing an forest healing program certification system according to criteria such as 1) activity, 2) disease-state, 3) duration, 4) location, and 5) environment; classify forest healing programs according to six major methods and which of the five senses are stimulated by activities; and provide insight to improve the quality of existing programs through our critical analysis.

Although various studies are currently being conducted, there are no clear criteria for evaluating the basis due to limitations such as targets, indicators, and periods, which will require continuous efforts to systematically measure health conditions for people using forest healing programs.

5. Conclusions

This study aimed to analyze the current status of forest healing programs operating in Korea and evaluated the evidence for their effects. To upgrade, develop, and operate the programs, it is necessary to establish a well-organized system based on the evidence of existing quantitative and qualitative effects. The largest number of programs were designed for participants without diseases, receiving plant therapy, activities with tactile stimulation, occurring outdoors, for a duration of one-day, and sessions longer than 60 min. According to the analysis of forest healing research cases, the operation of programs that are expected to have insufficient or low grounds for the effectiveness of forest healing depending on the on-site situation was prioritized. In addition, the medical basis for the statistically significant therapeutic effects found for depression, anger, and hypertension are being investigated. It is imperative that factors be identified and reviewed for patients with high probability for therapeutic response from forest healing program enrollment.

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Chapter 4

Psychological Assessments for the Establishment of Evidence-Based Forest Healing Program

1. Introduction

Rapid industrialization and urbanization have led to a decline in the quality and happiness of urban residents, and forest healing programs are drawing attention as a way to recharge their lives and improve their health [1]. At the same time, research on the effects of green space on human health, such as reducing stress and preventing diseases, and preventive medical effects are being actively carried out [2-9]. With growing interest in verifying forest healing effects through experience in green spaces, various studies are also underway to prove the physiological and psychological effects of forest healing. To demonstrate the physiological effects of forest healing, several studies have been conducted that found that forest healing has a positive effect on various diseases [10-15]. According to Twohig-Bennett and Jones' systematic review and meta-analysis (2018), 143 studies have shown that green space and forest healing programs not only reduce blood pressure, cortisol and heart rate, but also have positive effects on various human physiological health [16]. The study demonstrated that forest healing programs also affect neurological diseases, cancer, and reduced respiratory-related mortality rates. In addition, another study demonstrated that forest healing not only improved physical health indicators, but also improved the immune system through NK cell activation, resulting in preventive medical effects even after the program end [17].

In addition to physiological health, several studies are also underway to identify the positive effects of forest healing on psychological health [15,18-26].

According to a systematic review (2017), conducted by Lee and his colleagues among the preceding studies, it was concluded that the forest healing program greatly helped alleviate depression [18]. Furthermore, other studies have found that forest healing programs help relieve anxiety as well as depression [19]. In addition, other studies have demonstrated that forest healing can change mood positively, boosting vitality and reducing negative emotions such as tension anxiety, depression, anger, hostility, fatigue, and confusion [23]. It was also found that forest healing programs reflect on participants' own values, leading to positive psychological changes [26].

As such, forest healing has a positive effect on human physiological and psychological health, but it is not yet known exactly what mechanisms help promote them [27]. However, several prior studies have divided the forest healing effects into olfactory, visual, and social and environmental effects. The olfactory effect of forest healing through green space exposure can be obtained from monoterpene which radiates from forests and trees themselves. Monoterpene is a volatile substance produced in flowers and trees that functions as sterilization and insecticide. α-Pinene accounts for most of the monoterpenes produced in forests, and several prior studies have demonstrated anti-inflammatory, antioxidant and anti-anxiety effects of it [28-30]. In addition, several monoterpenes, including limonene and β-pinene, have been proven to have a positive effect on several diseases, including enhancing immune system, relieving cardiovascular disease, and improving depression [31-37]. The positive physical changes that can be achieved just by looking at forests and trees are representative visual components of the forest healing effect. Experiments conducted by Ulrich (1981) demonstrated positive psychological and physiological changes after viewing natural photographs, when participants were shown natural and urban photographs [38]. This proved that even if people don't visit the forest directly, the indirect experience of looking at the picture of the forest still has effective forest healing outcomes. Finally, the social and environmental effects of forests and green spaces are also components of forest healing effects. Prior studies have shown that the top 20% of the population with a green space rate within a radius of 250m around the home has a 12% lower mortality rate than the bottom 20% and it showed a more pronounced difference in respiratory and cancer-related mortality [39]. In addition, the green space rate near the residence was found to have a positive effect on improving mental health, including depression [27]. As a cause of this positive relationship between green space and health, researchers have noted the social and environmental functions of green spaces. In the case of green spaces around the house, residents' exercise activities and social engagements increase, stress decreases, and air pollution and noise are reduced. These improved surroundings and increased exercise activities naturally have an effect on physical health promotion, and increased social relationships and reduced stress have a positive effect on psychological health [27,40-41]. As mentioned earlier, the mechanisms for the development of forest healing effects have not yet been accurately identified, but based on research on these mechanisms, research on the impact of forest healing on individual human health indicators is also actively underway based on these prior findings.

However, most of the prior studies on the impact of forest healing on individual health indicators are short-term evaluations comparing pre- and post-test results on individual health indicators, but there is a limit that comprehensive evaluations using diverse indicators used for health and clinical investigations are not conducted. In addition, there are physiological and psychological effects analyses of forest healing programs, but not many studies have investigated the continuation and change of forest healing effects though further examination after the program ends. In order to establish a health and medical foundation for forest healing, it is necessary to be repeatable and continuous research, but there is not enough evidence to establish an evaluation system for forest healing based on prior researches. As the number of visitors to healing forests is rapidly growing, and citizens are increasingly curious about the actual effectiveness of the forest healing program, it is urgent to establish a medical basis to prove the effectiveness of forest healing.

This study was conducted to convey a comprehensive evaluation of the physiological and psychological effects of forest healing, based on health and clinical indicators, as a basic and pilot attempt to prepare a basis of forest healing program. It was intended to verify the effectiveness of forest healing and to confirm the sustainability and change of forest healing effects through pre-test, post-test and follow-up test of forest healing programs' participants. In addition, the experiment period and measurements were applied on a trial basis based on consideration of various indicators and measurement factors. Therefore, this study is meaningful in providing basis that can be referenced in future research and design for establishment of an evidence-based forest healing program. The research questions in this study are as follows. Is there a correlation between green space exposure level and health conditions? What are the indicators of distinct changes in the field? What indicators are robust to interpersonal deviations and which are likely to be vulnerable? What are the appropriate indicators for the short-term evaluation and which indicators require long-term observation?

2. Materials and Methods

2.1 Research Design

To investigate the physiological and psychological effects of the forest healing program, 92 participants joined the forest therapy program for two nights and three days. Two weeks before participating the forest therapy program, a clinical assessment and self-report survey were conducted on participants, and the same experiment was conducted on participants shortly after the program ended. After the forest healing program, participants were divided into three groups to confirm changes after returning to their daily lives after one, two and four weeks, respectively, and clinical assessment and self-report survey were conducted. The research design schematic diagram is shown in Figure 1.

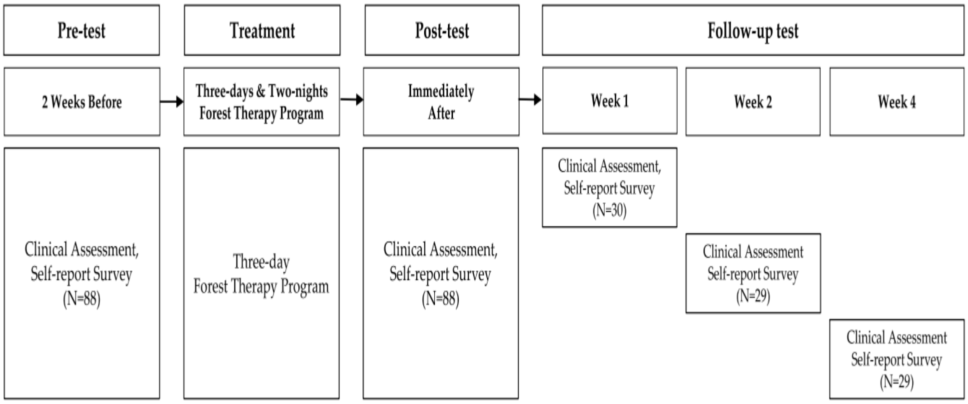

Figure 4.1. Schematic diagram of research design

2.2 Participants

The study was conducted on 92 adolescents between the ages of 13 and 18 in July and August 2017 supported by the Jung Mong-gu Foundation hosted by the Korea Forest Welfare Promotion Agency. Participants were from three different cities including Deajeon (33 students), Gimcheon (29 students) and Incheon (29 students). However, the final participants were 88 (30 participants from Daejeon, 29 participants from Gimcheon and Incheon, respectively) since two were absent and one was injured during the research period. Participants and their guardians from each institution were asked for consent by explaining the purpose and objectives of the research. Focus interviews and individual interviews for qualitative research were announced in advance. The demographic characteristics of the participants are shown in Table 1.

The NDVI (normalized difference vegetation index) of Gimcheon, Daejeon and Incheon, where participants came from, were examined, and the results were shown in Table 2. Gimcheon, where group 1 came from, was found to have the largest distribution of green areas in both living and walking distance areas, and the green area rate of Daejeon's living area was significantly lower than in other areas. The green area rate of walking distance area was the lowest in Incheon.

Table 4.1. Demographic characteristics of participants

Indicators		Total	Male	Female
		Mean±SD/n(%)	Mean±SD/n(%)	Mean±SD/n(%)
Gender		88(100)	49 (55.7)	39 (44.3)
Age	Under 15	46(52.3)	27 (55.1)	19 (48.7)
	More than 16	42(47.7)	22 (44.9)	20 (51.3)
Region	Gimcheon	30(34.0)	18 (36.7)	12 (30.8)
	Daejeon	29(33.0)	18 (36.7)	11 (28.2)
	Incheon	29(33.0)	13 (26.6)	16 (41.0)
Forest Therapy	None	60(68.2)	35 (71.4)	25 (64.1)

Experience	Once	26(29.5)	12 (24.5)	14 (35.9)
	Twice	2(2.3)	2 (4.1)	0 (0.0)
Health Examination	Height(cm)	165.14 ± 7.64	169.10 ± 5.99	160.08 ±6.49
	Weight(kg)	58.54 ± 10.44	59.95 ± 9.38	56.76 ± 11.52
	BMI	21.44 ± 3.45	20.91 ± 2.76	22.12 ± 4.12
	Total Body Water	33.31 ± 6.07	36.73 ± 4.57	28.94 ± 4.82
	Protein	8.90 ± 1.81	9.90 ± 1.28	7.63 ± 1.57
	Mineral	3.20 ± 0.54	3.45 ± 0.45	2.87 ± 0.47
	Body Fat Mass	13.08 ± 7.28	9.86 ± 5.47	17.19 ± 7.29
	Soft Lean Mass	42.68 ± 8.07	47.23 ± 5.91	36.89 ± 6.64
	Fat Free Mass	45.35 ± 8.47	50.08 ± 6.28	39.32 ± 6.94

Table 4.2. NDVI Analysis of participants' living areas

Region	Classification	Mean	SD	Median
Gimcheon	Living Area (500m)	0.2646	0.1043	0.2577
	Walking Distance Area (1000m)	0.2736	0.1102	0.2724
Daejeon	Living Area (500m)	0.0560	0.0670	0.2699
	Walking Distance Area (1000m)	0.2436	0.0771	0.2435
Incheon	Living Area (500m)	0.2330	0.1124	0.2478
	Walking Distance Area (1000m)	0.2077	0.1137	0.1645

2.3 Sites

The study was conducted at 'Heongseong SoopChewon' located in Gangwon, Korea. It is the national forest park which is a public institution providing forest welfare services located at 840m above sea level of Cheong-Tae Mountain. The Heongseong SoopChewon provides forest welfare services that enhance the human body's immunity and restore physical and mental health by utilizing various environmental factors and natural objects in the forest. In addition, the Heongseong SoopChewon was designated as the first forest education center in Korea in September 2007, and it actively provides forest education and healing programs to youth and other participants.

The percentage of forest area within walking distance was 92.24% and the crown density was 79.20%. The average value of NDVI (normalized difference vegetation index) was 0.392. The adjacent forest included 8 types of vegetation communities such as *Larix kaempferi, Quercus aliena, Pinus densiflora, Abies holophylla, Betula platyphylla, Pinus Koraiensis* community, and deciduous broad-leaved community or mixed community. The widest site was *Larix kaempferi* community (69.37%).

(**a**) (**b**)

Figure 4.2. Maps of the experiment site (a) Site location. point A is 'Heongseong SoopChewon', and points 1, 2 and 3 are three different cities where participants came from; (b) Aerial photographs of site

(**a**) (**b**)

Figure 4.3. Forest healing program photographs (**a**) Photograph of 'Heongseong SoopChewon'; (**b**) Photograph of forest healing program activity

Table 4.3. Site forest vegetation

% of Forest Area	91.24%
Crown Density	79.20%
NDVI	0.392
Vegetation Community	
Larix kaempferi community	69.37
Quercus aliena community	16.29
Deciduous broad-leaved community	3.23
Pinus densiflora community	3.05
Abies holophylla community	1.74
Betula platyphylla community	1.73
Pinus koraiensis community	1.63
Quercus-Pinus mixed community	1.46

* Nature environment around the study site was analyzed by GIS method. The data was extracted from remote sensing such as Landsat 8, forest cover map, land cover map. The analysis covers 500m buffered from the Heongseong SoopChewon.

2.4 Treatment

The three-day and two-night program was held in the forest. The program utilized various forest resources within the Heongseong SoopChewon such as free walking in the forest, recreation in the woods, and woodworking experience(Table 3). The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Wonkwang University Institutional Review Board (protocol code WKIRB-201705-BM-027 and date of approval May 29th, 2017).

Table 4.4. Forest healing program time schedule for the study

Day	Time	Program
Day 1	11:00 – 13:00	Pre-effectiveness measurement
	14:00 – 15:00	Orientation and safety education
	16:00 – 17:30	'Happy Dream' Forest Healing
	19:00 – 20:30	Making Healing Palace
	20:30 -	In the moonlight
Day 2	9:30 – 12:00	Healing Mission Trekking A program that enhances cooperation by finding a destination and solving a mission
	14:00 – 15:30 15:30 – 16:00	Making a wooden clock
	16:00 – 17:00	Lecture for supporting independence
	19:00 – 20:30	Forest musical
	20:30	In the moonlight
Day 3	9:30 – 11:30	Lecture at the 'Pinwheel Supporters' Post-effectiveness measurement

2.5 Measurement Methods

The measurement factors are divided into three main categories: self-report survey, clinical assessment and qualitative assessment. As it is shown in the Table 4, The self-report survey included an effectiveness evaluation indicating resilience, interpersonal competency, self-esteem, stress response and vigor. Clinical assessment included physical examination, complete blood count, biochemical examination, immunoserological examination, saliva test and urine test. Main indicators out of 87 total indicators of methods can be found in the Table 4. Lastly, qualitative assessment included youth interviews, including focus group interviews and personal interviews, as well as teacher interviews with forest education experts and program guidance teachers.

Table 4.5. Measurement factors

	Methods	Indicators
Physiological Indicator	Physical Examination	Systolic BP; Diastolic BP
		eNO
		LnTP; LnLF; LnHF; LnLF/HF; RMSDD; pNN50
	Complete Blood Count	RBC
		Platelet
		Total WBC; Lymphocytes; Monocytes; Eosinophils; Basophils
	Biochemical Examination	Cortisol; Serotonin
		d-ROMs
		BAP(Biological Anti-oxidant Potential)
		25-(OH) Vitamin D; 1,25-(OH)3 Vitamin D
		SGOT(AST); SGPT(ALT)
		Total protein; Albumin; Bilirubin; BUN (Blood Urea Nitrogen); Creatinine; Glucose
	Immuno-serological Examination	IL-4 HS Multiplex; IL-8 Multiplex
		TNF-α HS Multiplex
		IFN-γ HS Multiplex
		CD16+CD56 (count); CD16+CD56 (WB)
		IgA
	Saliva test	Secretory IgA (Saliva)
		Cortisol (Saliva)
	Urine test	8-OHdG
Psychological Indicator	Self-report Survey	Resilience
		Interpersonal competency
		Self-esteem
		Stress response
		Vigor

2.6 Analysis Methods

The relationship between pre-test, post-test and after-test was identified for a total of 88 participants. 88 participants included 49 male participants and 39 female participants, and they were tested three times throughout the program. Total of 87 variables including 82 physiological indicators and 5 psychological indicators were examined using R 4.0.3 version and R Studio for descriptive statistics and one-way repeated measures ANOVA. All values were rounded to the fifth decimal place, and the normality was satisfied by the central limit theorem. Bartlett's Test of Sphericity Tests were performed before the one-way repeated measures ANOVA for shpericity tests. Subsequently, the Tukey's Test for Post-Hoc Analysis was conducted on 46 indicators with $p < 0.05$ significance level from the result of one-way repeated measures ANOVA.

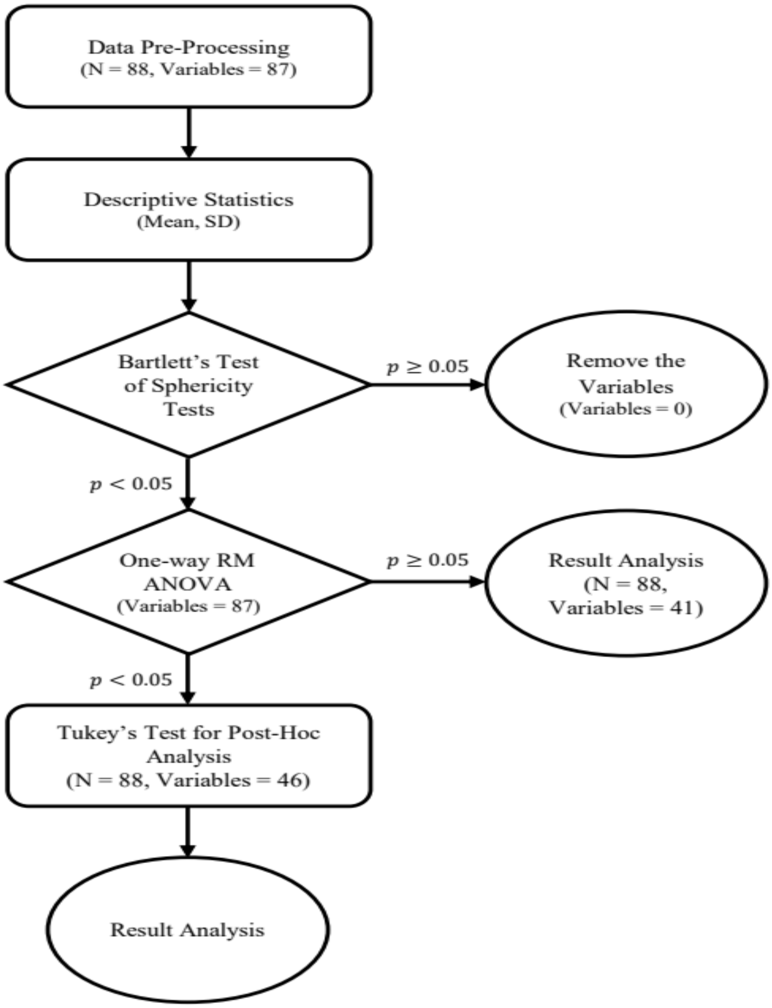

Figure 4.4. Data analysis process diagram

3. Results

When 88 participants and 87 health-related indicators were analyzed, a total of 46 indicators showed significant differnces in one-way repeated measures ANOVA and 28 indicators showed significant differences in Tukey's test for post-hoc analysis. The result tables of one-way repeated measures ANOVA and post-hoc tests can be found in Appendix A, B, C and D. The one-way repeated measures ANOVA results of every indicators can be found in Supplementary Document 1.

3.1 Blood Pressure and Autonomic Nervous System

Cardiovascular-related indicators show significant reductions in systolic and diastolic blood pressure and cholesterol levels in post-test, consistent with prior studies showing significant reductions in blood pressure after forest healing programs [17,20,42-43]. The diastolic blood pressure decreased significantly in follow-up test, but the systolic blood pressure and cholesterol tended to increase in follow-up tests. This is in the same context as the effect of forest healing has been reduced within three to five days in prior studies conducted more than a week after the end of the forest healing program [20,42-43].

Analysis of HRV indicators influencing stress responses showed that LnTP and RMSSD decreased significantly over pre, post and follow-up tests, and LnLF also tended to decrease over pre, post and follow-up tests, although not significant. LnHF decreased significantly in post-test compared to pre-test and increased in follow-up tests. LnLF/LnHF significantly increased than pre-test during post-test, but decreased during follow-up test. As such, the increased LnHF and the decreased LnLF/LnHF levels since the forest healing program are consistent with the results of prior studies, and considering that the effect was expressed in follow-up tests, not in post-test, it is expected to take some time for the effect to appear

[10,52]. Although no significant results were produced for pNN50, a significant decrease in post-test compared to the pre-test in male participants. The results of the analysis of HRV indicators were generally insignificant or negative, the results are all within the normal range and further studies need to be conducted.

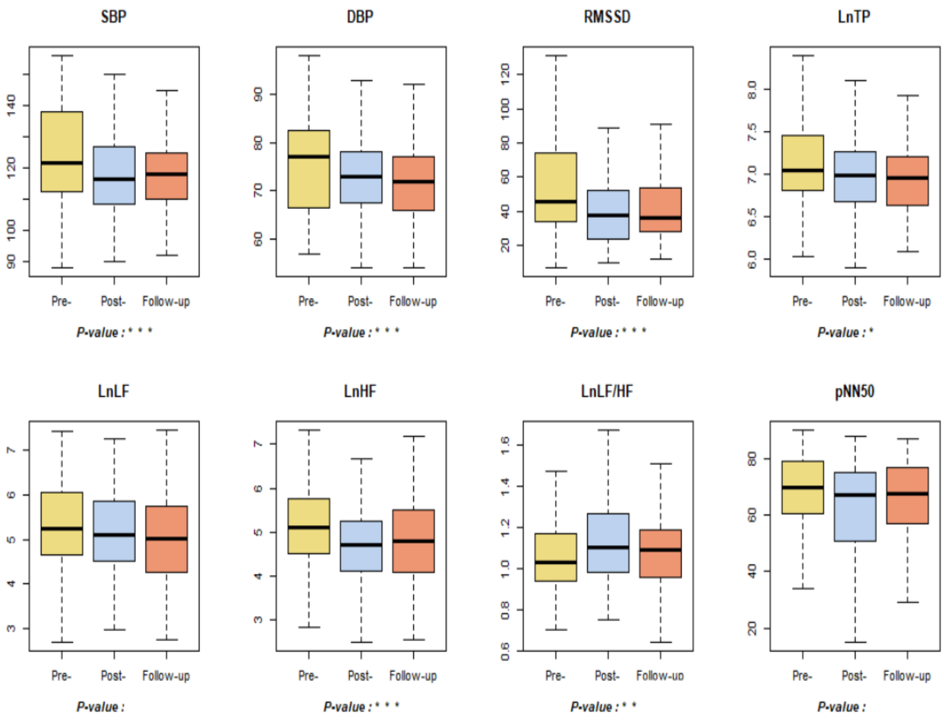

Figure 4.5. Analysis result of blood pressure and autonomic nervous system related Indicators

[1] * p < 0.05, ** p < 0.01, *** p < 0.001

[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

Blood pressure and HRV levels are known to affect each other, and diastolic blood pressure is more closely related to the autonomic nervous system than systolic blood pressure [45]. Previous studies have shown that diastolic blood pressure is inversely correlated with RMSSD, LF, HF and TP, and positively correlated with LF/HF. This is consistent with the results of this study, and although the diastolic blood pressure-related correlation analysis in this study did not show significant results for all of the above HRV indicators, it is confirmed that they tend to be the same as prior literatures [45-46]. However, in systolic blood pressure, there are some results that differ from the preceding literature, so follow-up research is needed. In addition, there has been a strong positive linear correlation between HRV-related indicators except for LnLF/HF, and a significant positive correlation between systolic and diastolic blood pressure. A slightly stronger linear relationship was shown in the after-treatment results than in everyday conditions, which include pre-treatment and follow-up experiment results.

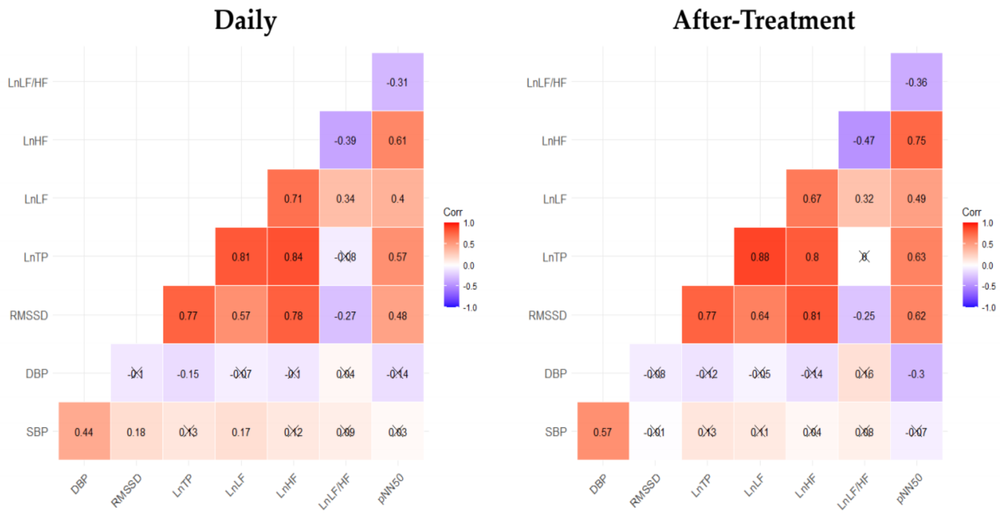

Figure 4.6. Pearson correlation results of blood pressure and autonomic nervous system related indicators

[1] The cell marked with X indicates that the correlation coefficient is not significant. ($p > 0.05$)

[2] Daily analysis includes pre-treatment and follow-up test results, and after-treatment analysis includes post-treatment results.

3.2 Immune Function and Inflammation

When looking at immune-related indicators, both CD16+CD56 (count) and CD16+CD56 (WB), which affect the activity of NK cells, decreased in post-test compared to pre-test, but increased significantly in follow-up test. This result is consistent with prior studies that show that forest healing effectively increases NK cell activity and population [17,28,47]. In cytokine analysis, IFN- γ significantly increased over pre-, post- and follow-up tests, and IFN- γ is known to enhance immunity by activating NK cells and macrophages. As previous studies have not identified significant changes in IFN- γ through forest healing programs, the results have shown that forest healing programs have a positive impact on anti-cancer and immune systems through an increase of IFN- γ [48]. IL-4 did not make a significant difference, and IL-8 increased abnormally after forest healing programs in group 1 and group 2. This is because IL-8 is closely related to the allergic inflammatory reaction, and when an allergic inflammatory reaction occurs, IL-8 levels increase [49-51]. Group 1 and group 2 showed significantly higher sensitization of allergic antigens compared to group 3, and IL-8 levels showed a higher allergic sensitization rate in group with a post-treatment increase than in the group with a post-treatment decrease compared to the pre-treatment (Appendix E). Group 1, in particular, showed a very high number of participants with plants-related allergic antigens compared to other groups [52-53]. In the case of TNF-α, significant reductions were made across pre=, post- and follow-up phases. Because TNF-α causes a strong inflammatory response, these reduced results have shown that forest healing programs help suppress inflammatory responses [54].

The indicators associated with inflammation, eNO showed no significant difference, and as a result of WBC (white blood cell) analysis, the total amount of WBC and Basophils decreased in post-test compared to pre-testing, but significantly increased in follow-up tests. Lymphocytes and Monocytes tended to decrease over pre-, post-, and follow-up test results, as opposed to a prior study which observed significant increases in lymphocytes and monocytes [49-50]. The reason for this difference is that the proportion and total number of WBC elements, including lymphocytes, vary depending on age group, and this study was conducted on adolescents while the prior study was conducted on participants in their mid-40s.

The human's immune function is achieved through the balance of two types of helper T cells, Th1 (Type 1) and Th2 (Type 2). Th1 is a regulator of cell-mediated immunity, which increases inflammation in infected cells, improves macrophage function in response to viral and bacterial infections, and it plays a role in innate immunity or attack and elimination of infectious substances. [57-62]. Th2 is a modulator of humoral immunity, which improves the function of eosinophils, basophils, and mast cells to counteract parasitic infections and immune to antigen antibody responses [57,61-62]. Among the indicators observed in this study, those corresponding to Th1 and Th2 can be found in Figure 7 below. If Th1 increases, autoimmune disease is known to increase, and if Th2 is enhanced, it can be thought that allergic disease is mainly present. [57-62]. Most of the indicators of Th1 and Th2 tracked in this study show that the figure has decreased since the forest healing program, which can be interpreted as a reduction in autoimmune and allergic related diseases.

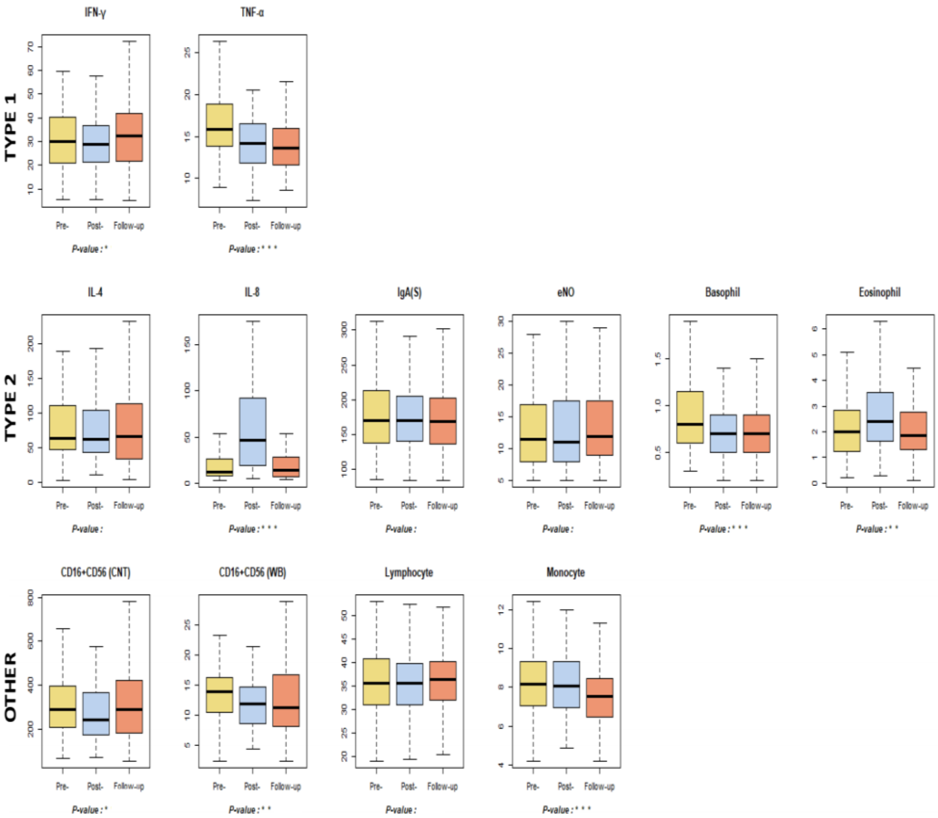

Figure 4.7. Analysis result of immune function and inflammation related Indicators

[1] * p < 0.05, ** p < 0.01, *** p < 0.001
[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

3.3 Oxidative Stress and Antioxidant

The analysis results of 8-OHdG and d-ROMs, indicators related to Oxidative Stress, showed minimal difference. Although there is a lack of prior research conducted on these indicators, based on the results of this study, it can derive the analysis that the forest healing program has a minimal impact on 8-OHdG and d-ROMs. BAP, an indicator related to antioxidant, increased significantly in post-test compared to pre-testing, and decreased in follow-up tests. This is consistent with the results of previous studies, where antioxidant levels increased significantly immediately after the forest healing program [57]. However, since the prior study did not conduct a further investigation into antioxidant functions, this study shows that antioxidant levels decrease again after a certain period of time from the forest healing program.

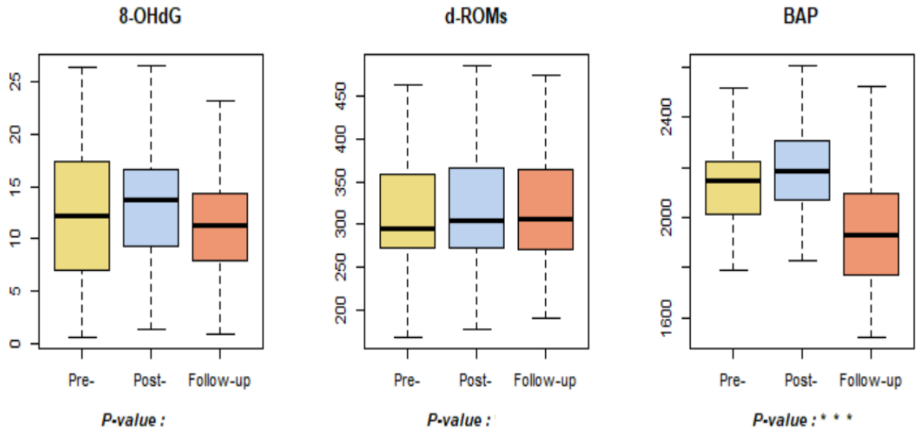

Figure 4.8. Analysis result of oxidative stress and antioxidant related indicators

[1] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

3.4 Stress (Hormone)

Neither Cortisol (CIA) nor Cortisol (Saliva) related to stress hormones showed significant changes, which is the opposite of a prior study found that forest healing experiences had a positive effect on stress control by reducing cortisol levels [7]. However, since the study was conducted on middle-aged women, it is expected that the effects were not apparent in this study of adolescents. Serotonin has increased significantly over the course of pre-, post- and follow-up tests, which are the same as previous studies with significant increases in serotonin levels since the forest healing program [14].

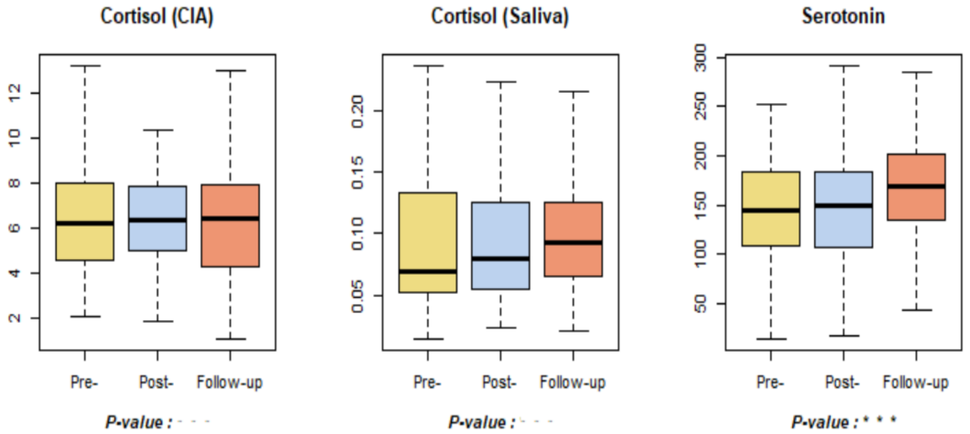

Figure 4.9. Analysis result of stress (hormone) related indicators

[1] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

3.5 Health Screening Parameters

As a result of looking at the indicators for health screening indicators, 25-(OH) Vitamin D increased significantly over pre-, post- and follow-up tests, while 1,25-(OH) 3 Vitamin D decreased significantly during post-test compared to pre-test and increased again during follow-up tests. Glucose, an indicator of obesity, was significantly reduced during post-test than during pre-testing, and increased during follow-up tests. A systematic review of the effects of forest healing observed a decrease in glucose levels immediately after forest healing, but this was limited to the inability to demonstrate a continuous trend in blood sugar levels [58-59]. Thus, the results of glucose obtained in this study demonstrate that blood sugar levels do not have a continuous trend of decline and tend to increase after forest healing. The BUN and creatine associated with renal function significantly decreased in post-test compared to pre-testing, and increased in follow-up examinations. This is in the same vein as a prior study which improved kidney function through forest healing programs but did not last long [7]. Among the indicators associated with liver function, bilirubin showed no significant results, and albumin and SGOT (AST) increased significantly in post-test, but decreased significantly in follow-up tests. SGPT (ALT) and platelets increased significantly throughout the pre-, post- and follow-up periods. As such, liver function figures are difficult to analyze due to a mixture of positive and negative results, but all indicators have changed within normal limits.

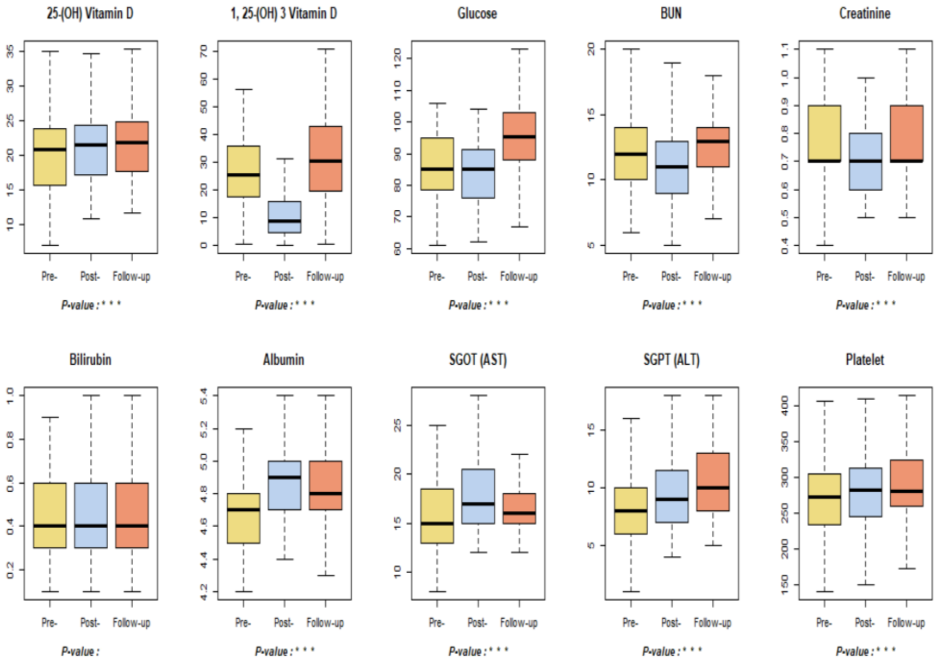

Figure 4.10. Analysis result of health screening related indicators

[1] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

3.6 Mental Health

Psychological indicators showed significant results in resilience, self-esteem, and vigor. Resilience increased significantly in post-test than in pre-test, and decreased in follow-up test. Self-esteem increased through pre-, post- and follow-up tests. On the other hand, vigor was reduced throughout the pre-, post- and follow-up phases, and further studies of degradation of vigor level are needed as a systematic review suggests that forest healing has a positive effect on vigor [60].

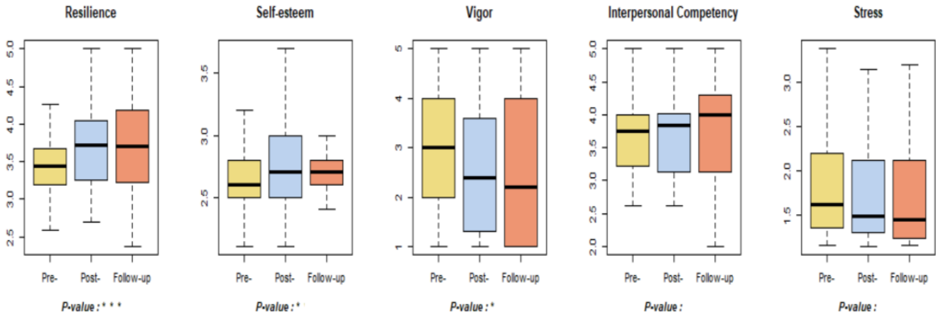

Figure 4.11. Analysis result of mental health related indicators

[1] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[2] Pre-: daily health conditions two weeks prior to the forest healing program, Post-: health conditions immediately after the forest healing program, Follow-up: daily health conditions one, two and four weeks after the forest healing program.

4. Discussion

Based on the analysis results of 3 days and two nights forest healing program, there were several indicators which showed positive changes. 87 indicators showed significant changes, including systolic blood pressure, diastolic blood pressure, cholesterol, serotonin, vitamin D, CD+16CD56 count, IFN-£, resilience, self-esteem, etc. IL-8 has been shown to be susceptible to interpersonal deviations, and cholesterol and BAP are considered appropriate for short-term effect observations.

In addition, long-term observations are required for indicators with has been proven to last in post-test such as blood pressure, TNF-α, IFN-£ and serotonin, and indicators such as CD16+CD56 (count, WB), IL-4, vitamin D and interpersonal competency where the effect was later expressed in follow-up tests.

When the results derived from this study are divided by health effects, the first health promotion effect that can be expected through forest healing programs is immunity enhancement (Figure 5). Among the many factors in forest healing, phytoncide is known to have excellent anti-bacterial and anti-inflammatory effects, which activate TLR (Toll Like Receptor) in the body, reducing inflammatory cytokines such as IL-6 and TNF-α and reducing oxidative stress. [56]. It has since been shown to inhibit NF-kB (Nuclear Factor kappa-enhancer of activated B cells), which are essential for viral protein production, and to inhibit the activation of MAPKs (Mitogen Activated Protein Kinases). As such, prior studies have demonstrated the mechanism of phytoncide's anti-inflammatory effects in the body [56]. This study also revealed anti-inflammatory effects of forest healing that both IL-8 and TNF-α, which are associated with inflammatory in vivo, have significantly decreased after the forest healing program. Meanwhile, phytoncide has significant effects on activating NK (Natural Killer) cells in the body and increasing the number of NK cells. NK cells play an important role in eliminating cancer cells, and NK cell activation and the increase in the number facilitate anticancer activity [57]. In particular, as NK activity significantly increases in cells exposed to phytoncide for more than 144 hours, it is important to reflect the long-term exposure to phytoncide during the establishment and planning of future forest healing programs [57]. Looking at the mechanism of chemotherapy through phytoncide, phytoncide promotes NK cell activation and an increase in the number of NK cells, which increases granzymes, perforin, and granulysin, which cause necrosis of target cells. It then increases Cytochrome-C and Apoptosis Inducing Factor (AIF), which carry out apoptosis of cancer cells, resulting in anticancer activity in the body [57]. Therefore, significant changes in CD16+CD56 (count), CD16+CD56 (WB), and IFN-γ through forest healing programs revealed in this study demonstrate that forest healing programs have a positive effect on the activity of NK cells, effective in anticancer and immunity enhancement.

The second health-promoting expected effect of forest healing programs demonstrated in this study is related to stress recovery (Figure 5). The theories related to natural preferences explain that humans have an instinct to prefer nature, based on biophilia and savannah hypothesis. [58] Furthermore, attention restoration theory interprets that humans who are constantly exposed to artificial environments instinctively visit nature [58, 59]. In addition, psycho-evolutionary theory suggests that the natural environment leads to positive psychological changes and reduces stress. [58]. Meanwhile, forest healing also has excellent preventive medical effects by relieving physical fatigue and promoting immune function recovery through a recovery environment of nature that stimulates the five senses of people [60]. Several prior studies argued for the stress reduction effect of forest healing, and recently, attempts have been made to scientifically explain the effects and mechanisms of stress reduction by nature based on neuroimaging through fMRI (functional magnetic resonance imaging). Sensory stimulation through looking at natural scenery or listening to natural sounds affects the autonomic nervous system, reducing stress [61, 62]. Sensory stimulation through nature promotes outward-directed focus of attention and rest-digest nervous system activity, and activates posterior cingulate, a part of the brain that responds to emotions. These changes in brain reduce the stress-related hormones such as cortisol and adrenaline, and increase serotonin. These hormonal changes cause physical stress relief, including muscle tension and reduced blood pressure and pulse rates. This study also found some evidence to support the above claims. Significant positive changes were observed in cardiovascular-related indicators, with no significant changes in cortisol, but significant increases in serotonin, which helps relieve stress. In addition, the survey found that participants' stress continued to decrease after the forest healing program.

This study conducted experiments on adolescents living homogeneous lives, making it difficult to generalize the effects of health promotion. In addition, it may have been difficult to produce accurate analysis due to the effects of the growth period, and it remains a limitation due to the lack of investigation and control over other factors that could affect, such as smoking and eating habits. Therefore, future studies need to investigate life patterns, drinking and smoking habits of participants in that negatively affect results in advance. It is also believed that the fear triggered by the collection of clinical tests may have affected the stress outcome values of participants. While it is most desirable to measure changes of health condition across the entire participant five times including pre-, post- and follow up (1 week, two weeks, and four weeks later) tests, this study was designed by changing the measurement process from 5 times to 3 times in total considering that the subjects were adolescents, and it may be difficult to track down all subjects and conduct 5 times of examinations. The group of participants was divided into three for the purpose of more efficient clinical trials. After testing the homogeneity of the subjects, the results of all the subjects were presented in pre-, post- and follow up tests, and the follow up test results were presented in subdivision of one, two and four weeks later. Sampling was attempted at the same time, but participants were required to participate voluntarily, making it difficult to control the exact the exact sampling time. It is thought that significant results were difficult to observe in cortisol and others with circadian rhythm, as difficulty in controlling the timing of sample collection and fear of testing can affect biological results. In the case of saliva measurement, it is necessary to examine more carefully in the field because there were too many missing values to analyze. On-site sampling of saliva is relatively easy and convenient, but researchers should be careful that analysis may be difficult, and if the right measurement can be obtained at the site in the future, it will be a beneficial to analyze forest healing effects. Furthermore, this study is of great significance as it has been observed before, after and follow up periods from the forest healing program, rather than short-term analysis through pre- and post-comparisons such as existing studies. However, in this study, a preliminary examination was conducted two weeks before the program, which may not have accurately measured indicators whose results change rapidly in a short period of time, such as cortisol. Therefore, subsequent studies expect that pre- and post-measurements can be performed within one day of the program to increase accuracy. In addition, this forest healing program includes an indoor program, so during the two-night and three-day program, the threshold remains that the actual time spent in the forest was less than 10 hours. However, based on the preceding literature that proved that the short forest walking program between 15 and 40 minutes had physical and psychological health promotion effects, the healing effect of the forest healing program conducted in this study is expected to have been sufficient, and in the future design of forest healing program, increasing the proportion of forest activities is expected to have a more pronounced effect [16].

As the program has been run for normal people, not patients, most of the results have changed within the normal range, making it difficult to observe the dramatic health promotion effect through forest healing. However, after forest healing programs, the number of outliers (outcomes outside the normal range) was significantly reduced, and significant health promotion effects were observed in several indicators including blood pressure. Although the study found that forest healing had a positive impact on various health-related indicators, including the autonomic nervous system, it was also found that the nature of forest healing led to various allergic reactions from participants. Higher levels of inflammation were observed in several participants due to allergic sensitization reactions, suggesting that forest healing programs may have a negative effect on those with allergies. Analysis of IL-8, an allergen-related indicator, showed an allergic sensitization rate of 54.93% in the group that showed increased levels of IL-8 after the forest healing program, much higher than 41.18% of allergic sensitization rate of the group which showed decreased levels of IL-8 after the forest healing program. For both groups with increased and decreased values, the t-test showed that the significance levels of both groups were below 0.001, indicating significant changes. However, no clear evidence has been found that forest healing programs cause allergic reactions and increase inflammation levels, and it is necessary to proceed with the program in consideration of this in the future. In the case of this study, group 3 seems to have been provided with a suitable forest healing program, and it is expected that a process of selecting the appropriate place, time and type of forest healing program will be needed for each participant when conducting a forest healing program.

Based on these limitations, future studies expect to attempt to build forest healing big data infrastructure and systems through sampling through non-invasive methods, investigating other influential factors affecting test results, and linking sensing and wearable technologies. This study is significant for a relatively large number of participants compared to small studies conducted previously, and is significant in that it conducted an attempt and pilot study to quantify forest healing effects using various physiological indicators such as urine and blood as well as psychological emotions. Therefore, for the establishment of an evidence-based forest healing program, indicators whose effects have been proven to continue after the participation in the forest healing program or whose effects have been relatively delayed, time-series changes could be measured with varying frequency and duration of forest healing program, and the persistency and continuity and the frequency and cycle of forest healing effects could be proposed.

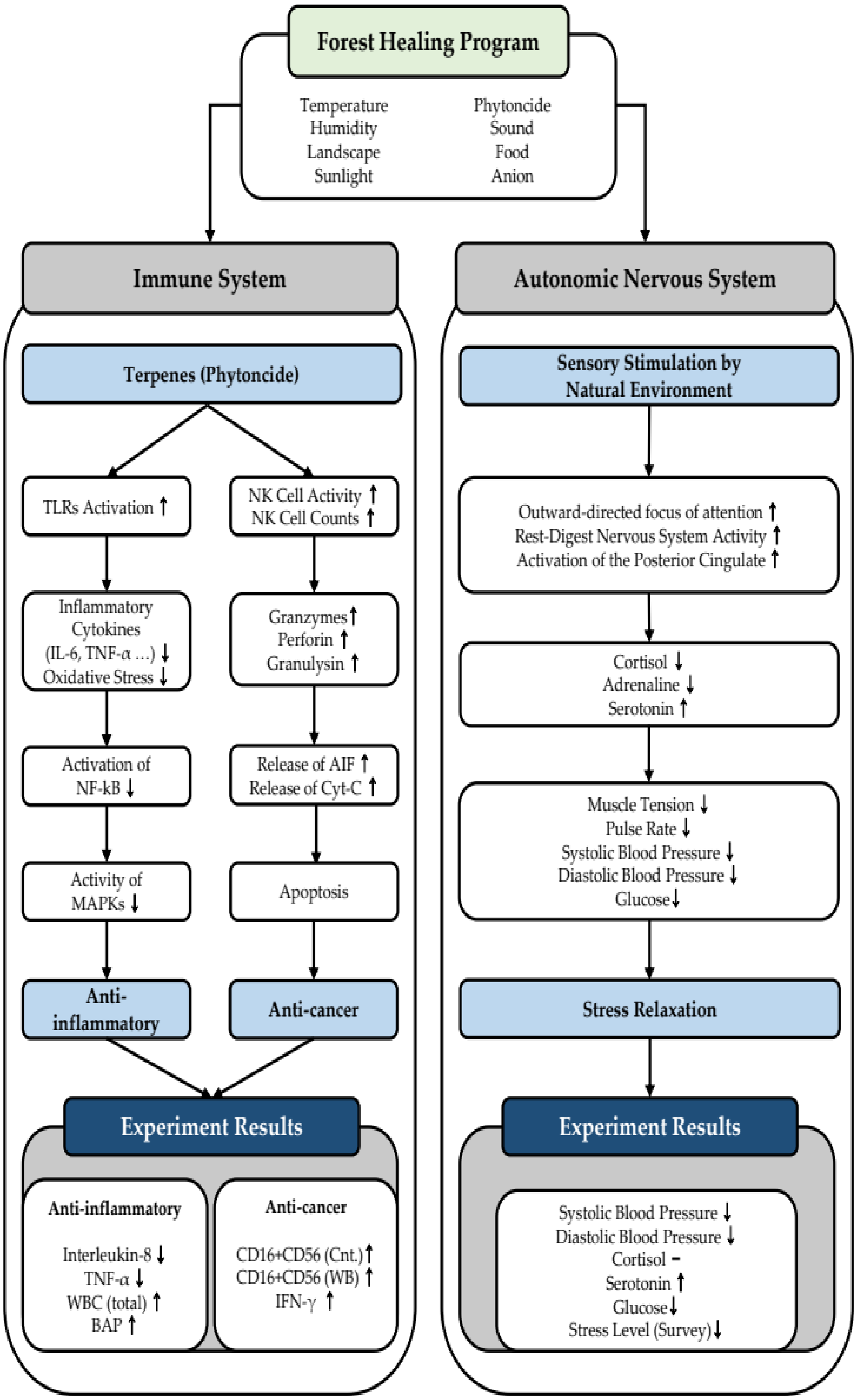

Figure 4.12. Mechanism of forest Healing Programs

5. Conclusions

The study proved that the three-day and two-night forest healing program generally has a positive effect on human physiological and psychological health. Of the 87 health-related indicators, 46 indicators showed a significant impact on various health conditions such as cardiovascular, immune function and mental health. In this study, the effectiveness of forest healing was assessed from various angles by applying such non-universal clinical indicators to forest healing programs. Furthermore, beyond comparison before and after the forest healing program, the trend was observed one week after, two weeks after, and four weeks after the program. Therefore, this study is aimed to provide a basis of selecting proper indicators when preparing a long-term follow-up survey system in the future, and is significant as a framework for evaluating forest healing effects and promoting related policies.

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Chapter 5. Summary and Overall Discussion

5.1 Summary and Conclusions

This study explored health influence in order to establish the supporting evidence for the green space-based programs that aim for public health promotion. I observed the effects by reviewing documentations about the effectiveness of forest-based interventions. I also evaluation the current status of the programs being performed in Korea and quality of their evidence. Through forest-based intervention programs, I established the basic system and verified (experimentally) the effects by using various health indicator.

Main contributions in this study can be summarized as follows. First, this is the first study that focused on the effects from each different activity performed in forests. It also evaluated overall how forest-based intervention affects health through documentation review. This study classified variable activities that are based on forest like walking, and exercise and observe psychological and physiological effects from each exposure. For example, walking in forests showed consistent beneficial health effects, and so did the other activities. Second, I analyzed in detail the various forest-based activities in Korea by dividing them into certain categories: targets, seasons, main contents, and performing locations. I also suggested the basic evaluation system for future program development and management by verifying the quality of the supporting evidence and re-organizing the potentially effective activities. Third, based on systematic reviews, I analyzed the aspect of how the experience from forest programs changed over certain period of time in order to verify that green space actually affects health by using various health-influence indicators. The short exposure time and activity alone had health effects such as immunity and cardiovascular system, and showed significant changes.

5.2 Recommendations for future studies

Currently, various studies are underway on human health due to exposure to natural environments and green spaces. Nonetheless, salient research gaps still exist and no exact mechanisms have been identified. In order to provide evidence-based programs that contribute to health promotion, it is important to confirm the safety and effectiveness in the aspects of medical science. It is necessary to establish such evidence and continue to verify the effects by accumulating data and study results from the case studies that are currently being performed.

국문초록

한국의 녹지이용 건강증진 프로그램 근거기반 구축 연구

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고령사회로의 진입과, 현대화, 건강에 관한 관심증가에 따라 자연과 산림을 활용하여 건강을 회복하고, 삶의 질을 향상시키려는 시도가 증가하고 있다. 자연환경은 심리적, 사회적, 교육적, 생리적인 측면에서 다양한 혜택을 준다. 숲, 공원, 나무, 정원과 같은 녹지공간은 사람들의 건강과 웰빙에 다양한 경로로 직, 간접적인 영향을 준다고 알려져 있다. 녹지 노출이 건강에 영향을 미칠 수 잇는 주요한 메커니즘으로 녹지가 신체활동의 기회를 제공하는 것, 사회적 활동을 촉진시키고 발전시키는 것, 녹지 노출 자체가 건강에 도움된다는 세가지가 제시되고 있다. 건강과 녹지 간의 연관성에 대해 지속적으로 연구되고 있으며 다양한 관점에서 근거가 축적되고 있다.

본 연구는 공익기능을 넘어 질병의 예방, 건강증진의 활동으로 확장되고 있는 녹지가 심리, 생리적으로 인체에 미치는 영향에 대한 과학적인 근거 마련을 위하여 수행되었다. 녹지노출에 따른 건강 수준의 연구 현황을 분석하고 체계적인 문헌고찰을 통해 녹지기반 프로그램 참여에 따른 심리, 생리학적 효과를 검토하였다. 국내에서 운영되고

있는 녹지 이용 프로그램의 현황을 조사하고, 프로그램의 구성현황과 보건학적인 근거 수준을 평가하였다. 또한 실제로 다양한 녹지 노출 중재를 수행하고 이에 따른 건강지표의 변화 수준을 확인하였다.

기존에 수행된 연구를 바탕으로 33개의 문헌을 분석한 결과, 산림 기반 중재에서 수행되는 활동을 머물러 있기, 걷기, 운동, 간접노출로 유형화하였다. 실제 녹지에서 행해지는 걷기는 심리적, 생리적으로 전반적인 영역에서 일관되게 건강증진 효과를 보였다. 녹지를 기반한 활동은 우울 및 불안, 인지기능, 스트레스 호르몬, 염증완화 등에서 녹지에서의 프로그램이 효과를 보이는 것으로 나타났으나 활동 유형에 따른 건강영향의 차이를 평가할 수 있는 근거는 부족하였다.

국내에서 개발, 운영되고 있는 대표적인 산림치유 프로그램 75개를 분석한 결과, 90%이상의 프로그램이 건강증진을 목적으로 하는 정상인을 대상으로 계획한 프로그램이었다. 프로그램 참여자는 청소년과 일반성인이 가장 높은 비율을 차지 하고 있었다. 세부 인자는 식물을 활용하고, 촉각을 자극하는 동적인 활동이 가장 많았고, 주로 걷기를 하였으며, 봄과 여름철에 시행되는 60분 이상의 실외 프로그램으로 당일형과 숙박형으로 이루어지는 것으로 조사되었다. 프로그램의 효과 수준을 chapter 2의 연구결과에 따라 구분한결과, 정신적인 측면에는 걷기를 1시간 미만으로 시행하였을 때, 신체적 측면에는 머무르기와 운동을 1시간 미만으로 시행하였을 때 효과의 크기가 가장 큰 것으로 나타났으나, 현재 운영되고 있는 프로그램들은 1시간 이상 걷기와 운동에 대부분의 프로그램들이 집중되어 있는 것을 알 수 있었다.

따라서 향후 프로그램 개발 시 근거의 수준이 높은 영역의 활동을 고려하는 것이 필요하다.

녹지가 건강에 미치는 영향에 대해 검증하기 위하여 2박 3일간의 산림에서의 프로그램 참여 경험이 사전, 사후, 그리고 일정한 시간이 지난 다음에는 어떻게 변화하는지 다양한 건강영향 지표들을 활용하여 그 양상을 분석하였다. 짧은 노출시간과 활동만으로도 면역과 심혈관계 등 건강상의 효과가 있었고, 통계적으로 유의미한 변화를 보였다

본 연구는 녹지노출에 대한 건강 영향을 객관적이 정량적으로 평가함으로써 국민건강증진을 위한 방안으로 녹지기반 프로그램의 가능성을 검토하였다. 향후 산림치유 프로그램 기획 시 필요한 기초자료를 구축하고, 녹지 이용에 대한 효과 검증 빅데이터 구축을 위한 기초체계를 마련하였다.

주요어: 녹지이용 프로그램, 산림치유, 산림치유 프로그램, 건강영향, 자연환경

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