



The Impact of Forest Therapy Programs on Stress Reduction: A Systematic Review

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Abstract: This systematic review aims to examine key findings of previous studies in order to explore how forest therapy programs impact stress reduction on physiological and psychological levels. It was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Quantitative studies that compared forest therapy program interventions with urban exposure were searched in February 2023 in six databases: CINAHL, EMBASE, Medline, PsycINfo, PubMed, and Web of Science (core collection). This review included 17 relevant articles selected from a total of 495 individual studies, in accordance with the set inclusion and exclusion criteria. The results of this review indicated that forest therapy programs were effective at relieving stress, particularly on a psychological level. Forest therapy programs could be used as a part of stress reduction projects. However, results regarding physiological effects have yet to be confirmed, and in the future, more in-depth and well-designed research will be required.

Keywords: forest therapy program; stress reduction; systematic review; physiology; psychology



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1. Introduction

Urbanization is one of the most important global trends in this century, with the estimation that about 68% of the world's population will live in urbanized areas by 2050 [1]. Historically, urban life is related to increased employment opportunities and better infrastructure, but there are also negative effects connected with it [2]. Urban residents, no matter working adults [2], students [3], or housewives [4], live stressful daily lives.

Stress was defined as "the quality of experience, produced through a person-environment transaction that, through either overarousal or underarousal, results in psychological or physiological distress" [5]. Psychological stress (measured by self-report methods) is the result of the evaluation of a stimulus in terms of its harmful and threatening potential [6]. Physiological stress response is characterized by a normal general, non-specific rise in arousal levels or activation levels [7]. It mobilizes biological resources, prepares the organism for a prompt response, and provides, in the long run, either a healthy adaptation or the accumulation of allostatic loads [8]. For many years, it has been assumed that there is a correlation between the different stress outcome systems, namely cognitive-emotional, physiological, and behavioral [9]. A cognitive evaluation of the significance of a stimulus and the available coping strategies is provided by the prefrontal cortex through the integration of sensory information. This subsequently leads to the formation of emotional responses through limbic connections, eventually leading to the activation of physiological systems such as HPA [10]. Stress is believed to be a major contributor to the onset and progression of a wide range of psychological or physiological problems, such as high blood pressure, colitis, gastric ulcers, anxiety, and burnout [11–13]. According to statistics, stressrelated diseases account for approximately 75% of all physician visits [14]. To tackle stress, millions of people worldwide turn to pharmacological treatment, which comes with countless contraindications and adverse effects [15–18]. There is, therefore, a strong demand for examining and developing promising non-pharmacological stress reduction interventions.

Stress Reduction Theory (SRT) states that building-dominant environments increase the stress levels of their occupants, while nature, such as forests, has the potential to create positive emotions and feelings that invoke a restorative effect [19]. In ancient Rome, people used the forest environment as a setting to improve physical and mental health, and for relief by taking refuge occasionally in the forest to escape from urban congestion [20]. Several recent studies have also demonstrated that forest environments are beneficial to stress recovery both physically and mentally. With the assistance of healing factors (e.g., green foliage, blue sky and water, tree-derived phytoncide, or the sound of running water) contained in the forest environment [21], the forest environment may help one recover from stress by reducing heart rate [22], blood pressure [23], sympathetic nervous activity [24], and salivary cortisol level [25], and increasing parasympathetic nervous activity [26] and NK cell activity [27]. Attention Restoration Theory (ART) contends that prolonged use of directed attention fatigues neural mechanisms [28]. As suggested by ART, exposure to nature, such as forests, can reduce the feelings of fatigue or psychological stress. Certain key properties of settings enable the recovery of effective functioning, such as "being away", "extent", "fascination", and "comparability". These components refer to the key characteristics of forests that contribute to the experience of restorative wellness [29]. Being in the forest can provide a sense of distance from the daily routine or the urban environment [30], which is crucial for reducing negative emotions [31], depression [32], anxiety [33], stress [34], and increasing positive emotions [35].

To maximize these capacities, a concept known as "forest therapy program" has been proposed [36]. "Forest therapy program" refers to a series of structured activities and cognitive-behavioral therapy-based interventions that utilize the forest environment in various ways to promote health [37,38]. This distinguishes forest therapy programs from forest therapy, which refers to activities designed to improve human health through the use of various environmental factors in forests, either with or without structured activities and cognitive-behavioral therapy [37,39,40]. The body of research on forest therapy programs is much smaller compared to the amount of research on forest therapy. In most countries, forest therapy programs are still relatively new, and only a few research studies have been conducted on them [38,41]. Previous studies [14,42] examined the physio-psychological benefits of forest therapy, but did not address forest therapy programs specifically. Separately, previous research synthesized stress measures with other constructs and did not examine the direct association between forest therapy programs and stress reduction. The actual relationship between forest therapy programs and stress reduction is still not discerned. To integrate the existing knowledge regarding forest therapy programs' effect on stress reduction, and to summarize the evidence for forest therapists, researchers, policy makers, and others with an interest in forest therapy programs, we conducted a systematic review to determine whether forest therapy programs improve physiological and psychological stress-related outcomes as well as which stress indicators are improved. Furthermore, by providing a systematic summary of the stress reduction effects of current forest therapy programs, this review paper could aid researchers in developing more effective future studies.

Two novel contributions are presented in our review of the literature. This is the first study, to the best of the authors' knowledge, to focus solely on the impact of forest therapy programs on stress reduction. This review could provide additional evidence and theoretical support for forest therapy programs' health effects. Second, more databases were included than in previous studies [14,42] in order to provide estimates of the impact of forest therapy programs on stress reduction.

2. Materials

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as the guideline for this study [43]. The literature review was conducted using six databases: CINAHL, EMBASE, Medline, PsycINfo, PubMed, and Web of Science (core collection) to identify relevant studies published until February, 2023. The search string contained two elements: forest therapy program and stress reduction outcome. Regarding the forest therapy program element, three keywords have been used: "forest therapy" or "shinrin-yoku" or "forest bathing". With respect to the stress reduction outcome element, keywords that included "stress", "stress reduction", "stress relief", or "restoration" were utilized. Search terms were based on those used in two related previous metaanalyses [14,44]. Separately from the above keywords, "cortisol" and "state anxiety" were also used as keywords in this study as outcomes related to stress reduction. Stress can be objectively measured through biological markers (biomarkers). Cortisol is a glucocorticoid hormone released by the adrenal glands. Cortisol levels can provide a measure of the integrated effect of a practice that addresses stress upon the neuroendocrine system of a person [45–47], and has long been regarded as a sensitive and reliable biomarker of stress [48,49]. State anxiety is defined as an emotional reaction to an individual's perception of a stressful experience [50,51]. For several decades, state anxiety has been operationalized as an outcome of psychological stress [52–54].

2.1. Inclusion and Exclusion Criteria

A total of five inclusion criteria were used in this study: (i) Evidence-based interventions, which utilized various forest components to alleviate stress. (ii) These studies were conducted in any country and in a real forest environment. (iii) No limit was set on the age of participants and year of publication. (iv) Quantitative studies, comparing forest therapy program intervention with urban exposure, were included. (v) Stress refers to a main outcome of this study. (vi) Peer-reviewed articles. (vii) Articles written in English. Studies that only involve forest walking, forest breathing, and/or forest sitting without structured activities and cognitive-behavioral therapy were excluded.

As for eligibility criteria, we distinguished between forest therapy programs, forest exposure, forest exercise, and forest therapy. The term forest exposure refers to being in a forest in some way, such as breathing or sitting in a forest. Forest exercise involves exercising in a forest, which can include walking. Forest exposure or forest exercise can be considered a form of forest therapy [55]. We operationalized the forest therapy program to include a combination of other structured activities and cognitive-behavioral therapy to improve one's health and well-being. Therefore, forest-based exposure and/or exercise, combined with other structured activities and cognitive-behavioral therapy (e.g., meditation, experiencing the forest through the senses), meet our definition of a forest therapy program. Nonetheless, simply being in a forest or exercising in a forest was not sufficient to qualify as a forest therapy program.

2.2. Study Selection Process

The keyword search conducted by Zhang Ya Wei (ZYW) and Feng Lu (FL) resulted in 495 individual studies. A detailed search strategy is presented in the supplementary material (Supplementary Tables S1–S7). References of the retrieved relevant review studies were manually inspected for additional manuscripts on forest therapy programs and stress reduction (Supplementary Table S8). An number of 173 duplicate articles were removed with the assistance of ENDNOTE X9 software. A number of 25 individual studies remained after title and abstract screening. Subsequent full-text screening based on inclusion and exclusion criteria resulted in 17 studies for systematic review (Figure 1). Eight articles were excluded for the following reasons: non-English articles (n = 1), and no forest therapy program intervention (n = 7). The selection process was conducted by ZYW and FL, and they selected the studies blindly from each other. Regarding selection conflicts, Duan Wen Jie (DWJ) was involved and made the final decision. An overview of the included studies is provided in Table 1, including author name, publication year, study conduct place, study design, mean age or age range of participants, number of participants, health condition of samples, forest therapy program group/control group activity, forest therapy program duration and frequency, outcome measure, and outcome. These main characteristics and outcomes were extracted by ZYW, and checked by FL and DWJ, and any disagreements were resolved through discussion. We were not able to conduct a meta-analysis due to the fact that these studies included differing methodological approaches, resulting in varying quantitative data, and recurring missing information in the results sections [43,56].



Figure 1. Flow diagram showing article selection process.

Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration		Results
Sung, Woo, Kim, Lim, and Chung, 2012 [57]	Republic of Korea	ССТ	Elderly hypertensive patients from two local health centers; N = 56 (FT group = 28, Control group = 28); Mean age: FT group = 63 years (SD = \pm 11), Control group = 66 years (SD = \pm 7)	Salivary cortisol level	FT group: 3 days (cognitive interventions and behavioral techniques in a forest environment); Control group: Urban daily routine	(a) (b)	The salivary cortisol level was significantly different between the two groups at the 8th week follow-up visit; The salivary cortisol level decreased significantly in the FT group.
Ochiai, Ikei, Song, Kobayashi, Miura, et al., 2015 [58]	Japan	pre/post	Females between the ages of 40 and 73 recruited from a health promotion center; N = 17; Mean age = 62.2 years (SD = \pm 9.4)	Salivary cortisol level	4 h and 41 min (stroll, lecture, deep breathing, lie down, abdominal breathing and chat)	(a)	The salivary cortisol level decreased significantly.
Ochiai, Ikei, Song, Kobayashi, Takamatsu, et al., 2015 [59]	Japan	pre/post	Males with high-normal blood pressure between the ages of 40 and 72; N = 9; Mean age = 56 years (SD = \pm 13.0)	Serum cortisol level	4 h and 35 min (stroll, deep breathing, lie down, and sit)	(a)	The serum cortisol level decreased significantly.
Chun, Chang, and Lee, 2017 [60]	Republic of Korea	RCT	Patients with chronic stroke recruited from a stroke welfare center; N = 59 (FT group = 30, Control group = 29); FT = 62.1 years (SD = \pm 8.3), Control group = 59.5 years (SD = \pm 9.7)	STAI-S; d-ROM level; BAP	FT group: 4 days (meditating, experiencing the forest with all five senses, and walking through the forest); Control group: 4 days (meditation and walking activities were conducted similarly in an urban setting)	(a) (b)	Significant differences in STAI-S and BAP were found between groups. No significant difference in d-ROM was found between groups; Significant decreases in STAI-S and BAP were found after FT. No significant difference was found in d-ROM level after FT.

Table 1. Characteristics of included studies.

Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration		Results
Chen, Yu, and Lee, 2018 [61]	China	pre/post	Middle-aged women recruited through the Internet; N = 16; Mean age = 46.88 years $(SD = \pm 7.83)$	Chinese revision of POMS; STAI-S; pulse rate; SBP; DBP; SAA	2 days (2.5-h guided forest walk to stimulate the four senses, night walking on trails, and do-it-yourself handcrafts)	(a) (b) (c)	Negative mood states, anxiety levels, and SBP were significantly reduced; Positive mood states were significantly improved; No significant differences were found in pulse rate, DBP, and SAA.
Jin and Son, 2018 [62]	Republic of Korea	ССТ	Low-income elderly living alone recruited from community service centers; N = 61 (FT group= 30, Control group= 31); FT = 76.3 years (SD = \pm 4.3), Control group = 77 years (SD = \pm 8)	SRI	FT group: 10 weeks urban forest therapy program (warming up, walking, five senses meditation, and traditional play); Control group: Urban daily routine.	(a) (b)	A significant difference in SRI was found between the two groups; SRI decreased significantly in the FT group.
Ernest Bielinis, Bielinis, Krupinska-Szeluga, Lukowski, and Takayama, 2019 [63]	Poland	pre/post	Young Polish adults recruited from former friends of researchers and their acquaintances; N = 21; Mean age = 23.86 years (SD = ±2.67)	Pulse rate; SBP; DBP; MAP; POMS; PANAS; ROS; SVS	5 h (program engaged participants' 4 senses, traveling between sites in forest).	(a) (b) (c)	Significant decreases were found in four negative mood states of POMS (confusion, anger or hostility, tension or anxiety, depression or dejection), negative affect of PANAS, pulse rate, SBP and MAP; Significant increases were found in ROS and SVS; No significant differences were found in fatigue and vigor of POMS, positive affect of PANAS, and DBP.

Table 1. Cont.

Table 1. Cont.

Intervention Condition Results

Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration	Results
E. Bielinis, Jaroszewska, Łukowski, and Takayama, 2019 [64]	Poland	pre/post	Patients in mental hospitals suffering from affective and psychotic disorders; N = 50; Mean age = 42.44 years (SD = ± 13.23)	POMS; STAI-S	1 h and 45 min (forest walks with additional exercises in the forest environment)	 (a) For patients with affective disorders, significant reductions were observed in four negative mood states of POMS (tension–anxiety, depression–dejection, fatigue, confusion) and STAI-S. A significant increase was observed in the vigor of POMS. No significant difference was found in the anger–hostility of POMS; (b) For patients with psychotic disorders, significant reductions were observed in four negative mood states of POMS (tension–anxiety, depression–dejection, anger-hostility, confusion) and STAI-S. A significant increase was observed in the vigor of POMS. No significant difference was found in the fatigue of POMS.
Rajoo, Karam, and Abdul Aziz, 2019 [65]	Malaysia	pre/post	University students; N = 29; Mean age = 21.83 (SD = ± 0.711)	SBP; DBP; pulse rate; non-standard academic stress self-assessment	1 day (stroll, river soaking, sensory enjoyment, deep breathing exercises, group sharing)	 (a) Significant differences in the mean SBP and DBP were observed on the FT day and the 3rd and the 5th day after intervention, but not on the 7th day; (b) No significant differences were observed in the mean pulse rate on the FT day and the 3rd and the 5th and the 7th day after intervention; (c) 63.2% of the students believed that forest therapy programs reduced their academic stress.

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Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration		Results
BH. Kang and Won-sop, 2020 [66]	Republic of Korea	ССТ	University students; N = 60 (FT group = 35, Control group = 25); Mean age = 21.5 years SD = ±1.74	MBI-SS; Job-Seeking Stress Survey	FT group: 8 weeks, 2 h per time (stroll, forest bathing, playing with natural objects, tree climbing, massage, making a bouquet using leaves, rope games, mandala with leaves, dance); Control group: Urban daily routine	(a) (b)	Between pre-test and post-test, there was a significant reduction in MBI-SS and job-seeking stress in the FT group, with the effect lasting for 12 weeks; In the control group, there were no significant changes between pre-test, post-test, and follow-up in MBI-SS and job-seeking stress survey scores.
Kim et al., 2020 [67]	Republic of Korea	pre/post	Menopausal women with insomnia; N = 35; Mean age = 58.8 years (SD = ± 3.9)	Serum cortisol level	6 days (meditation, gymnastics, walking, leg massage and stretch, alternately bathing in warm and cold water, a five senses experience program)	(a)	The level of serum cortisol decreased significantly.
Kim et al., 2020 [38]	Republic of Korea	RCT	University students; N = 38 (FT group = 19, Control group = 19); Mean age = 22 years	SRI-MF	FT group: 8 weeks, 1.5 h per session (forest dance, forest meditation, forest exercise, walk, others under the guidance of therapists); Control group: Urban daily routine	(a) (b)	FT group found significant decreases in total stress responses as well as all subscales (somatization, anger, depression); Control group did not show any significant changes in total stress responses or all subscales.

Table 1. Cont.

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Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration		Results
Rajoo, Karam, Wook, and Abdullah, 2020 [41]	Malaysia	pre/post	Middle-aged working women employed in service industries; N = 19; Mean age = 54.80 (SD = ±0.68)	SBP; DBP; pulse rate; non-standard stress self-assessment	1 day (leisurely stroll, sensory enjoyment, breathing exercises, group sharing)	(a) (b) (c) (d) (e)	For the before breakfast readings, significant differences were found in SBP and DBP between the baseline and the third day follow-up test; For the before lunch readings, significant differences were found in SBP and DBP between the baseline and post-test, and the effects were sustained for three days; For the before dinner readings, significant differences were found in SBP and DBP between the baseline and post-test. The effect on SBP persisted for three days, but not on DBP; No significant difference was found in pulse rate for all readings; 53% of the participants reported feeling rejuvenated and more at ease at work after the intervention.
Kim, Jeon, and Shin, 2021 [68]	Republic of Korea	RCT	University students; N = 38 (FT group = 19, Control group = 19); Mean age = 22.1 years, $SD = \pm 1.6$	SRI-MF	FT group: 8 weeks, 1 h per session (stretching, respiration, walking, meditation, and exercise); Control group: Urban daily routine	(a) (b)	A significant reduction in SRI-MF was observed in the FT group; SRI-MF did not show a significant change in the control group.

	Table 1.	Cont.				
Author and Year	Country	Study Design	Population and Sample	Tool for Outcome Assessment	Intervention Condition and Duration	Results
Bum-Jin et al., 2022 [69]	Republic of Korea	Crossover study	Middle-aged women; N = 53; Age = 40–65 years	POMS-B	3 days in forest (meditation, Zen yoga, walking, healing touch exercises), 3 days in an urban site (activities were conducted similarly in an urban setting)	 (a) The program in the forest significantly reduced tension, depression, anger, fatigue, and confusion, while increasing vigor; (b) The program in the urban area significantly reduced tension, but not depression, anger, fatigue, or confusion, nor did it increase vigor.
Choi et al., 2022 [70]	Republic of Korea	RCT	Full-time employees recruited from a public-sector manufacturing company; N = 42 (FT group = 21, Control group = 21); FT group mean age = 43.52 years, SD = \pm 7.33, Control group mean age = 45.86 years, SD = \pm 8.20	NK cell activity; salivary cortisol level; HRV; POMS; WSRI-MF; EQ-VAS	FT group: 2 days in forest environment (walking, mindfulness-based meditation, mandala coloring); Control group: 2 days in urban environment (activities were conducted similarly in an urban setting)	 (a) Significant differences were observed between groups when it came to HRV, WSRI-MF, and some POMS sub-factors (anger-hostility, vigor-activity, fatigue-inertia), EQ-VAS; (b) No significant differences were observed between groups when it came to salivary cortisol levels and NK cell activity; (c) Significant differences were observed between pre- and post-intervention for the FT group in NK cell activity, salivary cortisol level, HRV, WSRI-MF, POMS, and EQ-VAS.
Cvikl, Avgustin, and Kreft, 2022 [71]	Slovenia	pre/post	Tourists who were willing to spend forty-eight hours at Kranjska Gora; N = 47	DHEA; salivary cortisol level; SBP; DBP; heart rate; stress index	1 day (walking, forest based activities that emphasize hearing, sight, and smell)	 (a) SBP, DBP, heart rate, and stress index decreased significantly; (b) Salivary cortisol level and DHEA did not change significantly.

BAP, Biological Antioxidant Potential; CCT, Controlled Clinical Trial; DBP, Diastolic Blood Pressure; dhea, Dehydroepiandrosterone; d-ROM, Oxygen Metabolite; EQ-VAS, EuroQol Visual Analog Scale; FT: Forest Therapy Program; HRV, Heart Rate Variability; MAP, Mean Arterial Pressure; MBI-SS, Maslach Burnout Inventory-Student Survey; PANAS, Positive and Negative Affect Schedule; POMS, Profile of Mood States; RCT: Randomized Controlled Trial; ROS, Restorative Outcomes Scale; SAA: Salivary α –amylase; SBP, Systolic Blood Pressure; SRI, Stress.

3. Results

3.1. Study Characteristics

The studies included in this review were published between 2012 and 2022. Among the 17 studies, fourteen were conducted in Asia and three in Europe. The Republic of Korea had the highest number of included studies with nine, followed by Japan, Malaysia, Poland with two each, and China and Slovenia with one each.

More than half of the studies were single-group trials with pre- and post-tests (n = 9). Seven studies were two-group trials while four used a randomized controlled trial (RCT) [38,60,68,70]. One study used a two-period crossover design [69].

A total of 640 participants were involved in the 17 studies. The participants under investigation varied in size, with sample sizes ranging from 9 [59] to 61 [62]. Most of the participants were the middle-aged and the elderly. Five studies recruited young people, with 80% of those studies (n = 4) recruiting university students. Some studies identified specific populations. These included hypertensive patients [57], patients with chronic stroke [60], patients in mental hospitals with affective and psychotic disorders [64], menopausal women with insomnia [67] or adults with high-normal blood pressure [59]. The participants were all male in one study [59] and all female in five studies [41,58,61,67,69]. Ten articles had both male and female participants. The gender of the participants was not described in one study [62].

The forest therapy program duration ranged from finished within 1 day to 10 weeks, with finished within 1 day being the most common among forest therapy programs (n = 7), with more than 1 week having the least frequency (three studies lasting for 8 weeks [38,66,68] and one study lasting for 10 weeks [62]). Among the 17 articles, four conducted follow-up evaluations [41,57,65,66]. The contents of forest therapy programs and control interventions were not exactly the same in different articles. Other than walking in the forest being performed by all subjects, the forest therapy program intervention methods mentioned most frequently were experiencing the forest through the senses [41,57,60–63,65,67,69–71] and meditation in the forest [38,57,60,62,67–70]. The interventions taken in studies also included body massages [62,66,67,69], alternately bathing in warm and cold water [67], structured physical activities (e.g., stretching [62,64,68], breathing exercises [41,58,59,65,68], yoga [69], dance [38,66]), nature-based handcrafts [38,61,66,70], and traditional play [62]. In addition, seven of the 17 studies were facilitated by forest therapists or professionals trained with related knowledge [38,62,63,66,68,70,71], while the remaining studies did not specify whether therapists or professionals trained with related knowledge were involved. As for control groups, participants in five studies maintained a daily routine during the experiment without additional interventions, while participants in three studies [60,69,70] performed similar activities in an urban setting as those performed by the experimental group.

3.2. Physiological Impact of Forest Therapy Programs on Stress Reduction

3.2.1. Cardiovascular Outcomes

Five single-group studies [41,61,64,65,71] examined how forest therapy programs reduced stress by measuring systolic blood pressure (SBP) and diastolic blood pressure (DBP). In all of these studies, participants' SBP decreased significantly, and one study found that the effect could last for up to five days [65]. Three of these five studies [41,65,71] demonstrated a significant decrease in intervention pre-post DBP measures, while two [61,63] did not demonstrate such a decrease. To further examine the effect of forest therapy programs on blood pressure, Ernest Bielinis, Bielinis, Krupinska-Szeluga, Lukowski, and Takayama [63] included the measure of mean arterial pressure (MAP) in their study. MAP represents the average arterial pressure during one cardiac cycle and is likely to provide a more accurate indication of organ perfusion than DBP [72]. This study found a significant decrease in MAP as a result of the forest therapy program's implementation.

Five single-group studies involving pulse rate measurements yielded differing results. Studies on middle-aged women recruited through the internet [61], university students [65], and middle-aged working women employed in service industries [41] found no significant decline in pulse rate between pre- and post-intervention, whereas studies on young adults [63] and tourists [71] found significant reductions.

One study on employees in the manufacturing industry [70] which used heart rate variability (HRV) as a measure of physiological stress observed significant differences between the experimental group and the control group, and those participating in the forest therapy program had greater physiological improvement.

3.2.2. Cortisol Levels

Two controlled trials and two single-group studies investigated the effectiveness of forest therapy programs in reducing salivary cortisol levels. According to one controlled trial study involving elderly hypertensive patients recruited from health centers [57], and one single-group study with women recruited from a health promotion center whose ages ranged from 40 to 73 [58], salivary cortisol levels were significantly reduced after forest therapy programs, whereas another single-group study involving tourists [71] reported no significant pre-post improvement. Another controlled trial study [70] on full-time employees of a public-sector manufacturing company found that both forest and urban groups reduced salivary cortisol levels after the 2-day intervention, with no significant differences between the groups.

Two single-group studies examined forest therapy programs' serum cortisol level reduction effects. Study populations were males with high-normal blood pressure between the ages of 40 and 72 years [59] and menopausal women with insomnia [67]. Both studies reported significant reductions in serum cortisol levels after interventions.

3.2.3. Other Physiological Impact

Other physiological impacts of forest therapy programs on stress reduction were examined in four studies. One study examined the reactive oxygen metabolites (d-ROM) and biological antioxidant potential (BAP) of patients suffering chronic strokes. In this study, the BAP score in the forest group was significantly higher than in the urban group after the 4-day intervention; however, the d-ROM did not differ significantly between the two groups [60]. One study [70] examined the impact of a 2-day forest therapy program on natural killer (NK) cell activity in manufacturing employees. The results showed a significant increase in NK cell activity in the forest group, but not in the urban group. One study [71] investigated the influence of a 1-day forest therapy program on tourists, and reported that the forest intervention significantly reduced participants' stress index, but not their dehydroepiandrosterone (DHEA) levels. And one study [61] used salivary α -amylase (SAA) to assess the impact of a 2-day forest therapy program on stress reduction in women of middle age. The study reported no significant reduction in SAA levels after the intervention.

3.3. Psychological Impact of Forest Therapy Programs on Stress Reduction3.3.1. Emotional and Mood Outcomes

In studies that examined the emotional and mood outcomes of forest therapy programs on stress reduction, the Profile of Mood States (POMS) was the most widely used testing tool, appearing in five studies [61,63,64,69,70], with one of them using the Chinese revision of POMS by Chang and Lu [61]. POMS usually contains six domains for identifying and assessing transient, fluctuating moods: tension, vigor, depression, fatigue, anger, and confusion [73]. Chinese revision of POMS by Chang and Lu (2001) added one domain: self-esteem [74]. All five studies found significant improvements in the total POMS and in two negative mood states (tension and confusion) following forest intervention. However, other negative or positive states of the POMS scale, including depression [61], anger [64], fatigue [64], self-esteem [61], and vigor [63], only showed slight improvements after forest intervention (p > 0.05). Three studies measured emotional and mood outcomes with State-Trait Anxiety Inventory-State (STAI-S). STAI-S measures state anxiety, which is anxiety induced by a specific situation [75]. In this review, studies utilizing the STAI-S examined how forest therapy programs affected subjects' levels of anxiety. Study populations were patients diagnosed with chronic stroke [60], affective and psychotic disorders [64], and healthy middle-aged women [61]. All three studies reported that the forest intervention significantly reduced state anxiety levels [60,61,64].

One study [63] examined each participant's emotional impact using the Positive and Negative Affect Schedule (PANAS). A total of 20 items are included in PANAS questionnaire, 10 of which address negative affect and 10 of which address positive affect. Negative affect symptoms include subjective distress and unsatisfactory engagement. The level of positive affect refers to how much pleasure an individual experiences as a result of his or her engagement with the environment [76]. Young Polish adults who completed a 5-hour forest therapy program showed significant decreases in negative aspects, and slight increases in positive aspects (p > 0.05).

3.3.2. Self-Perceived Stress Outcomes

Seven studies included measures of self-perceived stress. The tools applied consisted of Stress Response Inventory (SRI) [38,62,68], Worker's Stress Response Inventory Modified Form (WSRI-MF) [70], non-standard stress self-assessment surveys developed by Rajoo et al. research group [41,65], and the Job-Seeking Stress Survey [66]. SRI [77] is one of the most important tools for assessing the effects of stress on mental health and physical health. This scale measures participants' levels of somatization, anger, and depression as a response to stress. WSRI-MF [77] is an adaptation of SRI, containing four additional items related to work. Non-standard stress self-assessment surveys developed by Rajoo et al. were used in the two studies [41,65] conducted by themselves. There was a slight difference between the two non-standard stress self-assessment surveys. One study [65] examined academic stress and the sources of stress, and the other [41] examined work stress and the sources of stress. In the Job-Seeking Stress Survey [78], four factors are considered: stress associated with studies, stress associated with personality, stress associated with college circumstances, and stress associated with family matters. These seven studies examining self-perceived stress outcomes were conducted with low-income elderly people living alone [62], university students [38,65,66,68], middle-aged working women employed in service industries [41], and full-time employees recruited from a public-sector manufacturing company [70]. In all the above studies, forest therapy program interventions were effective in reducing self-perceived stress.

3.3.3. Other Psychological Impact

The Maslach Burnout Inventory-Student Survey (MBI-SS) was used to measure academic stress among university students in one study [69]. It was reported that after an 8-week forest therapy program, academic stress was significantly reduced in the forest intervention group, and that effect was sustained for 12 weeks, while no significant changes were observed in the urban control group [66]. MBI-SS differences between groups were not reported in this study. One study [70] evaluated the stress-related outcome in fulltime employees recruited from a public-sector manufacturing company using the EuroQol Visual Analog Scale (EQ-VAS). EQ-VAS [79] is a tool for assessing health-related quality of life that ranges from the worst possible health state to the best possible health state. After a 2-day forest therapy program, EQ-VAS significantly increased in the forest group. However, EQ-VAS did not show significant increases in the urban control group. One study [63] examined the effects of a 5-h forest intervention on stress reduction in young Polish adults using the Restorative Outcomes Scale (ROS) and the Subjective Vitality Scale (SVS). ROS [80] consists of six items, measuring human restoration in forests. SVS [80] was used to assess vitality and there were four common items chosen in this study: "I feel alive and vital", "I don't feel very energetic", "I have energy and spirit", and "I look forward to

each new day". After the forest intervention, participants' restoration levels and vitality levels significantly increased compared to those before the intervention.

3.4. Duration of Forest Therapy Programs and Stress Reduction

Among the seven studies that finished forest therapy programs within 1 day, one study [58] reported significant reductions in salivary cortisol levels, another study [59] reported significant reductions in serum cortisol levels, two [63,71] showed significant reductions in pulse rate, three [41,65,71] revealed significant reductions in DBP, and four [41,63,65,71] exhibited significant reductions in SBP. Two studies [41,65] did not show a significant reduction in pulse rate, one [63] did not find a significant reduction in DBP, and one [71] did not find a significant reduction in salivary cortisol levels. All salivary cortisol levels [57,70] and serum cortisol levels [67] were significantly reduced in studies in which forest therapy programs ranged from more than one day to less than one week. In the studies with a duration ranging from more than one day to less than one week, one [61] showed a significant reduction in SBP, but no significant reduction in pulse rate or DBP. In light of the above results, interventions that last two to six days appear to be more physiologically effective than those that last one day when it comes to salivary cortisol levels. There were no physiological outcomes tested in studies in which the duration of forest therapy programs ranged from 8 weeks to more than 8 weeks. In all 17 studies, psychological stress was reduced significantly regardless of the length of the programs.

4. Discussion

4.1. Health Benefits of Forest Therapy Programs

In recent years, there has been a growing interest in forest therapy programs to promote well-being and health. We conducted this systematic review in order to synthesize existing evidence on the practicality of forest therapy programs for treating stress. Seventeen studies were included in the review. Study subjects in this review covered a wide range of ages and health statuses, including university students, the middle-aged, the elderly, patients in mental hospitals, patients suffering from stroke, people with high-normal blood pressure, etc.

In general, forest therapy programs have shown to be effective in relieving stress both physiologically and psychologically. The physiological studies found significant reductions in SBP [41,61,64,65,71], MPA [63] and serum cortisol level [59,67], improvement in HRV [70], and an increase in BAP [60]. However, in terms of DBP, pulse rate, and salivary cortisol level, the review showed heterogeneous results. Is there a reason why these physiological measurements yielded heterogeneous results? There is a possibility that some studies [61,71] did not take into account factors related to the environment such as temperature, humidity, negative air ions, and illumination. In previous studies, it has been demonstrated that many environmental factors affect physiological health [71]. The arrangement of the activity may also be a contributing factor. As stated in one study in which a pulse rate decrease was not observed, participants were measured for their pulse rate right after making essential oil body wash, which was part of structured activities designed to stimulate the participants' senses. As participants made the essential oil body wash, they walked around the classroom, which could have affected their pulse rates [61]. Therefore, measuring physiological parameters immediately following an activity may result in inaccurate results. There is also the possibility that it could simply be the result of inappropriate use of the measurements, as demonstrated in one study [57], which measured salivary cortisol twice: first as a pre-measure and then as a follow-up measure eight weeks after the intervention ended. The three-day program used in this study is unlikely to have an eight-week lasting effect. There may also be other factors to account for the decrease in salivary cortisol levels observed in this study, such as changes in lifestyle [57].

The psychological studies found significant improvement in the total POMS [61,63,64,69,70] and PANAS [64], EQ-VAS [70], ROS, and SVS [63]; reduction in STAI [61], SRI [38,62,68], non-standard stress self-assessment survey [41,65], WSRI-MF [70], MBI-SS, and the Job-

Seeking Stress Survey [66]; and an increase in ROS and SVS [63]. However, one concerning matter is that psychological measures are dominated by self-rated subjects. Because none of the studies concerning psychological conditions that were included in the review were conducted with the blindfolding of subjects, it is possible that a "nature-positive" bias may have been introduced [56]. Haga, Halin, Holmgreen, and Sörqvist [81] have scientifically demonstrated the "nature-positive" bias in psychological restoration through an experiment in which participants were exposed to the same soundtrack while performing cognitively demanding tasks. One group was told the sound came from a waterfall (nature sound-source condition), while the other was told it came from an industrial environment with active machinery (industrial sound-source condition). The findings showed that participants in the nature sound-source condition. Due to the fact that the psychological measures relate to self-referred individuals, there is every reason to suspect that the results may be biased in a "nature-positive" direction.

Forest therapy programs lasting between two and six days appear to be physiologically more effective than interventions lasting less than one day in terms of stress reduction, when it comes to salivary cortisol levels. It has been proposed by Christup [82] that long-term interventions produce more significant changes than short-term interventions. The study confirmed the results of the previous study to some extent. It should be noted, however, that there are only a few related studies in this review, which could result in inaccurate results. Further, based on the review, there have been no studies analyzing the physiological and psychological stress reduction effects of forest therapy programs with intervention durations of 1 to 7 weeks, as well as the physiological stress reduction effects of this, there is a lack of empirical research data regarding the evaluation of stress reduction effects and the duration of forest therapy programs. It is therefore not possible to examine in depth the relationship between stress reduction and the duration of the intervention. For a better understanding of the relationship, more empirical research is required.

4.2. Future Studies

Future studies should consider forest therapy programs' sustained effects. Most of these included studies did not evaluate forest therapy programs' sustained effects. Simply evaluating the physiological and psychological conditions of subjects immediately following forest therapy programs would lead to inaccurate conclusions regarding the sustained effects of the program. The optimal period of intervention exposure for forestbased stress therapy programs remains unknown. In order to examine the dose-response relationship, varying the duration (e.g., one versus two versus three weeks) and frequency (e.g., once per week versus twice per week versus three times per week) is recommended. Furthermore, more high-quality studies are necessary for better understanding the causal relationship between forest therapy programs and stress relief, as some results are drawn from studies with weaknesses in their design.

4.3. Limitations of This Study

There are some limitations to this review. This review was based on empirical studies using quantitative methods. It is possible that there are additional studies that are valuable concerning this topic that fall outside this scope, such as those that use qualitative or mixed methods [83]. Including only peer-reviewed papers also raises some concerns, as it may favor studies with significant findings and positive effects (publication bias) [84]. A further limitation concerns the inclusion of only English language studies, which may leave out relevant studies published in other languages [85].

5. Conclusions

Forest therapy programs are still in their infancy, so there are only a few studies with similar designs that could be compared. Previous research into psychological stress recov-

ery after forest therapy programs could support psychological effects. Results regarding physiological effects were more ambiguous. In conclusion, solid proof of forest therapy programs' benefits for stress reduction has yet to be confirmed. There is a need for more robust empirical research studies in the future. Although the benefits of forest therapy programs are still being investigated, policymakers and health professionals should consider recommending forest therapy programs to their patients and the general public, since the intervention has low potential side effects and is likely to increase outdoor activity.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f14091851/s1, Table S1: Search terms; Table S2: Web of Science (Core Collection) was searched on 17 February 23; Table S3: PsycINFO was searched using on 17 February 23; Table S4: CINAHL was searched using the EBSCOhost on 17 February 23; Table S6: Medline was searched on 17 February 23; Table S7: EMBASE was searched on 17 February 23; Table S8: Related review for hand search for other sources.

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