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Shinrin-Yoku (Forest Bathing) and Nature Therapy: A State-of-the-Art Review

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Abstract

Background: Current literature supports the comprehensive health benefits of exposure to nature and green environments on human systems. The aim of this state-of-the-art review is to elucidate empirical research conducted on the physiological and psychological effects of Shinrin-Yoku (or Forest Bathing) in transcontinental Japan and China. Furthermore, we aim to encourage healthcare professionals to conduct longitudinal research in Western cultures regarding the clinically therapeutic effects of Shinrin-Yoku and, for healthcare providers/students to consider practicing Shinrin-Yoku to decrease undue stress and potential burnout. **Methods:** A thorough review was conducted to identify research published with an initial open date range and then narrowing the collection to include papers published from 2007 to 2017. Electronic databases (PubMed, PubMed Central, CINAHL, PsycINFO and Scopus) and snowball references were used to cull papers that evaluated the use of Shinrin-Yoku for various populations in diverse settings. **Results:** From the 127 papers initially culled using the Boolean phrases: “Shinrin-yoku” AND/OR “forest bathing” AND/OR “nature therapy”, 64 studies met the inclusion criteria and were included in this summary review and then divided into “physiological,” “psychological,” “sensory metrics” and “frameworks” sub-groups. **Conclusions:** Human health benefits associated with the immersion in nature continue to be currently researched. Longitudinal research, conducted worldwide, is needed to produce new evidence of the relationships associated with Shinrin-Yoku and clinical therapeutic effects. Nature therapy as a health-promotion method and potential universal health model is implicated for the reduction of reported modern-day “stress-state” and “technostress.”

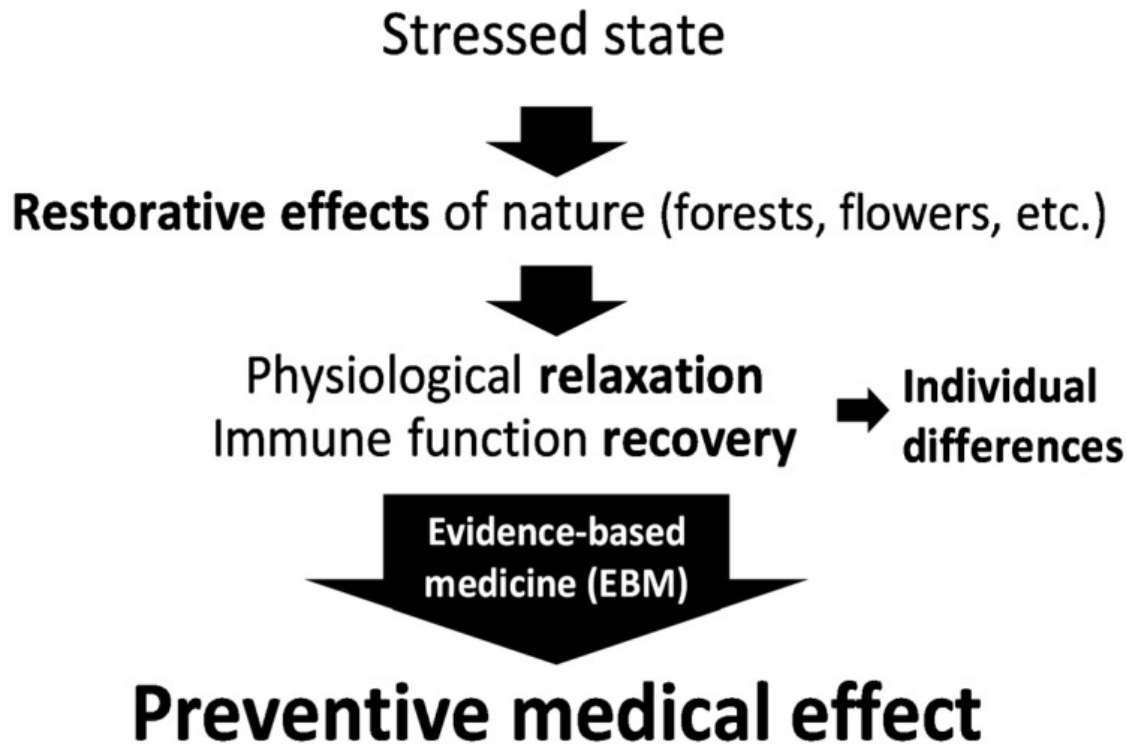
Keywords: Shinrin-Yoku, forest bathing, nature therapy, integrative medicine

1. Introduction

Research conducted in transcontinental Japan and China points to a plethora of positive health benefits for the human physiological and psychological systems associated with the practice of Shinrin-Yoku (SY), also known as Forest Bathing (FB) [1,2,3]. SY is a traditional Japanese practice of immersing oneself in nature by mindfully using all five senses. During the 1980s, SY surfaced in Japan as a pivotal part of preventive health care and healing in Japanese medicine [4]. The reported research findings associated with the healing components of SY specifically hone in on the therapeutic effects on: (1) the immune system function (increase in natural killer cells/cancer prevention); (2) cardiovascular system (hypertension/coronary artery disease); (3) the respiratory system (allergies and respiratory disease); (4) depression and anxiety (mood disorders and stress); (5) mental relaxation (Attention Deficit/Hyperactivity Disorder) and; (6) human feelings of “awe” (increase in gratitude and selflessness) [5]. Moreover, various contemporary hypotheses, such as: Kaplan’s Attention Restorative Hypothesis [6]; Ulrich’s Stress Reduction Hypothesis [7]; and Kellert and Wilson’s Biophilia Hypothesis [8] provide support and a lens for the practice of SY and other forms of nature engagement.

Furthermore, SY may be considered a form of Nature Therapy (NT). Song, Ikei and Miyazaki’s present day model: Concept of Nature Therapy (CNT) [9] clearly defines NT as “a set of practices aimed at achieving ‘preventive medical effects’ through exposure to natural stimuli that render a state of physiological relaxation and boost the weakened immune functions to prevent diseases” [9]. The conceptual model of NT starts with a “stressed state” at the top and then points to the “restorative effects” of nature (forests, flowers, etc.) where there is a hypothesis of improvement in “physiological relaxation” and “immune function recovery” responses (individual differences noted). These responses to nature are then incorporated in the Evidence Based Medicine (EBM) model and is illustrated by an arrow leading to the “preventive medical effect.” This clear model supports Song, Ikei and Miyazaki’s [9] review of some medically proven outcomes. Kaplan and Kaplan [6] associated with exposure to naturally occurring stimuli (all 5 senses) that has a direct effect on increasing the parasympathetic nervous system and a heightened awareness that leads to a state of relaxation (Figure 1).

Concept of nature therapy



[Figure 1](#)

Concept of nature therapy [9]. Permission to publish from Yoshifumi Miyasaki.

Individuals living and interacting in green spaces (GS) report being more energetic, in good overall health and, have more of a sense of meaningful purpose in life [10]. Current scientific findings are illuminating what humans intuitively know: nature has great benefits for the human brain and this is shown through increased happiness, health/well-being and cognition [5]. Historically speaking, Cyrus the Great intuitively built lush green gardens in the crowded urban capital of Persia 2500 years ago to increase human health and promote a sense of “calm” in a busy city. The 16th Century Swiss-German physician, Paracelsus, declared: “The art of healing comes from nature, not from the physician” [5]. These insights have lead SY researchers to investigate the modern health benefits of humans being exposed to nature or GS.

Several studies explored the therapeutic benefits of SY in Asian countries [2,3,9,11]. Physiological and psychological differences between participants in a “forest therapy (FT)” program and a control were examined in the Seoul Metropolitan area with findings of a significant reduction in chronic widespread pain and depression [3]. Song and colleagues [9] demonstrated how male Japanese students who walked 15-min in an urban park during the autumn season had decreased stress and heart rates. By using several valid psychological tests, researchers demonstrated the positive effects of FT on individuals coping with chronic side effects of a cerebral vascular accident - specifically anxiety and depression [2]. At the Center for Environment, Health, and Field Sciences, Chiba University, Japan, researchers measured oxyhemoglobin levels in the pre-frontal cortexes of research participants while

the participants observed three dracaena plants [11]. Results indicated a significant increase in participants' oxyhemoglobin levels for urban, domestic and workplace foliage effects which directly demonstrates the health-promotion effects associated with indoor foliage plants on humans [11].

While exploring recent research about the health benefits associated with SY a dearth of scientific research conducted in Western populations was determined. Therefore, the increasing interest and the current published significant research findings surrounding the healing benefits related to SY, GS and the wilderness offers healthcare professionals an opportunity to delve deeper into this complementary modality for the prevention of disease and to assist with the potential healing of certain existing conditions in Western cultures. Revealing current research methods and subsequent research outcomes associated with SY practices may provide researchers, clinicians and students with an intervention that assists with preventative medicine and evidence-based practice (EBP). Therefore, the aim of this paper is to offer: (a) an in-depth inquiry of the current literature, (b) invite researchers residing in Western cultures to design and conduct empirical research regarding the therapeutic benefits associated with SY and, (c) to encourage healthcare providers/students to consider practicing SY to decrease undue stress and potential disconnection.

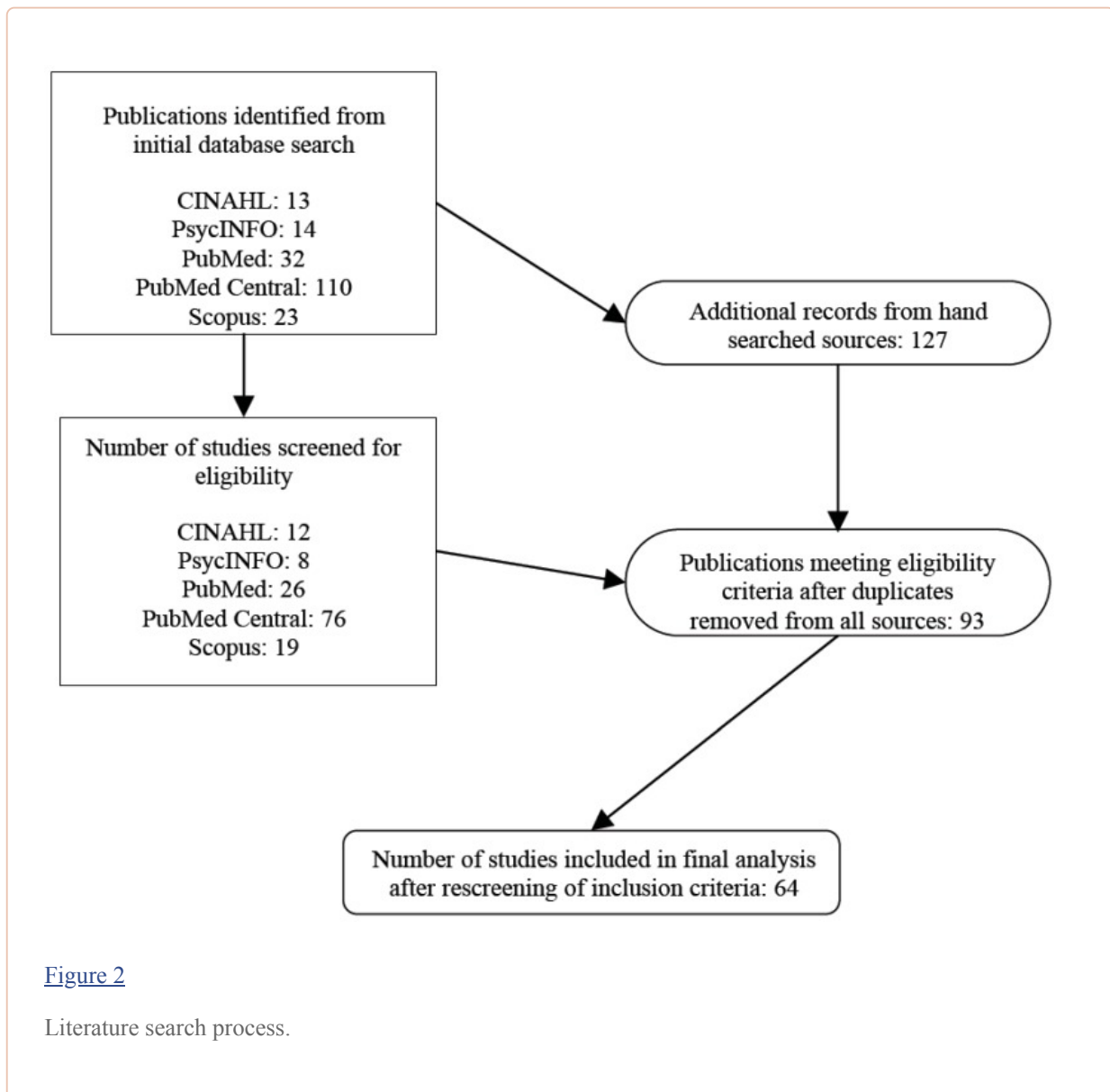
2. Materials and Methods

Review Method

The terms of this comprehensive review were to emphasize the core elements of the research proposition. The initial literature search was conducted with the intention of identifying publications that offered significant historic relevance to the practice of SY, included various populations, sample sizes and geographic locales, utilized evidence-based practices, illustrated measurable physiological and psychological effect parameters, expounded upon practical frameworks and methodologies for the practice of SY, explicated unique measurable criteria for the application of SY and deduced limitations of previous research.

Search Method

The electronic databases searched included PubMed Central, PubMed, CINAHL, Scopus, and PsycINFO (Figure 2). Hand searched bibliographies and reference lists from seminal researchers of SY were also applied to the initial culling of publications. PubMed Central was searched to ensure the incorporation of relevant publications not indexed in PubMed. Keywords were used for each database and during snowball searches. All titles and abstracts were searched with the following terms: "shinrin-yoku," "forest bathing," and "nature therapy." These searches were combined with the Boolean operators AND/OR. These terms were chosen from careful analyses of supporting literature. For example, the aforementioned terms "nature therapy", "shinrin-yoku", and "forest therapy" are used in conjunction with one another in the most recent scholarly literature review of NT in Japan [9].



To remain prescient, the reference range utilized in this review included literature published between the years 2007 and 2017. Therefore, the inclusion criteria allowed for publications that were available in English, dated from 2007 to 2017, incorporated transparent evidence based practices in reviews or trials, included robust quantitative and/or qualitative data, offered unique frameworks and theories, and explored current trends in research. Studies not meeting the tenets of this criteria, specifically those that pertained to physical exercise, fitness, landscape architecture, and laboratory, or animal studies were withdrawn from considerations.

3. Results

The findings of all relevant studies were synthesized ([Table 1](#)). The initial literature search revealed a series of topical themes apropos of the research aim. Articles were grouped into categories reflecting upon their most pertinent features. These categories include Background information, Frameworks, Physiological and Psychological effects, Sensory Metrics, and Limitations to findings. Previous Systematic Reviews and Literature Reviews were identified. Characteristics of publications specific to the themes of Physiological and Psychological Effects (PP), Sensory Metrics (SM), which is a subtopic of PP, and Frameworks (F) are delineated, an explicated within the key in [Table 1](#).

Table 1

Characteristics of selected studies and supporting evidence.

Study	Country	Population	Sample	Setting	Aim & Design
			Article total =		
		Articles were culled from PubMed, EMBASE, CINAHL, PsycINFO, Web of Science, SPORTDiscus, ASSIA, HMIC Data, LILACS, UK Natl. Research Register archives, TRIP database, UK Natl. Lib. for Health, Index to Theses Online, Directory of Open Access Journals, Economic and Social Data Service, Database of Promoting Health Effectiveness Reviews, Trials Register of Promoting Health Interventions, Cochrane Collab., Campbell Collab.	25. Studies that met the review inclusion criteria included crossover or controlled trials, which investigated the effects of short-term exposure to each environment during a walk or run. Including 'natural' environments, such as public parks and green university campuses, and synthetic environments, such as indoor and outdoor built environments.	Centre for Evidence-Based Conservation at the School of the Environment and Natural Resources, Bangor University, Bangor, Gwynedd, United Kingdom.	Systematic review to collate and synthesize the findings of studies that compare measurements of health or well-being in natural and synthetic environments. Effect sizes of the differences between environments were calculated and meta-analysis used to synthesize data from studies measuring similar outcomes. PP

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Key: PP: Psychological & Physiological. SM: Sense Metrics. F: Frameworks.

3.1. Physiological and Psychological (PP) Effects

Livni [12] published an editorial on the health benefits of SY and described the historic trends in biophysical and psychosocial research. While news of the beneficial elements of SY has been gathering momentum in popular lexicon, it has been the robustness of pioneering research, largely from Japanese scholars, that illuminates empirical links between the PP effects of SY. Tsunetsugu, Park and Miyazaki [13] conducted a novel review representing a didactic integration of various parameters specific to central nervous system (CNS) activity biomarkers; heart-rate variability (HRV), salivary cortisol levels (SCL), immunoglobulin A (IgA) and sense-specific metrics.

Of the studies included within the PP section, and irrespective of study aims, there was a trend towards small sample sizes, gender and age homogeneity, and skewed ratios of females to males/vice versa, which by either methods of convenience, purpose and/or imparted bias to the research. An overwhelming number of studies included homogenous gender sampling [14,15,16,17,18,19,20,21,22,23,24,25,26,27]. Population demographics specific to gender were unreported in [28,29,30]. Proportionately skewed ratios of male to females and vice versa were identified in these studies [31,32,33,34,35,36]. Studies may have been limited to research participants specific to the student body of the courses and facilities within which the research was designed. The aspects of cultural specificities and sensitivity in research design must be considered when approaching a literature review from a global lens. The methods, tests, and findings of 40 relevant publications expounding upon the PP indices are included in this review. These publications are further assorted into Heart-rate Metrics; Disease States; Autonomic Nervous System Effects; Endocrine Function; and Sense Metrics. The multitudinous reasons for natural environs generating the aforementioned positive qualities have been systematically incorporated into the investigation of the physiological and psychological effects of SY as follows.

3.2. Heart-Rate Metrics

As changes in cardiac function, revealed by cardiac monitoring, are correlational to the physiological effects of stress regardless of environmental setting, it is coherently expected more than one third of the articles reviewed observe not only standard vital signs, including heart rate (HR) and pulse rate (PR), systolic and diastolic blood pressure (SBP/DBP) and ECG interpretation, but also heart rate variability (HRV), as well as left ventricular function and right ventricular function (LVF/RVF). While LVF is attributed to the ability of the left ventricle to perfuse the body, RVF is related to pumping blood to the lungs. HRV is defined as the variation in the time interval between heartbeats and is associated with the activation of the parasympathetic nervous system (PNS) through high frequencies (HF) and the sympathetic nervous system (SNS) through low frequencies (LF).

The trends revealed by SY research over the past 10 years in relation to the cardiovascular and autonomic nervous systems (ANS) appears to have started with basic cardiac monitoring then shifted to the correlation of cardiac monitored data points with the PNS and SNS, and this started the development of a more in-depth study design to research the effects of SY on specific disease states, such as: hypertension (HTN), coronary artery disease (CAD), and chronic obstructive pulmonary disease (COPD).

According to Kobayashi, Song, Ikei, Song, Kagawa and Miyazaki [18], 625 Japanese males situated in 57 forest-sites and 57 urban-sites across Japan revealed an 80% increase in the parasympathetic indicators of HRV while experiencing the forest setting—physiologically demonstrating forest-viewing was more effective in reducing indicators of stress than in the urban participants. The methods and findings of this large sample study are grounded in some of the earlier pilot studies culled for this review. In Park et al. [37] quantitative study, the sample size was limited to 12 males; however, it was one of the earliest studies to interpret the R-R intervals of the electrocardiogram analyzing pulse rate, in addition to SBP/DBP and LF/HF) components of HRV. This study design [37] has been echoed

throughout multiple studies which limit physical activity levels to 20-min for each activity researched in order to control for the cardiovascular effects of physical exertion on each participant [19,22,27,38,39,40,41].

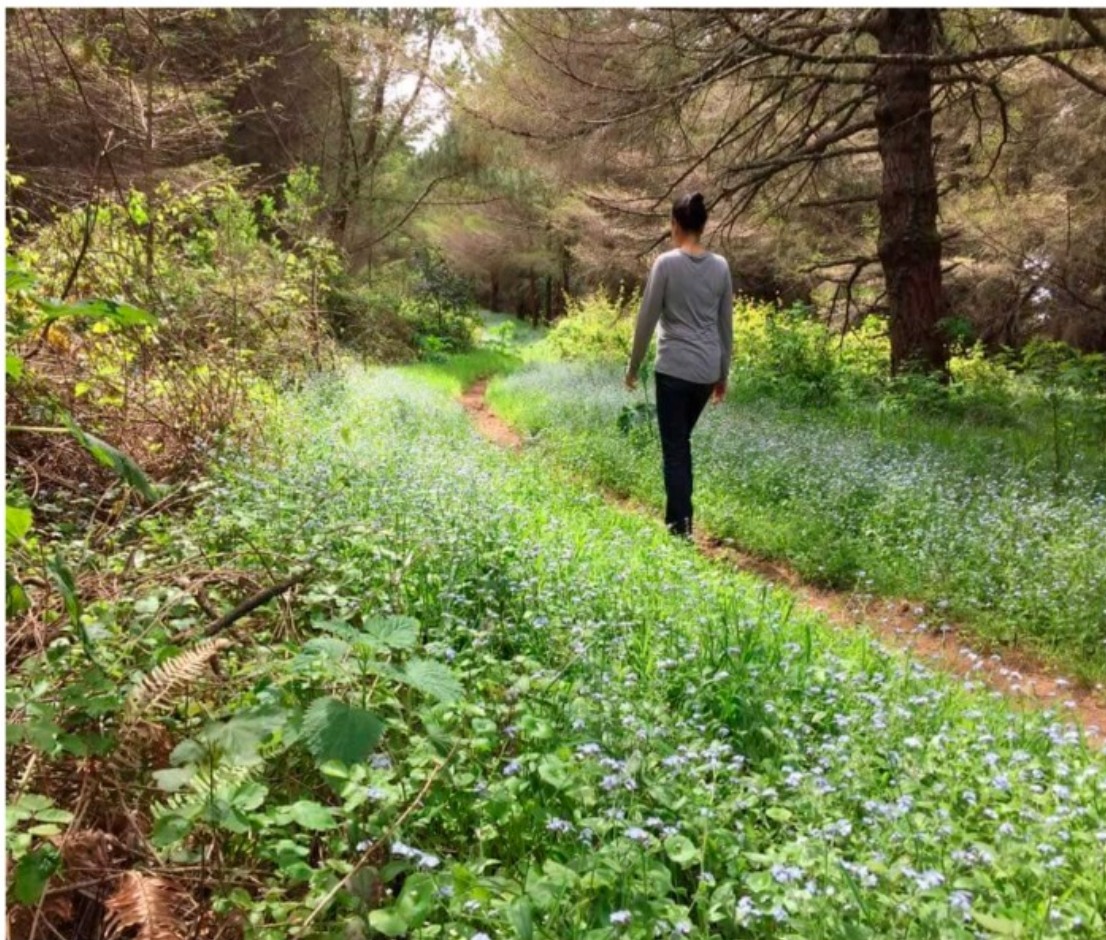
Blood pressure and PR also decreased while in the forest settings compared to the urban settings. In comparison to physical exercise tasks, Lee, Lee, Park and Miyazaki [20] measured HR and BP in relation to synthetic versus organic stimulation. This study revealed both HR and BP decreased in participants after they had completed a garden transplanting task compared with participants' HR and BP gradual increase throughout a computer performance task. Similar to the findings of Tsunetsugu et al. [40] consisting of 12 males, a study of 17 females over the age of 40 by Ochiai et al. [25] revealed an overall decrease in HR after one day of a "forest-therapy program". These studies demonstrate cardiovascular benefits for both genders. After controlling for both demographic and socioeconomic factors, Kardan et al. [42] conducted a correlation analyses of data acquired through the Canadian Ontario Health Study. High resolution satellite imagery suggests residents of neighborhoods with a higher density of trees on the streets report less ill cardio-metabolic conditions than do residents of neighborhoods with less trees. Thematically, it is evident the cardiovascular (CV) benefits of SY are apparent regardless of age, gender, socioeconomic background, or previous exposure to a nature setting.

3.3. Physiological Disease States

Significant research has revealed the effects of SY and NT on specific physiological disease states, including HTN, CAD, COPD, and Diabetes Mellitus Type II (DMII). In a randomized control trial (RCT) of 24 adults with HTN, Mao et al. [29] found throughout a week-long trip to a nature setting, BP indicators, and CV disease-related pathological factors decreased the activation of the renin-angiotensin system, therefore reducing the workload of the heart and helping to manage the symptoms of HTN. In a RCT of 20 Lithuanian adult patients with CAD, Grazuleviciene et al. [43] found after a week of 30-min sessions in nature, the participants' cardiac function improved overall. This is a groundbreaking study in there has never been a study prior to their publication that addressed "cardiovascular relaxation and recovery of homeostasis in CAD patients." Jia et al. [44] found a decrease of perforin and granzyme B expressions accompanied by decreased levels of pro-inflammatory cytokines and stress hormones in 20 patients diagnosed with COPD indicating some of the potential health benefits of SY for individuals living with COPD. Furthermore, in a longitudinal study of 48 adults diagnosed with DMII, Ohtsuka [45] found blood glucose readings declined after multiple SY practice sessions, therefore indicating a significant correlation between SY and the reduction of blood glucose levels. This study is one of the few measuring the effects of SY over time, which indicates further research may be conducted to confirm the long-term effects of SY, not only for its effects on patients with DMII, but for patients with different disease states as well [23,29,43,44,45].

3.4. Psychological

Morita et al. [46] noted while SY has been popularized in Japan given the ease of access to forested environments and its' conscientious governmental recommendations, individuals globally have reduced acute psychological distress from time spent in greenspace (Figure 3).



[Figure 3](#)

Walking in nature. Permission to publish from CiCi Lee.

Furthermore, Morita et al. [46] investigated SY's effect on 498 Japanese residents suffering from acute and chronic stress. Of these research participants, those suffering from chronic stress states reported the greatest reduction in subjective feelings of hostility, depression and anxiety as a direct result of time spent in the forested environs. Additionally, a RCT reflecting this practice, Sung et al. [47] developed a Cognitive Behavioral Therapy (CBT) based on a FT program, which included educational sessions and guided FB activities for middle-aged men and women diagnosed with Stage I HTN in South Korea. The CBT FT program incorporated elements of meditation and relaxation techniques in chosen forested environments, as well as participant self-reflection and goal setting [47]. The results of which demonstrated a significant decrease in the salivary cortisol (tested as a biomarker of stress), increase in Quality of Life (via the QoL questionnaire) and a decrease in anxiety. However, this study also gleaned a transient effect in the reduction of individual's manual self-reported BP measures. Self-reported manual BP reports are subject to reliability issues of measurement and bias. Moreover, the lack of additional objective analysis in the short-term forest-environment exposure are identified confounding variables, as well as the fact the participants took prescribed antihypertensive medications throughout the trials in the intervention and control groups respectively [47].

A hallmark of SY research has been the investigation of its' relaxation inducing properties and application for ameliorating psychological distress. Within this review, 12 studies specifically addressed psychological disorders/disease states and relevant comorbid conditions with popular reference to stress and stress related heart disease, emotional distress and chronic depression, alcoholism, sleep disorders, and pain [5,6,26,30,31,32,33,47,48,49,50,51]. Takayama et al. [49] noted the impetus for their SY research stemmed from a growing concern for overworked urban dwellers' chronic stressors. The results of this comparative study, while limited by sampling bias regarding the subject population consisting entirely of males, indicated a unanimous preference for forest walks versus urban walks based upon data synthesized from participants' responses to the Profile of Mood States (POMS), Restorative Outcome Scale (ROS) and Subjective Vitality Scale (SVS) pre- and post-intervention. Stress from urban environments caused by surmounting noise and environmental pollution, commuter traffic, financial expenses, increasing tasks, and lack of proximity to FB environs/attributes motivated Park et al. [26] to investigate the connection between psychological distress and greenspace accessibility. This study which included a large, single-sex sample of 168 males between the ages of 20 to 24 years of age, demonstrated subjects' preferences for forested environments, specifically in relation to temperature, as demonstrated by participants' reported lower Predicted Percentage Dissatisfied (PPD) scores related to summer climes within forested environs compared with higher air temperature and heat indexes in urban environments [26].

Citing the impact of chronic stress on growing populations with insomnia and poor sleep patterns in Japan, Morita et al. [32] studied forest-walking to induce relaxation and improve general sleep-wake cycles in a population of 71 men and women over the course of three months. Participants reported a statistically significant correlation between increased sleep time (from an average of 365.9 ± 89.4 min to 419.8 ± 128.7 min) post 2-h afternoon forest walks with decreased anxiety.

McCaffrey, Hansen and McCaffrey [30] investigated garden walking to reduce severity of signs and symptoms of depression in older adults. Participants' personal stories citing the emotionally healing attributes of the natural surroundings and garden walking paths at the Morikami Japanese Museum and Gardens in Delray Beach Florida, USA inspired the aforementioned researchers. Similarly, Kim, Lim, Chung and Woo [31] investigated the application of a 4-week forest-walking based CBT program for treating clinical depression. Research findings from Kim et al. [31] demonstrated a significant remission rate in the forest walking group at 61% over the traditional psychotherapy hospital-based group at 21%. Kim et al. [31] explicitly cited the work of Australian bush adventure therapy researchers Pryor, Carpenter and Townsend [52] in their pioneering work regarding the connection between time spent in nature and an increase in participants' health, well-being and emotional confidence. Kim et al. [31] employed a robust research design in so much as researchers incorporated the comparisons of a forest-walking based CBT program (N = 23), a hospital based treatment group (N = 19) and an outpatient control (N = 21). Yet, as with the Pryor et al. [52] research, inherent to the research aim of investigating the previous successes of nature-based therapy [31] is an implicit bias toward the functionality and reliable successes of the research outcomes.

Given SY practices are relatively innocuous when compared with other more invasive procedures, Chun, Chang and Lee [2] studied FT for patients (N = 59) diagnosed with depression and anxiety (roughly 60–80% of the participants), as well as oxidative stress (roughly 30–50% the participants) that is associated with stroke susceptibility and a positive stroke history. The results of this study, indicated the Beck Depression Inventory (BDI), Hamilton Depression Rating Scale (HAM-D17) and Spielberger State-Trait Anxiety Inventory (STAI) indicate scores were lowered in the post FT intervention group when compared with the control group scores. These results led researchers to recommend FT as a medically viable intervention for the psychological distress associated with chronic illness [2]. Since

its' inception in the 1970s, the STAI has been a hallmark test used to differentiate between participants' state and trait anxiety, however, its' brevity and pre-supposed delineation between anxiety-oriented temperaments inspires cause for concern over its' reliability [53].

Han et al. [3] and Kang et al. [50] focused on chronic widespread pain (CWP) and localized pain in relation to the emotional distresses of coping with the side-effects of intractable pain. In Han et al. [3] psychological indices were measured pre- and post- FT intervention with the BDI and the Visual Analog Scale (VAS) to measure intensity and frequency of CWP. The results revealed statistically significant decreases in pain and associated psychological distress as per the psychometric scales. Whereas, Kang et al. [50] utilized the VAS and the neck disability index (NDI) for chronic neck pain and the McGill pain questionnaire (MPQ) for localized pain, among other measures for physiological indices. Kang et al. [50] measured incidents of painful trigger points in the posterior neck region (TRPs) in the FB with exercise group compared with the FB without exercise, which resulted in reduction by nearly ½ of TRPs in the FB plus exercise group. Widely utilized as a metric for measuring pain, Kang et al. [50] noted the test's functional role in objectively evaluating participants' subjective experiences of pain. Researchers noted the popularity of the VAS [51], but further investigation was warranted to determine its' reliability and validity. The VAS does have a reported test-retest reliability among patients experiencing chronic pain ($r = 0.94$; $p < 0.001$) in a previous investigation [51], yet, given the subjective nature of pain and uncertain unanimous consensus on pain metrics in international medical literature, this study demonstrated a lack of criterion validity for the VAS.

With regards to human spirituality, Nakau et al. [33] noted in their pilot study involving 22 breast or lung cancer patients, consisting of 4 males (with an average age of 65.3 ± 2.6 years) and 18 females (with an average age of 56.6 ± 11.3 years), that FT can be viewed as an enhancement of spiritual health in cancer patients. Patients in this study [33] were all participating one month or more after undergoing surgery, chemotherapy, or radiation treatment. While patients were not considered to be at risk of life-threatening conditions at the time of study [33], the stress of undergoing treatment for chronic disease was implicated. All patients ($N = 22$), participated in the integrated FT, horticultural therapy, yoga exercise, meditation and group therapy treatment intervention at the Japan World Exposition (1970) Park in Suita, Osaka prefecture, Japan [33]. The results of this study indicated statistically significant correlations pre- and post-intervention between green environments and individuals' experiences of self-realization, increased emotional health and integrative well-being, as measured by the Japanese version of the Functional Assessment of Chronic Illness Therapy-Spiritual Well-Being Scale (FACIT-Sp), QoL questionnaire, Cancer Fatigue Scale, POMS and STAI, in addition to physiologic measures of NK activity [33].

3.5. Autonomic Nervous System Effects

Research on the cardiovascular effects of SY have precipitated a trend to discover how FB affects the ANS. At the level of the central nervous system (CNS) alone, marked changes in cerebral activity have been identified. Joung et al. [28] designed novel research to investigate identified specific anatomical cortices within the brain that vary in stimulation to both forest and urban areas. Activity in the prefrontal cortices of the forest-area group participants were significantly lower than that of the city-area group participants in the "after walking" through their randomly assigned locations. This decrease in activity suggests a strong correlation between nature settings and ANS activity [28]. Research has shown peak HF levels can be seen within 5–7 min of each nature experience, which demonstrates not only will SY benefit the health of the ANS, but that positive HF components of HRV are evident within minutes of forest immersion [9]. Regarding other physiologic indicators of stress, Mao et al. [24] conducted a quantitative RCT that demonstrated after short periods of time in nature, measures of malondialdehyde (MDA) concentrations, cytokine production, serum cortisol, testosterone, and lymphocytes decreased. Universal findings revealed LF components were significantly lower in the

forest areas than in the city areas, while HF components of HRV tended to be higher in the forest than in the city and therefore these research findings are important for further physiological research and the effects of SY [[17](#),[18](#),[20](#),[23](#),[24](#),[25](#),[27](#),[52](#)].

3.6. Endocrine Function

This section, a further investigation into the physiological and psychological effects of SY or NT via the physiological metrics relevant to endocrine included 11 publications. These resources specifically measured the effects of SY or NT on specific physiological and psychological indicators of stress via measures of salivary cortisol (sCort), and/or emotional indicators of health and well-being [[1](#),[17](#),[24](#),[25](#),[26](#),[27](#),[34](#),[36](#),[40](#),[47](#),[48](#),[49](#),[52](#),[53](#)]. Kobayashi and Miyazaki [[53](#)] studied baseline cortisol measures in 267 healthy male students from The University of Chiba, Japan, with the aim to compare measures in future SY studies. In Largo-Wright et al. [[48](#)] researchers deduced a correlation between increased contact with nature and decreased stress levels and generalized health complaints in office workers at a Southeastern university in the U.S. via the Nature Contact Questionnaire (NCQ), The Perceived Stress Questionnaire (PSQ), and a health behavior assessment derived from contact with the outdoors, over other types of contact with nature, such as indoor plants [[48](#)]. Additionally, practices of SY have demonstrated statistical significance in lowering blood-glucose. In a 2012 longitudinal trial, researchers from Hokkaido University, Japan, demonstrated forest-walking reduced blood glucose levels in 48 Type 2 diabetic patients [[34](#)]. A total of 48 participants, 16 males and 32 females, with a mean age of 66.8 years and diagnosed with DMII, walked for distances of 3 to 6 km nine times per week over a period of 6 years. There was no statistically significant difference between the subjects' glucose levels, or HbA1c levels between the shorter and longer walks. However, averages of both groups' blood glucose levels pre and post-forest walks declined by 79 ± 10 mg/dL and 76 ± 7 mg/dL respectively [[34](#)].

In the pilot study with a cross-over experimental design, investigators [[52](#)] addressed the impact of participants (N = 15) exposure to four urban and natural environments on physiological and psychological stress matrices. The study [[52](#)] utilized sCort and salivary amylase (sAA) as metrics, which the authors note via the work of Engert et al. [[54](#)] have been significantly reliable physiological biomarkers for stress. Additionally, Beil and Hanes [[52](#)] obtained data from questionnaires measuring participants' experience of stress via the Perceived Stress Scale (PSS), Perceived Restorativeness Scale (PRS), Subjective Stress Scale (SSS) and susceptibility of affective connections to natural environments via the Environmental Identity Scale (EID), pre- and post-intervention, which included a 20-min exposure to 4 different environments ranging from the "mostly built" to the "mostly natural." The participants' sAA and sCort levels respectively peaked after exposure to the urban environments, while levels were within normal range post exposure to the natural environments, which also correlated with participants' subjective impressions of stress [[52](#)]. The EID, while relatively novel, was noted to have been previously tested for its' effectiveness in ascertaining subjects' general health and welfare status in response to the environment [[52](#)].

3.7. Sensory Metrics (SM)

Fisher [[55](#)] illuminated an emerging interest in FT practices for psychological and physiological healing. By interviewing a proponent of FT, Fisher described the growing trend of individuals restoring native tree habitats with the dual purpose of environmental stewardship and psychological welfare of the persons involved in the process; paralleling the sentiments of many SY researchers [[9](#)] and supporting the Biophilia hypothesis [[8](#)]. Furthermore, Stigsdotter [[36](#)] conducted a case-study that followed up on survey driven data collected from a 2005 Danish Health Interview of 10,125 adult males and females and, results revealed significant positive correlations between access to green-space within 1 km, self-perceptions of stress and general health and well-being.

A subset of publications explicitly focused on sensorial stimuli, as a function of the effects of SY, which included time spent in forested outdoor environments, interactions with elemental aspects of natural environments and laboratory settings. Tsunetsugu et al. [13] synthesized evidence from physiological and psychological indices into subcategories, which exemplified the biomechanics of SY impact on the five senses. Eight key publications specific to SM were incorporated within this review, including: the metrics of olfaction [14,16], tactile stimulation [19], and visual stimulation, or neurological response [11,15,28,56,57].

Research included within the SM theme invariably measured nervous system activity and emotional response of participants in relation to experiencing authentic aspects of forested environments by comparative means. Igarashi et al. [56] studied participants' HRV, as an indicator of PNS activity in 48 high-school students viewing real vs. artificial pansies, the results of which illustrated a stronger correlation between relaxation with the real pansies versus the silk flowers. This was represented by a significant decrease in the ratio of LF/HF HRV, and subjective analysis of students' self-perception of relaxation indicating preference towards real flowers. Furthermore, Igarashi et al. [11] analyzed right and left prefrontal cortical activity in terms of cerebral blood-flow, and hemoglobin concentration changes via Near Infrared Time Resolved Spectroscopy (NIRS), which was measured in units of micro-meters (μM), according to the wavelengths observed. This was performed before and after participants were subjected to four visual conditions (real dracaena plants, images of dracaena plants, cardboard boxes and images of cardboard boxes) for timed intervals of 0–3 min each. Notably, μM concentrations were higher in participants viewing the actual dracaena plant stimulus for 3 min versus the pictorial sample for the same amount of time in right and left prefrontal cortical areas respectively [11]. Joung et al. [28] also utilized NIRS to determine μM levels pre-posttest upon participants viewing actual forested versus urban areas. Counter to the aforementioned Igarashi et al. [11] study, participants demonstrated increased subjective measurements of relaxation correlated with decreased μM concentrations and prefrontal cortical activity, and increased feelings of calmness from the forested site vs. urban site [28]. This may indicate not only are aspects of the natural environment optically stimulating as illustrated by Igarashi et al. [11] but they may also require less executive functioning as demonstrated by Joung et al. [28]. Mutual feelings of “calmness” were derived from each study.

Igarashi et al. [15] looked at comparisons between participants viewing images of kiwifruit orchards and specific urban areas in Japan. The POMS and HRV were used to evaluate participants' responses, which demonstrated moderate increases in PNS activity and feelings of “relaxation and calmness” when viewing the orchard versus an urban setting. Subjective measures of stress reduction have been consistently apparent in the studies focused on visual stimulation regardless of physiological indices. In Tsutsumi et al. [57], researchers aimed to investigate and compare participants' relaxation states before and after viewing visual footage of forested landscapes, and comparatively, seascapes. Measures of HRV, results from POMS questionnaires, and Bispectral Index System analysis (measured brain activity via electrode placement) allowed researchers to determine participants' sleep-wake states while comparing brain wave activity. Findings indicated significant decreases in HR, greater relaxation in post-intervention analysis in both groups, with the forest-viewing group demonstrating the greatest difference in relaxation-states across all measures [57]. These studies give statistically significant credence to the notion visual stimulation by aspects of forested environments reduces stress and increases a general sense of well-being in various study populations. Furthermore, these studies serve as templates to be integrated into therapeutic practices as suggested by Tsutsumi, et al. [57].

Koga and Iwasaki [19] investigated the potential for foliage-based tactile stimuli to induce relaxing effects that have been demonstrated via SY based field experiments. These researchers [19] utilized NIRS to detect cerebral blood-flow and the Semantic Differential (SD) model to determine emotional responses in participants' experiences with touching leaves versus other non-natural substances, such as plates of metal and fabrics. As noted by Park et al. [58], laboratory-based research on the

physiological and psychological effects of SY has been paramount. Furthermore, the Koga and Iwasaki [19] study revealed statistically significant correlations between touching natural substances, such as tree-bark, and incidents of decreased blood pressure. Moreover, these findings are associated with an increase in participants' subjective feelings of calmness. However, despite the clarity in exposition, researchers didn't identify the reliability and validity of the SD method utilized in the study. As with several SY studies, specific to psychological indices, self-reported measures in the form of questionnaires, such as the SD method, provided a bulk of the data. Therefore, leaving a question about the consistency, validity and reliability of the reported psychological outcomes.

Previous research regarding the effects of SY explored elements of olfaction as a sense metric relevant to the biological effects of experiencing forested environments. Tsunetsugu et al. [13] noted in their review, phytoncides, or volatile organic chemical compounds released from plants and trees have previously been associated with the effects of SY. Furthermore, Li et al. [63] described how the scent derived from phytoncides of 13 different tree species (phytoncides are unique to each specie and serve as a critical communication pathway between trees classified under the same genus) increased human Natural Killer Cell activity and decreased adrenaline in the FT intervention group of the study comparing urban and forested environments on human immune and stress function. Ikei et al. [16] studied the impact of α -pinene, a phytoncide from Japanese cedar wood (which is notably ubiquitous in forested areas of Japan) on ANS function via HRV indexes and the SD method. The results of which indicated an increase in PNS activity and a decrease in heart rate [16].

Jo et al. [14] focused research efforts on "floral scent", specifically Japanese plum blossoms, utilizing NIRS, HRV, POMS, and the SD as the physiological and psychological indices. Researchers created a unique apparatus for metering the floral and control scents, which involved a polypropylene pressurized bag with a constant flow of controlled air to be inhaled by participants. This novel approach controlled for many potential confounding factors given the ubiquity of various scents in laboratory settings. Utilizing multichannel NIRS enabled researchers to investigate the effects of olfactory stimulation on 47 localized neurological regions corresponding to areas noted for emotional, judgement, motor control, memory, somatosensory, cognitive, visual, auditory, and speech functions [14]. The literature expounding upon sense-metrics pertaining to the effects of SY illuminates a thorough pursuit of specificity and ingenuity.

Following a systematic review of 25 articles from databases including, but not limited to PubMed, EMBASE, CINAHL, and PsychINFO, Bowler [1] found each study suggested natural environments may have direct and positive impacts on humans' overall well-being. Bowler recognizes it is difficult to truly separate the raw effects of experiencing nature from confounding factors, such as physical activity performed, previous exposure to nature, as well as an optimal time frame for these effects. However, Bowler and every author mentioned throughout this literature review stress the aim to encourage research on the health benefits associated with the practice of SY. While research in primarily Japan and China has shown a positive impact of SY on both the physiological and psychological structures throughout the human body, it also calls for Western cultures to incorporate elements of the SY practice, so as to demonstrate compatible results world-wide for both patients and their healthcare providers [1].

3.8. Conceptual Frameworks

3.8.1. Nature Therapy

During the review of the literature, existing conceptual frameworks emerged that may be applied to SY practice and NT research. The first conceptual framework (CF) is Thomson's "vis medicatrix naturae," otherwise known as, "the innate ability of the body to heal itself" as presented in Logan and Selhub's review of the effects nature has on the human brain [59]. Thomson posits the healing power associated

with nature is directly connected with an individual's intentional contact with "animate and inanimate" aspects of the outdoors, such as touching the bark of a tree. While recognizing today's citizens' increased use of technology, exposure to air pollution and the associated increased stress responses, Logan and Selhub [60] present questions based on Thomson's framework. For example, "What might be an appropriate "dose" (duration and frequency) of nature contact to reduce stress?" "Are certain types of activities (e.g., gardening, walking in forest settings, contemplating in an urban park) more effective than others?" [60] Future directions for research, global urban planning and architecture, and policy making may be based on Thomson's framework of "vis medicatrix naturae." Furthermore, the research conducted by Selhub and Logan directly points to the health benefits associated with natural environments and may be parallel to the practice of SY and NT.

3.8.2. Psychological Underpinnings

The second CF is by Berger [61]. Berger presents a novel, autonomous and independent NT framework that serves as a model to support art and drama therapy. Within this theoretical and applied framework, which is considered "integrative" because it takes place in nature and serves as a part of the human healing process is the self- "reflexive" process that includes personal experiences. The NT model and theory are supported by past evidence derived from Gestalt psychology and the narrative research approach mixed with traditional "ritual" foundations. This novel theory attempts to put a spotlight on modern individuals' detachment from nature, absence from community engagement and spirituality through a psycho-eco-social lens. Berger purports individual's personal estrangement from nature, lack of involvement in community affairs and spirituality as being main factors influencing the modern-day spread of loneliness, depression, anxiety, low self-esteem and detachment. SY practice and NT research may be grounded in Berger's CF that recognizes the healing natural forces, resilience and recovery associated with nature.

The third CF is from a Threshold Concept and Transformational Learning perspective [62]. The practice of SY assisted by trained nature and forest therapy guides leads individuals into a "liminal" space. In this "liminal" space, also known as an "in-between" human state or "suspended state of partial knowing," the healing properties associated with SY are purportedly activated [62]. During the "liminal" phase, a person integrates, discards and experiences an "ontological shift" and then experiences "transformation" and a "changed discourse," known as a "post-liminal phase." The individual may experience a "pre-liminal" space in nature and may vacillate between old and emergent thoughts that may be disruptive. However, once in the "liminal" psychological space, the individual experiences a sense of calm and mastery. The immersion into nature may lead to a transformative way of knowing and understanding the self. These noteworthy concepts may serve as foundations for future research studies.

3.9. Limitations

Limitations of this review include the biases among the authors of the studies and articles culled, as well as the conceivable restrictions of SY as an evidence based practice within the traditional principles of Western medicine. While search criteria for the articles remained consistent across all database searches, publication bias must be acknowledged as most of the studies reviewed demonstrate a positive correlation among SY practice and NT with favorable physiological and psychological outcomes. In addition, original study sample sizes were often limited to less than 20 participants, with the inclusion criteria of primarily of healthy, young, male university students, making results difficult to generalize across entire populations. Other limitations within the studies include their inability to distinguish physical and psychological effects purely based on the participants' surroundings versus the participants' level of activity while present in either an urban or nature setting. Most studies offer little distinction among senses used, and which, if any, have a greater influence on positive or negative outcomes. While the current research has continued to trend toward the benefits of SY and NT on

specific disease states and diagnoses, it has primarily focused on the short-term effects of the practice of SY and NT with little research to indicate the longevity of its benefits. This concept of permanence relates not only to the amount of time spent in a nature setting for short-term optimal results within a study timeframe, but the participants' previous relationship with nature throughout their lifetime, and how a priming bias may influence the amplitude and frequency of corporeal effects. SY as a therapeutic practice to be exemplified by healthcare providers and recommended to their patients includes the limitations of theoretically defining SY for clinical use, the social and economic determinants of health which limit access to natural environments, and the correlation between the ever changing diversity of nature itself and the unpredictable physiological and psychological responses it may induce within the human body as noted by the Biophilia Hypothesis [8].

4. Discussion

4.1. Overview of Health Benefits of SY and NT

In general, from a physiological perspective, significant empirical research findings point to a reduction in human heart rate and blood pressure and an increase in relaxation for participants exposed to natural GS [13,40]. Even research involving the use of nature videos of the forest or the ocean have the same physiological effects [60]. From a qualitative and psychological perspective, Danish participants reported a sense of safety, calm and overall general wellbeing following exposure or engagement with nature [63]. South Korean participants with a known alcohol addiction and high pre-test scores of depression benefited more from the Forest Therapy Camp than participants with lower pre-test scores of depression and alcohol abuse [35]. Differences in culture, gender, education, marital or economic status were not associated confounding factors in many of the empirical studies. Overall, our review of the literature, as illustrated in Table 1, points to positive health benefits associated with SY and NT while confounding factors were clearly identified by the researchers.

4.2. Implications for Future Research

The aims of this state-of-the-art review are to showcase and elucidate the existing research on the effects of the practice of SY and NT on human physiological and psychological systems, existing frameworks and sense metrics in order to assist researchers in conducting future empirical research to substantiate, gain a better insight and enrich the scholarly literature. Longitudinal research is recommended to investigate the powers of nature as a healer and preventative element in today's modern/technological driven world over a long period of time. Proposed thoughtful and well-designed research would include both quantitative and qualitative approaches to identify specific SY and NT factors that influence disease and health promotion in Western Cultures. Furthermore, a systematic review of the current literature would honor the scholarly work completed to date and provide a higher level of evidence for the practitioner considering SY and NT as EBP interventions.

4.3. Implications for Future Healthcare Practice

This in-depth review illustrates, honors and supports the increased awareness of the positive health-related effects (e.g., stress reduction and increased holistic well-being) associated with humans spending time in nature, viewing nature scenes via video, being exposed to foliage and flowers indoors and the development of urban green spaces in large metropolitan areas worldwide. Not only valid and reliable psychometrics have been implemented, but valid and reliable physiological measurements have been used to show significant and potentially healing and health promoting effects. Furthermore, physiological and psychological research, based on sound NT frameworks and hypotheses is needed in the areas of healthcare professional/student stress-reduction and life balance [64,65].

Healthcare professionals and educators may turn to the SY and NT literature for simple, affordable and enjoyable complementary interventions to reduce stress, anxiety, and depression symptoms and enhance joy, relaxation, overall sense of well-being and balance in life. The founder and faculty member of the Association of Nature and Forest Therapy Guides and Programs, Amos Clifford, states the organization's mission is to integrate FT into healthcare systems [62]. Moreover, the profession of nursing and medicine has moved toward an integrative approach to healthcare. The third integrative nursing principle: "Nature has healing and restorative properties that contribute to health and well-being" supports the health benefits associated with the practice of SY and NT and serves as a part of the integrated healthcare model [66]. Furthermore, SY as a healing and restorative modality may support the clinician's and patient's whole-being while promoting a sense of peace, dignity and comfort. These ideas are supported by Watson's Carative Processes [67], specifically *Process Eight: Creating healing environment at all levels, whereby wholeness, beauty, comfort, dignity, and peace are potentiated*.

5. Conclusions

Advancements in complementary and alternative medicine (CAM) are indicative of a time in history when researchers and practitioners are willing to look at how humans evolved over the past 6- to 7-million years. When one ponders humans existing less than 0.01% of the species' history in modern surroundings and the other 99.99% of the time living in nature, it is no wonder some humans yearn and are drawn back to where human physiological/psychological functions began and were naturally supported. The Biophilia Hypothesis [8] supports SY and NT because it is steeped in the idea humans have an inner biological attraction to nature and its importance in our human development. Moreover, psychologically and spiritually speaking, humans intuitively know the relaxing, soothing and "awe" effects of being in or viewing forests, plants, flowers, urban green spaces, parks and natural wooden materials [68,69]. The mind-body-spirit experience associated with SY is for all humans and may be accomplished in various documented ways as illustrated in the novel review. These methods are supported by current scientific data, history and personal experiences reported over time. The practice of SY and NT are ontological realism and offer humans an authentic way of healing and health prevention for the mind, body and spirit [70,71,72]. How might we continue to encourage this health-promotion method and demonstrate scientifically and intuitively in order to add to EBP and global healthcare systems?

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Author Contributions

Margaret M. Hansen led the research as Primary Investigator and contributed to the writing/editing of the review. Reo Jones culled the research papers, organized and prepared the tables, literature search figure, contributed to the writing/editing of the review and supervised Kirsten Tocchini. Kirsten Tocchini organized the research papers and contributed to the writing/editing of the review.

Conflicts of Interest

The authors declare no conflict of interest.

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