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Therapeutic Effects of Forest Bathing on Human Health: A Systematic Review

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ABSTRACT

Introduction and Purpose: This comprehensive review aims to synthesize and analyze the existing scientific literature concerning the multifaceted impact of forest bathing, also known as shinrin-yoku, on human health and overall well-being. We will delve into the historical origins of shinrin-yoku while also meticulously examining the specific health domains.

Materials and Methods: A systematic search of the PubMed database was conducted to extract relevant articles published between 1975 and 2023. The search strategy employed the following key terms: "forest bathing," "shinrin-yoku," "human health," and "well-being."

Results: The analysis of the retrieved data revealed a consistent pattern of beneficial physiological effects associated with forest bathing. Specifically, a reduction in heart rate, as well as systolic and diastolic blood pressure, was observed in individuals who participated in forest excursions. The biogenic volatile organic compounds (BVOCs) emitted by forest

vegetation were shown to exert potent anti-inflammatory effects, inhibiting inflammatory processes implicated in conditions such as asthma, atopic dermatitis (AD), and rheumatoid arthritis (RA). Notably, a lower incidence of COVID-19 was observed in densely forested areas, potentially attributable to the natural barrier effect of forest vegetation against viral transmission and the lower levels of air pollution prevalent in these environments. Shinrin-yoku was also found to play a crucial role in maintaining mental health. In patients with dementia symptoms, forest bathing interventions resulted in improvements in language function and memory, among other cognitive domains.

Conclusions: Forest bathing represents an accessible and cost-effective intervention that holds significant potential for enhancing human quality of life. Therefore, it should be considered as an integral component of a healthy lifestyle and incorporated into routine daily activities.

Key words: forest bathing, shinrin-yoku, human health, well-being

INTRODUCTION

In 1982, the Japanese Ministry of Agriculture, Forestry, and Fisheries formally introduced the term *shinrin-yoku*, which translates to "forest bathing." [1] This concept served as the foundation for the development of forest medicine, an emerging interdisciplinary field dedicated to investigating the profound impact of forest environments on human health. This field encompasses aspects of both alternative and preventive medicine, supported by a growing body of research demonstrating that stress reduction achieved through forest exposure leads to improvements in both mental and physical health. [2] Recognizing the increasing importance of Evidence-Based Medicine (EBM) in scientific practice, the Association of Therapeutic Effects of Forests was established in 2004 to spearhead the Therapeutic Effects of Forests program in Japan, which conducts rigorous investigations into the effects of forest environments on human health. [1] In Europe, COST (Cooperation in Science and Technology) Action E39 on forests and human health was conducted from 2004 to 2008. [3] Concurrently, in 2007, the International Union of Forest Research Organizations (IUFRO) established a new task force in Finland to foster the development of forest medicine and facilitate collaboration among experts from various scientific disciplines. As a direct result of these efforts, the Japanese Society of Forest Medicine was established in 2007 under

the auspices of the Japanese Society for Hygiene, furthering scientific research in this area. [1]

Shinrin translates to "forest," and *yoku* translates to "bath." For centuries, people have sought solace and rejuvenation in the tranquility, clean air, and scenic beauty of forests. Forest bathing involves immersing oneself in the forest environment and engaging all five senses: sight (observing the forest landscape and appreciating the vibrant colors, particularly green), hearing (listening to the sounds of rustling leaves, bird songs, and other animal vocalizations), taste (experiencing the fresh taste of forest air and sampling edible forest fruits after ensuring their safety), smell (inhaling the earthy scents of soil and the fragrant aromas of flowers), and touch (feeling the textures of tree bark, moss, and the diverse surfaces of the forest floor and vegetation). [2] It is important to distinguish forest bathing from forest exercises, such as running or hiking, which involve more strenuous physical activity. [4]

Cardiovascular Health

Hypertension (HTN) is a leading cause of global mortality, representing the most common non-infectious cause of death worldwide. [5] It is a major risk factor for a range of serious health conditions, including kidney damage, stroke, myocardial infarction, and cognitive impairment. Despite the availability of effective pharmacological treatments, a significant proportion of patients fail to achieve target blood pressure levels. Furthermore, resistant hypertension, defined as the inability to control blood pressure even with five or more antihypertensive medications, presents a significant clinical challenge. [6]

The prevalence of HTN is strongly associated with residence in urban areas characterized by high levels of air pollution. [7] Exposure to forest environments has been shown to exert beneficial effects on cardiovascular health. In middle-aged men, contact with the forest environment resulted in a significant reduction in pulse rate. [8] Furthermore, after a walk in the forest, these individuals exhibited a decrease in urinary dopamine and adrenaline levels compared to those who walked in an urban environment. [8] These reductions are indicative of decreased sympathetic nervous system activity, which is associated with a lower risk of cardiovascular events. [9] A decrease in both systolic and diastolic blood pressure was also observed in older adults following forest bathing. [10]

Chronic heart failure, a leading cause of mortality worldwide, is defined as a complex clinical syndrome that results from structural or functional cardiac disorders that impair the ventricle's

ability to fill or eject blood. [11, 12] Common symptoms include edema, dyspnea, paroxysmal nocturnal dyspnea, fatigue, orthopnea, swelling, and abdominal pain. [13] The severity of heart failure symptoms is typically assessed using the New York Heart Association (NYHA) functional classification, a four-tiered scale. [12] Exposure to forest environments has been shown to result in a decrease in BNP and ET-1 levels [14], which are biomarkers that correlate with the severity of heart failure and the risk of mortality. [15]

Anti-Inflammatory Effects of Forest Bathing

Forest plants produce a variety of biogenic volatile organic compounds (BVOCs) as a defense mechanism against herbivores and pathogenic microorganisms. [16] Terpenes and terpenoids constitute the majority of BVOCs. [17] These compounds have been shown to exert potent anti-inflammatory effects by reducing the levels of pro-inflammatory mediators, such as interleukins, TNF-alpha, PGE2, and cytokines. [17]

Atopic dermatitis (AD), also known as atopic eczema, is a chronic, relapsing inflammatory skin disease that affects approximately 1 in 10 individuals throughout their lives. [18] The primary symptoms of AD include scaly, pruritic, erythematous lesions located on flexural surfaces, often accompanied by intense itching. [19] The Scoring Atopic Dermatitis index (SCORAD) is a widely used clinical tool for assessing the severity of AD. [20] The pathogenesis of AD is complex and multifactorial, involving a combination of genetic, environmental, and immunological factors. [21] Two of the most significant risk factors are a family history of AD and mutations in the filaggrin (FLG) gene. [22] FLG mutations compromise the integrity of the epidermal barrier, allowing direct skin contact with external irritants, such as allergens and microbes, resulting in an excessive immune response. [23] The clinical course of AD is influenced by the levels of pro-inflammatory cytokines. [24] In vitro studies have demonstrated that BVOCs, such as borneol, can exert strong inhibitory effects on the human transient receptor potential cation channel, member A1 (hTRPA1), leading to anti-inflammatory and anti-allergic outcomes. [25]

Rheumatoid arthritis (RA) is an autoimmune disease with an incompletely understood pathogenesis. While primarily affecting the joints, RA can also manifest as extra-articular symptoms, such as rheumatoid nodules and vasculitis. [26] Inflammation plays a significant role in the pathogenesis of RA, but its complexity leaves many patients unresponsive to current treatments, necessitating the development of novel therapeutic approaches. [27]

Research has shown that bornyl acetate, a BVOC, can increase the expression of IL-11 in chondrocytes and antagonize the pro-inflammatory cytokines IL-6 and IL-8, thereby significantly inhibiting cartilage destruction in RA. [17]

Increased Expression of Anti-Cancer Proteins

According to the National Cancer Institute (NCI), “cancer is a disease in which some of the body's cells grow uncontrollably and spread to other parts of the body.” [28] This uncontrolled proliferation and metastasis of abnormal cells leads to the disruption of normal tissue function and ultimately, the death of approximately 10 million people worldwide each year. [29]

The progression of cancer continues until one of several events occurs: spontaneous remission, surgical removal of the tumor, or the application of radiation therapy, chemotherapy, or other targeted therapies designed to selectively eliminate cancer cells. [30] The immune system plays a critical role in cancer surveillance and elimination. Natural killer (NK) cells and cytotoxic T lymphocytes (CTLs) are key components of this defense mechanism, inducing the death of tumor cells through various mechanisms. [31] One such mechanism involves the interaction between the Fas receptor on the tumor cell and its ligand (FasL) on the immune cell, triggering apoptosis. [32] Another pathway involves the release of cytolytic granules containing perforin, granzymes [33], and granulysin [34], which create pores in the tumor cell membrane and induce apoptosis.

Studies have shown that exposure to forest environments can enhance the activity of these anti-cancer immune cells. In subjects who underwent three-day forest bathing interventions, a significant increase in NK cell activity was observed during and after the intervention, compared to baseline levels measured three days prior to the trial. Furthermore, there was a notable increase in the expression of granulysin, perforin, and granzyme A/B-expressing cells, all of which are cytolytic molecules directly involved in NK cell-mediated anti-tumor activity. [4] These findings suggest that forest bathing may enhance the body's natural defenses against cancer.

Fighting COVID-19 and Managing Respiratory Diseases

Forest ecosystems provide a natural barrier against the transmission of zoonotic diseases. [35] Similar to the established benefits of a healthy diet and regular physical activity, exposure to

forests has been identified as a significant factor in reducing the incidence and severity of COVID-19. [35] During the COVID-19 pandemic, studies conducted in Italy demonstrated that regions with higher forest cover experienced lower rates of infection and mortality. [36] Conversely, areas with higher levels of air pollution were associated with increased mortality rates. [37] The volatile organic compounds (VOCs) emitted by forest vegetation are thought to play a role in inhibiting the spread of viral pathogens. [36]

Asthma is a chronic inflammatory disease of the airways that remains incurable. [38] The persistent inflammation of the airways leads to hyperreactivity, causing bronchoconstriction in response to triggers such as allergens, microbes, physical exertion, and emotional stress. This results in recurrent episodes of dyspnea, wheezing, coughing, and chest tightness. [39] Asthma often coexists with other atopic conditions, particularly allergic rhinitis. [40] The development of asthma is influenced by both genetic predisposition and environmental factors, such as exposure to air pollutants. [41] The pathogenesis of asthma involves a T helper cell type-2 (Th2) immune response, characterized by the release of pro-inflammatory cytokines, including IL-4, IL-5, IL-9, and IL-13, as well as the production of immunoglobulin E (IgE). [42] Over time, chronic inflammation leads to airway remodeling, resulting in progressive narrowing of the airways and impaired respiratory function. [43] Studies conducted in mice have shown that limonene, a volatile organic compound found in forest environments, can reduce airway remodeling. [44] Another VOC, 1,8-cineole, has been shown to be beneficial in the management of both asthma and chronic obstructive pulmonary disease (COPD). [45, 46]

Mental Health

The benefits of forest bathing extend beyond physical health to encompass mental well-being. [47] The demands of modern urban living, coupled with constant exposure to technology, contribute to elevated levels of stress, a phenomenon known as techno-stress. [2] Constant smartphone use and compulsive internet connectivity can lead to symptoms of depression, anxiety, and mental fatigue. [48] Cortisol, a hormone released in response to stress, serves as a key physiological marker of stress. [49, 50] *Shinrin-yoku* has been shown to effectively reduce cortisol levels, indicating a significant stress-reducing effect. [51]

Adolescents are particularly vulnerable to stress due to the pressures associated with academic performance, social development, and the pervasive influence of social media. [52] Social

media use, which often replaces face-to-face interactions, can lead to social isolation and exacerbate feelings of anxiety and depression. [53, 54] Adolescents who participated in forest bathing interventions and were assessed using the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS) reported significantly higher levels of mental well-being. [55]

Forest bathing has also demonstrated efficacy in the treatment of depression [56] and post-traumatic stress disorder (PTSD). [57] Patients with affective disorders who participated in forest bathing interventions reported a reduction in the intensity of four negative mood states, as measured by the Profile of Mood States (POMS) scale: tension-anxiety, depression-dejection, fatigue, and confusion. [58] Patients with psychotic disorders experienced an increase in vigor and a decrease in tension-anxiety (POMS). [58]

Shinrin-yoku has also been shown to be beneficial in combating insomnia. [59] Addressing sleep disturbances is crucial, as sleep disorders are a significant risk factor for depression and suicidal ideation and behaviors. [60] A two-hour walk in the forest has been shown to improve sleep quality the following night. [61] Middle-aged men who participated in two-hour forest bathing sessions for three consecutive days reported increased sleepiness and improved morning recovery. [62]

Burnout is an increasingly prevalent societal problem, particularly among healthcare workers, impacting both their well-being and patient safety. [63] Symptoms of burnout include depersonalization, emotional exhaustion, and a diminished sense of personal accomplishment. [64] While forest bathing interventions did not result in a significant improvement in burnout scores, they did lead to a reduction in stress and anxiety, which are key contributing factors to burnout. [63]

Dementia Symptoms Control

The increasing life expectancy worldwide has led to a corresponding increase in the prevalence of dementia, with Alzheimer's disease being the most common cause. Dementia is characterized by a constellation of psychological and behavioral symptoms known as Behavioral and Psychological Symptoms of Dementia (BPSD). [66] BPSD affects up to 90% of individuals with dementia, encompassing symptoms such as anxiety, elation, depression, apathy, aberrant motor behavior, hallucinations, and disinhibition. [67] The severity of BPSD symptoms tends to increase with disease progression, leading to a decline in functional

abilities, loss of self-care capacity, and the need for third-party assistance, often culminating in institutionalization. [66]

The Anti-Aging Standard Forest Healing Program (ASFHP) employs forest therapy as a non-pharmacological intervention for cognitive decline, with demonstrated benefits. [68] After 20 weeks of ASFHP, significant improvements were observed in total Cognitive Impairment Screening Test (CIST) scores and memory function. Patients who underwent the intervention showed improvements in immediate recall and language domains, as assessed by the Korean version of the Repeatable Battery for the Assessment of Neuropsychological Status (K-RBANS). [68]

CONCLUSIONS

Forest bathing has demonstrated a wide range of beneficial effects on human well-being. Its stress-reducing effects support its broader application in mitigating the detrimental effects of modern lifestyles, characterized by fast-paced living and constant exposure to technology. This could help manage psychiatric symptoms and support adolescents during their challenging developmental phase. Lowering blood pressure and slowing heart failure progression could reduce mortality in these patient populations. Reducing inflammatory changes offers a therapeutic avenue for patients unresponsive to current treatments, improving their quality of life. Enhanced functioning in dementia patients eases their care.

Forest bathing is an accessible (considering patient mobility and proximity to forests) and likely affordable (though some reserves charge entrance fees) way to address various health needs. It should be routinely offered to patients, both as treatment support and disease prevention. Contact with nature should be habitual and an integral part of daily life, forming a component of a healthy lifestyle.

DISCLOSURE

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