



Effects of a Forest Therapy Program on Stress Response and Heart Rate Variability in Older People Who Experienced the Jeju 4•3 Incident

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Abstract

We assessed the effects of a forest therapy program on physiological and psychological stress responses in older adults who experienced the Jeju 4•3 incident. This study included 20 older adults recruited from the Jeju 4•3 Trauma Center. Forest therapy was conducted on a once-a-week basis for 6 weeks. Self-reported stress-related reactions were assessed in all participants using the Stress Response Inventory (SRI), and heart rate variability was used as an index of physiological stress levels. Forest therapy significantly decreased the total SRI score ($p < 0.001$). We also observed a significant decrease in the low-frequency/high-frequency power ratio after forest therapy ($p = 0.002$). Our data indicate that forest therapy was effective in alleviating stress reactions and stabilizing physiological responses in older adults who experienced the Jeju 4•3 incident.

Keywords: Jeju 4•3 incident; Older people; Forest therapy; Stress; Heart rate variability

Introduction

The Jeju 4-3 incident refers to a series of armed uprisings and Counterinsurgency events that occurred on Jeju Island, South Korea from 1947 to 1954 [1]. It resulted in an estimated 14,000 to 30,000 casualties (approximately 10%-15% of the population of Jeju Island at that time) and the destruction of hundreds of villages on the island [2]. Recent studies have investigated the long-term psychological effects of the Jeju 4-3 incident on survivors. As a result of the prolonged period of exposure to traumatic events and violence, a significant number of the survivors of the 4-3 incident and their families still suffer from traumatic stress responses and depression 70 years later and have poorer health-related quality of life [3,4]. Accordingly, clinical interests with comprehensive and effective management of the long-term sequelae of traumatic events are needed in this population.

In recent years, researchers have increasingly focused on the therapeutic effects of health interventions involving forests [5]. Forest therapy, also known as 'forest bathing' or 'Shinrin-Yoku', involves activities developed to promote physical, mental, and emotional healing in a forest setting [6]. Forest therapy can improve health through exposure to fundamental components of nature, including biodiverse microbiomes, phytoncides, negative air ions, sunlight, and the general sights and sounds of natural environments [7]. Studies investigating the effects of forest therapy on psychological symptoms have demonstrated positive impacts on cognitive decline, anxiety, depression, and other stress-related conditions [8-10]. Potential benefits have also been reported with respect to the management of physical health problems, including pain, cancer relapse prevention, diabetes, and cardiovascular disease [11-13]. Based on these results, we hypothesized that forest therapy may improve physiological and psychological stress responses in older people experiencing the long-term effects of trauma, although research in this area is limited.

To assess the effectiveness of forest therapy in elderly survivors of the Jeju 4-3 incident, we quantified and compared participant psychological stress responses and Heart Rate Variability (HRV), as a physiological marker of stress, before and after a forest therapy intervention.

Material and Methods

Study participants

Survivors of the Jeju 4-3 incident were recruited at the Jeju 4-3 Trauma Center and have enrolled

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in this experiment voluntarily. Prior to the study, all participants received a detailed explanation of the study and provided informed consent. The exclusion criteria included medical conditions or physical disabilities that could interfere with outreach activities, as well as cognitive impairment (≤ 23 points on the Mini-Mental State Examination). This study was approved by the institutional review board.

A total of 20 participants were enrolled in the study. They had a mean age of 77.2 years (SD=4.1 years; range: 70-89 years), and 80% (n=16) of them were women.

Forest therapy program

The intervention program was conducted in Gotjawal Forest, which is located in Seogwipo, Jeju Island. Gotjawal Forest is 320 m to 760 m above sea level and hosts a diverse array of vegetation. The forest is at least 60 years old. Subtropical, temperate, and evergreen coniferous vegetation is distributed evenly, and the forest is approximately 174 ha in size, including 15 km of healing paths, five healing spaces, and six resting places allowing for barefoot walking, foot bathing, and wind bathing. We selected this study location because we thought it would be suitable for operating a forest therapy program.

The forest therapy program was conducted over six weekly 3-h sessions. The participants were divided into two groups of 10 individuals. Each session was led by a certified forest therapist and cofacilitated by a mental health professional (nurse or social worker). The forest therapy program consisted of two components. The first component involved physical activities in the forest, namely guided breathing, active walking, muscle stretching with a wooden cane, cognitive improvement-oriented gymnastics, and drinking herbal tea. The second component involved cognitive and mental activities using natural materials, i.e., making artwork with leaves, flower pots, and aromatic oils.

Measurement

Heart rate variability: HRV is a measure of the rhythmic variation in heart rate over time. It reflects autonomic nervous system activity and is used as an objective indicator of physiological responses in various situations. Physiological and psychological stress levels can be determined *via* HRV analysis according to autonomic nervous system reactions.

We used frequency domain analysis to assess the major components of HRV, i.e., the High-Frequency (HF: 0.15-0.40 Hz) and Low-Frequency (LF: 0.04-0.15 Hz) ratio. The LF/HF ratio reflects the overall balance of the autonomic nervous system, such that a

higher LF/HF ratio indicates that sympathetic nervous system activity is dominant relative to parasympathetic activity. The LF/HF ratio tends to be higher in individuals experiencing anxiety or tension, in whom sympathetic activity is higher than parasympathetic activity. In contrast, a lower LF/HF ratio indicates reduced physiological stress and better stress management and coping [14]. We measured HRV with the participant in a seated position using the Canopy 9 Plus portable device (IEMBIO, Korea). The HRV waves were measured at the left-hand forefinger for 5 min in a resting state.

Stress response inventory

We assessed psychological stress responses using the Stress Response Inventory (SRI), developed by Ko et al. [15]. The SRI consists of 39 items rated on a 5-point Likert scale and includes seven symptom subscales: tension, aggression, somatization, anger, depression, fatigue, and frustration. The maximum total score is 156 points, with higher scores indicating higher levels of psychological stress [15].

Statistical analysis

Given the non-normal distribution of the data according to the Shapiro–Wilk test, we used the Wilcoxon signed ranks test to compare the pre- and post-intervention data. All data are presented as median (Interquartile Range [IQR]) values. Data were assessed using SPSS software (version 25.0; SPSS Inc., Chicago, IL, USA), and p-values <0.05 were considered to indicate statistical significance.

Results

A total of 20 participants were enrolled in the study, and all participants completed the 6-week program. The post-intervention LF/HF ratio (1.25 [IQR: 0.89-0.54]) was significantly lower than the pre-intervention ratio (2.42 [IQR: 1.40-0.96], $Z = -3.099$, $p = 0.002$) (Figure 1), indicating that the intervention decreased sympathetic nervous system activity, anxiety, and tension. The pre–post changes in SRI scores are shown in Table 1. The post-assessment SRI total and subscale scores were lower than the pre-assessment ones (all $p < 0.05$).

Discussion

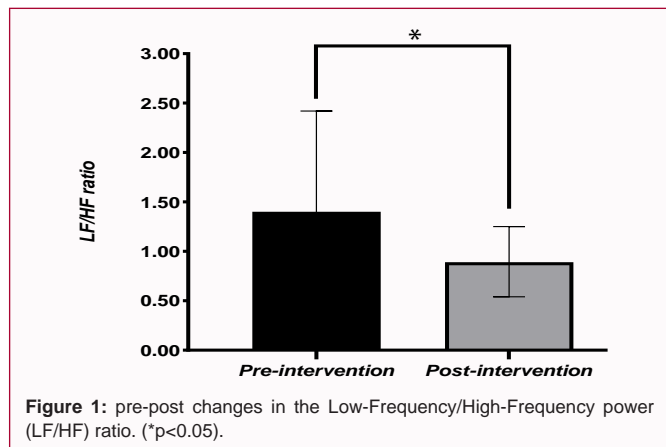
In this study, we assessed the effectiveness of forest therapy in older adults who survived through the Jeju 4-3 incident. We found that after the forest therapy program, physiological and psychological stress responses were significantly reduced.

Our findings are consistent with those of recent studies on the physiological effects of forest therapy in older adults. A recent systematic review showed that forest walking in healthy and pathological elderly populations had positive impacts on

Table 1: Pre-post changes in SRI scores.

SRI score	pre	post	Z	p
			Wilcoxon	
Total	29.50 (2024;38.50)	7.50 (4.25; 18.50)	-3.921	<0.001
Tension	5.00 (3.00; 7.75)	2.00 (1.00; 3.00)	-3.635	0.001
Aggression	3.50 (2.00; 5.75)	1.00 (0.00; 1.00)	-3.439	0.001
Somatization	1.50 (1.00; 4.00)	0.00 (0.00; 1.00)	-3.225	<0.001
Anger	5.00 (3.00; 7.75)	1.50 (0.00; 3.75)	-3.632	<0.001
Depression	4.50 (3.00; 7.75)	1.00 (0.00; 2.00)	-3.944	<0.001
Fatigue	4.00 (2.00; 5.00)	1.50 (0.00; 2.00)	-3.656	<0.001
Frustration	4.00 (3.00; 6.00)	2.00 (0.25; 3.00)	-3.636	<0.001

Values are presented as median (interquartile range). SRI: Stress Response Inventory



various cardiopulmonary (e.g., blood pressure, brain natriuretic peptide levels, cardio-ankle vascular index, pulmonary function, etc.) and neurochemical (e.g., C-reactive protein, interleukin-1 β , interleukin-6, interleukin-8, tumor necrosis factor α , and pulmonary and activation-regulated chemokine levels, etc.) parameters [16]. Physical activities conducted in forests, such as breathing, walking, and muscle stretching, promote relaxation and reduce muscle tension, neurological arousal, and psychological stress in older adults [17-19]. Along with these data, our results that the forest therapy modulated physiological stress responses measured by the HRV index support that forest therapy could bring favorable physiological or neurobiological changes.

Regarding psychological aspects, a recent systematic review showed that forest therapy activities in older adults improved symptoms of depression, stress levels, and self-perceived quality of life [16]. In addition, another study also reported the effects of a 10-week nature-based activity program, including walking and breathing in a forest therapy garden, in older veterans with posttraumatic stress disorder [20]. The results indicated that the nature-based activities provided the veterans with new tools to use in stressful situations, and the participants experienced an improvement in posttraumatic stress symptoms. These findings might contribute to the growing body of evidence regarding the benefits of forest therapy in older adults experiencing the long-term effects of traumatic events including the Jeju 4.3 incident. However, further research on the effects of forest therapy in other populations is needed to fully understand the therapeutic effects of this approach. Optimal program contents and duration would also be investigated.

Our study has several limitations. First, as we focused on older adults who experienced the Jeju 4.3 incident, it is difficult to generalize our findings to other trauma survivors or to the general older adult population. Second, we used a within-subjects, single-group design. Accordingly, there was no reference (control) group, which would have helped us evaluate the effectiveness of the program. Third, the small sample size did not allow for parametric analyses. Lastly, the long-term effects of the forest therapy intervention could not be established because no follow-up assessments were conducted after the end of treatment. Future studies should use larger samples, include a control group, and determine whether the short-term effects of forest therapy interventions are sustained.

Conclusion

The most significant outcome of our study is that it verified the

positive health effects of forest therapy in older adults exposed to traumatic events. Specifically, our data indicate that forest therapy can improve distressed physiological and psychological stress responses. Future studies with larger sample sizes, more diverse participant populations, and long-term follow-up assessments are needed to validate the effectiveness of forest therapy with respect to a variety of physiological and psychological parameters in older adults.

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