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Original article

Cardiac and pulmonary benefits of forest walking versus city walking in elderly women: A randomised, controlled, open-label trial

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Abstract

Introduction: Interest increases in the role of the natural environment providing health benefits. This study compared forest and city walking on arterial stiffness and pulmonary function.

Methods: A single-centre, parallel, randomised, and controlled, open-label trial was conducted. Seventy women >60 years were recruited into the study. The forest-walking group walked around a forested area for 1 h. The city-walking group walked around an urban area for 1 h. Blood pressure, arterial stiffness (CAVI), and pulmonary function (FEV1, FEV6) were assessed before and 30 min after the walking activity.

Results: Of the 70 women randomly assigned to the forest walking ($n = 50$) or city walking ($n = 20$) groups. Eight participants were excluded from analysis due to early dropout leaving43 participants in the forest-walking group and 19 in the city-walking group. One hour of forest walking significantly improved CAVI ($p < 0.01$), FEV1 ($p < 0.01$) and FEV6 ($p < 0.01$). No significant change was observed in the city-walking group. There were significant differences in changes of CAVI ($p < 0.01$), FEV1 ($p = 0.02$), and FEV6 ($p = 0.04$), between the city-walking and the forest-walking groups. No significant side effects were reported.

Conclusion: Our results showed that forest walking improved arterial stiffness and pulmonary function in 61 elderly Korean women. Further large scale and long-term studies are needed to better understand the clinical significance of these findings. Clinical trial registered with www.cris.org (KCT0000631).

Keywords: Forest environment; Arterial stiffness; Pulmonary function; Phytoncides; Exercise; Walking

Introduction

There is growing interest in the role of environment in human health. Environmental stressors such as air pollution and crowding in urban areas substantially increases stress [1]. In contrast, the natural environment has positive health effects [2]. A forest environment is one of the most accessible ways to experience the natural environment. Forests have been considered human resting places for a long time because of their beautiful scenery, fresh air, and quiet atmosphere. In Korea, forest bathing and "taking in" the forest atmosphere are the most popular activities associated with forests [3]. Many studies have evaluated the effects of forest bathing on human health [4–9]. Walking in forests has been shown to reduce levels of stress hormones [4,5], sympathetic nerve activity [6,7], and anxiety [7]. In addition, green spaces, such as forests and urban parks, are considered to help people recover from mental stress through soft stimulation without additional mental effort [1]. A previous study demonstrated EEG changes in participants who moved closer to trees in the urban city (green space) [8]. The EEGs indicated reduced frustration and arousal with an increased meditative state. Recent studies show that forest environments also affect cardio-metabolic parameters. Walking in a forest significantly reduces blood pressure [6,4] and fasting glucose levels [9]. Although the precise mechanism(s) underlying these findings is unknown, the harmonies of each forest element are considered important. Among them, many have studied the beneficial roles of tree phytoncides (tea tree oils). Phytoncides regulate autonomic function [10] and have anti-oxidant properties [11] that affect the human body both through the olfactory pathway and the blood stream.

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Atherosclerosis is one of the most common diseases among the elderly and significantly increases the risk of cardiovascular disease and mortality [12,13]. Chronic activation of sympathetic tone [14], and increased oxidative stress [15,16], with aging, promote atherosclerosis. Pulmonary function decreases with age [17,18] and can lead to adverse outcomes and mortality in older populations [19,20]. Although various factors affect pulmonary function, chronic accumulation of oxidative stress [21,22] and autonomic dysfunction [23] are known to lead to a decline in pulmonary function.

Because forest environments have been associated with changes in the autonomic nerve system and have anti-oxidant and anti-inflammatory properties, forest environments may also affect arterial stiffness and pulmonary function; however, current studies have not evaluate these relationships, and contain little information about the effects of forests on the elderly. We, therefore, investigated the acute effects of forest walking on arterial stiffness and pulmonary function in Korean elderly women.

Methods

Participants

We completed an unbalanced, randomised [2:1], open-label, parallel-group study involving people aged 60–80 years conducted in Korea. The study population was recruited by advertisement at the Senior Welfare Center in Mokpo City. Although we intended to recruit males and females, more than 95% of participants were female by the time approximately 50% of participants had been recruited. Therefore, we added the inclusion criteria that participants must be females aged 60–80 years. All subjects participated in the study voluntarily, and written informed consent was obtained from each participant. The study complied with the Declaration of Helsinki and the institutional review board of Yonsei University College of Medicine approved this study.

Participants with a history of chronic liver disease, chronic renal disease, coronary artery occlusive disease, cerebrovascular disease, dementia, and/or cancer were excluded. Women who had difficulties with walking because of disability or pain were also excluded as were participants with blood pressures higher than 160/100 mmHg. This resulted in 70 subjects who were then included into the study. Screening interviews were conducted at the public health center by a trained nurse.

Participants were randomly assigned to groups by computer-generated random selection of numbers. This simple randomisation procedure resulted in a 1:2 allocation into the forest versus city-walking group. Participants were asked to visit the public hospital of Mokpo city on either November 17th or 24th 2012 at 7:00 am and were not informed about their group assignment. Random allocation and assignment were performed by nurses working in the public hospital in Mokpo city. They assisted the study process as volunteers who were not involved in data analysis.

Study design

The forest-walking and the city-walking experiments were conducted separately (1 week apart) on different days. On Saturday, November 17, 2012, the forest-walking group visited the pyunback tree (*Chamaecyparis obtuse*) forest in Janghung, Mokpo City. The altitude of the forest was 150 m, and the surface was flat without inclines or declines. On Saturday, November 24, 2012 the city-walking group visited an urban area in Mokpo City. To control for variance, city walking took place at an altitude and on a surface similar to those in the forest setting. The altitude of the urban area was 50 m, and the surface was flat, paved, and lacked inclines or declines and lacked trees. On November 17, during the forest walking, the weather was clear, temperatures ranged from 13.3 to 20.1 °C, and humidity was 52.3%. The date for city-walking was selected based on a similar weather forecast. Walking in the city took place on November 24. The weather was also clear, the temperatures ranged from 14.4 to 19.4 °C, and humidity was 55.4%.

Participants walked at their usual pace for 1 h in the morning around the forest/urban area. Participants were educated about the walking protocol before the study began. Walking at a usual pace was defined as walking with normal breathing and without sweating, becoming over heated, or experiencing palpitations, and as if they were moving between the rooms in their house at a relaxed pace. Five assistants were placed in the walking area (within 10 km from the starting places) in case of an accident or a participant became lost. Assistants also monitored walking speed and distance. Participants were not permitted to go further than 10 km from the starting places. During the period of walking, we restricted entry of non-participants into the walking areas. Anthropometric, arterial stiffness, and pulmonary function measurements were obtained before and 30 min after walking activities. All of the measurements took place in a comfortable and quiet room, and each measurement was performed by one well-trained family medicine doctor. Because each test required about 5 min for completion, we divided participants into three groups to reduce the time and to standardize the time point for the forest- and city-walking groups. To control for the effects of caffeine and alcohol, the participants were not allowed to consume beverages that contained caffeine or alcohol during the experiments.

Measurements

All subjects completed a questionnaire about lifestyle, including smoking, alcohol consumption, and exercise. Smoking was defined as current cigarette smoking, and alcohol consumption was defined as either drinking alcohol more frequently than once per week or drinking 70 g or more of alcohol per week. Regular exercise was defined as physical exercise performed three times per week for either 30 min or more. The hypertension group ($n = 21$) was defined as subjects who used anti-hypertensive medicine; the diabetes group ($n = 9$) was defined as subjects who used either insulin or oral hypoglycemic medicine; and the dyslipidemia group ($n = 5$) was defined as subjects who used a lipid-lowering agent. Blood pressure was