

Article

Effects of Forest Bathing on Blood Pressure and Heart Rate in Older Adults in Mexico

María Guadalupe Garibay-Chávez ^{1,*} , Arturo Curiel-Ballesteros ¹, Javier García de Alba-García ²,
Miriam Borja-Arreola ³, Daniela Moreno-Ramírez ³ and Eliana Santos-Zamora ¹

¹ Department of Environmental Sciences, Institute of Environment and Human Communities, University Center of Biological and Agricultural Sciences, University of Guadalajara, Cam. Ramón Padilla Sánchez 2100, Las Agujas, Zapopan 44600, Jalisco, Mexico; arturo.curriel@academicos.udg.mx (A.C.-B.); eliana.santos7661@alumnos.udg.mx (E.S.-Z.)

² University System for the Elderly, University Center of Social Sciences and Humanities, University of Guadalajara, Av. de los Maestros, Alcalde Barranquitas, Guadalajara 44270, Jalisco, Mexico; javier_91046@yahoo.com

³ University Center of Health Sciences, University of Guadalajara, Sierra Mojada 950, Independencia Oriente, Guadalajara 44340, Jalisco, Mexico; miriamaxante@gmail.com (M.B.-A.); dan.morena156@gmail.com (D.M.-R.)

* Correspondence: ggaribay@academicos.udg.mx

Abstract: Currently, in cities in different regions of the world, forest bathing (FB) is considered a practice to promote public health in vulnerable groups, such as the elderly, who have a higher risk of hypertension. This practice has had limited development in Latin American countries, and therefore, the objective of this study was to evaluate the benefits of forest baths on blood pressure and heart rate in a group of older adults in Guadalajara, Mexico. A program of six sessions was designed, the first to welcome and recognize the natural environment of the urban forest and the other five dedicated to each of the senses (hearing, touch, smell, sight, and taste), using the methodology of the Forest Therapy Hub (FTHub). The type of study was observational (before and after) with a single group, where the participants' blood pressure and heart rate were evaluated. The results obtained showed significant effects of FB on reduction in high systolic blood pressure and diastolic hypertension before and after FB, with no significance on heart rate. Forest baths can be considered as an alternative strategy to manage the risk of hypertension in older adults, due to their ability to induce relaxation and normalize blood pressure levels.

Keywords: forest therapy; forest bathing; hypertension; blood pressure; heart rate; older adults



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1. Introduction

The term “shinrin-yoku”, or forest bathing (FB), was introduced in Japan by the Forestry Agency of the Japanese government in 1982. Initially, it was conceived as an intuitive practice that consisted of immersing oneself in the atmosphere of the forest, using all the senses to experience nature up close, and to reduce stress in people living in cities. [1]. In the little more than 40 years that have passed since then, there has been a marked increase in interest in stress management and relaxation for people living in cities. [2]. Currently, there is a global increase in the use of FB and forest therapy as a practice for the prevention, care, and restoration of health and well-being, with a notable increase in research in countries of different continents, especially in Asia—Korea, Taiwan, and China—and several European countries, [3] such as Spain.

The practice of FB has evolved and has become established as an activity and a model of holistic health and wellness. Its reported benefits are manifested at the physical, psychological, and social levels. In some countries, it has become a strategy to promote the health and well-being of people in different spaces such as urban parks and surrounding wild forests and is used as a tool to support health services.

FB offers exposure to a setting where biodiversity, landscapes, textures, colors, sounds, aromas, water, and wind, among other components of the natural environment, converge, and it is considered a strategy to promote human health and achieve positive states such as relaxation. This is reflected in the reduction in heart rate and blood pressure, the release of stress, and the strengthening of the immune system. All of these effects enhance the process of disease prevention and recovery [4].

In Japan, the practice of FB conceived as “breathing the atmosphere of the forest or bathing in the forest” has gained recognition for its ability to achieve states of relaxation and reduce stress [2]. According to Miyazaki [1] and Tsunetsugu and Miyazaki [5], the practice has restorative effects that can prevent diseases, especially those related to stress, through exposure to natural stimuli that generate physiological relaxation and support the recovery of impaired immune functions. FB is designed as a nature-based practice to reduce stress and improve overall human health and well-being. It helps to adapt to change in a more positive and healthy way, supporting a better quality of life. Forest therapy itself is a nature-based intervention therapy that requires several sessions on an ongoing basis and is led by a guide with specific skills and techniques to use nature as a therapeutic medium to support people with particular needs [6].

During the practice of FB, people are guided to slow down and find tranquility by disconnecting from their daily routine and are invited to experience the natural environment of the forest with their five senses to access healthy stimulation through connection with the natural environment, leading people to receive physiological, psychological, and social benefits from nature.

The starting point of this work is that the dynamics and lifestyles experienced in urban societies, in addition to physical inactivity and chronic stress, are detrimental factors that trigger health deterioration and contemporary diseases. Therefore, numerous efforts have been made to promote the improvement and restoration of human health through activities in nature [7], as well as address the disconnection and nature deficit of urban dwellers.

The Biophilia Hypothesis suggests that humans have developed an intrinsic connection to nature [8]. Building on this concept, the Attention Restoration Theory argues that modern mental fatigue is related to the depleted ability to sustain attention and that spending time in natural environments helps to overcome this fatigue [9]. Moreover, the Stress Reduction Theory explains how contact with nature activates the parasympathetic nervous system, reducing stress and autonomic arousal [10].

Although the literature supports the idea that urban forests provide health benefits in cities with a variety of conditions, the reality is that much of the world’s urban population does not have access to these types of environments.

Given that the cardiovascular system is a complex network that pumps blood and delivers oxygen and nutrients to every cell in the human body, systolic and diastolic blood pressure are important for health. These two measurements are crucial moments in the cardiac cycle, with systole representing the contraction of the heart during the ejection of blood and diastole representing the relaxation phase to allow blood to enter [11].

According to Goldman and Cecil [12], in industrialized societies, blood pressure increases progressively with age; if individuals lived long enough, almost all (>90%) would develop hypertension. The close relationship between stress and elevated blood pressure has also been emphasized. The physiological response to stress, characterized by the release of stress hormones, has been consistently associated with elevated blood pressure [13]. This phenomenon has been identified as a significant contributor to hypertension, underscoring the importance of addressing psychological factors in the management of cardiovascular health.

The practice of FB has previously been documented as leading to significant reduction in blood pressure [14]. There are studies that support the notion that FB may have a positive effect on the therapy of essential hypertension in the elderly population [15].

Most studies evaluating the beneficial effects of FB on human health have been conducted in different regions of the world, such as Asia (Japan, Korea, China, Taiwan), Europe

(Spain, United Kingdom), Oceania (Australia), and North America (Canada, United States). These studies have provided evidence of remarkable benefits for the physical and psychological well-being of individuals [16]. It is important to note, however, that there has been little research on this topic in Latin American countries. This is based on a search of the National Center of Biotechnology Information (NCBI) database over the last five years using the keywords “shinrin yoku” and “forest bathing”. Only 3 studies—out of a total of 237—concern this region.

This absence in the literature highlights the need to contribute to scientific knowledge in order to better understand the potential beneficial effects of the practice of FB in Latin American populations.

The objective of this research was to document and evaluate the beneficial effects of FB on blood pressure and heart rate in a group of individuals between 60 and 77 years of age in Guadalajara, Mexico. The proposed hypothesis is that forest bathing, performed in urban forests with environmental quality and therapeutic characteristics, contributes to the reduction and normalization of blood pressure in risk groups. We intend to contribute to the scientific knowledge of the beneficial effects of FB in older adults in a metropolitan area.

2. Materials and Methods

An FB program was conducted for a group of 11 older adults (60 years old and older) with self-reported stress. Six sessions of two hours each were conducted during the month of May. The participants had the functional capacity to perform independent activities in nature. The invitation to participate in the program was made through an open call at the University System for the elderly of the University of Guadalajara, and they agreed to participate on a voluntary basis.

FB was conducted by a guide trained by FTHub, who acted as a non-intrusive facilitator in the generation of reflective processes, thoughts, emotions, and positive psychological states in the participants, which were derived from their exposure to nature through the five senses, to achieve states of relaxation. Circuits of approximately 1 km were designed based on the characteristics and natural elements present in the environment of an urban forest in Guadalajara, Mexico, with environmental quality, therapeutic characteristics and attributes, infrastructure, and safety. The method used was that proposed by the FTHub [3] based on activities in nature. The first phase involved sensory activities related to the five senses: sight, hearing, touch, smell, and taste; the second phase involved connecting people with the elements of the environment; and the third phase involved integrating all the experiences.

2.1. Participants

Inclusion criteria were people over 60 years of age who were physically and mentally functional, interested in improving their health and well-being, able to walk approximately 1 to 1.5 km in the forest, with a completed participant registration form and signed informed consent, and with a commitment to participate in a total of six sessions (one welcome session and five forest therapy sessions).

Participants were women (82%) and men (18%), most of whom had at least one chronic disease (64%) and reported taking at least one medication during the study period (55%).

Of the participants, 73% had a history of some type of outdoor activity. The most common activity was walking (more than three times per week: 55%; twice per week: 18%), as indicated in Table 1.

Table 1. Characteristics of the study population.

<i>Characteristic</i>		
	Number	Percentage (%)
<i>Sex</i>		
Female	9	82%
Male	2	18%
<i>Age</i>		
61–64 years old	2	18%
65–68 years	5	46%
69–72 years	2	18%
73–77 years	2	18%
<i>Chronic degenerative diseases present</i>		
Diabetes mellitus type 2	4	36%
Cancer	2	18%
Systemic arterial hypertension	2	18%
Lower back pain	2	18%
Diverticulitis	1	9%
Angina pectoris	1	9%
Rheumatoid arthritis	1	9%
Osteoporosis	1	9%
<i>Use of medications</i>		
Yes	6	54%
No	5	46%
<i>History of previous activities in nature</i>		
Yes	8	73%
No	3	27%
<i>Type of activities in nature</i>		
Walking	7	64%
Camping	4	36%
Observation and contemplation of nature	4	36%
Hiking	1	9%
Fishing	1	9%
Bird watching	1	9%

Source: prepared by authors.

All the participants were able to complete the walk in the forest and were informed about the objectives of the project when they voluntarily signed the informed consent and commitment to participate form.

2.2. Study Site

The study site was the Los Colomos Urban Forest, located in the northwestern part of the city of Guadalajara, Mexico (Figure 1).



Figure 1. Location of the Los Colomos urban forest. Photo Luis Díaz Reynoso, 2011.

According to the work done by Díaz, the Los Colomos Urban Forest [17] is a green infrastructure in the city of Guadalajara that is characterized by a peaceful environment, which is essential to reducing stress and providing visitors with energy.

The Los Colomos Forest is an important regulator of air quality, particularly with regard to particles less than 10 microns, which are among the most prevalent pollutants exceeding the city's air quality standards. This is mainly attributed to the park's size, tree density, topographic diversity, and the presence of natural springs. These four attributes also mitigate the noise generated by the city's high vehicular traffic levels.

Furthermore, the forest is recognized as serving as a temperature regulator, which is why it is considered a site that mitigates exposure to risks related to increasingly frequent and intense heat waves in the urban area of Guadalajara.

The forest covers 92 hectares, with a forest mass of 32,000 trees, fauna, natural water springs, lakes, jogging tracks, sports fields, a Japanese garden (a space that celebrates the friendship between the sister cities of Guadalajara and Kyoto), and an infrastructure that currently promotes cultural activities.

There are six paths in the forest; one is a welcoming path for the recognition of and introduction to the natural environment, and five are designed for forest therapy sessions, where each of the senses (sight, hearing, touch, smell, and taste) were the central articulating axis of the activities in nature during the three stages established in the method proposed by the FTHub [3] for each of the sessions. Details of the sessions are listed as follows.

- Session 1: Welcome participants and recognize the natural environment of the urban forest. Distance: 600 m.
- Session 2: Sense of hearing. Participants were invited to listen to their breathing, the rustling of dry leaves, the singing of birds, and the wind. Distance: 725 m.
- Session 3: Sense of touch. Different textures of plants, leaves, rocks, wind, and soil were chosen for the participants to feel on their skin. Distance: 575 m.
- Session 4: Sense of smell. The aromas that the forest offers through leaves, stems, and flowers were identified. Distance: 600 m.
- Session 5: Sense of sight. The participants observed the landscape, water, fish, squirrels, rocks, big trees, and bushes. Distance: 650 m.
- Session 6: Sense of taste. Participants were invited to taste leaves and flowers of edible species directly or through infusions. Distance: 1400 m.

At the end of each session, integration activities were carried out, where some expressions were made through natural elements present in the forest, and the participants shared their experiences during the session and their feelings or comments regarding the activities carried out.

2.3. Research Design

Observational study (before and after) was conducted on a single group and included five FB sessions in which the participants' blood pressure and heart rate were evaluated. Measurements of these variables were taken at two different times, before and after the FB practice, allowing us to analyze and compare the physiological responses before and after the forest bathing experience.

The program was performed in the morning, with a duration of two hours, starting at 10 a.m. Blood pressure and heart rate data were collected before 9:30 a.m. and after, at 11:50 a.m. FB occurred at this time so that the temperature, solar radiation, light, and wind would be more comfortable for the participants.

The two-hour duration period was designed based on a review of the literature, which indicates that spending at least 120 min per week in nature is associated with good health and well-being [18] and that there is no additional benefit to spending more than 200 to 300 min per week in nature.

In each of the sessions, the FB included the three phases of the FTHub method: (1) the "initial phase," which focused on the senses; (2) the "intermediate phase," which focused

on connecting with the environment; and (3) the “final phase,” which aimed to integrate all experiences [3].

Systolic and diastolic blood pressure were considered separate study variables.

Blood pressure was measured using a Welch Allyn WADS44-MC (Welch Allyn, Tijuana, Mexico) aneroid sphygmomanometer with a size 11 cuff and a Littmann Classic III stethoscope (3M, St. Paul, MN, USA). Data collection was performed according to American Heart Association criteria [19], with the participant seated, back upright, feet flat on the floor, and left arm uncovered, obtaining a result for blood pressure in millimeters of mercury and for the heart rate using an FS20C finger pulse oximeter (Biocorp Europa, Gipuzkoa, Spain), with the ring finger measurement recording the number of heartbeats per minute. All measurements, including pre- and post-measurements, were performed by general practitioners.

Based on the information gathered from the literature, a decision was made to separate the analysis of the systolic and diastolic phases rather than approach them together. This approach allowed a more detailed examination of the benefits of FB. This analytical strategy was supported by a previous study [16], which also chose to treat these phases separately, allowing for a more direct comparison of the results obtained.

The World Health Organization (WHO)’s classification was used to classify blood pressure because it is an epidemiologically based classification that is shared by most other classifications.

According to the WHO [20], blood pressure is categorized as follows: <120 mm Hg systolic and <80 mm Hg diastolic—normal, 130 mm Hg systolic and/or 89 mm Hg diastolic—prehypertension, and ≥ 140 mm Hg systolic and/or ≥ 90 mm Hg diastolic—hypertension.

2.4. Data Analysis

In this study, blood pressure and heart rate measurements were compared before and after the FB intervention in the 11 participating older adults. A database with a total of 45 records of study variables that met quality criteria was obtained, as shown in Table 2.

Table 2. Study population and number of records/participant.

Participants			Num. of Sessions in Which He/She Participated (Maximum 5)	Disease That Increases the Risk of Vascular Complications	Highest Systolic Pressure	Highest Diastolic Pressure
Num.	Sex	Age (years)			mm Hg	mm Hg
1	Female	61	4		128	87
2	Female	64	3		125	87
3	Female	66	5	Diabetes type 2	149	92
4	Female	67	4		169	97
5	Female	67	2	Diabetes type 2	140	86
6	Male	68	5		129	90
7	Male	68	5	Diabetes type 2	132	87
8	Female	69	5		123	82
9	Female	71	3	Diabetes type 2	118	82
10	Female	75	5		123	87
11	Female	77	4		139	100
Total			45			

Source: prepared by authors.

Descriptive statistical analysis was performed using mean and variance. Inferential analysis was performed using a small sample *t*-test, with a *p* value of 0.05 or less considered significant.

As part of the descriptive statistics, box-and-whisker plots of the study variables were performed.

Pearson's correlation and regression tests were used to determine the trend in blood pressure (diastolic and systolic) and heart rate before and after FB.

3. Results

The 45-record total obtained in the study population during the five sessions allowed us to identify 18 records with elevated blood pressure and six with hypertension, as shown in Table 3.

Table 3. Comparison of blood pressure conditions before and after forest bathing in older adults.

Statistic	High Systolic Blood Pressure (130–140 mm Hg)		High Diastolic Blood Pressure (80–89 mm Hg)		Diastolic Arterial Hypertension (90 mm Hg and Above)	
	Before	After	Before	After	Before	After
Cases	8	8	10	10	6	6
Mean	138.13	122.88	85.00	82.80	93.33	84.33
Variance	97.55	30.69	3.55	52.62	15.46	51.46
<i>T</i>	3.80		0.93		2.69	
<i>P</i>	0.0019		0.335		0.022	
Statistical Significance	Yes		No		Yes	

Source: prepared by authors.

Note the following in Table 3:

- There is a statistical difference in the high systolic blood pressure recordings before and after FB.
- For high diastolic blood pressure, no statistically significant differences were observed before and after FB, but significance was found for values equal to and greater than 90 mm Hg.

For heart rate, the results are shown in Table 4.

Table 4. Comparison of average heart rate before and after forest bathing.

Statistic	Heart Rate Before	Heart Rate After
Cases	11	11
Mean	77.33	75.33
Variance	144.73	123.53
<i>T</i>	0.55	
<i>P</i>	0.28	
Statistical Significance	No	

Source: prepared by authors.

It should be noted that the average heart rate of the groups before and after FB decreased by two beats per minute (not significant).

Based on the total of 45 systolic and diastolic blood pressure recordings—before and after FB—in both types of pressure, there is a decrease in mm Hg value, with diastolic pressure showing a significant difference.

There is a trend in diastolic and systolic blood pressure after intermittent exposure to a five-session FB program; this effect is most evident in the negative correlation and regression values shown in Table 5.

Table 5. Cumulative effect of number of FB sessions (x) on blood pressure levels in older adults (y).

Variables *	Correlation	Regression	Trend
Systolic blood pressure FB session 2 and session 6	−0.483	$y = -2.27x + 134.44$	Inversely proportional
Diastolic blood pressure FB session 2 and session 6	−0.557	$y = -1.6x + 91.6$	Inversely proportional

* Note: session 1 was a welcoming session for participants to become familiarized with the natural environment. Source: prepared by authors.

4. Discussion

According to its design, this study shows validity and reliability mainly for the study group. However, these results can guide strategies and tactics for the analysis of the impact of FB on blood pressure.

The positive influence of forest bathing on systolic and diastolic blood pressure in older adults found in this research conducted in Guadalajara, Mexico, supports the existing literature on the benefits of exposure to natural environments and FB on cardiovascular health [13,15,21]. The results add to the evidence that FB has a statistically significant beneficial hypotensive effect in the population of older adults.

The significant reduction in systolic and diastolic blood pressure may be attributed to nature's ability to induce a relaxation and stress reduction response consistent with that reported by other authors [22].

The variability in diastolic blood pressure results, when in high-pressure conditions (80–89 mm Hg), does not show significance ($p = 0.33$), but it does at a level greater than or equal to 90 mm Hg ($p = 0.02$), suggesting that FB could be a public health strategy to reduce the risk of hypertension [15].

The lack of significant changes in heart rate found in this study is consistent with those reported by other authors [15,21] and could be due to several factors, including individual adaptation to the FB experience.

The failure to find a significant correlation between BFs and heart rate may be attributed to the fact that this study was limited to the month of May. Previous studies [23] have reported significant findings when examining data from different seasons of the year where changes in air quality and atmospheric environment were observed as mainly influenced by volatile organic compounds (VOCs) and negative air ions (NAIs).

Taken together, these findings underscore the importance of considering systolic and diastolic blood pressure as key indicators when assessing the cardiovascular effects of FB in older adults [13,15,22].

As limitations of this work, we consider the size of the study population and the peculiarities of working with older adults, recognizing that they may have a greater perceived benefit from this practice, adding the preponderance of women as another limitation.

The findings presented here are specific to older adults between the ages of 61 and 77 and should not be assumed to apply to other age groups.

This study provides a basis for future research to further explore the underlying mechanisms and the consistency of these findings in different populations and natural environments.

Given that blood pressure is the result of the interaction of heart rate, blood viscosity, and vascular resistance, according to our results, FB influenced the study group, affected blood pressure values, and reduced or improved vascular resistance, leading us to recognize FB as an adjuvant therapy for multidisciplinary management in the prevention and treatment of arterial hypertension.

5. Conclusions

In this study, performing FB in a five-day intermittent program in older adults with high systolic blood pressure (130–140 mm Hg) resulted in a significant difference in this group, as did cases with diastolic blood pressure greater than or equal to 90 mm Hg. Heart rate did not show statistically significant changes.

A guided FB intervention program comprising five sessions, designed for older adults, conducted in an urban forest that has over a century-long history, located within the city limits, and characterized by permeable soils, significant biodiversity, and a sizeable area (as the one undertaken in this study), following the method proposed by Forest Therapy Hub [3], is recommended as an option for healthy life habits in large cities to reduce blood pressure in older adults. It enables states of relaxation and emotional experiences that have a positive and significant potential to reduce blood pressure in at-risk individuals.

The implementation of FB could be considered as a comprehensive intervention strategy to improve cardiovascular health in older adults.

The findings presented here are representative of an urban park of nearly 100 hectares, with diverse access roads and public transportation and which is part of the city's history. The park has a diverse range of reliefs, plants, and animals, as well as the presence of water, enabling a visitor to detach from the stressful dynamics of the city.

It is recommended that additional studies be included for the same age group and for different age groups with similar health conditions.

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