

Effects of Cinnamomum Camphora Forest Environment on Elderly Patients with Hypertension: Implications for Adjunctive Therapy

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Abstract: Objectives: Increasing evidence demonstrates the benefits of forest environment on human health. However, the effect of tree-species-specific forest environment on human health was rarely studied. As one of the medical plants, *cinnamomum camphora* (*C. camphora*) have been found to possess anti-inflammatory activities. Thus, the present study explored the effects of *C. camphora* forest environment on elderly patients with hypertension (HTN). **Study design:** Cohort study. **Methods:** 31 elderly patients with essential HTN were randomly divided into two groups. Blood pressure (BP), pulse oxygen saturation (SpO₂%), heart rate (HR), heart rate variability (HRV) and levels of plasma high-sensitive-reactive protein (hs-CRP), as well as profile of mood states (POMS) test, were measured. Categorical variables were compared by Chi-square analysis. T-test was used to compare continuous data. **Results:** After three-day/ two-night forest bathing, patients in the forest group showed significantly lower levels of diastolic blood pressure (DBP), low frequency (LF), the ratio of low frequency and high frequency (LF/HF) and hs-CRP than in control group. However, levels of SpO₂% and high frequency (HF) were greatly higher than control group. Furthermore, negative mood subscale scores of POMS were significantly lower following forest bathing, while the positive score was much higher. **Conclusions:** *C. Camphora* environment could significantly decrease the DBP and inflammatory level, balance the autonomic activity and improve the mood state of participates, implying it might be an adjunctive therapy for HTN patients.

1. Introduction

Nowadays, artificial stimulations that filled in urban environments have been considered as a negative factor on human health. More attention has thus been paid on the natural environment, such as forest, which is an important factor in health promotion models¹. In the past decades, forest bathing (also named forest therapy) has been shown to alleviate the stress and anxiety²⁻⁷, boost the immune function⁸⁻¹⁰ and increase the expression of anti-cancer proteins⁸. In addition, our previous works have demonstrated that forest bathing have positive influence on young healthy student, and that it might be used as an adjunctive therapy on elderly patients with hypertension (HTN), chronic obstructive pulmonary disease (COPD) and chronic heart failure (CHF)¹¹⁻¹⁷.

In the forest environment, apart from numerous negative ions, abundant volatile and non-volatile substances called phytoncides (wood essential oil) were emitted from plants. Thus, different forest environment has different microenvironment with different phytoncides, which may have discrepancy influence on different subjects. *Cinnamomum camphora* (*C. camphora*) is an evergreen

broad-leaved tree belonging to the family Lauraceae, which is widely distributed in south China and often used as a virescent tree in urban gardens and streets. Due to its beautiful shape, it has become the “civic tree” in 19 cities in China, including Hangzhou¹⁸. Besides, as one of the important economic trees in China, *C. camphora* has long been prescribed in traditional medicines for the treatment of inflammation-related diseases such as rheumatism, sprains, bronchitis, asthma, indigestion and muscle pains¹⁹. Therefore, it is reasonable to speculate that different forest environment, for example *C. camphora* forest environment, has discrepancy influence on different subjects. However, related study hasn't been reported. In current study, we performed a forest bathing at *C. camphora* forest environment to determine the influence of tree-species-specific forest bathing, *C. camphora* forest, on elderly patients with HTN.

2. Methods

2.1. Subjects and Study Design

From 19 October 2017 to 21 October 2017, 31 patients with HTN from Hangzhou City participated the study. They were randomly divided into two groups consisting of 11 in control group and 20 people in forest group according to the ratio of 1:2. The inclusion and exclusion criteria and experimental program were described in previous study¹¹. All procedures of our study were in line with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the ethics committee of Zhejiang Hospital. Signed informed consent was obtained from every subject.

2.2. Blood Pressure (BP), Heart Rate (HR), Oxygen Saturation (SpO₂%) and Heart Rate Variability (HRV) Measurement

Systolic, diastolic blood pressure (SBP, DBP) and HR were obtained from the right arm using a portable digital sphygmomanometer (HEM-7000-E, Omron, Kyoto, Japan). The fingertip pulse oximeter (YUWELL YX301) was used to measure pulse SpO₂%. HRV, including low frequency (LF), high frequency (HF) and the ratio of low frequency and high frequency (LF/HF), were assessed by SA-3000P (Medicore Inc., Seoul, Korea).

2.3. Bio-indicators Determination

Plasma level of high-sensitive-reactive protein (hs-CRP) was determined by an automatic biochemistry analyzer (Hitachi Model 7600 Series Automatic Analyzer, Japan).

2.4. Profile of Mood States (POMS) Evaluation

The standard version of the POMS questionnaire was used to measure mood states²⁰.

2.5. Data Analysis

Categorical variables and continuous data were compared by Chi-square analysis and T-test, respectively. All statistical analyses were completed using the SPSS 19.0 software (SPSS China, Shanghai, China), $P < 0.05$ was considered statistically significant.

3. Results

3.1. Clinical Characteristics of the Participants

The clinical characteristics of the participants were shown in Table 1. No significant differences in the baseline characteristics of the participants, including gender, age, body mass index (BMI), SBP, DBP, HR, SpO₂%, HRV, hs-CRP and POMS score, were observed between the two groups.

Table 1. Baseline level of the indicators of subjects before experiment (Mean±SD)

	Baseline of control group (n=11)	Baseline of forest group (n=20)	p-value
Age (year)	73.91±6.640	73.50±5.889	0.861
Gender (male/female)	12/8	7/4	0.106 ^a
BMI (kg/m ²)	23.564±2.176	23.759±1.768	0.788
SBP (mmHg)	137.64±5.887	139.25±12.594	0.693
DBP (mmHg)	72.45±4.275	73.75±7.691	0.611
HR (bpm)	70.00±5.514	74.40±7.769	0.108
SpO ₂ (%)	97.09±1.700	97.85±1.089	0.202
LF (m/s ²)	39.786±21.766	40.681±15.888	0.896
HF (m/s ²)	59.760±22.164	59.319±15.888	0.949
LF/HF	0.918±0.781	0.887±0.903	0.922 ^b
hs-CRP (mg/L)	3.064±1.777	3.135±2.968	0.943 ^b
Tension-anxiety (T)	14.874±1.794	14.686±1.489	0.757
Depression-dejection (D)	29.091±2.343	29.105±1.747	0.985
Anger-hostility (A)	23.18±1.328	24.00±1.170	0.086
Vigor-activity (V)	23.82±0.982	23.65±1.089	0.674
Fatigue-inertia (F)	15.45±1.214	14.55±1.234	0.059
Confusion-bewilderment (C)	16.00±0.775	15.60±1.095	0.294

^a the chi-squared test was used; ^b Mann-Whitney U test was used; others were analyzed by using the independent-samples t test.

Abbreviation: BMI, body mass index; SDP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; hs-CRP, high-sensitive-reactive protein.

3.2. Effects of C. Camphora Forest on BP and SpO₂%

After experiment, the level of DBP was significantly lower in the forest group than in control group (67.95±2.69 Vs 71.64±4.20, P<0.05; Figure 1). In contrast, the value of SpO₂% was significantly higher in forest group than in control group (97.55±0.82 Vs 98.10±0.64, P<0.05; Figure 1). There were no obvious alteration was observed for HR and SBP.

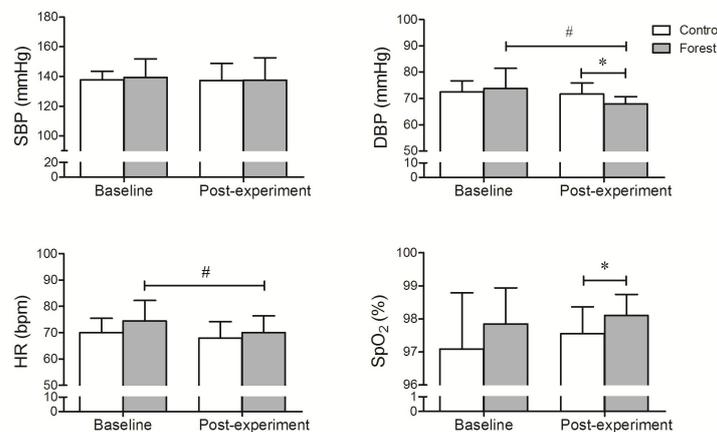


Figure 1. Effects of C. camphora forest bathing on BP-related indicators. *p<0.05; #p<0.05, analyzed by the Kruskal-Wallis test followed by the Dunn-Bonferroni test. SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; SpO₂%, pulse oxygen saturation

3.3. Influence of Forest Bathing on HRV

As an important tool for studying autonomic control of the heart and autonomic dysfunction, HRV has been widely measured in heart diseases such as cardiac infarction, heart failure, arrhythmia and syncope²¹. As shown in Figure 2, C. camphora forest bathing significantly decreased the levels of LF (35.40±13.98 Vs 50.88±14.32, P<0.05) and LF/HF (0.68±0.52 Vs 1.36±1.29, P<0.05), when

compared with control group. Instead, HF level was significantly higher in forest compared to the control's (60.54 ± 14.26 Vs 48.37 ± 14.42 , $P < 0.05$).

3.4. Inflammatory Cytokines Level

Inflammatory factors, hs-CRP, were analyzed in present study. At the end of the experiment, subjects experiencing forest bathing showed a significantly lower level of hs-CRP than that of the control group (1.77 ± 1.09 Vs 3.34 ± 1.80 , $P < 0.05$, Figure 2). These data suggested that *C. camphora* forest bathing alleviated the level of inflammatory response in elderly patients with HTN.

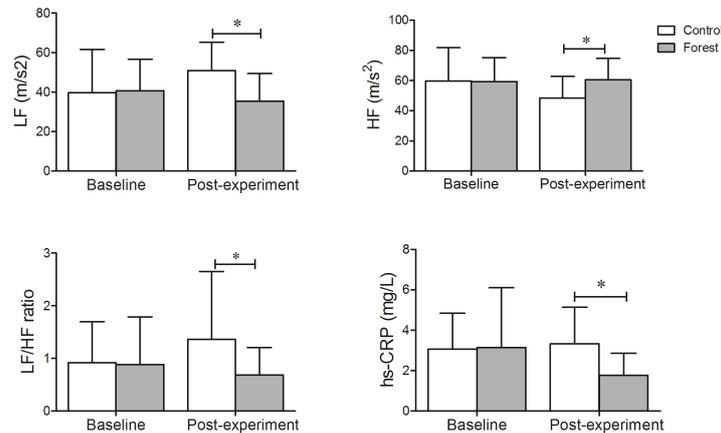


Figure 2. Influences of *C. camphora* forest bathing on HRV and inflammatory cytokines. * $p < 0.05$, analyzed by the Kruskal-Wallis test followed by the Dunn-Bonferroni test. LF, low frequency; HF, high frequency; LF/HF ratio, low frequency/high frequency ratio; hs-CRP, high-sensitive-reactive protein.

3.5. Mood State of Participants

From the POMS subscale score, as is shown in Figure 3, after forest bathing, much lower scores of tension-anxiety (T), depression (D), confusion (C) and fatigue (F) were found in the forest group compared to the control group (T, 12.90 ± 0.97 Vs 15.55 ± 0.93 , $P < 0.05$; D, 25.72 ± 1.45 Vs 29.82 ± 1.08 , $P < 0.05$; C, 13.75 ± 0.97 Vs 16.64 ± 1.36 , $P < 0.05$; F, 13.80 ± 1.11 Vs 15.55 ± 0.69 , $P < 0.05$) or itself baseline scores (T, 12.90 ± 0.97 Vs 14.69 ± 1.49 , $P < 0.05$; D, 25.72 ± 1.45 Vs 29.11 ± 1.75 , $P < 0.05$; C, 13.75 ± 0.97 Vs 15.60 ± 1.10 , $P < 0.05$; F, 13.80 ± 1.11 Vs 15.55 ± 1.23 , $P < 0.05$), while it has opposite trend in the score of vigor-activity (V, 26.90 ± 1.59 in forest, 24.36 ± 1.29 in control and 23.65 ± 1.09 in forest baseline, $P < 0.05$).

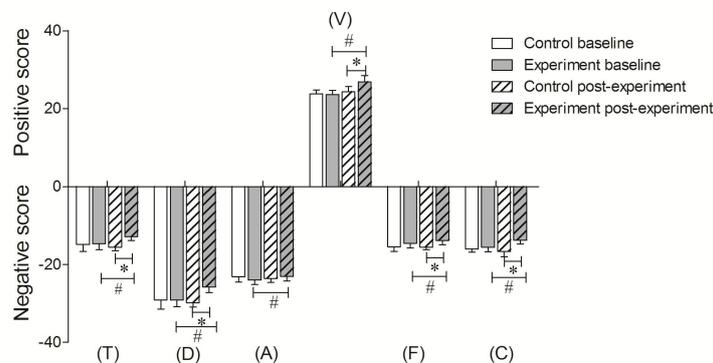


Figure 3. Impacts of *C. camphora* forest bathing on the mood state of subjects. * $p < 0.05$; # $p < 0.05$, analyzed by the Kruskal-Wallis test followed by the Dunn-Bonferroni test. T, tension-anxiety; D, depression; A, anger-hostility; F, fatigue; V, vigor-activity; C, confusion

4. Discussion

The present study aimed to determine the influence of tree-species-specific forest environment on elderly patients with HTN. The results showed that *C. camphora* forest bathing decreased DBP, but increased the level of SpO₂%. In the HRV analysis, values of LF and LF/HF ratio were significantly lower in forest group than in controls, while HF value was statistical higher than in controls, suggesting the more balanced autonomic activity of elderly patients after forest bathing. Interestingly, similar HRV response were often seen in yoga therapy ^{22, 23}. In addition, *C. camphora* forest environment significantly reduced the hs-CRP level and improved the mood state of participates in comparison to the control group. These results indicated that *C. camphora* forest bathing has a health promotion effects on elderly patients with HTN.

C. camphora is an evergreen broad-leaved tree of the Lauraceae family, which is widely distributed in south China and often used as a virescent tree in urban gardens and streets for its beautiful shape. It has become the “civic tree” in 19 cities in China, including Hangzhou ¹⁸. It volatilizes a large number of compounds called phytoncides, which has strong property to anti-fungi and anti-inflammation ¹⁹. Generally, different species volatilize phytoncides with different constituents. The main component of phytoncides emitted from *C. camphora* is oxy-terpene, which accounts for the most abundant constituent in all volatile oils (flowers 50.83%, leaves 70.75%, branches 78.22%) ²⁴. As one of the important natural products, most of terpenes have multiple important physiological activities, such as BP modulator, anti-tumor, antifungal, anti-inflammatory, reducing blood lipid, etc ^{19, 25}. Additionally, *C. camphora* leaves has also been reported as a biosorbent for the removal of copper ions, as well as for toxic air including SO₂, NO₂, and Cl₂, because it has satisfactory absorption ²⁶.

This study has been revealed for the first time that the tree-species-specific forest environment, *C. camphora* forest bathing, has positive influences on elderly patients with HTN, however, the exact mechanisms were not fully understood. This experiment was performed at a *C. camphora* forest area named Changle farm, which is located in Jingshan country, 42 kilometers distant from Hangzhou city (Zhejiang province, China). Averagely, it is 200 meters above sea level and the highest is 800 meters, which is covered a square of 86,658 m² and included 230 various camphor tree species. For comparison, a suburban area in Jingshan country was used. Except for the air humidity, the other factors of air quality in two sites were similar. However, the main components of the VOCs in two sites were obviously different, the one were terpenes and aromatics, and the other was esters and aromatics. Therefore, the possible mechanisms resulted in the significantly discrepancy results of the two experimental sites can be attributed to the different VOCs and the properties in two experimental sites(Supplementary table 1).

Supplementary Table 1. The air quality and constituent of VOCs in two experimental sites

	Suburban area	Forest area
Temperature	19.87±1.57	17.86±1.30
Humidity	71.65±5.20	83.48±2.39 *
Negative ions	304.68±150.42	492.99±97.50
PM2.5	0.04±0.02	0.03±0.01
PM10	0.05±0.01	0.04±0.01
Comfort index	72.33±3.51	69.00±3.00
Terpenes	2.66±3.34	29.26±6.84 *
Hydrocarbons	0	0
Aromatics	48.99±9.05	29.75±11.27 *
Aldehydes	0	13.68±3.30 *
Ketones	2.44±2.31	0
Alcohols	0	0
Esters	35.74±10.52	14.79±6.89 *
Organic acids	0	6.65±8.35
Others	10.17±2.92	5.86±6.18

Note: * independent –samples t-test were used.

In conclusion, although the sample size was small, it is worth noting that C. camphora forest bathing can significantly decrease the level of DBP, LF and LF/HF, increase the levels of SpO₂%, HF and hs-CRP and promoted the mood state of participates. This study has revealed for the first time that C. camphora forest bathing had an adjunctive therapy effect on elderly patients with HTN. Therefore, so it is necessity to conduct a randomized clinical trial with larger sample sizes and longer intervention in the future.

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Competing interests

None.

Ethical approval

All procedures of our study were in line with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the ethics committee of Zhejiang Hospital.

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