

Original Article

Effects of aromatherapy essential oil inhalation on the stress response after exposure to noise and arithmetic subtraction stressor: randomized controlled trial

Iklyul Bae^{1*}, Ji-Ah Song^{1*}, Mikyoung Lee², Myunghaeng Hur²

¹Konyang University, Daejeon, South Korea; ²Eulji University, Daejeon, South Korea. *Equal contributors.

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Abstract: Objective: This study used a nonequivalent control group pretest/posttest design in order to compare the effects of aromatherapy essential oil (EO) inhalation on psychological and physiological responses after exposure to stressors. Methods: This study was a Randomized single Blind Controlled Trial. A total of 95 individuals who met the selection criteria were included as research subjects, and divided into experimental (n=33), placebo (n=31), and control (n=31) groups. In order to determine the effects of aromatherapy EO inhalation, subjects were asked a series of repeated arithmetic subtraction problems, in which they subtracted increments of 17 from 6315 for 2 min following a stressor: 3 min of white noise using a headset. The experimental group was inhaled 2 drops (2 drops=0.1 cc) of the blended EO of *Lavandula officinalis* and *Cananga odorata*, placebo group, 2 drops of 0.9% saline solution; and control group, no inhalation. Measurements of stress scores, stress index, sympathetic nerve activity, serum cortisol levels, and blood pressure were examined in 4 test sessions: prior to the experiment (pre-test), right after exposure to the stressor, 10 min after the experiment, and 30 min after the experiment. Results: The stress index showed significant differences among the three groups (F=4.546, P=.013). Sympathetic nerve activity also showed significant differences among the three groups (F=6.056, P=.003), while cortisol levels were only partially significantly different among the three groups (F=3.110, P=.049). Both systolic (F=4.380, P=.015) and diastolic (F=4.438, P=.014) blood pressure readings showed significant between-group differences. Conclusion: The inhalation of aromatherapy EO was effective in reducing the stress score, stress index, sympathetic nerve activity, serum cortisol level, and blood pressure of participants.

Keywords: Stress, noise, essential oil, sympathetic nerve, cortisol, blood pressure

Introduction

Stress is emerging as an important issue in modern society. Appropriate regulation of stress is a vital element in improving one's health, although individuals manifest varied responses to both routine and diverse stress-inducing factors [1].

Long-term stress can induce physiological responses, including autonomic nervous system (ANS) responses from stimulation of the hypothalamus by the cerebral cortex, and the activated sympathetic nervous system releasing catecholamines [2]. As a result, blood pressure and heart rate increase and cortisol is released into the blood vessels by a hypothala-

mus-pituitary-adrenal response [3]. According to a study by Lee, Hwang, and Kim [4], excessive excretion of cortisol from persistent and excessive stress can cause diverse problems associated with the cardiovascular, digestive, and musculoskeletal systems, and cause lost homeostasis and emotional stability. It can also cause disease as an ineffective stress coping mechanism.

As such, there is an increasing interest in non-pharmacological treatments without adverse effects as intervention measures for stress relief [5]. With the recent surge in interest in complementary and alternative medicine (CAM) therapies, comprehensive care for stress intervention is being emphasized [6]. There have

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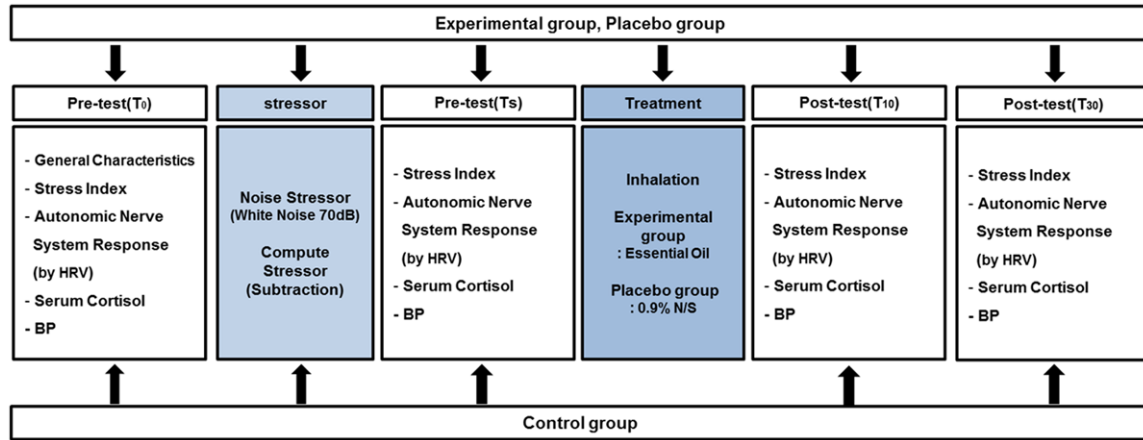


Figure 1. Study design.

been previous studies on the effects of abdominal massage for providing stress relief [7], the effects of hand massage on stress responses [4], and the efficacy of aromatherapy on stress [8]. Massage therapies, as many have pointed out, are limited by the need for skilled practitioners to perform the massage [9], as well as difficulties in sustaining the therapy on an individual basis due to the need for separate spaces and/or equipment [7].

On the other hand, inhalation of essential oil (EO) involves both short application times and quick physical response in patients, with EO components being detected in blood within 5 min and reaching maximum levels within 20 min. It is a non-invasive method that affects the brain directly, is a CAM therapy that is not restricted by time or place, is fast acting, and shows virtually no adverse effects [5]. Further, this method has an outstanding efficacy, as it spreads to the entire body through respiration to induce chemical reactions with enzymes, brings about enhanced psychological and physical relief effects [10], and can positively affect blood flow [11].

Earlier studies on stress intervention using aroma inhalation have examined its effects on blood pressure and stress response in patients with essential hypertension [9], its effects on physical resistance to ANS and stress in patients after stroke [12], and its effects on patients with breast cancer receiving radiation therapy [13]. However, many of these studies were limited either to participants with various

diseases or to pretest/posttest evaluations on experimental treatments.

Thus, the present study was conducted on healthy adults, in order to investigate intervention effects on both relief and prevention of stress induced after exposure to noise and arithmetic subtraction stressor. Moreover, for the development of scientific and objective nursing interventions, environmental effects were minimized and, as a measure to control exogenous variables, the study was conducted in a laboratory with constant environmental settings. Furthermore, by identifying the effects of EO inhalation on stress over time, we could better investigate its time-based anti-stress effects.

Participants and methods

Study design

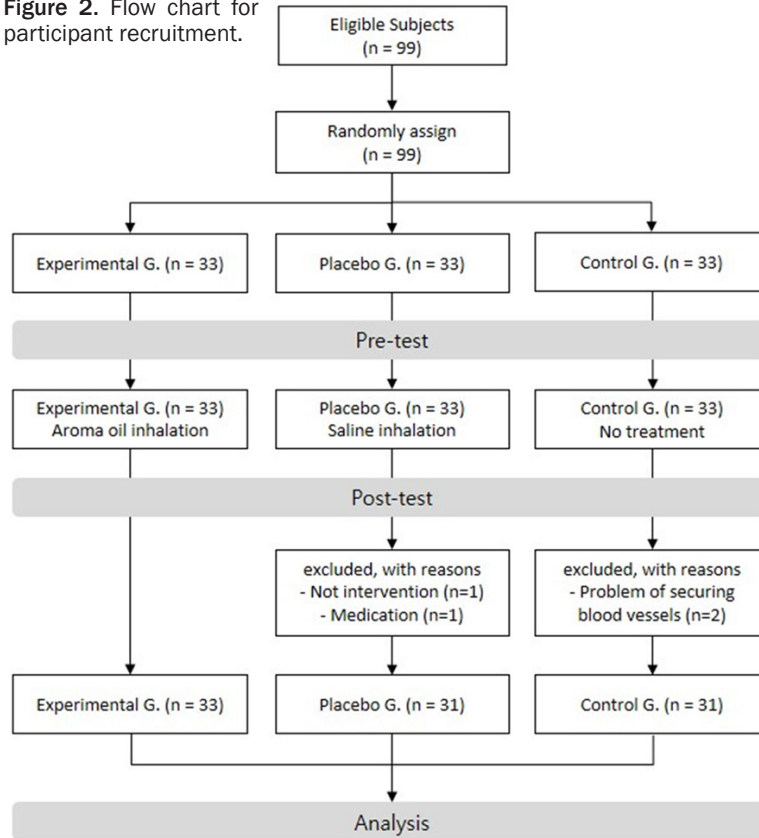
The present study used a parallel control group non-synchronized design to examine the effects of EO inhalation on stress index, sympathetic/parasympathetic nerve activities, cortisol, and blood pressure after exposure to noise and arithmetic subtraction stressor (Figure 1).

Participants

The study participants consisted of those who were recruited volunteers between July and September 2013. Selection criteria included understanding the study objectives and volunteering to participate; male and female adults

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Figure 2. Flow chart for participant recruitment.



between the ages 20 and 35 years and exclusion criteria were suffering from rhinitis, asthma, or cold that could affect sense of smell. Individuals who were currently receiving treatments for physical or mental conditions or who were taking anxiolytics or hypnotic medications were excluded.

Data were collected in accordance with the following procedures.

(1) Candidates were recruited through an announcement, and selections made after verifying the status on any diseases and medications taken.

(2) Explanations on experimental treatment, investigation methods, self-determination, and self-withdrawal were given to the candidates, and signed consent forms were received from those consenting to participate.

(3) The MS Excel program (Microsoft, Redmond, Wash) was used to randomly assigned participants to the experimental, placebo, and control groups.

(4) Data were collected from the control, placebo, and experimental group, in order, as part of a non-synchronized design.

(5) The data ID was codified to numbers and analyzed anonymously following data collection.

Concealment and blinding

After securing a list of participants through the recruitment announcement, the experimental, placebo, and control groups were randomly assigned. As a non-synchronized design, data were collected from the control group first, followed by the placebo group and then the experimental group. After group assignment, the participants were not given any information regarding their group assignment.

Sample size calculation

Sample size was obtained by inputting alpha value, statistical power, and effect size into theG-power 3.1.7 program (Heinrich Heine University, Dusseldorf, Germany). To compare the differences between the three groups, effect size was calculated, based on a previous study [9], by inputting the number of groups, standard deviation, and mean, which resulted in an effect size of .34. The sample size was calculated with the effect size, significance level (α), and the power ($1-\beta$), .34, .05, and .9, respectively into the formula, it was determined that the total sample size needed was 90. In the present study, the total number of participants was 99, allowing for a 10% drop-out rate, and the experimental, control, and placebo groups were assigned 33 participants each. However, 2 people in the control group dropped out owing to problems in securing an IV line, and 2 in the placebo group dropped out: one for inability to take the treatment medication and the other for inability to participate in the experiment. Therefore, the final number of participants was 95: with 33, 31, and 31 participants

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in the experimental, control, and placebo groups, respectively (**Figure 2**).

Outcome measures

Stress index

The stress index represents the value for stress conditions based on balance of the ANS derived from heart rate variability (HRV) measured continuously for 5 min using the Canopy 9 professional 4.0 (IEMBIO, Gangwon-do, Korea), an ANS measurement instrument. The stress index is based on a scale of 1 to 10, with higher scores indicating greater exposures to stress conditions.

Low frequency activity

Sympathetic nerve activity was measured by low frequency activity of HRV which is the value representing the area of low frequency (LF), as a sympathetic nerve index. This was calculated from the value using HRV, measured continuously for 5 min with Canopy 9 professional 4.0. Higher sympathetic nerve activity values indicate greater exposures to stress conditions.

Serum cortisol

Cortisol is a response variable for stress. Thus, our experiments were conducted between 4 pm and 7 pm, when cortisol variability is lowest. In order to minimize the influence of external factors on cortisol, minimizing smoking, controlling diet, and other precautions were announced in advance, and compliance was verified with all participants before administering experimental treatments.

To measure serum cortisol levels, a nurse performed a venipuncture; after which, a 3-way syringe stopcock was used to secure a vein in order to draw 3 mL of venous blood. The collected blood was centrifuged in a well-equipped laboratory and then cold-stored. Then, the specimens were sent to laboratories for analysis of a cortisol with Cobra 5010 Quantun analysis equipment (Packard Instrument Co., Meridian, Conn); the unit of analysis was mcg/dL.

Blood pressure

For measurement of participants' blood pressure, an electronic blood pressure monitor (Omron IA2, Kyoto, Japan) was used to measure

the systolic and diastolic pressures. Measurements were taken from the upper arm in a sitting position after the participants were stabilized.

Laboratory preferences

The area of the laboratory was 19.83 m², and the temperature inside the measurement site was set to 22 to 24°C, which was considered to be the appropriate temperature for the human body, as well as for measuring ANS response and blood pressure. The laboratory was well-ventilated, and the measurement site was furnished with a sofa, a table, and chairs to provide a comfortable environment for the participants.

Intervention

Stressor

White noise refers to a series of noises with a frequency that is distributed in a continuously uniform manner throughout the entire audible range of 20 to 20,000 Hz, as well as fixed sounds that do not have specific audible patterns. As white noise has been found to have negative effects on mental arithmetic operations, as well as physical and mental health, it was effectively used as the stressor. Based on the results from a previous study [14], the participants had heard 70 dB white noise for 3 min through headphones (MDR-1R, Sony Corporation, Tokyo Japan) as a stressor, after which, as a stress stimulus via mental arithmetic operations, they were instructed to perform subtractions, starting from 6,135 and continuously subtracting 17 from the resultant, for 2 min. If an incorrect answer was given, they were instructed to start over from the beginning.

EO selection

Based on the results from a study by Oh [10], which reported that blending 2 to 3 aroma EOs with similar effects maximizes their synergistic effects, as well as advice from experts that have completed international aromatherapy certifications, oils that affect stress and ANS [15] were selected and blended. Accordingly, the oils used in the present study were *Lavandula officinalis*, which has effects on subduing excitation of the heart, reducing blood pressure, and treating hypertension and heart

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Table 1. Homogeneity test on general characteristics of participants

Characteristics/Variable	Category	Exp. (n=33)	Plac. (n=31)	Cont. (n=31)	F/X ²	P
		Mean ± SD or N (%)	Mean ± SD or N (%)	Mean ± SD or N (%)		
Age (yr)		21.45±1.94	21.06±1.98	21.74±1.67	1.024	.363
Height (cm)		163.91±6.73	163.48±7.42	165.61±8.08	0.718	.491
Body weight (kg)		57.21±11.05	55.06±8.79	58.23±11.21	0.744	.478
Gender	Male	5 (15.2)	7 (22.6)	9 (29)	1.795	.408
	Female	28 (84.8)	24 (77.4)	22 (71)		
Drinking alcohol	No	20 (60.6)	14 (45.2)	20 (64.5)	2.659	.265
	Yes	13 (39.4)	17 (54.8)	11 (35.5)		
Smoking	No	31 (93.9)	30 (96.8)	26 (83.9)	3.712	.156
	Yes	2 (6.1)	1 (3.2)	5 (16.1)		
Initial Stress Index		2.67±1.51	3.26±1.94	2.48±1.45	1.867	.160
Initial LF activity		5.42±0.58	5.70±0.68	5.83±1.08	2.090	.130
Initial Cortisol (mcg/dL)		7.65±3.64	8.15±4.54	6.85±2.80	0.957	.388
Initial SBP (mmHg)		114.85±10.35	116.06±10.15	115.90±12.10	0.250	.779
Initial DBP (mmHg)		72.64±8.92	72.81±5.81	72.67±6.94	0.105	.901

Exp.: Experimental group, Plac.: Placebo group, Cont.: Control group. Mean ± SD: Mean ± Standard Deviation. SBP: Systolic Blood Pressure. DBP: Diastolic Blood Pressure. LF: Low Frequency.

palpitations, and *Cananga odorata* which is effective in reducing blood pressure, relieving heart palpitations and nervous tension, and mental relaxation. *Lavandular officinalis* and *Cananga odorata* were blended at a 1:1 ratio and cold-stored before use.

Data collection

Pre-surveys (T₀): In terms of study procedures, pre-surveys were conducted when the participants first visited the laboratory. After participants seated in a chair for 5 min to be stabilized, an IV line was secured, using a 3-way syringe stopcock for blood collection, followed by another 5 min for stabilization. After the stress score was measured, blood pressure was also monitored. We measured both stress index and sympathetic/parasympathetic nerve activities, and then collected and stored 3 mL of venous blood from each participant.

Experimental treatment

The experimental group

After loading the stressor, each participant was stabilized comfortably, followed by EO inhalation. In terms of the inhalation method, two drops of cold-stored EO (2 drops=0.1 cc), a blend of *Lavandular officinalis* and *Cananga odorata*, were dropped onto an aroma stone

and placed 10 cm away from the participant's nose for 10 min of inhalation in a comfortable position.

The placebo group

After loading the stressor, each participant was stabilized comfortably, followed by inhalation of a 0.9% saline. The inhalation method was the same as the experimental group.

The control group

After loading the stressor, each participant was stabilized comfortably for 10 min.

Post-survey (T₁₀, T₃₀)

The first post-survey (T₁₀) was performed 10 minutes after the experiment and the second post-survey (T₃₀) was performed 30 minutes after the experiment. Stress scores, blood pressure, stress index, and sympathetic/parasympathetic activity were measured in each post-surveys. 3 mL of venous blood was collected using a secured 3-way syringe stopcock and stored in a blood-collection container. Afterwards, the participants were instructed to complete the post-survey questionnaire.

Ethical considerations

This study was approved (EU 13-17) through the institutional review board of our institution.

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Table 2. Comparison on stress index, sympathetic/parasympathetic nerve activities, cortisol, systolic/diastolic blood pressure between the experimental, placebo, and control groups (N=95)

Variable		Exp. (n=33)	Plac. (n=31)	Cont. (n=31)	F	P	F (p)*
		Mean ± SD	Mean ± SD	Mean ± SD			
Stress Index	T ₀	2.67±1.51	3.26±1.94	2.48±1.45	1.867	.160	Time 49.336 (<.001)
	T _s	4.70±1.68	5.61±1.78	4.06±1.80	6.085	.003	G*T 3.229
	T ₁₀	3.21±1.69 ^a	5.06±2.11 ^b	3.65±1.78 ^b	8.519	<.001	(.004)
	Difference (T ₁₀ -T _s)	-1.48±1.76 ^a	-0.54±1.85 ^b	-0.41±0.76 ^b	4.536	.013	Group 8.811
	T ₃₀	2.73±1.62 ^a	4.61±1.83 ^b	3.10±1.66 ^b	10.791	<.001	(<.001)
	Difference (T ₃₀ -T _s)	-1.96±1.82 ^a	-1.00±1.46 ^b	-0.96±1.16 ^b	4.546	.013	
LF activity	T ₀	5.42±0.58	5.70±0.68	5.83±1.08	2.090	.130	Time 70.312 (<.001)
	T _s	6.12±0.81	6.27±0.85	6.65±1.03	2.890	.061	G*T 5.504
	T ₁₀	5.43±0.68 ^a	6.11±0.63 ^b	6.28±1.06 ^b	9.906	<.001	(<.001)
	Difference (T ₁₀ -T _s)	-0.69±0.64 ^a	-0.15±0.53 ^{a,b}	-0.37±0.47 ^b	7.397	.001	Group 6.560
	T ₃₀	5.08±0.63 ^a	5.77±0.68 ^b	6.02±1.08 ^b	11.322	<.001	(.002)
	Difference (T ₃₀ -T _s)	-1.03±0.64 ^a	-0.49±0.74 ^b	-0.62±0.54 ^b	6.056	.003	
Cortisol (µg/dL)	T ₀	7.65±3.64	8.15±4.54	6.85±2.80	0.957	.388	Time 12.434 (<.001)
	T _s	8.67±5.01	9.60±5.04	8.06±3.26	0.907	.407	G*T 1.25
	T ₁₀	7.69±4.89	8.19±4.65	7.79±4.11	0.108	.898	(.280)
	Difference (T ₁₀ -T _s)	-0.98±2.39	-1.41±1.81	-0.86±2.14	2.756	0.69	Group .447
	T ₃₀	6.74±3.82	7.58±4.42	7.28±3.53	0.377	.687	(.641)
	Difference (T ₃₀ -T _s)	-1.93±3.04 ^a	-2.01±2.22 ^a	-0.62±1.96 ^b	3.110	.049	
SBP (mmHg)	T ₀	114.85±10.35	116.06±10.15	115.90±12.01	0.250	.779	Time 40.145 (<.001)
	T _s	119.45±11.98	119.37±11.08	121.07±11.13	0.475	.624	G*T 4.581
	T ₁₀	109.70±9.07 ^a	115.23±8.70 ^b	117.33±10.34 ^b	6.276	.003	(<.001)
	Difference (T ₁₀ -T _s)	-9.76±6.18 ^a	-4.15±3.84 ^b	-3.90±4.18 ^b	14.87	<.001	Group 1.881
	T ₃₀	107.58±10.30	113.13±10.81	115.23±8.447	5.054	.008	(.158)
	Difference (T ₃₀ -T _s)	-11.87±9.46 ^a	-6.24±9.08 ^b	-5.83±8.82 ^b	4.380	.015	
DBP (mmHg)	T ₀	72.64±8.92	72.81±5.81	72.67±6.94	0.105	.901	Time 19.650 (<.001)
	T _s	74.67±8.56	74.45±7.06	75.03±7.40	0.475	.624	G*T 3.025
	T ₁₀	68.09±8.06 ^a	71.19±7.40	73.40±6.02 ^b	6.276	.003	(.007)
	Difference (T ₁₀ -T _s)	-6.58±5.71 ^a	-3.26±8.83	-1.71±5.77 ^b	4.438	.014	Group 1.444
	T ₃₀	67.64±6.81 ^a	70.06±7.28	72.33±5.85 ^b	5.054	.008	(.241)
	Difference (T ₃₀ -T _s)	-7.03±6.21	-4.38±8.07	-2.70±7.22	2.916	.059	

Exp.: Experimental group, Plac.: Placebo group, Cont.: Control group. Mean ± SD: Mean ± Standard Deviation. *Repeated Measures of ANOVA. G*T: Group * Time. SBP: Systolic Blood Pressure DBP: Diastolic Blood Pressure LF: Low Frequency. T₀: Baseline. T_s: Loading stressor. T₁₀: 10 min after Experimental Treatment. T₃₀: 30 min after Experimental Treatment. Means for each group with different superscript (a, b) indicate a significant difference (Scheffe test; P<.05).

Consent and signatures were received from individual participants, and it was explained to them that they had the right to withdraw participation at any time during the study. Study participants were informed about possible adverse effects from EOs (e.g., vomiting, nausea, allergic reaction, headache) during experimental treatment.

Statistical analysis

The collected data were analyzed using IBM SPSS Statistics 20.0. The test of homogeneity among the three groups was assessed with

X²-test and ANOVA. The test for the differences between pre- and post-experiment conditions of the stress index, sympathetic nerve activity and parasympathetic nerve activity, serum cortisol level and blood pressure were analyzed by ANOVA, Scheffe' method and LSD method. In addition, repeated measures of ANOVA and repeated measures of ANCOVA were performed to analyze the differences in the measurements for stress response, response of autonomic nervous system, cortisol level and blood pressure of the experimental, placebo and control groups according to the time interval.

Results

We performed a homogeneity pre-test on the three groups, and confirmed homogeneity, as no significant differences were seen between the experimental, placebo, and control groups for general characteristics and dependent variables (**Table 1**).

The four measurements taken for verification of the effects of EO inhalation on stress index showed significant differences based on time ($F=49.336$, $P<.001$); the reciprocal action between group and time also showed significant differences ($F=3.229$, $P=.004$) (**Table 2**).

Sympathetic nerve activities showed significant differences based on time ($F=70.312$, $P<.001$); the reciprocal action between group and time also showed significant differences ($F=5.504$, $P<.001$) (**Table 2**).

Repeated-measures analysis of variance (ANOVA) results on cortisol concentration showed no significant differences between the three groups, but the level of decrease did show significant differences between the three groups ($F=3.110$, $P=.049$). The post-hoc analysis results indicated significant decreases in cortisol in the experimental and placebo groups, in comparison to the control group ($P<.05$) (**Table 2**).

There were significant differences in systolic pressure based on time ($F=40.145$, $P<.001$); the reciprocal action between group and time also showed significant differences ($F=4.581$, $P<.001$) (**Table 2**).

Analysis results on diastolic pressure showed significant differences based on time ($F=19.650$, $P<.001$); the reciprocal action between group and time also showed significant differences ($F=3.025$, $P=.007$) (**Table 2**).

Discussion

Our study sought to identify the effects of EO inhalation on both stress responses and on physiological responses, such as stress index, sympathetic/parasympathetic nerve activities, serum cortisol, and blood pressure. To load the stress, the participants were exposed to noise and arithmetic operation stressors prior to treatment. The experimental group was given

blended *Lavandular officinalis* and *Cananga odorata* EO, the placebo group was given 0.9% saline, and the control group was given nothing for inhalation. Measurements were taken at four points: prior to experimental treatment, after presenting the stressor, 10 min after treatment, and 30 min after treatment, in order to identify time-based effects.

Ward [15] reported that noise has a negative effect on task performance; in a study related to heart rate, it was reported that exposure to mental arithmetic tasks increased sympathetic nerve activities, while decreasing the parasympathetic nerve activities. In other words, stress is felt when performing tasks or engaging in thoughts that require close attention [1]. As such, the stressors used in the present study—70 dB level noise and arithmetic subtraction operations represent a stress level that we would often encounter in our daily lives. In the present study, white noise and arithmetic subtraction operations did ultimately act as stressors.

Stress index was measured at 10 and 30 minutes after treatment. The measured results at 10 and 30 minutes showed decreases in stress index for all three groups after withdrawing stressor (Ts) and giving treatment, but there were no decreases from the initial stress index. However, after EO inhalation, the experimental group showed a significant decrease in comparison to the placebo and control groups, and showed a tendency of greater decrease at 30 min after treatment than at 10 min after treatment. We determined from these results that EO inhalation is effective in reducing the stress index, and that it effectively regulated the activity of the hypothalamus to provide stable and relaxing conditions by creating balance and harmony in the sympathetic nervous system, indicating its potential for effective use in stressful conditions.

Sympathetic nerve activity in the experimental group showed reduction to the initial sympathetic nerve activity level at 10 minutes after post-stressor treatment. At 30 minutes post-stressor treatment, sympathetic nerve activity was decreased to a level that was lower than the initial sympathetic nerve activity level. On the other hand, the placebo and control groups did not show decreases in sympathetic nerve activity to initial levels at either 10 or 30 min-

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post-treatment. Based on these results, it was confirmed that EO inhalation reduced stress scores and sympathetic nerve activities to levels prior to inducement of stress, and thus is effective in aiding recovery from the stress response.

These results are consistent with other studies that indicated sympathetic nerve activity was reduced after aroma EO inhalation [16], and that stress scores decreased at 10 minutes after treatment for stress using aroma EO, blended with lavender, ylangylang, rosemary, and lemon [17]. Moreover, when compared to the study by Nord [6] on the use of single oil, it is believed that using blended EOs shows more synergistic effects that using a single oil in reducing stress. This is consistent with another study that reported blending 2 to 3 different oils maximized their efficacy through synergistic effects [18].

When the effects of aroma EO inhalation on serum cortisol were tested, the results showed no significant differences between the three groups at 10 minutes after treatment. However, at 30 minutes after treatment, significant differences between the three groups were observed, with the experimental and placebo groups showing significant decreases in comparison to the control group. Changes in cortisol in the three groups consisted of an increase in cortisol levels after being subjected to the stressor and a decrease in serum cortisol at 10 and 30 minutes after treatment in the control group, which only had the stressor removed; the experimental group, which had the stressor removed and was treated with EO inhalation; and the placebo group, which had the stressor removed, and was treated with a saline inhalation. From this, it was indirectly confirmed that serum cortisol changes depend on the levels of stress. However, in the study results, no significant differences between the experimental and placebo groups were discovered. Therefore, in order to explain the effects of aroma EO inhalation on serum cortisol concentration, further studies, which supplement additional information on frequency and time of inhalation and the components and types of oil used, are deemed necessary.

Finally, to investigate the effects of EO inhalation on vital signs, systolic and diastolic blood pressures were measured. As a result, for sys-

tolic blood pressure, the experimental group showed a significant decrease compared to the placebo and control groups at both 10 and 30 minutes after treatment. When compared to a study that reported a decrease in systolic blood pressure after a 4-week inhalation of blended lavender and ylangylang EO through necklace and aroma stone applications [19], our results were more effective, time- and cost-wise, as recovery and reduction in systolic blood pressure were seen after just 10 minutes.

It appeared these physically relaxing effects and decreases in sympathetic nerve activities indicated feelings of stability, which led to a decrease in blood pressure. In particular, systolic blood pressures measured in the laboratory showed decreases in the experimental group of approximately 9.76 mmHg within 10 minutes and 11.87 mmHg after 30 minutes. This quick decrease in blood pressure from acute effects of EO inhalation could represent a meaningful finding. Moreover, diastolic blood pressure showed a significant decrease in the experimental group at 10 minutes after EO inhalation, compared to the placebo and control groups, but significant differences were not seen after 30 minutes. This demonstrated that inhalation of blended *Lavandular officinalis* and *Cananga odorata* aroma EO had an immediate effect on diastolic blood pressure, but after recovery to a certain level, it stabilized.

Most of the recent studies on applying aroma EO for studying ANS and blood pressure involved participants with various diseases, and relied on pre- and post-experimental treatment comparisons. In other words, there are virtually no studies conducted on adults who had not been diagnosed with a disease that examine the effects of aroma EO inhalation. The present study was conducted in a laboratory setting to identify the effects of aroma EO inhalation on stress score, stress index, sympathetic/parasympathetic nerve activities, serum cortisol, and blood pressure in healthy adults.

From a nursing research perspective, it was determined that for aroma EO applications for stress relief, blended oils were more effective, through synergistic effects, than single oils. The EO applications had an effect on sympathetic nerve activity and blood pressure, particularly how they reduced these levels to below the initial stress values. If future studies on

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decreases in blood pressure based on time can confirm the time frame of stress recovery, EO inhalation could potentially have broad-based applications in practical nursing.

Further, the results of this study can contribute to the development and the utilization of aroma EO inhalation applications as a CAM therapy that can be easily used as a relaxation therapy in daily life. Indeed, it could potentially serve as a self-nursing intervention measure for stress relief for adults, and contribute to enhancing both their quality of life and maintenance of their health.

In conclusion, aroma EO inhalation was shown to be effective for stress relief, as it decreased stress score as a psychological response, and reduced stress index, sympathetic nerve activity, and blood pressure as a physiological response. Therefore, it can be used as a method for relieving stress in both clinical and everyday settings, in which there are greater exposures to diverse stressors.

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Disclosure of conflict of interest

None.

Address correspondence to: Myunghaeng Hur, College of Nursing, Eulji University, 77 Gyeryong-ro, 771 Beon-gil, Jung-gu, Daejeon 34824, South Korea. Tel: 82(0)10-3348-0870; E-mail: mhhur@eulji.ac.kr

References

- [1] Brunner LS, Smeltzer SCC, Bare BG, Hinkle JL and Cheever KH. *Brunner & Suddarth's textbook of medical-surgical nursing*. Philadelphia, Lippincott Williams & Wilkins 2010.
- [2] Ha BJ. *Aromatherapy*. Seoul, Soomoonsa, 2006.
- [3] Hal JE. *Guyton and Hall textbook of medical physiology*. Philadelphia, Saunders Elsevier, 2011.
- [4] Lee HS, Hwang HS and Kim YA. Effects of hand massage with aroma oil on stress responses and serum immunity of registered nurse during the night duty. *J Korean Acad Soc Nurs Educ* 2007; 13: 169-176.
- [5] Rimmer L. The clinical use of aromatherapy in the reduction of stress. *Home Healthc Nurse* 1998; 16: 123-126.
- [6] Nord D and Belew J. Effectiveness of the essential oils lavender and ginger in promoting children's comfort in a perianesthesia setting. *J Perianesth Nurs* 2009; 24: 307-312.
- [7] Chung M and Choi E. A comparison between effects of aroma massage and meridian massage on constipation and stress in women college students. *J Korean Acad Nurs* 2011; 41: 26-35.
- [8] Park MK and Lee ES. The effect of aroma inhalation method on stress responses of nursing students. *Taehan Kanho Hakhoe Chi* 2004; 34: 344-351.
- [9] Hwang JH. The effects of the inhalation method using essential oils on blood pressure and stress responses of clients with essential hypertension. *Taehan Kanho Hakhoe Chi* 2006; 36: 1123-1134.
- [10] Oh HK, Choi JY, Chun KK, Lee JS, Park DK, Choi SD, Chun TI, Kim MK and Kim SB. A study for antistress effects of two aromatic synergic blending oils. *Proceedings of Korean Jungshin Science Symposium* 2001; 14: 33-49.
- [11] Battaglia S. *The complete guide to aromatherapy*. International Centre of Holistic Aromatherapy, Australia. Perfect Potion, 2003.
- [12] Shin YS, Cho YS and Jung YJ. The effects of aromatherapy on autonomic nerve system and physical resistance of a stress. *JKBNS* 2004; 6: 5-17.
- [13] Yun SH, Cha JH, Yoo YS, Kim YI, Chung SM and Jeong HL. Effects of aromatherapy on depression, anxiety and the autonomic nervous system in breast cancer patients undergoing adjuvant radiotherapy. *Korean J Hosp Palliat Care* 2012; 15: 68-76.
- [14] Yoon YH, Kim SH, Lee HJ, Lee JH and Kim HT. The effects of task stressor, noise stimulus, conifer needle odor and soundguard on SCR, PPG and behavioral performance. *Korean Journal of Clinical Psychology* 1997; 16: 435-445.
- [15] Ward WD and Fricke JE. Noise as a public health hazard: proceedings. *American Speech and Hearing Association*, 1969.
- [16] SM Peng, Koo M and Yu ZR. Effects of music and essential oil inhalation on cardiac autonomic balance in healthy individuals. *J Altern Complement Med* 2009; 15: 53-57.
- [17] Muzzarelli L, Force M and Sebold M. Aromatherapy and reducing preprocedural anxiety: a controlled prospective study. *Gastroenterol Nurs* 2006; 29: 466-471.

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- [18] Hongratanaworakit T and Buchbauer G. Relaxing effect of ylang ylang oil on humans after transdermal absorption. *Phytother Res* 2006; 20: 758-763.
- [19] Kiml H, Kim C, Seong K, Hur MH, Lim HM and LeeMS. Essential oil inhalation on blood pressure and salivary cortisol levels in prehypertensive and hypertensive subjects. *Evid Based Complement Alternat Med* 2012; 2012: 984203.