

# Immediate effects of lavender soy wax candle on autonomic nervous system, stress, and reaction time in adolescents

Panida Hanphitakphong, Somruthai Poomsalood 

Department of Physical Therapy, School of Allied Health Sciences, University of Phayao, Thailand

## Abstract

*Study aim:* The study aimed to investigate the immediate effects of a lavender soy wax candle on the autonomic nervous system, stress, and reaction time in adolescents with moderate stress levels.

*Material and methods:* Fifty-two males and females (mean age:  $19.85 \pm 0.78$  years) with a moderate stress level determined by Suanprung Stress Test-20 (SPST-20) were enrolled. All participants were randomly assigned to either the control ( $n = 26$ ) or experimental ( $n = 26$ ) groups. The control group inhaled the lavender scent through a bowl filled with warm water, while the experimental group inhaled the scent from the lavender soy wax candle. In a peaceful environment, each participant was suggested to sit on a comfortable recliner chair in a private room while inhaling the scent for 20 minutes. Blood pressure, heart rate, respiratory rate, reaction time, and emotional states were assessed before and after the scent inhalation. The emotion states were based on the conceptual model proposed by the Geneva Emotion and Odor Scale (GEOS), consisting of 12 items.

*Results:* The results indicated no significant differences between the two groups in all the parameters, except for the three items of emotion states (relax:  $p = 0.03$ , stress:  $p = 0.04$ , and calm:  $p = 0.04$ ).

*Conclusions:* This study suggested that the inhalation of lavender soy wax candles for 20 minutes can be used as adjuvant therapy for improving emotional states and enhancing cognitive function among adolescents with moderate stress levels.

**Keywords:** Lavender – Aromatherapy – Autonomic nervous system – Emotional stress – Reaction time

## Introduction

Stress can increase risks for long-term health issues [13]. High levels of perceived stress have been observed in individuals with early signs of suicidal thoughts, particularly in the young generation [15]. Additionally, previous studies suggested that psychological stress can affect cognitive function in the short and long term [1, 8, 16, 17]. Therefore, stress management is essential to break the accumulation of stress in human life. Multiple evidence strands indicate that aromatherapy can be helpful, especially when treating stress [5, 9].

Aromatherapy has been studied based on the psychophysiological responses in humans. The olfactory system plays a key role for transmission of the sensation of smell to the brain by the olfactory nerves in the interior part of the nose. The olfactory bulbs located in the forebrain is intimately associated with the limbic system. This limbic

system is part of the brain that controls emotional behaviors and memories [4].

It is well known that using aromatherapy candles can promote a sense of calmness and relaxation. The market size of scented candles is expected to grow by USD 3.93 billion between 2022 and 2030. Interestingly, aromatic candles are organic products and very simple to use [2, 19].

The results of a recent study indicated that lavender aroma could reduce the stress effects of watching a stressful video since the levels of salivary chromogranin in the aroma group showed statistically significant decrease throughout the experimental period [20]. Additionally, more recent research has discovered that sleep quality can be improved by lavender essential oil. It was found that the inhalation of lavender essential oil during a short-duration sleep cycle suppressed the stress response, especially that of the sympathetic nervous system [21]. Although there is clear evidence suggesting the

health benefits of lavender aromatherapy, there is a current lack of studies investigating the effects of lavender aromatherapy with soy wax candles on stress parameters. Since stress can lead to serious health problems, it is necessary to provide scientific evidence for using lavender soy wax candles to help reduce stress. Therefore, this current study aimed to determine the immediate effects of a lavender soy wax candle on the autonomic nervous system, stress, and reaction time in adolescents with moderate stress levels.

## Material and methods

### Study design and participants

This study used a two-group pretest-posttest design. Ethical clearance was obtained from the Ethic Review Board of the University of Phayao (Ethic Code: UP-HEC 1.2/022/65). The participants provided written informed consent prior to data collection.

The sample size was determined based on the t-test mean differences between two independent groups using a statistical power analysis program (G\*Power 3.1.9.7; University of Dusseldorf, Dusseldorf, Germany). With an effect size of 0.50, a minimum sample size of 26 participants for each group was required to achieve 80% power at a 0.05 significance level to detect differences between the two groups.

### Eligibility criteria for participants

A total of 52 healthy participants (25 female and 27 male undergraduate students) were included in the study. The participants were screened according to the inclusion and exclusion criteria. The criteria for inclusion were 1) 18 to 25 years of age, 2) normal perception of smell, 3) a score of 3–5 on the pleasantness of smell on the five-point Likert scale (5 = very much like, 4 = like, 3 = moderately, 2 = do not like, 1 = hate), 4) moderate level of stress using Suanprung Stress Test-20 (SPST-20) [11], 5) no history of allergy, sinusitis, respiratory disease, hypertension, and brain injury, and 6) no experience of aromatherapy. Subjects were excluded if they had color blindness, took muscle relaxants, and consumed food and beverage that contained caffeine, theophylline, and alcohol within 24 hours prior to data collection.

### Outcome measures and instrumentation

Blood pressure (BP), Heart Rate (HR), Respiratory Rate (RR), stress level, and simple Reaction Time (RT) were determined before and after inhalation by the same investigator. The BP and HR were measured using a digital BP monitor. The RR was assessed by observing chest wall movements and counting for 60 seconds. The Geneva

Emotion and Odor Scale (GEOS) assessed the stress level [3]. The RT was determined using a multichoice reaction timer regarding dominant hand visual RT.

The stress level evaluation was determined by the Geneva Emotion and Odor Scale (GEOS). This tool was developed as a self-report scale enabling an assessment of odor-induced emotions. This scale consists of 12 items that involve five domains including pleasant feeling (feel good), unpleasant feeling (feel bad, uncomfortable, disgusted, frustrated, and stressed), sensuality (romantic), relaxation (relax, calm, and drowsy), and refreshing (fresh and active). Each item has a continuous 100 mm horizontal line based on visual analog scale subjective evaluation method.

The examination of RT was based on visual choice reaction time determined using a multichoice reaction timer. After familiarization with the test, visual choice RT was recorded for red, green, and blue colors using the dominant hand. The assessment was performed three times for all the participants. Mean values of RT (ms) were analyzed. Test-retest reliability was done with 10 participants who did not attend the main experiment prior to data collection. Intra-rater reliability with the Intraclass Correlation Coefficient (ICC) provided a value of 0.76, indicating good reliability [7].

### Interventions

For the experimental group, the odor of the lavender soy wax candle was diffusive through a candle warmer in a private room for 10 minutes before the participants entered the room. For the control group, lavender oil was dropped into a glass of plain water. The same candle warmer was used in all groups for standardization. The candle warmer was an electric warmer that melted the lavender soy wax candle to release its scent. It contained a soft orange light bulb and was smokeless. The temperature was adjustable. For both groups, the participants were instructed to sit on a comfortable recliner chair for 20 minutes to inhale the scent based on their groups. The period of inhalation was based on the findings in a previous study [20] and our pilot study. The volunteers were prohibited from doing any activities while sitting in the experimental room.

### Statistical analysis

All data were presented as mean±Standard Deviation (SD). An Independent t-test was used to compare dependent variables between the control and experimental groups pre – and post-inhalation. A chi-square test was used to compare the proportion of male and female participants between the two groups. Paired samples t-test was used to test for within-group differences before and after *inhalation*. The level of significance was set at 0.05.

## Results

The personal information of the participants in both groups is shown in Table 1. No significant differences were observed between the groups concerning gender, age, weight, height, Body Mass Index (BMI), SPST-20 score, and pleasantness of smell on the five-point Likert scale.

There were no significant between-group differences in BP, RR, HR, and RT at baseline and immediately after

the 20-minute inhalation. After the inhalation, both groups had significant changes in BP, RR, HR, and RT, as shown in Table 2.

At baseline, no significant between-group differences were found in any items of the GEOS, as presented in Table 3. However, after the inhalation, participants who inhaled the lavender soy wax candle presented significantly higher scores on relax and calm items ( $p = 0.03$  and  $0.04$ , respectively) and lower scores on stress ( $p = 0.04$ ).

**Table 1.** General characteristics of the participants ( $n = 52$ )

Characteristics	Control group ( $n = 26$ )	Experimental group ( $n = 26$ )	p-value
Gender M:F	8:18	14:12	0.08
Age [years]	$19.73 \pm 0.78$	$19.96 \pm 0.77$	0.29
Weight [kg]	$56.21 \pm 7.41$	$60.42 \pm 8.27$	0.06
Height [cm]	$163.58 \pm 8.38$	$168.00 \pm 7.62$	0.05
BMI [ $\text{kg}/\text{m}^2$ ]	$20.93 \pm 1.30$	$21.30 \pm 1.29$	0.31
Score of SPST-20	$31.46 \pm 4.23$	$33.04 \pm 4.44$	0.20
Pleasantness of the smell	$3.96 \pm 0.72$	$4.31 \pm 0.55$	0.06

Abbreviations: M – male; F – female; SPST – Suanprung stress test.

**Table 2.** Mean differences in BP, RR, HR, and RT before and after the 20-minute fragrance inhalation ( $n = 52$ )

Variables	Time	Control group ( $n = 26$ )	Experimental group ( $n = 26$ )	p-value	Effect sizes
SBP [mmHg]	Baseline	$105.96 \pm 7.86$	$110.46 \pm 9.11$	0.06	0.540
	After	$98.50 \pm 7.00^b$	$102.92 \pm 9.23^b$	0.06	
DBP [mmHg]	Baseline	$73.77 \pm 7.31$	$77.73 \pm 7.89$	0.07	0.245
	After	$66.92 \pm 7.83^b$	$68.88 \pm 8.18^b$	0.38	
RR [breaths/min]	Baseline	$17.69 \pm 9.46$	$18.27 \pm 7.30$	0.24	0.021
	After	$15.15 \pm 8.48^b$	$15.00 \pm 5.73^b$	0.81	
HR [beats/min]	Baseline	$78.35 \pm 1.49$	$80.23 \pm 1.97$	0.43	0.772
	After	$70.65 \pm 1.87^b$	$72.38 \pm 2.56^b$	0.40	
RT [ms]	Baseline	$0.71 \pm 0.11$	$0.67 \pm 0.09$	0.11	0.381
	After	$0.65 \pm 0.10^a$	$0.61 \pm 0.11^b$	0.12	

Abbreviations: SBP – systolic blood pressure; DBP – diastolic blood pressure; RR – respiratory rate; HR – heart rate; RT – reaction time; <sup>a</sup>  $p < 0.05$ , <sup>b</sup>  $p < 0.01$ .

**Table 3.** Mean differences in Geneva Emotion and Odor Scale (GEOS) before and after the 20-minute fragrance inhalation (n = 52)

Variables (12 items)	Time	Control group (n = 26)	Experimental group (n = 26)	p-value	Effect sizes
Good	Baseline	54.00 ± 5.50	56.73 ± 4.98	0.07	0.561
	After	57.19 ± 6.08 <sup>b</sup>	60.50 ± 5.71 <sup>b</sup>	0.05	
Bad	Baseline	21.88 ± 4.17	22.31 ± 4.88	0.74	0.075
	After	21.81 ± 5.59	21.39 ± 5.56	0.79	
Active	Baseline	50.69 ± 6.12	50.27 ± 5.60	0.80	0.079
	After	50.96 ± 6.62	50.46 ± 6.08	0.78	
Drowsy	Baseline	31.50 ± 5.59	32.42 ± 5.64	0.56	0.062
	After	31.35 ± 6.50	31.73 ± 5.69	0.82	
Fresh	Baseline	38.92 ± 4.40	40.88 ± 4.17	0.11	0.095
	After	40.19 ± 5.86	40.77 ± 6.34	0.74	
Relax	Baseline	74.65 ± 7.86	78.73 ± 7.68	0.06	0.608
	After	80.23 ± 9.23 <sup>b</sup>	85.35 ± 7.54 <sup>b</sup>	0.03	
Stress	Baseline	19.15 ± 3.40	17.62 ± 3.63	0.12	0.586
	After	16.69 ± 3.12 <sup>b</sup>	14.92 ± 2.92 <sup>b</sup>	0.04	
Uncomfortable	Baseline	18.58 ± 3.36	17.38 ± 2.71	0.17	0.269
	After	17.19 ± 3.20	16.27 ± 3.63	0.34	
Romantic	Baseline	30.54 ± 5.62	31.15 ± 7.71	0.67	0.068
	After	31.69 ± 7.51	32.15 ± 5.92	0.81	
Frustrated	Baseline	16.46 ± 3.11	16.81 ± 3.33	0.70	0.038
	After	15.27 ± 3.22	15.39 ± 3.14	0.90	
Clam	Baseline	51.00 ± 5.56	53.92 ± 5.53	0.06	0.575
	After	55.19 ± 6.30 <sup>b</sup>	58.73 ± 6.02 <sup>b</sup>	0.04	
Disgust	Baseline	13.15 ± 2.60	12.38 ± 3.05	0.33	0.179
	After	12.27 ± 3.87	11.69 ± 2.43	0.52	

<sup>b</sup>  $p < 0.01$ .

## Discussion

The current study focused on changes in the autonomic nervous system, stress, and reaction time in adolescents with a moderate stress level after smelling a lavender soy wax candle compared with the conventional style, where lavender oil was dropped into a glass of plain water. It was hypothesized that, in lavender aromatherapy, the lavender soy wax candle would create a more relaxing atmosphere than the conventional style. The present data demonstrated that both methods of lavender aromatherapy improved BP,

HR, RR, RT, and emotional states. In addition, the results showed that a soy wax candle was superior to the conventional style in improving emotional states.

In the past few years, some studies have attempted to determine the effectiveness of lavender aromatherapy in physiological outcomes and cognitive performance [12, 18, 20]. However, no previous research has investigated the effects of lavender aromatherapy with soy wax candles on health-related outcomes in stressed individuals. According to the review, our findings may contribute to the choice of using lavender aromatherapy. Possibly, application lavender essential oil in the form of scented candles

may result in more sense than the conventional style as mentioned in control group. Producing the light by candle warmer may create room ambience and consequently enhance feelings of relaxation. In this study, the light-yellow color was autonomic generated by candle warmer may help to reduce irritated feelings and resulting in cozy and relaxing atmosphere [22].

It is well known that lavender aromatherapy can help decrease BP due to evaporation of aroma particles of essential oil in the air. In mucosa, particles of essential oil are dissolved through the internal part of the nose which has gotten stimulation from the receptor. The olfactory receptor cells contain cilia where the tied aromatic molecules are removed. The olfactory nerve merges with long nerve tissue and aroma electric chemistry message of the olfactory receptor cell. Olfactory nerve tissue passes through the cribriform plate where ethmoid bone is stored in nasal roof and then reaches olfactory bulb where an aroma signal is chemically transformed before it is sent out to the brain. The connection between message and olfactory bulb has been established after the impulse of olfactory cell passes rapidly into the olfactory canal and directly to the cerebral cortex. Among the structures of limbic system, amygdala is considered as a primary region for processing the aroma, particularly emotional response. The limbic system is connected to structures in the cerebral cortex and is associated with thoughts and feelings. It also directly interacts with brain parts that control BP, RR, stress level, and hormone secretion. Since inhaled particles pass through the lungs, several molecules will directly affect respiration and can also be absorbed into the cardiovascular system [6].

This study also used a choice reaction time task to explore the effects of lavender soy wax candles on cognitive performance. It has been previously reported that working memory is disturbed by anxiety [10]. Since both groups showed significant decreases in emotional stress, the cognitive-enhancing effect of both methods of lavender aromatherapy observed in this study may be associated with the anxiolytic effect.

According to the results, the participants who inhaled the lavender soy wax candle significantly presented higher scores on relax and calm items ( $p = 0.03$  and  $0.04$ , respectively) and lower scores on stress ( $p = 0.04$ ) assessed by GOES. After the inhalation, both groups significantly demonstrated decreased BP, HR, RR, and RT. However, no significant differences were found between the two groups regarding physiological and cognitive function parameters. A possible explanation for this might be that both groups received an intervention of potentially the same benefit with respect to the active components that were contained in lavender essential oil. Because linalyl acetate and linalool were inhaled, they interacted with neurotransmitters in the brain to promote relaxation and

lessen agitation and consequently influence cognitive performance [4-6].

No previous research has investigated the effects of lavender aromatherapy with soy wax candles on psychological states (both subjective and physiological elements). Therefore, it is challenging to compare the results of this study with previous studies. In the present study, relax and calm scores were higher and stress scores were lower in the experimental group than in the control group. This may be due to the scent of the organic soy wax candle blended with lavender oil to create a relaxing atmosphere in the experimental group [14]. Also, the autonomic light-yellow color produced by the candle warmer may help to lessen agitated feelings and create a warm and comforting environment [22].

Several limitations need to be addressed before making generalized conclusions. First, the participants might not represent the whole population, as this study focused on late adolescents with moderate stress. Second, it should be noted that a self-assessment scale increases the risk of response bias. Additionally, there were not enough outcomes to analyze and prove the effects of the lavender soy wax candle on cognitive performance. Future studies should concern other parameters, such as digit-span tasks and visual-spatial working memory. Finally, the research design could not demonstrate long-term effects. As a result, the findings should be confirmed in further studies.

## Conclusions

In conclusion, lavender soy wax candles positively affected the autonomic nervous system, stress, and reaction time. Results from this study showed that the inhalation of lychee soy wax candles over 20 minutes reduced BP, HR, and RR, improved reaction time, and enhanced emotional states. Accordingly, it can be an alternative therapy complementing current health care for adolescents with moderate stress levels. Further research is required to examine long-term effects of these findings in adults or elderly. It may be necessary to add stress (cortisol) test, brain wave and memory test to properly assess these effects.

**Conflict of interest: Authors state no conflict of interest.**

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