Physiological Effects of Lavender Essential Oil After Moderately Intense Physical Activity

Physiology 435 Lab 601 Group 12

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ABSTRACT

For this study, the effects of lavender essential oil on the rate of relaxation after physical stress were investigated. While previous studies have been performed relating lavender aroma to decreased psychological stress, little data exists on the effect of lavender aroma on physical stress. Physical and mental stress share many of the same physiological effects including increases heart rate, respiration rate, and galvanic skin conductance. Due to these similarities it is probable that physical stress will reduce these values by comparable amounts to mental stress when lavender aroma is administered during recovery time. It was hypothesized that exposing subjects to lavender essential oil after moderate physical activity would decrease the recovery time for heart rate, respiration rate, and skin conductance to return to baseline, compared to control subjects not treated with lavender aroma. To test this hypothesis, the average recovery time and percent change of physiological vitals, including heart rate, respiration rate, and galvanic skin conductance between treatment groups were compared. From the results, no significant data was observed, therefore, it can be concluded that the presence of lavender does not have any appreciable effect on lowering heart rate, respiration rate and skin conductance after moderately intense physical activity, which the study used as indicators of physical stress.

**Keywords:** Aromatherapy, essential oil, exercise, Galvanic Skin Response (GSR), heart rate, lavender, physical stress, psychological stress, recovery time, relaxation time, respiration.

**Word Count:** 2,793
INTRODUCTION

Aromatherapy is the practice of using naturally-extracted aromatic essences to benefit an individual's physical and psychological health (Price, 1999). Aromatherapy has been studied and found effective in treating pathological conditions like anxiety, asthma, depression, and stress (Gaware, 2013). The basis of this therapy relies on essential oils, which are chemicals extracted from plants with unique aromas and complex chemical properties (National Cancer Institute, 2018; Worwood, 2016). Many essential oils show trends of relaxation or stimulation, along with antimicrobial properties (Yang, 2016).

Lavender is a popular essential oil that has relaxing and sedative properties (Price & Price, 2011). Because of these effects, it is often used in treatment for reducing anxiety, stress, and other pathological disorders. Specifically, a study found that applying lavender exposure after acute psychological stress increased the speed of stress reduction and processing capabilities (Chamine, 2016); This was concluded by analyzing cortisol, respiration rate, and chromogranin A percent change from baseline. Cortisol, a hormone, and chromogranin A, a protein, are both mental stress markers. Therefore, these amounts of cortisol and chromogranin A were decreased at a faster rate once lavender were administered. Similar results were seen when analyzing sleep disorder patients, where lavender exposure increased their rate of relaxation (Koulivand, Khaleghi Ghadiri, & Gorji, 2013; Toet, 2010).

Though there is past research relating lavender to the relaxation of subjects after being exposed to psychological stress, very little scientific data has been collected on essential oil effect on physical stress, such as exercise. Physical stress induces similar symptoms as psychological stress, including increased cortisol levels, blood pressure, heart rate, increased galvanic skin response (GSR), and respiration rate (Dickerson and Kemeny, 2004). One study
found that aromatherapy reduced the physical stress suffered by women going through menopause (Murakami, 2005); however, this study included a narrow age and gender demographic and focused only on menopausal symptoms. Another study directly researched the effect of aromatherapy on vitals after physical activity, finding that pulse, cardiac output, and body temperature showed marked reduction due to aromatherapy (Ali, 2017); this study had similar demographic restrictions, with small scale subject numbers and considered only one sex.

In this study, we investigated how lavender exposure after moderate physical stress from exercise affects the relaxation rate of subjects. We hypothesized that exposing subjects to lavender essential oil after moderate physical activity would decrease the recovery time for heart rate, respiration rate and skin conductance to return to baseline, compared to control subjects not treated with lavender aroma. These physiological measurements were used due to their connection to the body’s physiological sympathetic response to psychological stress and the practice of past studies (Nogueria-Ferreira, et. al). To determine if lavender had similar relaxation effects on physiological function after physical stress as it does on psychological stress, we compared the recovery time of heart rate, respiration rate, and skin conductance measurements between treatment groups.

MATERIALS

BioPac MP36
BioPac Respiratory Effort Transducer - Model SS5LB
BioPac BSL EDA Finger Electrode - Model SS3LA
BioPac Gel 101 Isotonic Recording Electrode Gel
Covidien Curity Sterile 6” Cotton Tipped Applicator
Nonin Pulse Oximeter/Carbon Dioxide Detector - Model 9843
Artizen Lavender Essential Oil (100% PURE & NATURAL - UNDILUTED), 1 fluid oz
Up and Up Exfoliating Cotton Rounds
Gold’s Gym Cycle Rainer 390R (Seated Stationary Bike)
Blindfold (plain black sleeping mask)
Kleenex 2-ply tissues

METHODS

Subjects were recruited from students enrolled in Spring 2018 Physiology 435 lab at University of Wisconsin-Madison, 36 students were tested. Students signed a consent form prior to participating in the study informing them of the involved physical activity and the possible use of scented essential oils; the specific aroma was omitted to prevent expectancy biases. Students then took a generalized survey (Figure 1) and were excluded from the study if they had any of the following conditions: scent-related allergy, exercise-induced asthma, severe nasal cold symptoms, or medical history of decreased sense of smell. These students were considered to have non-normal vitals and/or be unable to be affected by the lavender treatment. Students were randomly and blindly assigned to either the aroma group with lavender) or the no aroma group to control for physiological factors and heterogeneity. Subjects of both groups were hooked up to the BioPac MP36 with the BioPac Respiratory Effort Transducer - Model SS5LB strapped tightly around the widest part of their chest; the BioPac BSL EDA Finger Electrode - Model SS3LA attached to the index and middle fingers of their left hand after application of Gel101 with a cotton tipped applicator; and a Nonin Pulse Oximeter/Carbon Dioxide Detector - Model 9843 placed on their right index finger. All subjects were blindfolded at the start of the experiment to keep confounding variables and placebo effects at a minimum; a study on the expectancy biases of aromatherapy found that priming subjects for the use of lavender aroma
resulted in increased psychophysiological relaxation after stress (Howard, 2010). After remaining seated on a stationary bike for two minutes with arms relaxed at their sides, each subject’s resting heart rate (Pulse Oximeter), respiration rate (Respiratory Transducer), and electro dermal activity (EDA) were continuously measured and recorded as a baseline for both treatment groups.

A pilot study for the positive control was conducted on four students to show that physical activity on the stationary bike was capable of increasing heart rate (Figure 2), respiration rate (Figure 3), and EDA (Figure 4). Subjects began in the same position as in the experiment, with their feet on the ground while attached to the BioPac MP36 with the BioPac Respiratory Effort Transducer - Model SS5LB, the BioPac BSL EDA Finger Electrode - Model SS3LA, and a Nonin Pulse Oximeter/Carbon Dioxide Detector - Model 9843. After 2 minutes to establish baselines, subjects put their feet on the pedals and began exercising. This exercise was conducted for two minutes with the rotations per minute (RPM) not surpassing 80 to keep the physical activity from being too strenuous and fatiguing subjects (Martinez-Quintana, 2010). A negative control pilot study was then performed by measuring the same vitals while subjects relaxed after exercise in a seated position on the stationary bike with their feet on the floor to show the subjects’ measurements homeostatically return to baseline over a given amount of time.

After baseline was determined for both the aroma group and no aroma group, each subject placed their feet on the foot pedals and pedaled for 2 minutes until the heart rate increased to 60-90% of their age-predicted maximum according to the American College of Sports Medicine. (CDC, 2015). After two minutes of moderate exercise, subjects returned to a seated position on the bike, remaining blindfolded. Subjects in the aroma group received treatment of a cotton round pad with one drop of pure lavender essential oil wafted six inches
from their nose after aerobic activity. The exposure to undiluted lavender oil at this distance
ensured aroma detection by subjects, as shown in past studies (Salamati, 2017). Subjects in the
no aroma group, received no lavender treatment. These subjects had a dry cotton round pad with
no lavender essential oil wafted six inches from their nose after aerobic activity; this reduced
possible confounding effects of the cotton, ensuring lavender aroma was the only dependent
variable. This methodical timeline of subject participation is shown in Figure 5.

Heart rate measurements were collected every ten seconds by means of manual entry in a
Google spreadsheet to determine recovery time required to return to baseline. Figure 6 shows a
sample of data collection from an individual subject during this experiment timeline of heart rate.
Recovery time was measured from the end of exercise to when subjects’ heart rate returned to
baseline; returning to baseline is defined as having a heart rate +/-10% (20% range) of the initial
baseline measurement at rest since we did not measure heart rate continuously (Nogueria-
Ferreira, et. al). Respiration and EDA data was collected continuously using BioPac software,
however, data collection was stopped once heart rate reached baseline because we were unable to
determine respiration rate and EDA return to baseline during BioPac data collection. Since both
heart rate and respiration rate decrease after stress is removed (Schubert, 2009), the assumption
could be made that the baseline heart rate was an adequate determinant of when subjects reached
their overall baseline. Respiration rate and EDA data collected on BioPac was transferred to a
Microsoft Excel spreadsheet for statistical analysis. A representative screenshot of EDA data as
the experiment progressed with a typical subject from BioPac is shown in Figure 7, to be a visual
supplement the calculated values. The respiratory rate before and after exercise was determined
by counting the number of breaths per minute. Heart rate recovery time was measured from peak
heart rate after exercise until baseline was reached, as shown in Figure 6, in order to determine
the average speed of heart rate recovery in beats per minutes. Percent change of respiration was calculated by dividing the average breaths per minute after exertion (during recovery time) over the average breaths per minute for baseline for each subject. This value was then multiplied by 100 to convert to percentage and 100 was then subtracted to deduce the percent change from baseline. The same method was used for EDA percent change, however, in units of $µS$. Results were analyzed using an unpaired T-Test with a $p$-value < 0.05 for significance.

**RESULTS**

For this study, there were 35 subjects ($N=35$), but one subject was excluded from the study due to asthma and three others due to equipment failure. Of the 31 eligible subjects, nineteen were female and twelve were male, as shown in Figure 8. Subject age ranged from 21 to 25 years old, with the majority (15 subjects) in the 22 years category, as shown in Figure 9. Physical activity was self-reported by subjects, with males engaging in physical athletic activity for an average of 5.33 hours a week and females for an average of 4.79 hours a week, as shown in Figure 10.

The average recovery time required to reach baseline heart rate for the aroma group (lavender aroma) was 96.67 seconds, while the average recovery time for the no aroma group was 154.67 seconds, as shown in Figure 11. However, after running the recovery times for the aroma group and no aroma group through an unpaired T-Test, the results were found to be statistically insignificant with a $p$-value = 0.0930 (>0.05). The average speed of heart rate recovery for the aroma group was found to be 0.46 beats per minute, while the average speed of heart rate recovery for the no aroma group was 0.40 beats per minute, as shown Figure 12; this data was found to be statistically insignificant, with a $p$-value = 0.4453 (>0.05).
The study found that the percent change of respiration rate for the aroma group was 10.40%, while the no aroma group was 19.60%, as shown in Figure 13; this data was found to be statistically insignificant, with a p-value = 0.284 (>0.05).

The percent change of EDA for the aroma group was found to be 52.4%, while the percent change of EDA for the no aroma group was 34.0%, as shown in Figure 14; this data was found to be statistically insignificant, with a p-value = 0.603 (>0.05).

**DISCUSSION**

Our data does not reflect any significant reduction in the recovery time necessary for heart rate, respiration rate, or skin conductance to return to baseline resulting from exposure to lavender aroma, leading us to reject our hypothesis for college-age students. Although data generally showed faster average recovery speed of physiological vitals in subjects treated with lavender aroma, none of the data was statistically significant. Based on these statistical results, determining if lavender essential oil has similar relaxation effects on physiological function after physical stress as it does on psychological function after mental stress was not fully answered.

For this study, one of the assumptions for our methods was that the heart rate baseline recovery was an adequate determinant of when overall baseline of all our physiological vitals was reached because respiratory and EDA baseline recovery during BioPac data collection was unable to be determined. This assumption was necessary in determining subjects’ return to baseline, but may have limited the data collection for respiration rate and EDA since very few reached baseline within the time for heart rate recovery. Therefore, with more time and data, subjects’ respiration rates and EDA may have returned to baseline and proved statistically significant. Of the data sets excluded for heart rate, more were excluded from the no aroma group (3 sets) than the aroma group (2 sets), which may have slightly affected the accuracy of
average heart rate recovery times. Furthermore, since heart rate was recorded every ten seconds, our recovery time measurements may not have been as accurate as if heart rate was recorded continuously. Some of the EDA data did not record correctly on BioPac, preventing us from being able to quantify that data. This reduced our confidence in the EDA average values and percent change. There is also a chance of human error in determining respiration rate and assessing EDA return to baseline from raw BioPac data. While equal sex distribution between treatment groups was not possible due to the female-dominated subject pool of the Physiology 435 lab (70% female) and maintenance of random group assignment, there was no statistical significance between male and female subjects’ physical activity level, leading us to ignore this gender disparity in assessing our confidence in our data. Also, using time differences and percent change to quantify data reduced physiological differences between males and females, like heart size and heart rate, from affecting our data representation.

While aromachology, the study of olfactory effects on mood, physiology, and behavior, has proposed that lavender has sedative effects via neuropharmacological mechanisms, the dosage of lavender odor used in aromatherapy is not adequate enough to be pharmacologically detected (Herz, 2009). The study on expectancy biases of aromatherapy found no effect of lavender aroma or placebo on EDA during relaxation after mental stress (Saki, 2001). While this study only considered females, this may have affected our data, as shown by the majority of subjects’ EDA measurements not returning to baseline across treatment groups. Another study attributed some of the physiological effects of lavender aroma to expectancy biases from its popular, well-known use as a relaxant, resulting in different physiological changes when recognized compared to the less recognizable placebo aromas with similar relaxation effects (Chamine, et al. 2016). If our subjects recognized the lavender aroma, our data may have also
been affected by expectancy biases. One study found that exposing subjects to lavender aroma for ten minutes resulted in decreased EDA, suggesting that longer exposure was required for lavender to have its desired relaxation effect on EDA (Saki, 2001).

Expanding the subject population beyond college-age students could provide more information on the relationship between lavender aroma and physiological relaxation in different age groups. Future studies could determine if greater concentrations and/or exposure times of lavender essential oil is capable of producing statistically significant increased physical relaxation after stress. Future studies could also address the knowledge gap of whether usage of lavender aroma is as effective at reducing physical stress as it is at reducing mental stress. Due to lavender’s widespread marketed use in aromatherapy for pathological disorders, larger, more comprehensive studies are needed to prove if lavender essential oil has significant relaxation effects on physical stress.
Lavender Essential Oil Effects on Physical Stress

References


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Figures

**Figure 1:** A generalized survey that was created in order to screen for subjects that did not have full sense of smell or respiratory impairments. The survey also included questions to gauge demographics, such as male or female, age, and athletic activity level. All answers were self-reported.

![Physiology 435 Experimental Screen](image)

**Confidentiality Notice**

While there may be printed reports as a result of this study, your name will not be used. Only group characteristics will be reported – that is results with no identifying information about individuals will be used in any reported or publicly presented work.
**Figure 2:** Positive control of average heart rate. Graph shows the control starting at baseline heart rate (time = 0s), maximum heart rate at (time = 70s), and returning to baseline heart rate (time = 150s), displaying that heart rate does increase during moderate exercise and returns to baseline after exercise.

![Positive Control for Average Heart Rate vs Time](image)

**Figure 3:** Positive control for Respirations per minutes. This graph shows how at initial baseline for 60 seconds, the baseline is 14 respirations per minute. As subject engaged in moderate physical activity, respirations per minute reached a peak at 240-300 seconds, at 30 respirations per minute. During resting state, respirations per minutes returned to near baseline levels.

![Positive Control for Average Respirations vs Time](image)
Figure 4: Positive control for EDA measurements. Displays trend of baseline EDA being at a lower average microsiemens, rising during exercise until it reaches a peak EDA level, and returning to near baseline during the rest portion.

![Positive Control for EDA vs Time](image)

Figure 5: Participation Timeline for an individual subject.
\textbf{Figure 6:} Representative Data collected as subject sat quietly (baseline), performed two minutes of strenuous activity (exertion), and then rested quietly until within 10% of baseline heart rate was reached (recovery).

\textbf{Figure 7:} Representative screenshot of EDA data as the experiment progressed with a typical subject from BioPac. The average $\mu$S value was calculated by the accompanying software and compared at the two points indicated by boxes (A and C) on the trace. D represents the difference that change in percent was calculated from.
**Figure 8:** Displays the percentage of gender for the subjects of the study. n=31

![Gender of Subjects Pie Chart](image)

**Figure 9:** Displays the ages of the subjects used in this experiment. n=31

![Age of Subjects Bar Chart](image)
**Figure 10:** Displays average self-reported athletic activity in hours between male and female subjects. n=31

![Male Vs. Female Average Athletic Activity](image)

**Figure 11:** The average rate of recovery for heart rate for both the aroma and no aroma groups was calculated by measuring the seconds it took for subjects to return to within 10% of their baseline heart rate after facilitated exertion. Shown in bold are the averages ± S.D. (Insignificantly different from baseline, p-value>0.01).

![Average Recovery Time of Heart Rate](image)
**Figure 12:** The average speed of heart rate recovery for both the aroma and no aroma groups was calculated by taking the change in beats per minute from peak (end of exertion) to within 10% baseline after treatment, divided by the time it took to return from peak to within 10% baseline heart rate. Shown in bold are the averages + S.D. (Insignificantly different from baseline, p-value>0.01).

![Speed of Heart Rate Recovery Graph](image)

**Figure 13:** Percent change of respiration was calculated by dividing the average breaths per minute after exertion (during recovery time) over the average breaths per minute for baseline for each subject. This value was then multiplied by 100 to convert to percentage and 100 was then subtracted to deduce the percent change from baseline. All percent changes for the aroma group and no aroma group were averaged to provide values below. Shown in bold are the averages + S.D. (Insignificantly different from baseline, p-value>0.01).

![Percent Change of Respiration Graph](image)
**Figure 14:** Percent change of EDA was calculated by dividing the average micro Siemens after exertion (during recovery time) over the average micro Siemens for baseline for each subject. This value was then multiplied by 100 to convert to percentage and 100 was then subtracted to deduce the percent change from baseline. All percent changes for the aroma group and no aroma group were averaged to provide values below. Shown in bold are the averages ± S.D. (Insignificantly different from baseline, p-value>0.01).