Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 14(4), 1626-1635, 2024
Journal of the Institute of Science and Technology, 14(4), 1626-1635, 2024
ISSN: 2146-0574, eISSN: 2536-4618
Chemistry **DOI: 10.21597/jist.1506140**
Research Article
Received: 27.06.2024 **Accepted: 28.08.2024**

To Cite: Naldan, H, Naldan, M. E., Taş N. & Akbulut Ö. (2024). How Does Lavender Affect Lactic Acid Levels Increased With Exercise?. *Journal of the Institute of Science and Technology*, 14(4), 1626-1635.

How Does Lavender Affect Lactic Acid Levels Increased With Exercise?

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Highlights:

- Lavender significantly reduces lactic acid levels.
- Lavender reduces fatigue levels.
- Lavender reduces pain after fatigue.

Keywords:

- Lavender
- Anaerobic Exercise
- Lavandula Angustifolia,
- Lactic Acid.

ABSTRACT:

This study examines the effects of lavender plants on fatigue levels and performance. The research started by randomly dividing 60 participants aged 18-25 into study and control groups. The Wingate Anaerobic Test was applied to the participants and the study group was administered a sauna filled with lavender. Data were collected and analyzed by measuring blood lactate levels. In all physiological characteristics examined, the differences between the control group and the study group before the study were found to be statistically insignificant. In both the study group and the control group, except for diastolic blood pressure, changes in all physiological characteristics and blood values according to measurement times (0, 1, 5 and 15 min) were found to be very significant ($p<0.001$). When the control group and the study group were compared, significant differences were found between pulse values in the first minute ($p=0.023$), saturation in the fifth minute ($p=0.020$) and lactate averages ($p=0.023$). In particular, it was observed that the lactate average in the fifth minute was 1.64 units lower in the study group than in the control group. Blood sugar levels decreased gradually in both groups compared to the initial value. This feature decreased by 17.45 units in the control group and 9.30 units in the study group at minute 1 compared to the initial value. It can be said that the calmness provided by the lavender scent causes less blood sugar drops. Findings support lavender's fatigue-reducing effects and suggest it may reduce painful conditions. Our study shows that these effects occur because lavender reduces lactate levels. Additionally studies in the literature confirm these results. The mechanism of lavender explains that inhalation affects the limbic system and hypothalamus causing relaxation, decreased anxiety, increased attention and concentration. It has been emphasized that lavender inhalation is a safe option. The study states that the results of a more comprehensive study that includes a larger sample and gender differences are needed. However research points out the difficulty of finding sufficient participants. This study provides an essential contribution to the potential health benefits of lavender.

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Ethics Committee Approval: Ethics Committee Approval was received for included in this article, with the decision of the "Atatürk University Hospital Medicine Faculty Ethics Committee" dated: 26.01.2023, Meeting No. 2023-1.

INTRODUCTION

Medical aromatic plants have been used for healing and gaining biological strength from ancient times to the present day. Numerous studies have been conducted on the historical development of these plants, how they spread across different cultures and geographies and their contemporary significance (Asadi-Samani et al., 2013; Kooti et al., 2014). Medical aromatic plants are known to have lower side effects and be more economical compared to synthetic drugs. These natural therapeutic agents can be applied as antispasmodic agents against various gastrointestinal system disorders such as constipation diarrhoea irritable bowel syndrome (IBS) and possessing bronchodilator properties (Nathanand and Scholten, 1999). Moreover, they reduce anxiety, muscle-skeletal spasms. Irritability and emotional stress and improve sleep quality (Bauer et al., 2010; Nasiri Lari et al., 2020). Antispasmodic medicinal plants exert their effects through various mechanisms including the activation of potassium ATP channels, inhibition of neurotransmitters like acetylcholine and serotonin or 5-hydroxytryptamine, reduction of extracellular calcium, blockade of muscarinic receptors and sodium channel inhibition (Gálvez et al. 2001; Taqvi et al., 2009; Mehmood et al. 2011).

Lavender is a widely used medicinal aromatic plant for treating various diseases. Lavender oil's antispasmodic activity may benefit respiratory diseases like asthma, bronchitis COPD and digestive disorders like IBS. It has been observed to possess antispasmodic action on the rat uterus and guinea pig ileum in vitro. The antispasmodic effect of lavender oil is known to occur through cAMP. Lavender contains bioactive compounds with Linalool being one of the major bioactive components with antispasmodic activity (Reiter & Brandt,1985; Lis-Balchin & Hart, 1997; Kang & Seol, 2015). Lavender essential oil has been shown to comprise 28 components with linalool (32.52%) and linalyl acetate (21.57%) being the predominant constituents (Kim & Cho, 1999; Peana et al., 2002).

Lactic Acid (LA) is a product of anaerobic glycolysis and is continuously produced by various tissues in the body. Skeletal muscles are the most significant site of LA metabolism. While muscles grow LA they also metabolize the LA they receive from circulation. Intramuscular LA production significantly increases during intense exercises leading to an elevated amount of LA entering the bloodstream. Passive and active muscles receive LA from circulation during recovery after high-intensity exercise or during low to moderate-intensity prolonged exercise. Accumulation of LA in muscle fibers due to decreased intracellular pH is a significant contributor to fatigue. The decrease in intracellular pH affects both glycolysis and contraction. Therefore, the rate at which LA leaves the muscle fiber especially during high-intensity intermittent activities can positively impact athletic performance. It has been accepted that LA produced by skeletal muscles enters or exits cells through simple diffusion. It has been determined that blood LA concentration and muscle blood flow rate influence the utilization of LA by tissues. Factors such as tissue metabolic rate the rate of transport across the cell membrane for LA. pH difference between muscle and blood muscle fiber type and aerobic exercises play roles in the entry or exit of LA from cells. Depending on the intensity of exercise exceeding the limits of aerobic metabolism increases the glycolytic rate resulting in the accumulation of LA in both blood and muscle. The decreased pH caused by LA leads to metabolic acidosis slowing glycolysis and reducing energy-providing metabolites. Accumulated LA in muscles and blood contributes to fatigue.

Under normal conditions there is approximately ten mg/L (or 1.1 mmol/L) of LA in 100 cc of blood (Kim, & Cho, 1999).LA is oxidized to water and carbon dioxide at a higher rate in the aerobic energy system during active recovery than in passive recovery. Glucose in the muscle first turns into

pyruvate and then lactate which is transported to the liver through the bloodstream and converted back to glucose via pyruvate. This cycle is known as the Cori Cycle.

In conducted studies it has been observed that lavender essential oil relaxes vascular smooth muscle. In a study on rabbits continuous and progressive relaxation during the contraction induced by phenylephrine in carotid artery samples was demonstrated when lavender essential oil's main component linalyl acetate was applied (Palmer et al., 1987; Chen et al., 1988). Furthermore, the compounds found in lavender essential oil have been investigated for their antinociceptive immunomodulatory and anti-inflammatory properties (Peana et al., 2002). In these studies, it has been noted that the effects are dependent on various volatile oil components present in lavender such as α-pinene α-terpinene terpin-4-ol α-terpineol linalyl acetate and linalool. These studies have concluded that the compounds found in lavender essential oil may have direct or indirect anti-inflammatory or antinociceptive activities. There are various application methods for medicinal aromatic plants. Inhalation aromatherapy where volatile oils are inhaled is a method that can reduce multiple psychological symptoms such as stress anxiety depression. and restlessness (Lee & Hwang, 2011), (Kim et al., 2011). Previous research on the advantages of aromatherapy with lavender essential oil has shown that lavender possesses sedative, antiseptic, calming, antispasmodic, analgesic and healing properties (Fayazi et al., 2011; Bikmoradi et al., 2015; Bagheri et al., 2020). Due to these properties of lavender. It is believed that it may benefit recovery parameters in sports. However previous studies have not identified any research showing that inhaling lavender reduces fatigue and lowers LA levels during exercise.

Today, it is widely accepted that engaging in sports is crucial for physical and mental health (Bulut, 2013; Holvast et al., 2017). Interest in sports continues to grow and people are looking to escape sedentary lifestyles through sports. Different sports disciplines determine their unique movements and exercises (Holvast et al., 2017). Proper timing and location of exercises and training contribute significantly to athletes' success by ensuring better performance and coordination. The human body especially during high-intensity physical activities exerts varying degrees of strain on homeostatic balance causing fatigue to some extent. Energy athletes need during physical activity is obtained by breaking down ATP which is limited in muscles. Energy must be sourced through aerobic or anaerobic pathways to replenish the ATP muscles use and achieve this gain. Some recovery models are used to achieve maximal efficiency sooner such as sauna massage low-intensity aerobic exercises swimming pool walking hot/cold water therapies relaxation techniques and exercise and competition post-recovery (Howatson et al., 2005). Sauna usage constitutes a passive recovery method and affects respiration rate muscle tone and blood flow. A sauna creates an environment with high temperature and low humidity resulting in a ten °C rise in temperature on the skin's upper surface when the sauna is used. The temperature beneath the skin's surface is approximately one °C higher than usual. This increased temperature enhances antibody production. accelerates blood circulation and triggers a significant sweating response to prevent excessive heat buildup beneath the skin eliminating accumulated toxins and relieving muscle pain caused by removing lactic acid (Kadhelm, 1966). In conclusion rapid muscle recovery in sports is critical for better performance. Adequate recovery is essential for athletes to overcome fatigue from exercise or competition and replenish energy reserves. This study aimed to determine the effects of respiratory inhalation of lavender oil aerosol during effort or exercise on specific physiological and blood characteristics.

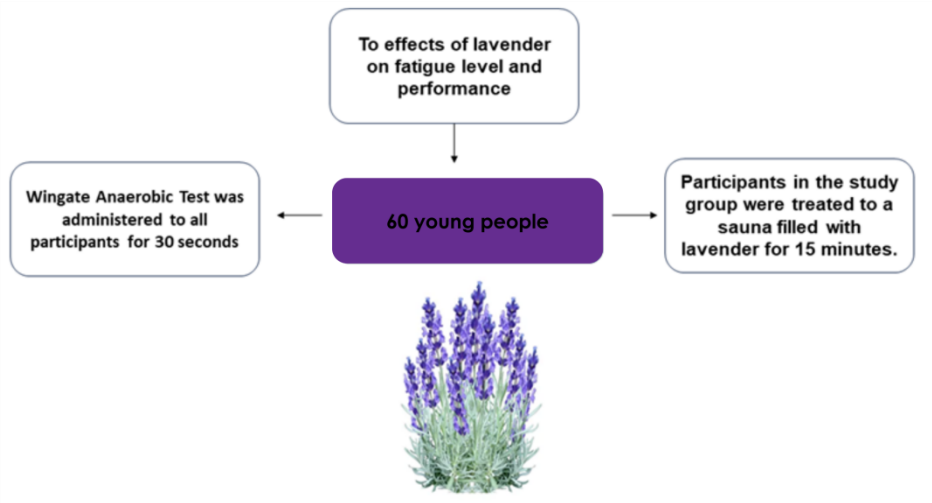

Figure 1. Workflow of this study

MATERIALS AND METHODS

This research was conducted on 60 male university student-athletes aged between 18 and 25 to evaluate their physical performance. The Wingate Anaerobic Power and Capacity test was administered at the Atatürk University Athlete Performance Measurement Evaluation and Rehabilitation Center to assess the participants' physical performance. Ethical approval for the research was obtained from the Atatürk University Ethics Committee under protocol code B.30.2.ATA.0.01.00/1 in January 2023. The participants were randomly selected and evenly distributed into study and control groups. All participants were informed about the study's objectives and were required to complete a voluntary participation consent form. They were also instructed not to consume food that could affect the test results and to refrain from exercising. Measurements for the control and study groups were conducted on different days under identical conditions between 08:30 and 12:00.

All participants performed a 30-second Wingate Anaerobic Power and Capacity test as an intense exercise in standard conditions at 25 degrees Celsius. Both groups were in the same steam room conditions; however in the study group. Two ccs of pure lavender volatile oil were added to the steam room (routine steam room usage procedures conducted this process) in contrast to the control group. Both groups remained in the sauna for 15 minutes after exercise. Post-exercise measurements were taken immediately and during the rest period. the study group was placed in a sauna with a lavender-scented environment. while the control group rested in a sauna with no added substances. Blood lactate (LA) measurements were conducted using a blood lactate analyzer and test strips. Blood was obtained from the fingertip and immediately analyzed by dripping it onto the test strips. Blood sugar measurements were taken from blood samples obtained from the fingertip. A manual blood pressure monitor obtained systolic and diastolic blood pressure measurements. Heart rate and SPO2 values were measured using an SPO2 probe.

Anaerobic Power (Wingate Test)

The Monark Ergomedic 839 E bicycle ergometer was used for the study's Wingate Anaerobic Test (WAnT). To determine anaerobic characteristics. the Wingate test assesses anaerobic performance by evaluating the lactic acid (average power) and a lactic acid (peak power) component. The Wingate Anaerobic Power Test involves maximum pedaling against a predetermined constant load for 30 seconds. Measurements during the test were automatically taken at six equal intervals of five seconds each. Athletes were given the necessary information before the test. and ample opportunity for practice trials before the test was administered (Yapici & Cengiz, 2015).

Figure 2. Monark Weighted Anaerobic Ergometer (Inbar and Bar-Or)

Data Analysis

The arithmetic means and standard deviation values of the examined variables were calculated. A preliminary analysis was conducted to assess the variables' normality analytically (Shapiro-Wilk test) and graphically (Histogram). The examined characteristics were found to align with a normal distribution. The differences between the control and study groups at each measurement time were analysed using an independent-sample t-test. The Repeated Measures ANOVA test determined measurement changes in the control and study groups over time. The significance level was set at $p<0.05$. The SPSS 20.0 program was used for data evaluation.

RESULTS AND DISCUSSION

Statistically no significant differences were found between the pre-test control and study groups in all examined physiological characteristics. This indicates that the groups were similar before the experiment. In both the study and control groups significant changes ($p<0.001$) were observed in all physiological characteristics and blood values at all measurement times (0. 1st. 5th. and 15th minutes). except for diastolic blood pressure. When comparing the control group and the study group significant differences were found in pulse values at the first minute ($p=0.023$) saturation at the fifth minute ($p=0.020$) and lactate averages at the fifth minute ($p=0.023$). Mainly it was observed that the lactate average at the fifth minute in the study group was 1.64 units lower than in the control group. Blood sugar values gradually decreased in both groups compared to the initial values. This feature indicates that the calmness provided by the lavender scent led to a less significant decrease in blood sugar. Except for blood sugar (glucose) the highest average value for all other characteristics was obtained at the first minute. After the first minute the averages of all features gradually decreased at the 5th and 15th minutes.

The lactate value increased by 4.52 units in the control group and 3.75 units in the study group compared to the initial value at the 1st minute. Similarly, the pulse rate increased by 41.1 units in the control group compared to the initial value while in the study group it increased by a lower 28.6 units.

These findings can be interpreted as a result of the positive effect of lavender inhalation on these characteristics.

Table 1. Mean standard deviation and statistical analysis results in control and study groups

Variable			*Measurement Times*								
			0 d		1.d		5.d		15.d		
		n	mean	sd	mean	sd	mean	sd	mean	sd	P(1)
Lactate	Control	30	2.69 d	.71	7.21 a	3.39	6.50 b M	2.70	3.92 c	1.54	<.001
	Study	30	2.70 d	1.28	6.45 a	1.96	4.86 b N	1.49	3.44 c	0.91	<.001
	P(2)		.976		.387		.023		.237		
T systolic	Control	30	113.0 b	8.2	136.5 a	22.7	111.3 b	12.8	110.5 b	10.9	<.001
	Study	30	116.0 b	7.7	137.3 a	15.9	115.8 b	14.7	119.3 b	15.1	<.001
	P(2)		.240		.904		.308		.042		
T diastolic	Control	30	80.8 a	10.5	76.0 a	15.0	76.3 a	10.9	80.8 a	10.2	.152
	Study	30	82.3 a	11.4	79.3 a	9.5	81.8 a	12.5	84.8 a	12.0	.373
	P(2)		.668		.418		.146		.262		
Saturation	Control	30	96.00 ab	1.6	96.4 a	1.1	95.2 bc M	1.2	95.1 c	.9	<.001
	Study	30	96.3 a	1.2	96.7 a	.1.0	96.1 a N	1.1	95.4 b	1.2	.001
	P(2)		.512		.378		.020		.370		
Pulse	Control	30	94.1 c	14.6	135.2a M	23.0	108.9 b	14.1	107.5 b	11.1	<.001
	Study	30	90.3 c	12.6	118.9 a N	20.3	103.0 b	12.6	105.4 b	17.3	<.001
	P(2)		.389		.023		.168		.643		
Blood Sugar	Control	30	107.40 a	16.92	89.85 b	18.73	97.70 ab	12.52	95.85 b	12.38	.003
	Study	30	106.95 a	8.80	97.65 b	8.86	93.40 b	7.78	96.25 b	9.57	<.001
	P(2)		.917		.100		.200		.910		

a. b. c. d: Different letters within the same row indicate that the means are significantly different from each other ($p < 0.05$).
M. N: Different letters within the column indicate that the means differ significantly ($p < 0.05$).
P(1): Represents the significant results of the Repeated Measures ANOVA test.
P(2): Represents the significant results of the independent two-group (Control and Study) t-test between the control and study groups at specific time points.

Our study aimed to investigate the effect of an easily accessible and cost-effective medicinal aromatic plant like lavender on fatigue levels and performance. In our study we applied the Wingate Anaerobic test to young individuals for 30 seconds. Subsequently individuals in the study group inhaled lavender for 15 minutes in a sauna. When compared to the control group which did not receive lavender it was observed that blood lactate (LA) levels did not increase as much in the study group and decreased more significantly and rapidly. This effect of lavender in reducing potentially painful conditions that can occur during strenuous sports activities is one of its wonderful positive effects. The literature emphasises that excessive fatigue can lead to headaches and other muscle pains in individuals. Studies indicate that lavender can also reduce such types of pain (Kim, 2007; Rafie et al., 2016; Yuan, 2021).

Lavender inhaler form has been used in studies for migraine-type headaches and headaches after post-dural puncture and it is effective (Sasannejad et al., 2012; Nasiri et al., 2022). Studies involving oral lavender application also exist. Oral administration is generally used to treat acute and chronic infections in the gastrointestinal system and it is reported to have analgesic and gastroprotective effects in addition to its antiseptic effects. When inhaled lavender essential oils stimulate the limbic system and hypothalamus through olfactory receptors activate the parasympathetic nervous system slow metabolism and release dopamine, serotonin and endorphins in the brainstem (Başaran, 2009; Watanabe, 2015). This supports the reduction of pain, tension, anxiety and depression in individuals as well as improving attention and concentration (Buckle, 2015; Donelli, 2019; Seifi, 2019).

When lavender is used as an inhaler it also reduces stress. When lavender's fatigue-relieving effect is combined with its analgesic and anxiolytic effects it can significantly impact performance in sports activities. Despite being such an effective medicinal, aromatic plant lavender is one of the least reported aromatics for side effects (Buckle, 2015; Seifi, 2019). Therefore, using lavender via inhalation is both a safe and practical option. In addition, it helps avoid potential high doses and side effects that may occur with oral intake. However, the inhalation technique also has some disadvantages. For example, factors such as the concentration quality, purity and source of the compounds in lavender oil can affect the effectiveness of inhalation. Additionally, some individuals may develop allergic reactions or respiratory problems due to lavender oil (Oruç at al., 2017). Therefore, it is necessary to consult a doctor and perform a small test before using lavender oil. However, it is known that long-term use of lavender can lead to drowsiness, fatigue, mild dizziness and headaches.

Our study did not observe any adverse reactions or allergic conditions in the group where lavender was applied. An advantage of our research is that participants were evaluated based on objective laboratory values rather than subjective criteria such as personal opinions, complaints and pain scales.

CONCLUSION

In conclusion our study shows that an easily accessible and cost-effective medicinal aromatic plant like lavender can significantly reduce individuals' fatigue levels and potentially enhance their performance. In particular the considerably lower average lactate levels in the study group compared to the control group at the fifth minute indicate that inhalation of lavender markedly reduces blood lactate levels. Those in the group using lavender performed their activities much more comfortably and were more vigorous. From another perspective using lavender volatile oil in massage and meditation rooms provides a sense of happiness. These results show that it lowers blood lactate levels making individuals feel less tired and relaxed. Usually, it takes approximately 5 minutes for the lactic acid accumulated in the muscles after maximum exercise to reach its highest level in the bloodstream. Beyond this time frame our study achieved significantly lower lactate levels in the study group. In our study we investigated the effects of lavender volatile oil on human physiology during exercise. This study can be done with professional athletes working in a wider range of different sports.

Conflict of Interest

The article authors declare that there is no conflict of interest between us.

Author’s Contributions

The authors declare that they have contributed equally to the article.

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