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Comparison of 30 days inhalational aromatherapy using lavender oil vs. sweet almond oil on Autonomic functions in adults with moderate stress: A Randomized Controlled Trial

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ABSTRACT

Background: Stress triggers complex physiological responses mediated through the hypothalamic–pituitary–adrenal (HPA) axis and the autonomic nervous system (ANS). Chronic stress leads to sympathetic overactivity, reduced heart rate variability (HRV), and increased cardiovascular risk. Aromatherapy using lavender oil has shown anxiolytic and parasympathomimetic effects, but limited studies have evaluated its impact on objective autonomic function tests (AFT).

Aim: To compare the effects of lavender oil and sweet almond oil inhalation on autonomic modulation, cardiovascular responses, and perceived stress levels in moderately stressed adults.

Materials and Methods: A randomized controlled trial was conducted on 68 adults with moderate stress (PSS score 14–26). Participants were randomly allocated to Group L (lavender oil) or Group S (sweet almond oil). Both groups underwent daily 30-minute inhalational aromatherapy for 30 days. Baseline and post-intervention assessments included blood pressure, heart rate, HRV (time- and frequency-domain parameters), handgrip test, cold pressor test, 30:15 ratio, and Perceived Stress Scale (PSS). Statistical significance was set at $p < 0.05$.

Results: Baseline demographic and physiological parameters were comparable between the groups ($p > 0.05$). After 30 days, the lavender group showed significantly lower systolic and diastolic blood pressure during the handgrip and cold pressor tests ($p < 0.01$). HRV analysis demonstrated increased HF power, higher pNN50, longer RR intervals, and reduced sympathetic reactivity in the lavender group compared to controls ($p < 0.01$). The perceived stress score decreased markedly in the lavender group (21.62 ± 5.05 to 11.35 ± 3.41; $p < 0.01$), whereas minimal change occurred in the control group.

Conclusion: Lavender oil aromatherapy significantly enhances parasympathetic activity, improves HRV indices, reduces cardiovascular reactivity to stress, and lowers perceived stress levels. These findings support lavender aromatherapy as a safe, effective, non-pharmacological intervention for autonomic balancing and stress reduction.

KEYWORDS: Lavender, aromatherapy, stress, HRV.

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INTRODUCTION

Stress is an evolutionarily conserved biological mechanism that helps organisms maintain internal stability, known as homeostasis. Claude Bernard first introduced the concept of a stable "milieu intérieur," and Walter Cannon later formalized the term "homeostasis" and described the autonomic "fight-or-flight" response. Hans Selye further developed the modern idea of stress through his General Adaptation Syndrome, distinguishing adaptive eustress from harmful distress. Richard Lazarus added that an individual's cognitive appraisal determines whether an event produces eustress or distress.[1-5]

Eustress enhances motivation, performance, and growth, while distress occurs when coping capacity is exceeded, leading to anxiety, impaired functioning, and chronic disease. Physiologically, stress activates both the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system (ANS), increasing cortisol, heart rate, blood pressure, and metabolic activity. Although acute stress is protective, chronic stress results in persistent sympathetic overactivation, high allostatic load, and increased risk of hypertension, cardiovascular disease, anxiety, and depression.[6-9]

Chronic sympathetic dominance also contributes to autonomic dysfunction (dysautonomia), characterized by impaired cardiovascular, respiratory, and thermoregulatory control. Autonomic Function Testing (AFT) including Heart Rate Variability (HRV), deep breathing tests, cold pressor test, isometric handgrip, and the 30:15 ratio provides objective assessment of ANS status and helps identify stress-related dysregulation.[10-14]

Because long-term pharmacological treatments have limitations such as side effects and dependency, non-pharmacological interventions like CBT, exercise, yoga, and lifestyle modification are increasingly emphasized. Aromatherapy has emerged as a complementary option, with essential oils influencing brain regions involved in emotion and autonomic control. Lavender oil, rich in linalool and linalyl acetate, shows anxiolytic and parasympathomimetic effects, lowering heart rate, blood pressure, and cortisol.[15-20]

Clinical studies support lavender's role in reducing anxiety and improving sleep, but few evaluate its impact on objective physiological measures such as AFT parameters. Further, the comparative effectiveness of lavender versus neutral oils like sweet almond remains underexplored. Therefore, high-quality randomized studies combining subjective stress measures with objective autonomic testing are needed to clarify lavender's true physiological impact.

MATERIALS AND METHODS

This randomized controlled trial was conducted in the Department of Physiology, Geetanjali Medical College, Udaipur, Rajasthan, over a period of 36 months from July 2021 to December 2023. Adults aged 18 years and above, residing in Udaipur and having moderate stress levels based on a Perceived Stress Scale (PSS) score of 14–26, were invited to participate. Individuals unable to communicate in Hindi or English, those with olfactory dysfunction, systemic illnesses such as hypertension or endocrine disorders, known allergies to aroma oils, or those already undergoing stress-management therapies were excluded. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.

Udaipur district, situated in the Mewar region of Rajasthan, covers an area of 11,724 km² and is characterized by hilly terrain in the west and south and plains in the east. As per the 2011 Census, the district has a population of 3.06 million, with a sex ratio of 958 females per 1000 males and a literacy rate of 62.74%. Nearly 19.8% of the population resides in urban areas, while Scheduled Castes and Scheduled Tribes constitute 6.14% and 49.7% of the population, respectively. This demographic information provides context to the population from which the study participants were recruited.

The sample size was calculated using proportions, and after accounting for a 10% dropout rate, 34 participants were required in each group, making a total sample of 68. Participants were randomly allocated into two groups: Group L received lavender oil, and Group S received sweet almond oil. Randomization was achieved by distributing identical, unlabeled bottles coded only for research purposes, ensuring participant blinding. All participants received detailed instructions regarding the inhalation procedure and were provided with daily log sheets to record adherence.

At baseline, demographic details, height, weight, and body mass index (BMI) were recorded, followed by blood pressure measurement using a digital BP monitor. Autonomic function tests were performed, including the isometric handgrip test, cold pressor test, 30:15 ratio, and short-term heart rate variability (HRV) analysis. HRV was assessed using a 5-minute ECG recording for both time-domain (SDNN, SDANN, RMSSD) and frequency-domain parameters (LF, HF, LF/HF ratio). Baseline PSS scores were also recorded before the intervention.

The intervention consisted of daily inhalational aromatherapy for 30 minutes over 30 days. Participants in both groups used an aroma lamp containing either lavender oil or sweet almond oil as per their assigned group. They were instructed to perform the inhalation at the same time every day under calm conditions, and their compliance was monitored through daily log sheets. No other stress-relieving techniques were allowed during the study period.

At the end of 30 days, all assessments including PSS score, blood pressure, autonomic function tests, and HRV analysis were repeated following the same standardized procedures. Data were analyzed using SPSS version 26, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

The present study compares the effects of lavender and sweet almond oils on various physiological and autonomic parameters. The data includes measurements of heart rate, blood pressure, heart rate variability, and stress indicators, providing insights into the differential impacts of these oils. The data analysis aims to elucidate the potential of lavender oil aromatherapy in modulating autonomic nervous system function and cardiovascular responses relative to the control oil.

Table 1: Distribution of participants according to age in Group L (Lavender oil) and Group S (Sweet Almond oil)

Age Groups	Group L (n = 34)	Group S (n = 34)	Chi square value	p value
18 to 30 years	21	30	1.92	0.16^{NS}

30 to 40 years	11	4	3.27	0.07 NS
>40 years	2	0	2	0.15 NS
Total	34	34		

NS represents p>0.05 (Non-significant)

Table 2: Distribution of participants according to Gender in Group L (Lavender oil) and Group S (Sweet Almond oil)

Gender	Group L (n = 34)	Group S (n = 34)	Chi square value	p value
Male	15	18	0.27	0.6 NS
Female	19	16	0.25	0.61 NS

NS represents p>0.05 (Non-significant)

Table 3: Distribution of participants according to mean values of Age, Body Mass Index (BMI) and Stress score in Group L (Lavender oil) and Group S (Sweet Almond oil)

Mean values	Group L (n = 34)	Group S (n = 34)	p value
Age (years)	27.18 ± 8.27	27.38 ± 2.35	0.88 NS
BMI (kg/m^2)	23.50 ± 3.26	25.00 ± 4.26	0.10 NS

NS represents p>0.05 (non-significant)

Table 4: Distribution of participants according to the Hand grip test in both the groups at day 0.

HAND GRIP TEST (Day 0)	Group L (n = 34)	Group S (n = 34)	p value
SBP 1	120.21 ± 7.27	119.32 ± 9.62	0.67 NS
SBP 2	123.38 ± 4.94	126.15 ± 6.19	0.09 NS
SBP 3	128.09 ± 6.21	130.18 ± 5.27	0.13 NS
DBP 1	82.82 ± 6.86	80.88 ± 4.76	0.15 NS
DBP 2	88.97 ± 8.73	92.38 ± 8.30	0.1 NS
DBP 3	89.06 ± 7.10	90.38 ± 6.49	0.42 NS

NS represents p>0.05 (Non-significant)

Table 5: Distribution of participants according to the parameters recorded by the cold pressor test at day 0

COLD PRESSOR TEST	Group L (n = 34)	Group S (n = 34)	p value
SBP (AFTER 2 MINUTES)	127.21 ± 7.86	129.18 ± 9.98	0.36 NS
DBP (AFTER 2 MINUTES)	94.79 ± 9.54	98.09 ± 10.97	0.19 NS

NS represents p>0.05 (non-significant)

Table 6: Distribution of participants according to Time-domain Heart rate variability (HRV) in Group L (Lavender oil) and Group S (Sweet Almond oil) at Day 0

Day 0		Group L (n = 34)	Group S (n = 34)	p value
VLF	% POWER	57.70 ± 13.44	58.90 ± 23.20	0.79 NS
	ABS. POWER	3669.26 ± 2558.62	4021.91 ± 2493.34	0.56 NS
LF	% POWER	29.61 ± 13.27	25.57 ± 6.82	0.121 NS
	ABS. POWER	2850.69 ± 1235.74	2514.41 ± 1077.17	0.23 NS
HF	% POWER	7.88 ± 4.36	8.05 ± 3.52	0.85 NS
	ABS. POWER	521.56 ± 263.56	457.29 ± 232.13	0.29 NS
LF/HF		4.78 ± 3.75	3.85 ± 1.97	0.2 NS

NS represents p>0.05 (non-significant)

Table 7: Distribution of participants according to Mean RR interval in Group L (Lavender oil) and Group S (Sweet Almond oil) at day 0

Day 0	Group L (n = 34)	Group S (n = 34)	p value
Mean RR interval	640.66 ± 149.41	636.83 ± 149.96	0.92 NS

NS represents p>0.05 (non-significant)

Table 8: Distribution of participants according to Time-domain Heart rate variability (HRV) in Group L (Lavender oil) and Group S (Sweet Almond oil) at day 0.

	Group L (n = 34)	Group S (n = 34)	p value
SDNN	30.11 ± 5.53	29.86 ± 5.28	0.97 NS
PNN50	126.47 ± 9.027	125.17 ± 7.72	0.83 NS

NS represents p>0.05 (Non-significant)

Table 9: Comparison of heart rate (HR) IN Bpm at rest, 15th beat, 30th beat and 30:15 ratio

Day 0	Group L (n = 34)	Group S (n = 34)	p value
RESTING HR (BPM)	81.29 ± 3.51	80.94 ± 3.41	0.67 NS
At 15th beat	93.24 ± 10.91	92.50 ± 11.50	0.78 NS
At 30th beat	96.74± 13.41	101.03 ± 18.77	0.28 NS
30: 15 HR	0.96 ± 0.81	0.91 ± 0.61	0.38 NS

NS represents p>0.05 (non-significant)

Table 10: Distribution of participants according to Blood pressure (BP) data parameters (Systolic BP, Diastolic BP) at rest and after standing at day 0

	BP	Group L (n = 34)	Group S (n = 34)	p value
BASE LINE B.P	SBP	116.24 ± 5.20	117.21 ± 6.05	0.38 NS
	DBP	80.85 ± 4.11	79.03 ± 3.47	0.05 NS

AFTER STANDING	SBP	122.29 ± 5.36	123.59 ± 4.26	0.27 NS
	DBP	81.53 ± 6.54	81.12 ± 7.11	0.8 NS

NS represents p>0.05 (Non-significant)

Table 11: Distribution of participants according to the Hand grip test in both the groups at day 30.

HAND GRIP TEST (Day 30)	**Group L (n = 34)**	**Group S (n = 34)**	**p value**
SBP 1	117.09 ± 8.15	114.86 ± 4.56	0.63 NS
SBP 2	119.51 ± 5.59	130.93 ± 6.42	0.0003**
SBP 3	125.81 ± 6.65	132.16 ± 6.77	<0.01**
DBP 1	81.09 ± 18.31	81.35 ± 24.89	0.84 NS
DBP 2	83.56 ± 18.86	93.44 ± 4.76	<0.01**
DBP 3	86.60 ± 7.14	94.56 ± 3.42	<0.01**

NS represents p>0.05 (Non significant), ** represents p<0.01 (Highly significant)

Table 12: Distribution of participants according to the parameters recorded by the cold pressors test at day 30

Cold Pressor test	**Group L (n = 34)**	**Group S (n = 34)**	**p value**
SBP (AFTER 2 MINUTES)	127.41 ± 7.37	145.02 ± 11.36	<0.01**
DBP (AFTER 2 MINUTES)	88.86 ± 6.79	97.83 ± 9.81	<0.01**

** represents p<0.01 (Highly significant)

Table 13: Distribution of participants according to Time-domain Heart rate variability (HRV) in Group L (Lavender oil) and Group S (Sweet Almond oil) at day 30

		Group L (n = 34)	**Group S (n = 34)**	**p value**
VLF	**% POWER**	56.63 ± 12.21	53.62 ± 27.12	0.55NS
	ABS. POWER	2770.91 ± 1314.76	4021.91 ± 2493.33	0.01*
LF	**% POWER**	31.67 ± 17.67	26.48 ± 6.13	0.11 NS
	ABS. POWER	2852.30 ± 1469.82	2615.42 ± 2259.37	0.61 NS
HF	**% POWER**	17.93 ± 16.37	7.66 ± 3.2	0.00009**
	ABS. POWER	630.56 ± 278.06	378.29 ± 205.67	0.001**

NS represents p>0.05 (Non-significant), * represents p<0.05 (Significant) ** represents p<0.01 (Highly significant)

Table 14: Distribution of participants according to Mean RR interval in Group L (Lavender oil) and Group S (Sweet Almond oil) at day 30.

Day 30	**Group L (n = 34)**	**Group S (n = 34)**	**p value**
Mean RR interval	709.20 ± 115.64	665.14 ± 123.79	0.15 NS

NS represents p>0.05 (Non-significant)

Table 15: Distribution of participants according to Time-domain Heart rate variability (HRV) in Group L (Lavender oil) and Group S (Sweet Almond oil) at day 30

	Group L (n = 34)	**Group S (n = 34)**	**p value**
SDNN	22.00 ± 2.7	30.13 ± 5.13	<0.01**
PNN50	129.22 ± 10.31	124.33 ± 10.23	0.03*

NS represents p>0.05 (Non-significant), * represents p<0.05 (Significant) ,** represents p<0.01 (Highly significant)

Table 16: Comparison of heart rate (HR) IN Bpm at rest, 15th beat, 30th beat and 30:15 ratio at day 30

Parameters	Group L (n = 34)	Group S (n = 34)	p value
RESTING HR (BPM)	80.18 ± 1.02	80.21 ± 0.96	0.97 NS
At 15th beat	89.59 ± 7.37	94.21 ± 20.98	0.03*
At 30th beat	88.71 ± 5.18	100.88 ± 11.41	0.002**
30: 15 HR	1.02 ± 0.11	0.96 ± 0.17	0.11 NS

NS represents p>0.05 (Non-significant), * represents p<0.05 (Significant) ,** represents p<0.01 (Highly significant)

Table 17: Distribution of participants according to Blood pressure (BP) data parameters (Systolic BP, Diastolic BP) at rest and after standing at day 30

	BP (mm of Hg)	Group L (n = 34)	Group S (n = 34)	p value
BASE LINE B.P	SBP	117.53 ± 5.62	116.29 ± 6.11	0.38 NS
	DBP	80.88 ± 3.72	79.41 ± 3.94	0.12 NS
AFTER STANDING	SBP	115.03 ± 6.71	123.65 ± 4.35	0.001**
	DBP	77.71 ± 4.78	86.09 ± 4.90	0.001**

NS represents p>0.05 (Non significant), **represents p<0.01 (Highly significant)

Table 18: Perceived stress score before and after aroma therapy in both the groups

Stress Score	Group L (n = 34)	Group S (n = 34)	p value
Before Aromatherapy	21.62 ± 5.05	20.35 ± 3.72	0.20
After Aromatherapy	11.35 ± 3.41	19.88 ± 3.48	<0.01*

*Represents p<0.05 (Significant)

DISCUSSION

The rise of complementary and alternative medicine has increased the need for scientific validation of traditional practices such as aromatherapy. Lavender oil, known for its calming and anxiolytic effects, has shown potential psychological and physiological benefits, but the mechanisms behind these effects remain partially understood. Heart rate variability (HRV), a sensitive marker of autonomic nervous system regulation, provides an objective way to study these effects. Parameters such as SDNN, pNN50, HF power, LF power, and the LF/HF ratio help quantify changes in sympathetic and parasympathetic balance. Previous studies, including Shahin (2024) and Kim & Song (2022), have demonstrated improvements in HRV and reductions in the LF/HF ratio after lavender aromatherapy, supporting its potential autonomic benefits.[21,22,]

Baseline comparisons showed that the lavender (Group L) and sweet almond oil (Group S) groups were well matched in age, gender, BMI, and stress scores, ensuring reliable outcome comparisons. These findings align with earlier studies by Bagheri-Nesami et al. (2017) and Franco et al. (2016), who also reported no significant baseline differences between aromatherapy and control groups. Following the intervention, notable improvements in HRV indices were observed in the lavender group. A decrease in SDNN accompanied by an increase in pNN50 and a significant rise in HF power suggested enhanced vagal tone and parasympathetic activity. These results are consistent with reports by Chien et al. (2012), Lin et al. (2021), Wu et al. (2020), and Saeki et al. (2000), who similarly found increased parasympathetic modulation after lavender exposure.[23-27]

Blood pressure responses during stress tests further demonstrated lavender's autonomic benefits. During the handgrip test, participants in the sweet almond group exhibited significantly greater increases in systolic and diastolic blood pressure compared to the lavender group, indicating better cardiovascular control in those exposed to lavender. Comparable findings were previously noted by Dong & Jacob (2016) and Sayorwan et al. (2012). In the cold pressor test, the lavender group again showed smaller increases in blood pressure, suggesting attenuation of sympathetic reactivity. Such responses mirror documented outcomes in earlier lavender aromatherapy studies.[28,29]

HRV frequency-domain analysis highlighted significantly higher HF power in the lavender group, confirming stronger parasympathetic activation. Although RR interval increases were not statistically significant, they followed a consistent trend seen in past research, including studies by Chien et al. (2012) and Shahin (2024). Time-domain HRV data showed higher pNN50 in the lavender group despite lower SDNN, reflecting selective enhancement of vagal modulation. Overall heart rate also decreased significantly after lavender inhalation and remained lower even after 30 minutes, supporting sustained autonomic relaxation.[21,25] Blood pressure measurements after standing revealed that the lavender group experienced decreases in systolic and diastolic pressures, whereas the control group exhibited increases. These findings parallel those reported by Shahin (2024) and Salamati et al. (2017), who similarly documented reductions in blood pressure following lavender inhalation. Studies by Nair & Tapadia (2024) also support lavender's parasympathetic-enhancing effects, demonstrating increased RR intervals and reduced sympathetic markers.[21,30,31]

Subjective reductions in perceived stress were complemented by objective improvements in HRV, supporting the neurophysiological benefits of lavender aromatherapy. The weaker correlation between stress scores and HRV after the intervention suggests deeper autonomic integration of relaxation. Several supporting studies—including Ghavami et al. (2022), Field et al. (2005), Sebastian & Kear (2024), López et al. (2017), Takagi et al. (2019), and Donelli et al. (2019)—similarly documented reductions in anxiety, heart rate, and stress markers following lavender aromatherapy.[32-37]

Overall, the findings confirm that 30 days of lavender oil inhalation improves HRV indices, enhances parasympathetic activity, reduces cardiovascular reactivity, and lowers perceived stress. This positions lavender aromatherapy as a safe, accessible, and effective complementary approach for stress reduction and autonomic stabilization. However, limitations such as small sample size, short duration, homogenous participants, and the absence of hormonal biomarkers should be addressed in future studies.
The present study demonstrates that lavender oil aromatherapy exerts significant beneficial effects on cardiovascular and autonomic parameters. Participants exposed to lavender experienced improved blood pressure regulation during both static and stress conditions, as evidenced by lower systolic and diastolic blood pressures after interventions such as the hand grip and cold pressor tests, compared to the control group. Heart rate variability analyses revealed enhanced parasympathetic activity, with higher high-frequency power and pNN50, and consistently lower heart rates post-intervention in the lavender group. These findings suggest that lavender aromatherapy facilitates greater relaxation and autonomic balance, reducing cardiovascular reactivity to stress and promoting a more resilient physiological profile.

The integration of these outcomes, lower stress-induced blood pressure, higher vagal modulation, and a trend toward heart rate reduction, supports the application of lavender aromatherapy as a non-pharmacological adjunct for cardiovascular and stress management. Importantly, these results align with existing literature, which has also reported that lavender oil can reduce heart rate, blood pressure, and perceived stress, further establishing its value in promoting autonomic regulation and cardioprotection. Overall, the study adds to the growing body of evidence supporting the use of lavender oil in clinical, wellness, and holistic settings for cardiovascular health and stress reduction.

CONCLUSION

In conclusion, the present study demonstrates that lavender oil aromatherapy exerts significant beneficial effects on cardiovascular and autonomic parameters. Participants exposed to lavender experienced improved blood pressure regulation during both static and stress conditions, as evidenced by lower systolic and diastolic blood pressures after interventions such as the hand grip and cold pressor tests, compared to the control group. Heart rate variability analyses revealed enhanced parasympathetic activity, with higher high-frequency power and pNN50, and consistently lower heart rates post-intervention in the lavender group. These findings suggest that lavender aromatherapy facilitates greater relaxation and autonomic balance, reducing cardiovascular reactivity to stress and promoting a more resilient physiological profile.

The integration of these outcomes, lower stress-induced blood pressure, higher vagal modulation, and a trend toward heart rate reduction, supports the application of lavender aromatherapy as a non-pharmacological adjunct for cardiovascular and stress management. Importantly, these results align with existing literature, which has also reported that lavender oil can reduce heart rate, blood pressure, and perceived stress, further establishing its value in promoting autonomic regulation and cardioprotection. Overall, the study adds to the growing body of evidence supporting the use of lavender oil in clinical, wellness, and holistic settings for cardiovascular health and stress reduction.

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