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PHYSIOLOGICAL EFFECTS OF LAVENDER, ROSEMARY, AND SAGE ESSENTIAL OILS ON THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS

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Abstract
The study investigates the physiological effects of lavender (Lavandula angustifolia), rosemary (Rosmarinus officinalis), and sage (Salvia officinalis) essential oils on the cardiovascular and respiratory systems. Essential oils derived from these medicinal plants are known for their complex biochemical composition and regulatory influence on autonomic nervous system activity. Experimental observations demonstrated that controlled inhalation of the essential oils produced moderate hypotensive and bronchodilatory effects, as well as improvement in oxygen saturation and pulse stability. These findings suggest that lavender, rosemary, and sage essential oils may have potential supportive value in maintaining cardiovascular and respiratory homeostasis, as well as in the prevention of functional disorders associated with stress and hypoxia.

Keywords: Lavender essential oil, Rosemary essential oil, Sage essential oil, Cardiovascular system, Respiratory system, Physiological effects, Aromatherapy, Autonomic regulation, Hypoxia prevention.

Introduction

In recent decades, there has been a growing interest in the physiological and therapeutic potential of essential oils derived from medicinal plants. Among the most widely studied are the essential oils of Lavandula angustifolia (lavender), Rosmarinus officinalis (rosemary), and Salvia officinalis (sage), which possess a broad spectrum of pharmacological and biological activities. These natural volatile compounds are composed of diverse bioactive constituents, including monoterpenes, esters, phenolic acids, and flavonoids, which exert regulatory effects on the central and autonomic nervous systems, cardiovascular function, and respiratory dynamics.

The cardiovascular and respiratory systems are highly sensitive to changes in neurohumoral regulation and oxidative stress, both of which are major contributors to modern lifestyle-related disorders such as hypertension, ischemic heart disease, and chronic obstructive pulmonary disease. Recent studies have demonstrated that inhalation or topical application of essential oils can modulate autonomic balance, improve microcirculation, and promote oxygen transport by influencing both the sympathetic and parasympathetic branches of the nervous system. This regulatory mechanism has been associated with reductions in blood pressure, normalization of heart rate variability, and facilitation of bronchial smooth muscle relaxation.

Lavender essential oil has been recognized for its anxiolytic, sedative, and mild hypotensive properties, primarily mediated through modulation of γ-aminobutyric acid (GABA) receptors and suppression of sympathetic outflow. Rosemary oil, on the other hand, exhibits antioxidant and circulatory-stimulating effects, enhancing cerebral and peripheral blood flow through its active compounds such as 1,8-cineole and camphor. Sage oil contains thujone, camphor, and borneol, which possess bronchodilatory and anti-inflammatory properties, contributing to improved respiratory efficiency and alveolar ventilation.

The integrated evaluation of these three essential oils is of particular interest, as their combined or comparative effects may reveal complementary physiological mechanisms beneficial for maintaining cardiopulmonary homeostasis. Despite the increasing popularity of aromatherapy and phytotherapy in clinical practice, there remains a need for evidence-based studies that clearly define the physiological responses and safety profiles of these bioactive substances.

Therefore, the present study aims to investigate the physiological effects of lavender, rosemary, and sage essential oils on the cardiovascular and respiratory systems. Through experimental observation and analysis, this research seeks to clarify their influence on hemodynamic parameters, respiratory function, and autonomic regulation, providing a scientific foundation for their potential application in integrative medicine and functional therapy.

Materials and Methods

Study design. This experimental study was designed as a randomized, double-blind, placebo-controlled, crossover trial to investigate the short-term physiological effects of Lavandula angustifolia (lavender), Rosmarinus officinalis (rosemary), and Salvia officinalis (sage) essential oils on cardiovascular and respiratory functions. Each subject participated in four sessions — lavender, rosemary, sage, and placebo — conducted in random order, with a minimum 72-hour washout period between sessions to avoid cross-contamination or residual effects.

Ethical approval and participants. The study was approved by the Institutional Ethics Committee of [University or Institute name], and conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision). All participants provided written informed consent before enrollment.

Thirty healthy adult volunteers (15 males, 15 females; aged 20–50 years) were included. Inclusion criteria were: normal body mass index (18.5–25.0 kg/m²), absence of chronic cardiovascular or respiratory disease, and no current medication influencing autonomic nervous system activity. Exclusion criteria included: history of asthma, chronic obstructive pulmonary disease, cardiac arrhythmia, allergy to essential oils, pregnancy, or acute respiratory infection during the study period.

Essential oils and placebo. Therapeutic-grade essential oils of Lavandula angustifolia, Rosmarinus officinalis, and Salvia officinalis were obtained from a GMP-certified manufacturer (provide brand and country). Each oil's chemical composition was verified using gas chromatography–mass spectrometry (GC–MS), confirming the presence of principal constituents such as linalool and linalyl acetate (lavender), 1,8-cineole and camphor (rosemary), and thujone and borneol (sage). Oils were stored in amber glass bottles at 4 °C until use.

For experimental sessions, essential oils were diluted to 2% v/v in odorless propylene glycol. The placebo consisted of propylene glycol without essential oil. All solutions were prepared and coded by an independent technician not involved in data collection to maintain double blinding.

Exposure protocol. Each session was performed in a temperature- and humidity-controlled laboratory environment (22 ± 2 °C, 50 ± 5% relative humidity). Participants were seated comfortably and instructed to relax for 20 minutes before baseline measurements.

A standard ultrasonic diffuser (output particle size < 5 µm) was placed one meter in front of the participant. A 0.5 mL aliquot of the prepared solution (essential oil or placebo) was added to the diffuser, and inhalation exposure lasted 15 minutes with spontaneous breathing. The total room volume was approximately 20 m^3, and air exchange was minimized during exposure.

To control confounding factors, participants were instructed to avoid caffeine, alcohol, nicotine, and physical exertion for at least 12 hours before each session.

Measurements and instrumentation. All physiological measurements were performed at baseline (pre-inhalation), during inhalation (15 min), and post-exposure (30 min).

Primary cardiovascular parameters: Systolic and diastolic blood pressure (SBP, DBP): measured with an automated validated oscillometric device (average of two readings).

Heart rate (HR) and heart rate variability (HRV): recorded continuously using a 3-lead electrocardiograph (sampling frequency ≥ 500 Hz). Time-domain (SDNN, RMSSD) and frequency-domain (LF, HF, LF/HF ratio) indices were computed using Kubios HRV software.

Primary respiratory parameters: Respiratory rate (RR): measured using inductive plethysmography.

Peripheral oxygen saturation (SpO_2): monitored with a fingertip pulse oximeter (average of 30 s intervals).

Spirometry: forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured according to ATS/ERS guidelines using a calibrated spirometer before and 30 minutes after exposure.

Secondary parameters: Subjective relaxation and anxiety levels were assessed using a 100 mm visual analogue scale (VAS) before and after inhalation.

Adverse effects such as dizziness, throat irritation, or cough were recorded immediately and 24 hours post-session via standardized questionnaire.

Data Analysis

Raw ECG data were preprocessed to remove artifacts and ectopic beats. HRV indices were calculated over 5-minute segments during baseline, exposure, and post-exposure periods.

All data were analyzed using SPSS Statistics v27.0 (IBM Corp., USA). Results are expressed as mean ± standard deviation (SD).

Normality was tested by the Shapiro–Wilk method. For normally distributed variables, a repeated-measures ANOVA with Greenhouse–Geisser correction was applied to assess the effects of treatment (lavender, rosemary, sage, placebo) and time (baseline, exposure, post-exposure). Post-hoc comparisons were performed using the Bonferroni correction. For nonparametric data, the Friedman test followed by Wilcoxon signed-rank tests was used.

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A p-value < 0.05 was considered statistically significant. Effect sizes (Cohen's d and partial η^2) and 95% confidence intervals were calculated for key outcomes.

Quality control and safety considerations

All equipment was calibrated before each measurement day. Room environmental parameters were recorded for every session. Participants were continuously monitored by medical personnel for signs of respiratory discomfort or hemodynamic instability. No serious adverse events were observed during pilot testing.

To ensure reproducibility, complete methodological details — including essential oil chemical profiles, exposure conditions, and raw data structure — were documented in supplementary materials.

Results

The physiological effects of lavender, rosemary, and sage essential oils on the cardiovascular and respiratory systems were systematically analyzed in a cohort of healthy volunteers. All participants completed the study protocol without protocol deviations or adverse clinical events. Baseline hemodynamic and respiratory parameters were within normal physiological limits and did not differ significantly between sessions, confirming the homogeneity of the sample and the reliability of the crossover design.

Cardiovascular responses

Inhalation of lavender essential oil resulted in a mild but statistically significant reduction in both systolic and diastolic blood pressure compared to baseline values. This effect was accompanied by a moderate decrease in heart rate, indicating a shift toward parasympathetic dominance. The changes were transient but consistent throughout the exposure period, and heart rate returned to baseline levels within 30 minutes after the session.

In contrast, rosemary essential oil produced a tendency toward sympathetic activation. During inhalation, a slight elevation in systolic blood pressure and heart rate was observed, suggesting an increase in central nervous system arousal and peripheral vascular tone. These effects were short-lived and returned to baseline within the post-exposure recovery phase.

Exposure to sage essential oil did not produce statistically meaningful alterations in arterial pressure or heart rate. The values remained stable throughout the entire observation period, demonstrating that sage, under the tested conditions, exerts minimal acute cardiovascular influence.

Heart rate variability (HRV) analysis

Analysis of heart rate variability parameters revealed that lavender inhalation significantly increased parasympathetic markers such as RMSSD and high-frequency (HF) power, while simultaneously decreasing the low-frequency/high-frequency (LF/HF) ratio. This reflects a pronounced enhancement of vagal tone and autonomic stability.

Rosemary exposure, on the other hand, produced an increase in LF power and the LF/HF ratio, signifying a relative dominance of sympathetic activity. Sage inhalation caused only minor, statistically insignificant shifts in HRV indices, maintaining a near-baseline autonomic profile.

Respiratory system parameters

Respiratory responses to essential oil inhalation were generally mild and within physiological limits. Lavender inhalation led to a small but notable decrease in respiratory rate, accompanied by a subjective sensation of relaxation and ease of breathing. Peripheral oxygen saturation remained unchanged and stable across all exposures.

Rosemary and sage inhalations did not cause significant changes in respiratory rate, oxygen saturation, or spirometric indices. None of the participants exhibited clinical signs of respiratory distress, bronchospasm, or oxygen desaturation throughout the study.

Subjective effects

Self-reported subjective assessments using visual analogue scales demonstrated a clear pattern of psychological and physiological response. Participants described a significant reduction in anxiety and increased relaxation following lavender inhalation, corresponding with the physiological markers of parasympathetic activation. Rosemary exposure induced a sense of alertness and mild stimulation without anxiety or discomfort. Sage inhalation elicited neutral or slightly calming sensations but lacked statistical significance in comparison to placebo.

Safety observations

All essential oils were well tolerated. No clinically important adverse effects were reported during or after exposure. Mild, transient sensations such as slight dizziness or throat dryness occurred in a few participants but resolved spontaneously without intervention. No cardiovascular or respiratory complications were recorded, confirming the safety of short-term aromatherapy exposure under controlled conditions.

Summary of findings

In summary, lavender essential oil produced a consistent pattern of parasympathetic activation manifested by decreased heart rate, lower blood pressure, enhanced heart rate variability, and reduced respiratory rate, along with subjective relaxation. Rosemary oil demonstrated mild sympathetic stimulation, characterized by modest increases in blood pressure and alertness. Sage oil exhibited minimal acute effects on both cardiovascular and respiratory parameters. These findings support the hypothesis that specific essential oils can modulate autonomic and respiratory functions through distinct physiological pathways, providing a scientific basis for their controlled therapeutic use.

Conclusion

The present study demonstrated that inhalation of different essential oils produces distinct physiological effects on the cardiovascular and respiratory systems. Lavender essential oil induced a mild but consistent decrease in heart rate and arterial blood pressure, accompanied by enhanced heart rate variability, indicating increased parasympathetic activity and autonomic stabilization. These findings suggest that lavender exerts a calming and harmonizing influence on autonomic regulation without causing hemodynamic instability.

In contrast, rosemary essential oil elicited a moderate increase in systolic blood pressure and heart rate, reflecting transient sympathetic activation and elevated alertness. This stimulating effect appears to be mediated by mild activation of the central nervous system and increased vascular tone. Sage essential oil produced minimal changes in cardiovascular and respiratory parameters, maintaining physiological stability throughout the observation period. Such a neutral response indicates that sage acts as a mild and well-tolerated agent under short-term exposure conditions.
All three essential oils were well tolerated, and no clinically significant adverse reactions were observed during or after inhalation. The absence of harmful cardiovascular or respiratory effects confirms the safety of short-term aromatherapy under controlled conditions.
Overall, the findings suggest that lavender essential oil may be recommended as a physiologically safe natural agent capable of promoting autonomic balance, relaxation, and mild cardiovascular regulation. These results provide scientific evidence supporting the rational and controlled use of aromatherapy as an adjunctive method for reducing stress-related autonomic imbalance and optimizing physiological homeostasis.

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