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Original Article

Impact of Inhaled *Cymbopogon Citratus* Essential Oil on Lower Frequency Brain Waves through Quantitative EEG Analysis in healthy volunteers: A Self-controlled Study

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Abstract

Background: *This research delves into the intriguing question of how aromatic stimulation impacts brain activity, with a focus on alterations in lower frequency brain waves (delta and theta) across different brain regions. Using Quantitative Electroencephalogram (QEEG), this study examines the effects of exposure to the scent of Cymbopogon Citratus essential oil.* ***Objective:*** *To assess the influence of inhaling the aroma of Cymbopogon Citratus essential oil on EEG patterns in awake, healthy female adults, utilizing power spectral analysis.* ***Method:*** *In this self-controlled experiment, 30 healthy adult female participants were exposed to a water mist as a control following baseline recordings. Subsequently, participants inhaled aromatic mist from the room air, and brain activity was recorded again using QEEG. Data were collected from scalp electrode readings and compared before and after exposure to the aroma using the Wilcoxon Matched-Pairs Signed Rank Test.* ***Result:*** *Significant increment (p= <0.0001) of absolute delta power in parietal and temporal region along with raised absolute theta power in central, parietal, temporal and occipital brain regions observed.* ***Conclusion:*** *Inhalation of C. citratus essential oil elicits relaxing effects on the brain, providing insight into its potential as a natural relaxation aid.*

Keywords: *Cymbopogon Citratus, aromatherapy, absolute power, delta and theta wave, quantitative EEG*

Introduction: Aromatherapy utilizes fragrant compounds derived from diverse natural sources to address a range of ailments. This therapeutic approach is valued for its holistic benefits in nurturing the well-being of individuals, encompassing mental, physical, and spiritual dimensions. Across millennia, civilizations such as Egypt, China, and India have embraced aromatherapy as a widely practiced complementary and alternative therapy.[1] Fragrance, being a volatile chemical component, is perceived by humans through the olfactory system. Inhalation of these fragrances can elicit diverse psychophysiological effects by interacting with the central nervous system. Essential oils, as the main therapeutic agents among various natural fragrant components, are highly concentrated, volatile, and complex mixtures of aromatic compounds obtained from different plant organs.[2] *Cymbopogon* citratus or lemongrass, is widely used in various cuisines for its refreshing lemon-like scent. Its essential oil, primarily composed of citral, serves multiple purposes as traditional medicine.[3] Scientific research into the effects of *C. citratus* on brain activity is still limited, especially regarding its impact on specific brain wave patterns. One study noted a sense of calmness and alertness after inhalation,[4] whereas another study found contradictory results, indicating a significant relaxation effect.[5] Various electrophysiological methods, including quantitative electroencephalogram (QEEG), hare heen employed to evaluate spontaneous neural activity changes resulting from fragrance inhalation.[6] Quantitative analysis of electrical signals within specific frequency bands express energy as numerical parameter such as absolute power, which

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represent amount of total energy of a specific brain wave. The EEG spectrum is a composite signal generated by postsynaptic potentials of cortical pyramidal cells, which are captured through metal electrodes positioned on the scalp's surface.

There's a hypothesis suggesting that low-frequency oscillations within the delta (0.0-0.4 Hz) and theta (4.0-8.0 Hz) ranges are linked with motivational and emotional processes. Delta activity might predominantly influence the baseline operations and functionality of certain brain regions in alert individuals. Theta waves reflect a state of calmness and creative thought guided by the subconscious, while also being essential for short-term memory processes and stabilization of memories.[8,9,10] Examining these frequencies can provide key insights into how scent influences mental states, cognitive processing, and brain function.

Methods:

Ethical consideration

The research proposal received approval from the Institutional Review Board, BSMMU. Prior to participation, all participants provided written informed consent.

***Cymbopogon citratus* essential oil**

The essential oil was procured from Sri Venkatesh Aromas, located in Delhi, India, a certified manufacturing company registered with The International Organization for Standardization. The company laboratory provided the Gas Chromatography-Mass Spectrometry analysis report.

Participants

An advertisement for the study project was disseminated through social media and wall posters to recruit healthy female adult volunteers. Employing purposive sampling, a total of 30 female subjects were enrolled for the study. The inclusion criteria comprised a) right-handed individuals assessed by the Edinburgh Handedness Inventory scale, b) subjects with a normal sense of smell confirmed through the n-butanol test, c) nonsmokers, d) without symptoms of upper respiratory infection, hypertension, or cardiovascular disease, e) no history of neurological illness or epilepsy, and f) not currently or previously taking central nervous system medication, sedative drugs, or hormonal contraceptives. The essential oil's pleasantness was rated on a five-point Likert scale, including participants with scores between 2 and 4. Participants allergic to essential oil or experiencing headaches were excluded from the experiment.[11]

Experimental procedure:

Participants were instructed to avoid using hair spray, antiperspirants, perfumes, alcohol, and caffeinated beverages. They were also advised to have a light breakfast without caffeine, ensure a good night's sleep, and remove any accessories or electronic devices upon arrival. Each participant sat comfortably in a soundproof room with controlled temperature (23-25°C), darkness, and humidity (40-50%). EEG electrodes were attached to the scalp using the international 10-20 system, with reference electrodes placed at the ear lobes (A1 and A2). Baseline EEG measurements were recorded for 2 minutes, followed by inhalation of water mist released from an ultrasonic aroma diffuser for 20 minutes, after which EEG recording was conducted. Subsequently, C. citratus essential oil, diluted at a 1:1000 ratio with water, was diffused into the room air using the same method, and participants inhaled the scent for another 20 minutes. Thereafter, recording was taken for an additional 2 minutes. All recordings were in eye close state.

Data analysis:

From each recording session, total 60 seconds recording which had minimum deflection in each electrode, from baseline and post-exposure periods were analyzed using BrainTech 40+ Standard version 4.47a software. Data were presented as median (IQR), and the Wilcoxon Matched-Pairs Signed Ranks Test was utilized to compare pre-exposure and post-exposure values. Statistical analysis was performed using SPSS version 24.0, with a p-value of ≤ 0.05 considered statistically significant.

Results:

The median and interquartile range (IQR) of absolute power were computed for delta and theta frequency bands during baseline, water inhalation, and C. citratus oil inhalation.

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Table I: Demographic and clinical data of the subjects (N=30)

Parameters	Minimum	Maximum	Mean ± SD
Age (years)	28	38	32.4 ± 2.50
BMI (kg/m^2)	20.50	24.92	23.35 ± 1.11
Pulse (beats/min)	64	88	77.33 ± 7.78
SBP (mmHg)	108	126	115.47 ± 5.48
DBP (mmHg)	64	84	74.47 ± 5.98
Smell test (Bottle no.)	9	11	10.3 ± 0.70
Handedness (Score)	60	100	77.33 ± 14.13

BMI- Body Mass Index; SBP- Systolic blood pressure; DBP- Diastolic blood pressure; N- Total number of subjects.

Comparison between baseline and post exposure to water mist showed no significant change in absolute power of neither delta nor theta wave. But, absolute power of delta wave was significantly higher after *C. citratus* oil mist exposure compared to baseline and post water mist exposure in parietal and temporal regions of brain (Table II). On the other hand, significantly higher absolute power of theta wave was observed after essential oil exposure when compared to both baseline and post water mist exposure in central, parietal, temporal and occipital regions (Table III).

Table II: Median and IQR of absolute power values (µv2) of delta brain wave in baseline, water mist and *C. citratus* essential oil mist inhalations.

Regions	Baseline	Water mist	*C. citratus* oil mist	p value B and W	p value B and O	p value W and O
Parietal	0.67(0.30)	0.62(0.55)	1.03(0.54)	0.925	<0.0001*	<0.0001*
Temporal	0.71(0.48)	0.65(0.37)	1.66(0.98)	0.382	<0.0001*	<0.0001*

Data expressed as median (IQR). *depicts significant difference, p-value < 0.05 Baseline (B), Water (W), *C. citratus oil* (O). Wilcoxon matched pair signed rank test was done for comparison among three session**s.**

Table III: Median and IQR of absolute power values (µv2) of theta brain wave in baseline, water mist and *C. citratus* essential oil mist inhalations.

Regions	Baseline	Water mist	*C.citratus* oil mist	p value B and W	p value B and O	p value W and O
Central	0.76(0.56)	0.75(0.35)	0.95(1.54)	0.609	<0.0001*	<0.0001*
Parietal	0.79(0.49)	0.88(0.48)	2.17(2.88)	0.891	<0.0001*	<0.0001*
Temporal	0.99(0.84)	1.11(0.96)	3.0(4.13)	0.882	<0.0001*	<0.0001*
Occipital	1.61(1.34)	1.32(1.36)	5.72(3.14)	0.974	<0.0001*	<0.0001*

Data expressed as median (IQR). *depicts significant difference, p-value < 0.05 Baseline (B), Water (W), C. citratus oil (O). Wilcoxon matched pair signed rank test was done for comparison among three sessions.

Discussion:

Our investigation revealed substantial theta activity in centro-parietal, temporal and posterior brain regions. The temporal cortex is responsible for processing hearing, smell, language comprehension, and emotions. The parietal cortex interprets sensory input, influencing perception, abstract reasoning, and mathematical analysis, while the occipital cortex oversees visual processing. Inhaling Chrysanthemum indicum essential oil, similar to our findings, led to increased theta activity in the temporal, parietal, and occipital regions, believed to indicate mental and physical relaxation.[12] Other studies have also shown heightened theta activity in the posterior brain region following inhalation of grapefruit and cannabis essential oils, suggesting a relaxed state of mind. [13,14] Additionally, inhalation of Inula helenium, Cyperus rotundus, and sweet orange essential oils resulted in decreased theta power, further supporting our findings and indicating increased arousal and attentiveness.[15,16,17] Our experiment also revealed substantial delta activity in parietal and temporal regions. In awake individuals, rhythmic delta activity may indicate the proper functioning of the brain's neocortical networks. Inhaling cannabis essential oil increased delta activity in the posterior brain region, paralleling our findings.[14] An intriguing discovery surfaced in a study indicating an increase in delta frequency power during mental tasks in the parietal and temporal regions after inhalation of lemon essential oil. This finding suggests a potential association with the suppression of sensory inputs that disrupt internal concentration.[18] The rapid inhalational effect suggests aroma's immediate impact on brain rhythms, with fragrant particles interacting through olfaction and bloodstream.[19,20]

Conclusion:

Although preliminary, our study provides initial support for using C. citratus essential oil in therapies aimed at stress or depression relief. The results suggest potential benefits in promoting relaxation and reducing anxiety.

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Limitation:
The small study population is a limitation. Future research should involve a larger, more diverse sample for more significant data. Examining various age groups and comparing sexes could also offer valuable insights.

Declaration of interest:
The authors declare no conflicts of interest. They are solely responsible for the accuracy and integrity of the paper's content.

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