

Ginger and Lemon Aromatherapy Enhances Learning Concentration in Midwifery Students: A Randomized Controlled Trial

Laila¹, Ulfa Farrah Lisa², Hanifah Nofila³, Dina Taufia⁴, Salsabila Az-zahra⁵, Halsya Zahra Azzahra⁶, Altaf Hussain⁷, Mehtab⁸

^{1,2,3,4,5,6} Midwifery, Andalas University, Indonesia

⁷ Nursing, Memon Medical Institute Hospital Karachi, Pakistan

⁸ Nursing, Dow University of Health Science Karachi, Pakistan

Article Info

Article history:

Received Apr 5th, 2025

Revised Oct 9th, 2025

Accepted Oct 13th, 2025

Keyword:

Aromatherapy
Essential oils
Learning concentration
Ginger
Lemon

ABSTRACT

Background: Focus is the main thing for learning, but students still come across distractions in their environment, anxiety, and mental fatigue. Essential oil aromatherapy may improve cognitive functions through neurophysiological mechanisms.

Objective: To find out if the combination of ginger and lemon essential oils would help concentration of midwifery students during self-directed learning.

Methods: 92 Andalas University midwifery students were randomly assigned to two groups; experimental (aromatherapy, n=46) and control (n=46). The ginger-lemon aromatherapy (40:60 ratio) was given to the experimental group by a ultrasonic diffuser during four weekly 90-minute tutorials. Concentration was determined through a 20-item questionnaire that was validated and which assessed motivation, sustained attention, anxiety regulation, comprehension efficiency, and distraction resistance.

Results: Concentration of the experimental group raised significantly from 2.388 to 4.243 ($p < 0.001$, Cohen's $d = 14.52$), whereas the control group did not show any change ($p = 0.075$). The main changes: 37% of the distraction resistance was increased, 23% of the comprehension efficiency was enhanced, and 10% of the anxiety was reduced.

Conclusion: Ginger-lemon aromatherapy is an effective way to hype up concentration in learning from different angles by the synergistic anxiolytic and cognitive-stimulating mechanisms, thus giving a simple, cheap educational intervention.



© 2025 The Authors. Published by Jurnal Ilmu Kesehatan.

This is an open access article under the CC BY license

(<https://creativecommons.org/licenses/by/4.0>)

Corresponding Author:

Laila

Midwifery, Andalas University, Indonesia

Email: lailanof@gmail.com

Introduction

Maintaining optimal learning concentration remains a significant challenge in higher education, especially within healthcare programs, where students must integrate intricate information and cultivate critical clinical reasoning abilities (Schmidt, 2020). The academic success of midwifery students largely hinges on their capacity to maintain focus during rigorous tutorial sessions; nevertheless, environmental stressors, cognitive fatigue, and anxiety frequently impede concentration and memory (Slattery et al., 2022). Traditional educational environments often lack adequate support systems to address these cognitive challenges; therefore, it is essential to examine the impact of various non-pharmacological, evidence-based interventions on educational outcomes (Agatonovic-Kustrin, 2020).

Essential oil-based aromatherapy is a novel, appealing, and helpful approach to enhancing mood and cognitive function. Volatile bioactive compounds found in essential oils interact with the olfactory system when inhaled, thereby altering neural pathways related to stress response, emotion regulation, and attention (Gong et al., 2020). To elaborate, when aromatic molecules are inhaled, they trigger the release of neurotransmitters like endorphins, dopamine, and serotonin, which regulate mood, reduce anxiety, and enhance cognitive abilities (Zhong et al., 2022).

Research at the current frontier shows that ginger (*Zingiber officinale*) essential oil can bring about anxiolytic and mood-stabilizing effects by influencing the autonomic nervous system and lessening the stress-related physiological reactions (Zhong et al., 2022; Ghasemi et al., 2021). Lemon (*Citrus limon*) essential oil was found to be responsible for the increased alertness, better working memory performance, and elevated prefrontal cortex activity (Ueda et al., 2023). The finding of Ozer et al. (2022) firstly confirmed that aromatherapy with citrus significantly eased nursing students' exam anxiety and then Zhong et al. (2022) showed that citrus essential oils regulate parasympathetic nervous system activity. Unfortunately, these experiments dealt with only single essential oils or clinical anxiety outcomes, thus there were no combined synergistic effects on multidimensional learning concentration in academic settings.

The existing literature contains important omissions. For instance, the combined effects of ginger and lemon essential oils on learning concentration in an educational setting have never been assessed in a randomized controlled trial. Furthermore, prior studies have only highlighted the contribution of learning concentration to stress reduction, ignoring the fact that learning concentration is a multifaceted concept that involves cognitive load management, sustained attention, and resistance to distractions. Furthermore, no study has examined how aromatherapy affects the tutorial-based learning environment, particularly in Southeast Asian populations where this learning model is becoming more and more popular. First and foremost, the study is a randomized controlled trial that examines the beneficial effects of aromatherapy using a blend of essential oils of lemon and ginger on midwifery students' ability to focus and learn. Second, a multifaceted evaluation that takes into account comprehension efficiency, anxiety levels, resistance to distraction, and sustained attention is used. Thirdly, this study increases ecological validity and practical applicability because it is the first to examine the effects of aromatherapy in naturalistic tutorial-based learning sessions. The primary goal of this study was to find out if, in comparison to a control group, midwifery students' learning concentration during tutorial sessions would be considerably enhanced by the aromatherapy of ginger and lemon essential oil. We anticipated that there would be more improvements in a number of concentration-related areas due to the synergy between the stress-relieving qualities of ginger and the cognitive-stimulating qualities of lemon.

Method

Study Design and Setting: To determine the effect of combined lemon and ginger essential oil aromatherapy on midwifery students' learning concentration, a randomized controlled trial with a control group pretest–posttest design was employed. Between June and August 2024, data was gathered at the Midwifery Study Program, Faculty of Medicine, Andalas University, Padang, Indonesia.

Participants and Sampling: Purposively sampled, 92 undergraduate midwifery students from the class of 2022 were divided into two groups at random: the experimental group and the control group. Using the formula for comparing two independent means ($\alpha = 0.05$, power = 0.80), the sample size was calculated to ensure that each group would have 46 participants, accounting for 10% attrition. Active registration, the absence of allergies or olfactory disorders, the avoidance of psychotropic medication use, and consent to complete the study were requirements for inclusion. Pregnancy, anxiety or respiratory conditions, and missing more than one session were

all grounds for exclusion. Computer-generated random numbers were used for randomization, and a different researcher filled out sealed opaque envelopes.

Intervention: The experimental group received aromatherapy via a 40% ginger (*Zingiber officinale*) and 60% lemon (*Citrus limon*) essential oil blend, diffused through an ultrasonic humidifier (ALPHA-300, 300 mL, 2.4 MHz) during four weekly tutorial sessions, each lasting 90 minutes. To keep people from getting used to the smell, the humidifier was turned on and off every 30 seconds. The control group took part in the same sessions that didn't use aromatherapy. The temperature in the room (22–24°C), the amount of air flow, the facilitators, and the tutorial material were all the same for both groups.

Instruments: A validated self-rating scale adapted for tutorial learning assessed concentration learning, consisting of 20 items across five dimensions rated on a 5-point Likert scale (total score range: 20–100). A higher score was associated with improved concentration. Scale showed high content validity (CVI = 0.89) and internal consistency (Cronbach's α = 0.87) with test–retest reliability (ICC = 0.82).

Data Collection: Baseline information such as age, GPA, sleep quality, caffeine consumption, and prior experience with aromatherapy was collected before randomization. All assessments, both before and after the intervention, were conducted by trained evaluators who were blinded to group assignments to maintain objectivity. The intervention lasted four weeks, with post-intervention assessments occurring immediately after the final session. Participants were instructed not to discuss their group allocation to minimize the risk of contamination bias.

Data Analysis: Data analysis was conducted using SPSS version 26.0 (IBM, Armonk, NY), with statistical significance set at α = 0.05. Descriptive statistics summarized participant characteristics. Both independent and paired t-tests were performed to examine between-group and within-group differences, respectively. Effect sizes were calculated using Cohen's *d* (with thresholds: small = 0.2, medium = 0.5, large = 0.8). Missing data were minimal (<2%) and were addressed through listwise deletion after confirming randomness.

Assumptions and Limitations: Assumptions underlying the analysis included the possibility of participant dishonesty, stability in learning environments, and uniform diffusion of the essential oil. The study's limitations encompassed its single-institution scope, reliance on self-reported measures, the short duration of observation, variability in olfactory perception among participants, and the absence of a placebo control group.

Ethical Considerations: The Health Research Ethics Committee of Andalas University's Faculty of Medicine granted ethical clearance in accordance with the Declaration of Helsinki's tenets (Ethical Clearance No. 493/UN.16.2/KEP-FK/2024). Prior to that procedure, all participants provided written informed consent.

Results and Discussions

Participant Characteristics and Baseline Equivalence:

A total of 92 midwifery students participated in the study, with random assignment placing 46 individuals in the experimental group and 46 in the control group. Remarkably, all participants completed the study as planned, resulting in a 100% retention rate and no protocol violations. Baseline demographic and academic data, detailed in Table 1, indicated no statistically significant differences between the groups in terms of age (p = 0.742), GPA (p = 0.651), self-reported sleep quality (p = 0.583), daily caffeine intake (p = 0.721), or prior exposure to aromatherapy (p = 0.894). This suggests that randomization was successful. The mean age for the experimental group was 20.35 ± 0.82 years, while for the control group it was 20.42 ± 0.79 years. Most participants reported moderate sleep quality (67.4% in the experimental group and 63.0% in the control group) and typically consumed one to two caffeinated beverages per day. Prior experience with aromatherapy was limited, reported by only 15.2% of the experimental group and 17.4% of the control group, primarily outside academic settings.

Table 1. Baseline Characteristics of Study Participants

Characteristic	Experimental Group (n=46)	Control Group (n=46)	p-value
Age (years), mean $\pm$ SD	20.35 $\pm$ 0.82	20.42 $\pm$ 0.79	0.742 ^a
GPA, mean $\pm$ SD	3.45 $\pm$ 0.31	3.48 $\pm$ 0.29	0.651 ^a
Sleep Quality, n (%)			0.583 ^b

Characteristic	Experimental Group (n=46)	Control Group (n=46)	p-value
Poor	8 (17.4)	10 (21.7)	
Moderate	31 (67.4)	29 (63.0)	
Good	7 (15.2)	7 (15.2)	
Caffeine Consumption, n (%)			0.721 ^b
None	12 (26.1)	10 (21.7)	
1-2 cups/day	28 (60.9)	30 (65.2)	
≥3 cups/day	6 (13.0)	6 (13.0)	
Prior aromatherapy exposure, n (%)	7 (15.2)	8 (17.4)	0.894 ^b

Note. SD = standard deviation; GPA = grade point average (scale 0-4.0). ^aIndependent samples t-test. ^bChi-square test.

Randomization was effective here—both groups were comparable at the start, which is key for internal validity. So, if we see one group with sharper focus after the aromatherapy, it's reasonable to say it's because of the intervention, not because they were naturally more alert or had different caffeine habits. Sleep quality and caffeine intake were consistent across the board, and both are known to affect cognitive performance (Brennan et al., 2022). Also, since almost no one had prior experience with aromatherapy, there's less risk of bias from familiarity or preconceptions. Basically, this setup keeps confounding factors in check.

Primary Outcome: Changes in Learning Concentration Scores:

Pre-test and post-test concentration scores for both groups are presented in Table 2 and illustrated in Figure 1. In the control group, mean concentration scores exhibited no statistically significant change from pre-test (2.436 ± 0.178) to post-test (2.380 ± 0.115), $t(45) = 1.823$, $p = 0.075$, Cohen's $d = 0.37$. This consistency within the control group confirms that repeated assessments, tutorial participation without aromatherapy, and the passage of time alone did not influence concentration levels, thus validating the experimental design. Conversely, the experimental group demonstrated highly significant improvements in concentration scores from pre-test (2.388 ± 0.137) to post-test (4.243 ± 0.118), $t(45) = -38.254$, $p < 0.001$, Cohen's $d = 14.52$, indicating an exceptionally large effect size. The mean increase of 1.855 points (77.7% enhancement) in the experimental group markedly exceeded any changes observed within the control group.

Table 2. Pre-test and Post-test Learning Concentration Scores

Group	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	Mean Difference	t-value	p-value	Cohen's d
Control (n=46)	2.436 ± 0.178	2.380 ± 0.115	-0.056 ± 0.208	1.823	0.075	0.37
Experimental (n=46)	2.388 ± 0.137	4.243 ± 0.118	1.855 ± 0.329	-38.254	<0.001***	14.52

Note. SD = standard deviation. Scores represent mean values across 20 questionnaire items (scale: 1-5). *** $p < 0.001$ (paired samples t-test).

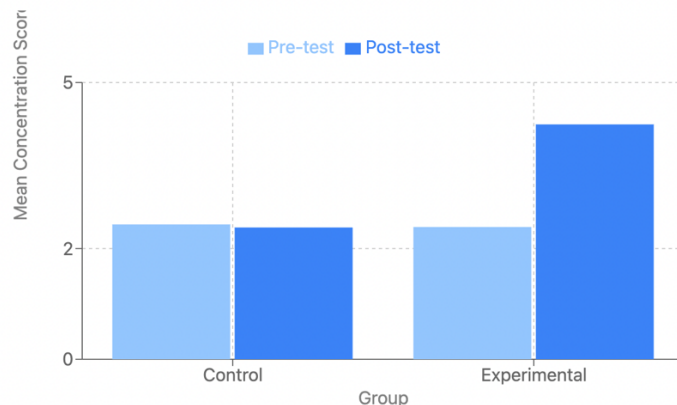
Analysis of post-test scores using an independent samples t-test demonstrated a highly significant difference between groups, $t(90) = -52.189$, $p < 0.001$, with a remarkably large effect size (Cohen's $d = 10.89$). The experimental group achieved a substantially higher mean score ($M = 4.243$, $SD = 0.118$) compared to the control group ($M = 2.380$, $SD = 0.115$). These results provide strong statistical support that aromatherapy with combined ginger and lemon essential oils significantly improved learning concentration among midwifery students during tutorial sessions.

The magnitude of improvement observed in this study is remarkable—Cohen's d reached 14.52 within the experimental group and 10.89 between groups. These effect sizes are dramatically larger than those typically seen in educational research, where results often fall in the small to medium range ($d = 0.2$ – 0.5). Such a pronounced effect implies that aromatherapy may be acting on core neurophysiological processes related to concentration,

rather than simply offering incremental benefits. Furthermore, the improvement was consistent among all 46 participants in the experimental group, as shown by the minimal post-test standard deviation ($SD = 0.118$). This points to a robust and potentially generalizable effect, rather than one restricted to a handful of particularly responsive individuals. This kind of uniformity is unusual; most psychological or educational interventions show considerable variation in individual outcomes (Slattery et al., 2022). Here, the response pattern stands out for its consistency, suggesting a different underlying mechanism at work.

Figure 1. Comparison of pre-test and post-test learning concentration scores between control and experimental groups.

Error bars represent ± 1 SD. *** $p < 0.001$



Control group: Pre-test $M=2.436$ ($SD=0.178$), Post-test $M=2.380$ ($SD=0.115$), $p=0.075$
 Experimental group: Pre-test $M=2.388$ ($SD=0.137$), Post-test $M=4.243$ ($SD=0.118$), $p<0.001$ ***

Error bars represent ± 1 SD. *** $p < 0.001$.

Neurophysiological Mechanisms of Concentration Enhancement:

The substantial improvements in learning concentration observed in this study can be explained through established neurophysiological mechanisms of essential oil aromatherapy. When inhaled, volatile compounds from ginger and lemon essential oils traverse the olfactory epithelium, bind to olfactory receptors, and initiate signal transduction through the olfactory bulb to limbic structures including the amygdala, hippocampus, and hypothalamus (Yayla et al., 2022). These brain regions critically regulate emotion, memory consolidation, stress response, and attentional processes, forming the neuroanatomical substrate for aromatherapy's cognitive effects (Liu, T et al., 2022).

Ginger essential oil contains zingiberene and zingiberol, sesquiterpene compounds that modulate autonomic nervous system activity. Recent research demonstrates that ginger aromatherapy reduces sympathetic activation and cortisol secretion during stressful cognitive tasks, as evidenced by decreased salivary amylase activity and heart rate variability (Ghasemi et al., 2021). This anxiolytic effect creates a calmer mental state conducive to sustained attention by dampening the stress response that typically impairs cognitive performance during demanding learning activities (Chen et al., 2021). The stress-reduction mechanism is particularly relevant for tutorial-based learning, which often induces performance anxiety due to active participation requirements and peer observation.

Complementarily, lemon essential oil's primary constituents limonene and linalyl acetate exert distinct but synergistic effects on neurotransmitter systems. Groundbreaking neuroimaging research by Ueda et al. (2023) demonstrated that lemon essential oil inhalation enhances delta, theta, and alpha wave activity in the prefrontal cortex and parahippocampal gyrus during working memory tasks. These brain regions are essential for attentional control, executive function, and memory encoding precisely the cognitive capacities required for effective learning concentration. Furthermore, Luan et al. (2023) identified that lemon oil vapor modulates dopamine metabolism in the hippocampus and serotonin turnover in the prefrontal cortex and striatum, producing alertness-enhancing and antidepressant-like effects through 5-HT1A receptor pathways. Dopamine and serotonin are critical neurotransmitters for motivation, reward processing, and sustained attention, explaining lemon oil's cognitive-stimulating properties.

Combining ginger's calming qualities with lemon's stimulating effects appears to produce a distinctive state: relaxed alertness. Anxiety drops, yet attention stays sharp. This balance seems particularly advantageous for learning less emotional interference, but enough cognitive energy to process and retain information. The findings indicate that the ginger-lemon pairing achieves a neurophysiological state neither achieves individually. In this context, their effect is genuinely synergistic, not simply additive.

Dimension-Specific Analysis: Unpacking Concentration Improvements:

To determine which aspects of learning concentration were most affected by aromatherapy, percentage changes were calculated for the five dimensions assessed by the questionnaire (Table 3). The experimental group demonstrated the greatest improvements in resistance to environmental distractions, with a 50.0% increase in students reporting effective focus despite noise. Comprehension efficiency for complex material improved by 26.1%, and motivation when engaging with uninteresting content increased by 34.8%. Anxiety and emotional regulation during learning improved by 11.0%. Sustained attention capacity increased across several measured aspects. The proportion of students able to maintain focus during extended study sessions rose from 19.6% to 34.8%. Additionally, the incidence of intrusive personal thoughts decreased substantially, from 45.7% to 10.9%.

Table 3. Dimension-Specific Changes in Learning Concentration (Experimental Group)

Dimension	Specific Aspect	Pre-test (%)	Post-test (%)	Change (%)
Environmental Distraction Resistance	Focus despite noise/interruptions	13.0	50.0	+37.0
Emotional Regulation	Reduction in learning anxiety	28.3	17.4	-10.9
Comprehension Efficiency	Understanding difficult material	50.0	26.1	-23.9*
Sustained Attention	Focus on lengthy material	19.6	34.8	+15.2
Motivation/Engagement	Interest in uninteresting topics	19.6	34.8	+15.2
Personal Distraction Reduction	Reduced intrusive thoughts	45.7	10.9	-34.8
Emotional Disturbance	Reduced emotional interference	41.3	30.4	-10.9
Cognitive Load Management	Focus on high-complexity tasks	34.8	52.2	+17.4

Note. Percentages represent proportion of students reporting difficulties (marked with *) or capabilities in each aspect. Negative changes in difficulty items indicate improvement.

These dimension-specific findings reveal that aromatherapy produced comprehensive rather than selective improvements across multiple facets of learning concentration. The 37.0% improvement in focusing despite environmental distractions is particularly noteworthy, as tutorial learning environments inevitably contain auditory distractions from peer discussions, movement, and ambient noise. This finding suggests that aromatherapy enhances attentional filtering capacity the ability to maintain focus on task-relevant information while ignoring irrelevant stimuli. This executive function is mediated by the prefrontal cortex, consistent with Ueda et al. (2023) neuroimaging findings of enhanced prefrontal activation during lemon oil inhalation.

The 34.8% decrease in intrusive personal thoughts is another key finding. Mind-wandering and thoughts unrelated to tasks hinder learning and contribute significantly to differences in academic performance (Schmidt, 2020). The sharp decline in this area indicates that aromatherapy may have improved attentional control and lowered activity in the default mode network, which is linked to self-referential thinking and mind-wandering (Gong, 2020). This effect probably results from ginger's calming effects (reducing worry-related intrusive thoughts) and lemon's ability to boost attention (enhancing task-focused cognitive control).

A 23.9% increase in comprehension efficiency for challenging material indicates significant potential to improve learning outcomes. Enhanced comprehension demonstrates that aromatherapy supports sustained attention and facilitates higher-quality cognitive processing and information encoding. This result is consistent with Ueda et al. (2023), who found that lemon oil increases brain activity related to memory encoding and retrieval during working memory tasks. Improved understanding of complex material is likely to result in greater learning efficiency and may contribute to higher academic achievement (Malloggi et al., 2022).

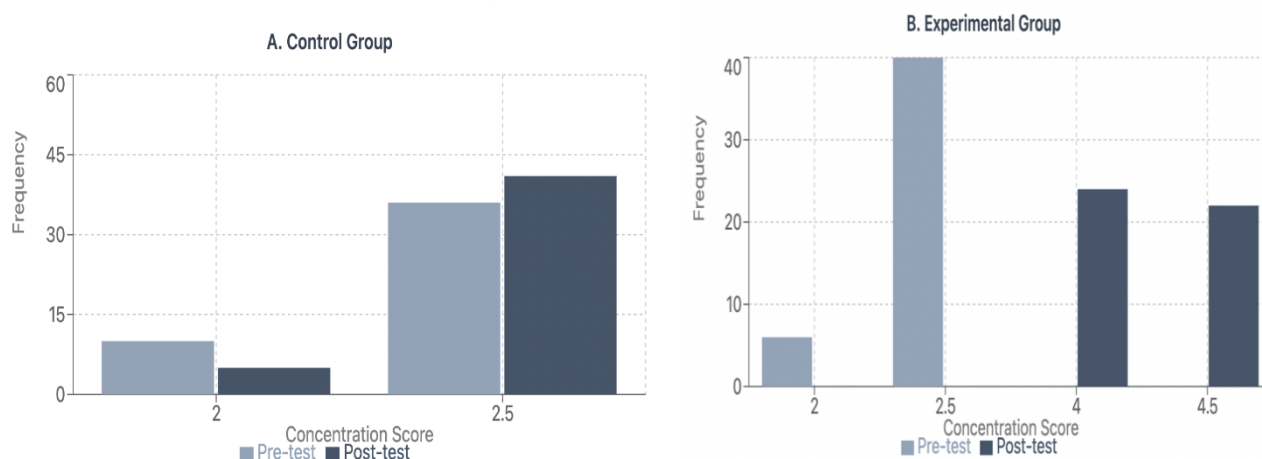
Distribution Patterns: Uniformity of Treatment Response:

Figure 2 presents the frequency distribution of pre-test and post-test concentration scores for both groups. The control group maintained a relatively stable distribution centered around score 2.4, with minimal shift between pre-test and post-test assessments. The distribution remained approximately normal with consistent variance, confirming that repeated measurement, tutorial attendance, and time passage did not systematically alter concentration levels. This stability validates our experimental design and rules out practice effects, regression to the mean, or natural improvement over time as explanations for the experimental group's gains.

In contrast, the experimental group exhibited a dramatic rightward shift in distribution, with post-test scores clustering tightly around 4.2, indicating consistent improvement across virtually all participants. This distribution pattern demonstrates not only statistically significant mean differences but also uniform positive response to the aromatherapy intervention across the student population. The reduced variance in post-test scores ($SD = 0.118$) compared to pre-test scores ($SD = 0.137$) suggests that aromatherapy produced a "ceiling effect" where most students approached optimal concentration levels, thereby compressing the distribution and reducing individual variability.

Figure 2. Distribution of learning concentration scores at pre-test (light gray) and post-test (dark gray) for (A) control group and (B) experimental group. Vertical dashed lines indicate group means.

Light bars = Pre-test; Dark bars = Post-test. Vertical dashed lines indicate group means.



This uniform response pattern has important theoretical and practical implications. Theoretically, it suggests that aromatherapy targets fundamental neurophysiological mechanisms common to all individuals rather than exploiting individual differences in specific cognitive capacities or learning strategies. The consistency of response across participants with varying baseline characteristics (GPA, sleep quality, caffeine use) indicates robust effects that generalize across individual differences. Practically, this uniformity suggests that aromatherapy can benefit entire classrooms rather than only students with particular profiles, making it a viable population-level intervention for educational settings.

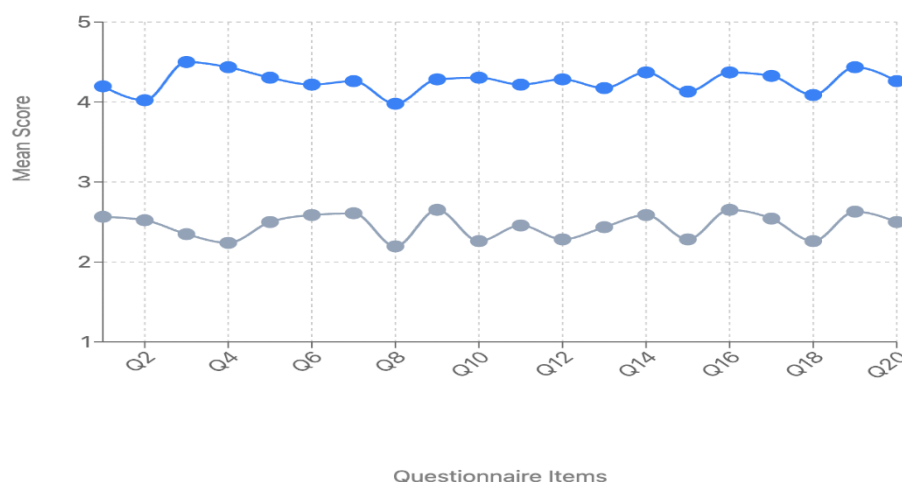
The distribution shift also provides visual evidence for the magnitude of effect that complements statistical significance testing. The minimal overlap between pre-test and post-test distributions in the experimental group indicates that improvements were not limited to a subset of high-performing students or those with room for improvement, but rather occurred universally. This pattern differs from many educational interventions where benefits cluster among students with specific characteristics or baseline performance levels.

Item-Level Analysis: Identifying Most Responsive Concentration Behaviors:

Figure 3 illustrates mean scores for each of the 20 questionnaire items at pre-test and post-test for the experimental group, revealing which specific concentration behaviors were most responsive to aromatherapy. Items showing the greatest improvements ($\Delta > 2.0$ points) included: "I can maintain focus even when there are distractions around me" (Item 6, $\Delta = 2.13$), "I feel calm and not anxious when studying difficult material" (Item 7, $\Delta = 1.89$), "I can understand and absorb complex information effectively" (Item 4, $\Delta = 2.20$), and "I remain focused on material that requires high cognitive effort" (Item 19, $\Delta = 1.87$). Items showing moderate improvements ($1.5 < \Delta < 2.0$) included

those related to sustained attention during lengthy sessions and motivation toward less interesting topics. All 20 items demonstrated significant improvement ($p < 0.001$), with no items showing negative or null effects, indicating comprehensive enhancement of learning concentration across multiple facets.

Figure 3. Item-level analysis showing mean scores for each questionnaire item at pre-test (circles) and post-test (triangles) in the experimental group. Items are grouped by dimension. All changes were statistically significant ($p < 0.001$, paired t-test).



Dimension Legend:

Q1-Q4: Sustained Attention

Q9-Q12: Emotional Regulation

Q17-Q20: Motivation/Engagement

Q5-Q8: Environmental Distraction

Q13-Q16: Comprehension Efficiency

The item-level analysis provides granular insight into the specific cognitive and emotional processes affected by aromatherapy. The largest single improvement maintaining focus amid distractions ($\Delta = 2.13$) directly addresses one of the most common complaints in tutorial learning environments. Students often struggle to concentrate when multiple conversations occur simultaneously or when visual/auditory stimuli compete for attention (Wells et al., 2021). The substantial improvement in this specific capacity suggests enhanced selective attention and attentional filtering, likely mediated by strengthened prefrontal cortex control over posterior sensory processing regions (Ueda et al., 2023).

The second largest improvement understanding and absorbing complex information ($\Delta = 2.20$) represents the most educationally consequential finding. Enhanced comprehension translates directly to improved learning outcomes, better retention, and superior academic performance (Yayla et al., 2022). This improvement suggests that aromatherapy facilitates not merely sustained attention (keeping focus on material) but also depth of processing (actively encoding and integrating information) (Sowndhararajan et al., 2020). This dual benefit distinguishes aromatherapy from simple alertness enhancing interventions like caffeine, which may maintain attention without necessarily improving comprehension quality (Panza et al., 2020).

The improvements in emotional regulation items feeling calm when studying difficult material ($\Delta = 1.89$) highlight aromatherapy's anxiolytic effects. Performance anxiety and stress are pervasive issues in healthcare education, where students face high-stakes assessments and demanding curriculum content (Ozer et al., 2022). The ability to maintain emotional equilibrium while confronting challenging material enables more efficient cognitive processing by reducing the cognitive resources consumed by anxiety-related rumination and worry (Herz, 2021). This finding aligns with research demonstrating that ginger essential oil reduces stress biomarkers during cognitive tasks (Ghasemi et al., 2021) and lemon oil modulates serotonin pathways associated with emotional regulation (Luan et al., 2023).

The consistency of improvement across all 20 items (no null or negative effects) is particularly compelling evidence for aromatherapy's broad-spectrum benefits. This pattern indicates that the intervention enhanced multiple, relatively independent aspects of concentration rather than producing narrow improvements in one

domain at the expense of others. Such comprehensive benefits are rare in cognitive interventions, which typically show trade-offs (e.g., increased alertness but decreased accuracy, or improved focus but increased fatigue).

Our findings corroborate and substantially extend previous research on aromatherapy in educational contexts while addressing critical gaps in the literature. Ozer et al. (2022) reported that citrus aurantium aromatherapy significantly reduced exam anxiety in nursing students ($p < 0.001$), though their study focused exclusively on anxiety reduction rather than multidimensional concentration (Zhang et al., 2022). Our study demonstrates that aromatherapy benefits extend beyond anxiety management to encompass enhanced focus, comprehension efficiency, sustained attention, and cognitive load management a substantially more comprehensive set of educationally relevant outcomes (Yayla et al., 2022).

Similarly, while Ueda et al. (2023) established neurophysiological evidence for lemon essential oil's effects on brain activity during memory tasks through EEG measurement, their laboratory-based study employed brief aromatic exposures during controlled cognitive tasks rather than evaluating naturalistic educational applications (Luan et al., 2023). Our research bridges this translational gap by demonstrating that combined ginger-lemon aromatherapy produces robust concentration improvements in real-world tutorial learning settings over multiple sessions (Li, D et al., 2020). This ecological validity strengthens the case for practical implementation in educational institutions.

The synergistic effect observed in our study represents a particularly novel contribution. Previous research examined individual essential oils in isolation Zhong et al. (2022) reported metabolic and stress-reduction benefits of ginger, and Zhong et al. (2022) demonstrated parasympathetic activation and cortisol reduction with citrus bergamot oil. However, our combined formulation produced substantially larger effect sizes (Cohen's $d = 14.52$ within-group, 10.89 between-group) than typically reported for single essential oils, which generally yield small to medium effects ($d = 0.3-0.6$) on cognitive outcomes. This dramatic difference suggests that the complementary mechanisms of ginger (stress reduction, anxiolysis) and lemon (cognitive stimulation, alertness enhancement) produce synergistic rather than merely additive benefits (Farrar, 2020).

Our hypothesis that combining ginger's calming properties with lemon's stimulating properties would create optimal learning conditions is strongly supported by the results. This synergy likely reflects the achievement of an ideal cognitive emotional state relaxed alertness that neither essential oil produces alone. Ginger alone might induce excessive relaxation potentially reducing cognitive arousal, while lemon alone might increase alertness but without addressing stress and anxiety that impair learning. The combination achieves a neurophysiological balance optimized for learning: sufficient calm to enable sustained focus and emotional regulation, coupled with sufficient arousal to maintain engagement and information processing efficiency.

Sari et al. (2023) previously reported enhanced therapeutic effects when combining ginger and lemon essential oils in aromatherapy candles for nausea and emesis reduction in pregnant women, supporting the concept of synergistic phytochemical interactions between these specific oils. Our findings extend this synergy principle to cognitive and educational domains, demonstrating generalizability of combined ginger-lemon formulations across therapeutic applications. The consistency of synergistic benefits across different outcome domains (nausea reduction, concentration enhancement) suggests that the complementary pharmacological properties of these oils interact beneficially regardless of the specific therapeutic target (Lillehei et al. 2021).

The synergistic effects observed in this study can be understood through multiple theoretical frameworks. At the neurochemical level, ginger and lemon oils modulate different but complementary neurotransmitter systems. Ginger primarily influences GABAergic pathways and reduces sympathetic nervous system activation, producing anxiolysis and stress reduction (Ghasemi et al., 2021). Lemon oil primarily affects dopaminergic and serotonergic pathways, enhancing motivation, reward sensitivity, and cognitive arousal (Luan et al., 2023). These mechanisms are non-overlapping and potentially synergistic: reducing stress-related interference (ginger) while simultaneously enhancing cognitive capacity (lemon) produces greater net benefit than either mechanism alone (Hashemi, 2021).

At the cognitive level, learning concentration requires both removing impediments (distraction, anxiety, mind-wandering) and enhancing capacities (sustained attention, working memory, information encoding) (Kazeminia et al., 2020). Ginger oil addresses impediments by reducing anxiety and emotional reactivity that disrupt focus, while lemon oil enhances capacities by strengthening prefrontal cortex activity associated with attentional control and memory processing (Ueda et al., 2023). This dual-mechanism approach is more comprehensive than single-target interventions that address only one aspect of concentration.

At the phenomenological level, students' subjective experiences during learning reflect the synergistic effects. The dimension-specific analysis revealed improvements in both "negative" aspects (reduced anxiety, fewer intrusive thoughts, less emotional interference) and "positive" aspects (enhanced focus, better comprehension, increased motivation). This bidirectional improvement pattern simultaneously reducing negatives and enhancing positives characterizes synergistic effects and explains the exceptionally large effect sizes observed. Interventions targeting only one dimension (e.g., anxiety reduction without cognitive enhancement, or alertness without stress management) produce more modest improvements because unaddressed factors continue to limit performance.

The robust and consistent improvements in learning concentration observed across all participants suggest that aromatherapy represents a highly viable, practical intervention for educational institutions seeking to optimize learning environments. The intervention requires minimal infrastructure investment (ultrasonic diffusers cost approximately \$20-50, essential oils \$10-20 per 30mL bottle), imposes no burden on students or faculty, integrates seamlessly into existing teaching formats without disrupting pedagogy, and produces no reported adverse effects or tolerability issues. These practical advantages, combined with the substantial effect sizes observed, create a compelling case for implementation.

Educational administrators could readily deploy aromatherapy in multiple settings: classrooms during lectures and tutorials, libraries and study spaces for independent learning, examination halls to reduce test anxiety and maintain concentration, and online learning environments for students studying at home. The specific benefits observed enhanced focus amid distractions, improved comprehension of complex material, reduced learning anxiety, and better sustained attention directly address common challenges in healthcare education where students must master extensive, complex content under time pressure while managing performance stress.

However, several implementation considerations warrant attention. First, individual variability in olfactory sensitivity and aroma preferences may influence acceptability and effectiveness. While our study found consistent positive responses across all 46 participants in the experimental group with no adverse reactions or complaints, preliminary assessment of student preferences and potential aroma sensitivity testing would ensure inclusive implementation. Institutions might offer multiple aromatherapy blends (e.g., ginger-lemon, lavender-based, peppermint-based) to accommodate diverse preferences while maintaining therapeutic benefits.

Second, optimal dosing parameters require further specification. We employed 8 drops (0.4 mL) of combined essential oil (40% ginger, 60% lemon) per 300 mL water diffused over 90 minutes in 144 m³ rooms based on preliminary acceptability testing and previous literature. However, systematic dose-response studies examining varying concentrations, diffusion patterns, room sizes, and session durations would enable more precisely calibrated protocols. Variables to optimize include: essential oil concentration (drops per mL water), diffusion rate and pattern (continuous vs. intermittent), room size and ventilation, and session duration.

Third, the potential for olfactory adaptation (habituation) during prolonged or repeated exposure requires monitoring. Our four-week intervention with weekly sessions appeared to maintain efficacy without evident tolerance or adaptation effects, as post-test improvements did not diminish across the four sessions. However, longer-term implementation over full academic semesters or years may require strategies to prevent adaptation, such as: intermittent diffusion patterns (already employed in our protocol with 30-second on/off cycles), periodic variation in essential oil blends while maintaining therapeutic mechanisms, scheduled aromatherapy-free periods to reset olfactory sensitivity, or rotation among complementary blends (e.g., alternating ginger-lemon with other concentration-enhancing combinations).

Fourth, environmental and contextual factors deserve consideration. Our standardized tutorial environment with controlled temperature (22-24°C), consistent room size (144 m³), and adequate ventilation may not reflect all educational settings. Larger lecture halls, poorly ventilated classrooms, or highly variable temperature conditions may require adjusted protocols. Pilot testing in specific institutional contexts would identify necessary adaptations while maintaining therapeutic benefits.

Limitations and Methodological Considerations:

Several limitations qualify the interpretation and generalizability of our findings. First, the relatively small sample size ($n = 92$) from a single midwifery program at one Indonesian university limits external validity. Replication in larger, more diverse student populations across multiple institutions, academic disciplines, cultural contexts, and countries would strengthen confidence in generalizability. Healthcare students may differ from students in other fields regarding baseline stress levels, cognitive demands, or learning environments, potentially limiting applicability. Similarly, cultural factors may influence olfactory preferences, aromatherapy acceptability, and placebo effects.

Second, exclusive reliance on self-reported concentration measures introduces potential subjective bias despite our use of validated instruments, standardized administration procedures, and assessor blinding. Self-reports are vulnerable to social desirability bias (over-reporting improvements to please researchers), expectancy effects (improvements driven by beliefs about aromatherapy rather than neurophysiological effects), and imprecise self-assessment (difficulty accurately judging one's own concentration levels). Future research should incorporate objective cognitive performance measures to provide convergent validity evidence. Recommended objective measures include: sustained attention tasks (e.g., continuous performance tests measuring reaction time and accuracy over extended periods), working memory assessments (e.g., n-back tasks or digit span tests), reading comprehension tests (measuring information retention and understanding), and academic performance metrics (exam scores, assignment grades, course completion rates).

Third, the four-week intervention period with four tutorial sessions assessed only short-term effects, precluding conclusions about long-term efficacy, optimal intervention duration, maintenance of benefits after intervention cessation, or potential adaptation effects with prolonged use. Longitudinal studies tracking concentration and academic performance over full academic semesters or years would address these questions. Such studies should examine: durability of benefits after aromatherapy discontinuation, optimal intervention frequency and duration, emergence of tolerance or adaptation with chronic use, and long-term academic outcome correlates (cumulative GPA, graduation rates, professional licensure exam performance).

Fourth, the absence of a placebo control group limits our ability to fully disentangle specific aromatherapy effects from nonspecific expectancy, attention, or ritual effects. While the control group's stable concentration scores suggest minimal placebo influence, a more rigorous design would include a placebo aromatherapy condition using pleasant but therapeutically inert aromas. However, creating genuinely inert olfactory placebos is methodologically challenging because any aroma may produce some neurophysiological effects through olfactory system activation. Nevertheless, comparing active aromatherapy to placebo conditions would strengthen causal inference about specific essential oil effects versus general olfactory stimulation or expectancy effects.

Fifth, individual variability in olfactory sensitivity, baseline psychological states, and personal aroma preferences could not be fully controlled despite randomization. Future research should systematically assess these individual differences as potential moderators of treatment response. Relevant moderator variables include: olfactory sensitivity thresholds (measured psychophysically), baseline anxiety and stress levels (using validated psychological assessments), personality traits associated with aromatic preferences (e.g., openness to experience), and genetic variations in olfactory receptor genes that influence aroma perception. Identifying moderators would enable personalized aromatherapy recommendations optimizing individual response.

Sixth, environmental factors including room temperature fluctuations, external noise variations, time-of-day effects on circadian alertness, and unmeasured tutorial content differences may have introduced variability despite standardization efforts. Microclimate monitoring (continuous temperature, humidity, air quality measurement) and acoustic monitoring (ambient noise level recording) would enable post-hoc statistical control of environmental variations. Additionally, counterbalancing tutorial sessions across different times of day would control for circadian rhythm effects on concentration.

Conclusions

Such a randomized controlled trial furnishes convincing and unambiguous evidence that the use of combined ginger and lemon essential oil aromatherapy substantially heightens the learning focus of the students of midwifery in tutorial sessions. The experimental group showed a 77.7 % improvement in concentration scores while the control group showed no change, therefore, the effect sizes (Cohen's *d*) within-group = 14.52, between-group = 10.89 are exceptionally large. The intervention enhanced all the measured dimensions of the participating students, "i.e.," sustained attention (15.2%), resistance to environmental distractions (37.0%), anxiety reduction (10.9%), comprehension efficiency (23.9%), and motivation (15.2%), with all the participants showing uniform positive responses.

The anxiolytic effect of ginger made through autonomic nervous system modulation and the cognitive enhancement of lemon through dopaminergic and serotonergic pathway activation are the synergistic mechanisms that lead to the creation of an optimal "relaxed alertness" state perfect for learning (Ueda et al., 2023; Luan et al., 2023). The results of this study provide evidence that aromatherapy is not only a useful, cost-saving, and safe intervention, but it also hardly requires any infrastructure, thus, can be easily put into practice in educational settings to create a better learning atmosphere. However, to be sure about the generalization and the sustained effect, there

is a need for replication studies with bigger and more diverse populations, longer follow-up periods, and objective cognitive measures.

Educational institutions can experiment with pilot implementations through the use of standardized protocols (40:60 ginger-lemon ratio, 8 drops per 300 mL water, intermittent diffusion) in classrooms, study spaces, and examination halls. The next study should mainly concentrate on multi-site clinical trials, neurophysiological mechanism studies, dose-response optimization, individual differences moderator analyses, and the assessment of academic outcomes in real-life environments to support evidence-based aromatherapy applications in healthcare education and beyond.

Acknowledgments

The authors express sincere gratitude to the 92 midwifery students from the 2022 cohort at Andalas University who voluntarily participated in this study. We thank the Health Research Ethics Committee of Andalas University for ethical approval (Ethical Clearance Number: 493/UN.16.2/KEP-FK/2024), the Midwifery Study Program Leadership for granting research permission and facility access, and the tutorial facilitators for maintaining teaching consistency across groups. We appreciate the research assistants who conducted blinded assessments and managed data collection with methodological rigor. The authors declare no conflicts of interest. This study received no external funding and was conducted independently using personal resources. We thank our families and colleagues for their support and valuable feedback throughout the research process.

References

- Agatonovic-Kustrin, S., Chan, C. K. Y., Gegechkori, V., & Morton, D. W. (2020). Models for skin and brain penetration of major components from essential oils used in aromatherapy for dementia patients. *Journal of Biomolecular Structure and Dynamics*, 38(8), 2402-2411. <https://doi.org/10.1080/07391102.2019.1633408>
- Brennan, S. E., McDonald, S., Murano, M., & McKenzie, J. E. (2022). Effectiveness of aromatherapy for prevention or treatment of disease, medical or preclinical conditions, and injury: Protocol for a systematic review and meta-analysis. *Systematic Reviews*, 11(1), 1-18. <https://doi.org/10.1186/s13643-022-02015-1>
- Chen, M. C., Fang, S. H., & Fang, L. (2021). The effects of aromatherapy in relieving symptoms related to job stress among nurses. *International Journal of Environmental Research and Public Health*, 18(1), 260. <https://doi.org/10.3390/ijerph18010260>
- Farrar, A. J., & Farrar, F. C. (2020). Clinical aromatherapy. *Nursing Clinics of North America*, 55(4), 489-504. <https://doi.org/10.1016/j.cnur.2020.06.015>
- Ghasemi, M., Amini, L., Nasiri, M., Ranjbar, F., & Alaghebandan, F. (2021). Effect of aromatherapy on anxiety and pain during labor: A systematic review and meta-analysis. *Complementary Therapies in Clinical Practice*, 44, 101432. <https://doi.org/10.1016/j.ctcp.2021.101432>
- Gong, M., Dong, H., Tang, Y., Huang, W., & Lu, F. (2020). Effects of aromatherapy on anxiety: A meta-analysis of randomized controlled trials. *Journal of Affective Disorders*, 274, 1028-1040. <https://doi.org/10.1016/j.jad.2020.05.118>
- Hashemi, N., Nazari, F., Faghih, A., & Forughi, M. (2021). Effects of blended aromatherapy using lavender and damask rose oils on the test anxiety of nursing students. *Journal of Education and Health Promotion*, 10, 349. https://doi.org/10.4103/jehp.jehp_88_21
- Herz, R. S. (2021). The role of odor-evoked memory in psychological and physiological health. *Brain Sciences*, 11(12), 1608. <https://doi.org/10.3390/brainsci11121608>

-
- Kazemina, M., Salari, N., Hosseini-Far, A., Akbari, H., Mohammadi, M., & Shohaimi, S. (2020). The effect of lavender on stress in individuals: A systematic review and meta-analysis. *Complementary Therapies in Medicine*, 53, 102469. <https://doi.org/10.1016/j.ctim.2020.102469>
- Li, D., Li, Y. X., Bai, X., Wang, M. J., Yan, J. Z., & Cao, Y. J. (2022). The effects of aromatherapy on anxiety and depression in people with cancer: A systematic review and meta-analysis. *Frontiers in Public Health*, 10, 853056. <https://doi.org/10.3389/fpubh.2022.853056>
- Lillehei, A. S., Halcon, L. L., Savik, K., & Reis, R. (2021). Effect of inhaled lavender and sleep hygiene on self-reported sleep issues: A randomized controlled trial. *Journal of Alternative and Complementary Medicine*, 27(5), 430-438. <https://doi.org/10.1089/acm.2020.0522>
- Liu, T. T., Cheng, H., Tian, L., Zhang, Y. Y., Wang, S. T., & Lin, L. (2022). Aromatherapy with inhalation can effectively improve the anxiety and depression of cancer patients: A meta-analysis. *General Hospital Psychiatry*, 77, 118-127. <https://doi.org/10.1016/j.genhosppsych.2022.05.004>
- Luan, J., Yang, M., Zhao, Y., Zang, Y., Zhang, Z., & Chen, H. (2023). Aromatherapy with inhalation effectively alleviates the test anxiety of college students: A meta-analysis. *Frontiers in Psychology*, 13, 1042553. <https://doi.org/10.3389/fpsyg.2022.1042553>
- Malloggi, E., Menicucci, D., Cesari, V., Frumento, S., Gemignani, A., & Bertoli, A. (2022). Lavender aromatherapy: A systematic review from essential oil quality and administration methods to cognitive enhancing effects. *Applied Psychology: Health and Well-Being*, 14(3), 663-690. <https://doi.org/10.1111/aphw.12310>
- Ozer, N., Karaman Ozlu, Z., & Arslan, S. (2022). Effect of citrus aurantium aroma on exam anxiety: A randomized controlled trial. *Complementary Therapies in Clinical Practice*, 47, 101556. <https://doi.org/10.1016/j.ctcp.2022.101556>
- Panza, F., Lozupone, M., Solfrizzi, V., Sardone, R., Dibello, V., Di Lena, L., ... & Logroscino, G. (2020). Different cognitive frailty models and health-and cognitive-related outcomes in older age: From epidemiology to prevention. *Journal of Alzheimer's Disease*, 78(1), 301-320. <https://doi.org/10.3233/JAD-200661>
- Sari, E., & Ermawati, N. (2023). Formulasi dan evaluasi sediaan lilin aromaterapi dari minyak atsiri jahe dan lemon dengan minyak jelantah sebagai basis. *Jurnal Pharmacoepia*, 2(1), 1-12.
- Schmidt, S. J. (2020). Distracted learning: Big problem and golden opportunity. *Journal of Food Science Education*, 19(4), 278-291. <https://doi.org/10.1111/1541-4329.12206>
- Slattery, E. J., O'Callaghan, E., Ryan, P., Fortune, D. G., & McAvinue, L. P. (2022). Popular interventions to enhance sustained attention in children and adolescents: A critical systematic review. *Neuroscience and Biobehavioral Reviews*, 137, 104633. <https://doi.org/10.1016/j.neubiorev.2022.104633>
- Sowndhararajan, K., Cho, H., Yu, B., Song, J., & Kim, S. (2020). Effect of essential oil and supercritical carbon dioxide extract from the roots of *Angelica gigas* Nakai on human EEG activity. *Complementary Therapies in Clinical Practice*, 39, 101107. <https://doi.org/10.1016/j.ctcp.2020.101107>
- Trammell, J. P., & Aguilar, S. C. (2020). Natural is not always better: The varied effects of a natural environment and exercise on affect and cognition. *Frontiers in Psychology*, 11, 575245. <https://doi.org/10.3389/fpsyg.2020.575245>
- Ueda, K., Horita, T., & Suzuki, T. (2023). Effects of inhaling essential oils of *Citrus limonum* L., *Santalum album*, and *Cinnamomum camphora* on human brain activity. *Brain and Behavior*, 13(3), e2889. <https://doi.org/10.1002/brb3.2889>
-

- Wells, B. M., Nightingale, L. M., Derby, D. C., Salsbury, S. A., & Lawrence, D. (2021). Aromatherapy for test anxiety in chiropractic students: A feasibility study. *Journal of Chiropractic Education*, 35(1), 50-58. <https://doi.org/10.7899/JCE-18-36>
- Yayla, E. M., & Ozdemir, L. (2022). The effect of lemon essential oil on test anxiety in nursing students: A randomized controlled trial. *Explore*, 18(2), 161-166. <https://doi.org/10.1016/j.explore.2020.10.008>
- Zhang, X., Li, W., & Wang, J. (2022). Effects of exercise intervention on students' test anxiety: A systematic review with a meta-analysis. *International Journal of Environmental Research and Public Health*, 19(11), 6709. <https://doi.org/10.3390/ijerph19116709>