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Original Research

The effect of Aromatherapy with *Pelargonium graveolens* (*P. graveolens)* on the fatigue and sleep quality of critical care nurses during the Covid-19 pandemic: A randomized controlled trial

Nasrin Karimi [a], Shirin Hasanvand [b,*], Afsaneh Beiranvand [b], Mohammad Gholami [b], Mehdi Birjandi [c]

[a] *Student Research Committee, Lorestan University of Medical Sciences, Khorramabad, Iran*
[b] *Social Determinants of Health Research Center, School of Nursing& Midwifery, Lorestan University of Medical Sciences, Khorramabad, Iran*
[c] *Nutritional Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran*

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ABSTRACT

Objectives: Measures to reduce nurses' fatigue are necessary to improve the patient's care and the nurse's health and well-being. This study investigated the effectiveness of aromatherapy with *Pelargonium graveolens* (*P. graveolens)* essential oil on fatigue and sleep quality of nurses working in intensive care units (ICU).
Methods: In this double-blind, randomized, controlled clinical trial, 84 nurses working in the ICU of Covid-19 patients were assigned to two groups of *P. graveolens* and placebo by the stratified block method. The intervention group inhaled one drop of pure *P. graveolens*. The placebo group inhaled one drop of pure sunflower oil in three consecutive shifts (morning or evening) and each shift twice for 20 min. Using the Visual Analog Fatigue Scale (VAS-F), fatigue was measured 30 min before the intervention, immediately, and 60 min later. Also, on the morning of the intervention days, sleep quality was assessed with the Verran and Snyder-Halpern (VSH) Sleep Scale. Data analysis was performed using SPSS, version 24. Independent t-tests, Mann-Whitney, Chi-square tests, and MANOVA, were used.
Results: The mean score of fatigue immediately and 60 min after aromatherapy in the *P. graveolens* group was lower than in the control group ($P < 0.05$). There was no significant difference between the mean sleep scores of nurses in the *P. graveolens* group before and after the intervention ($P > 0.05$).
Conclusion: Inhalation aromatherapy with *P. graveolens* essential oil can reduce nurses' fatigue in the ICU. The findings of this study can make nurses interested in using aromatherapy as a self-care method.

Introduction

The coronavirus (Covid-19) has created a public health crisis and posed many challenges for providers and healthcare systems.[1] In this global crisis, the ICU cares for and treats patients with life-threatening symptoms caused by this disease.[2] In the ICU, nurses are constantly exposed to unpredictable conditions, critical patient care, therapeutic communication with anxious families and the use of advanced equipment, and working with advanced equipment in the confined space of the patient bed.[3] Therefore, studies prior to this epidemic have reported high levels of stress, fatigue, sleep disturbances and burnout among intensive care nurses.[4] In addition, resource constraints, long shifts, sleep disorders, life and job imbalances and occupational hazards associated with exposure to COVID- 19 increase the stress of ICU nurses and physical and mental fatigue.[5] Along with the coronavirus epidemic, according to the results of a study, physical and psychological issues of ICU nurses, such as decreased appetite and indigestion (59%), fatigue (55%), sleep disorders (45%), nervousness (28%), frequent crying (26%) and even suicidal ideation (2%) have been reported.[6] Fatigue is complex and multi-dimensional in nature.[7] Evidence suggests that reducing the quality of care, the level of patient safety, and the increase in medical errors are among the most well-known and critical consequences of nurse fatigue on patients.[8]

Moreover, fatigue in nurses can reduce self-confidence, reduce or eliminate job satisfaction, cause rejection of organizational responsibilities, and increase relocation or leaving the profession.[9] If

* Corresponding author.
E-mail address: hasanvand.sh1390@gmail.com (S. Hasanvand).

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nurses do not understand the possible consequences of not being adaptive and working effectively when they are fatigued, they hurt themselves or their patients.[10]

Moreover, when assessing the effect of nursing on patient outcomes, sleep disorder among nurses is recognized as one of the major factors.[11] These consequences are particularly disturbing in the ICU, where patients are seriously ill and unable to take care of themselves from decisions or mismanagement.[12] Evidence suggests that nurses' injuries, infections and illnesses are associated with fatigue and sleep disorders. Nurses with poor sleep quality are more prone to burnout, depression, and anxiety.[13] The systematic review findings show that many healthcare providers and nurses in the prevalence of Covid-19 experience mood and sleep disorders, emphasizing the need for measures to reduce mental health risks in epidemic conditions.[14] However, strategies to reduce nurse fatigue have been taken into account in limited research.[15]

Studies have demonstrated that non-pharmacologic interventions in psychology and complementary medicine, such as cognitive behavioral therapy, music therapy, progressive muscle relaxation, meditation, and acupuncture, effectively reduce fatigue and improve nurses' sleep quality.[16–18] Furthermore, aromatherapy is a complementary medical method which is easy, safe and relatively inexpensive to implement.[19] As a result of the participant's active participation, there is no need for additional equipment, expertise, skills or staff, and people can complete the treatment, no matter when or where, it offers several advantages over other methods of complementary medicine.[20] The efficacy of aromatherapy with essential oils in reducing stress and fatigue, creating a feeling of calm and improving the quality of sleep of nurses is recommended.[19,21,22] Chen et al. (2015) demonstrated a decrease in physical symptoms as a result of work stress, including fatigue. They enhanced the quality of the nurses' sleep after 4 days of inhaling lavender essential oil aromatherapy.[23] In the study by Farahani et al. (2017), the effectiveness of aromatherapy with essential oils of lavender and Rose Damascene on the fatigue of emergency nurses was shown.[22] While some studies have reported on the effectiveness of aromatherapy in reducing nurse fatigue, existing studies have methodological limitations, such as no placebo, the number of times aromatherapy is done, and the duration of the intervention.[22,23] Therefore, further studies are needed to conclude on the effect of aromatherapy on reducing the symptoms of nurses' work stress.

Studies show that the essential oil of Pelargonium graveolens (*P. graveolens*),a plant in the *Geraniaceae* family, contains citronellol, citronelly acetate, citronelly formate, and geraniol[24] and has balancing, calming, and uplifting effects. It regulates the body's hormonal system, relieves premenstrual problems, and reduces fatigue and chronic stress. It is also a mood stimulant and a good antidepressant.[25] In addition, *P. graveolens* can reduce anxiety, anger, restlessness, and emotional depression due to its antioxidant effects.[26] In the study by Montibeler et al., a significant decrease in biological parameters caused by work stress, such as nurses' blood pressure and heart rate, was observed after aromatherapy massage with lavender and *P. graveolens*.[27] Furthermore, based on the results of a study, the use of essential oils of rosemary, lavender, *P. graveolens,* sandalwood, and orange is recommended to reduce chronic fatigue.[28] However, despite the therapeutic benefits of *P. graveolens*, research on it still needs to be conducted.[27] Therefore, due to the importance of paying attention to the problems of nurses, this study was conducted to investigate the effect of aromatherapy with *P. graveolens* essential oil on the fatigue and sleep quality of nurses working in the ICU during a Covid-19 pandemic.

Materials and methods

Study design and participants

This study was a double-blind, placebo-controlled, randomized clinical trial. The study population was nurses in the intensive care unit of Covid-19 patients in seven hospitals affiliated with Lorestan University of Medical Sciences, western Iran, from February 2021 to September 2021. Inclusion criteria include willingness to participate in the study, having at least two years of work experience and three months of work experience in the ICU of Covid-19 patients, rotational shift with night shift, having at least 3-night shifts in the monthly schedule, olfactory health, no history of allergic rhinitis, respiratory allergies or problems and migraines, no history of liver and kidney problems, no allergies to herbal and aromatic products, no use of sedatives and analgesics, no pregnancy (for women), no participation in relaxation activities, yoga, massage therapy and a score of 3 or higher on the VAS-F (indicating moderate to severe fatigue). Exclusion criteria also include the unwillingness of individuals to continue participating, being at the peak of Covid-19 disease, the occurrence of an unforeseen crisis or event such as participants or their family members getting Covid-19, or any other illness that causes sick leave, discomfort with the smell of essential oil during the study and, the occurrence of possible annoying side effects (headache, nausea).

Sample size estimation

The sample size was determined due to the lack of a similar study and based on the researchers' expectations of the intervention effect size. Therefore, the sample size was calculated at a 95% confidence level, and 80% test power and the average effect size was 0.29 using G-power software version 3.1.9.2. The minimum sample size in each group was 35 people. However, considering each group's 20% probable loss, 42 people were considered in two intervention groups ($N = 42$) and placebo ($N = 42$). A total of 84 people participated (Fig. 1).

Randomization

The eligible nurses for the study were allocated two groups of *P. graveolens* and placebo by stratified block randomization method to have two similar groups regarding gender and body mass index(BMI). Two gender categories (male and female) were identified to achieve this goal. Subsequently, the BMI for distinct genders was determined as underweight – average weight (<18.5–25) and overweight- obese (25->30). Finally, four categories were formed based on gender and BMI. Each category was used by the quadruple block method to assign nurses to two groups, A (*P. graveolens*) and group B (placebo). First, the list of blocks was written (AABB-ABAB-ABBA-BBAA). Then, random numbers between 1 and 6(1, 4, 5, etc.) were selected using a table of computer-generated numbers. Finally, the list was based on a sequence of letters A and B (AABB (1) - ABAB (2) -ABBA (3) -BBAA (4) - BABA (5) - BAAB (6)) was formed.

Blinding

All bottles containing essential oil were identical in appearance. The pharmacist considered a specific and random number on each bottle; the numbers containing *P. graveolens* and placebo essential oil were recorded on a table and remained with the pharmacist. The pharmacist was blind to the allocation of groups. The study groups (*P. graveolens* -placebo) received fragrances at different times and places. The researcher collecting data and the person responsible for recording the data in the software and analyzing the data were not aware of how nurses were assigned to the intervention and control groups.

Preparation of essential oils

At first, a botanist prepared *P. graveolens* shoots, including leaves and stems of plants from the rangelands of northwestern Iran (West Azerbaijan, Urmia), after pharmacologist approval and dried them in the shade at a temperature of (18–20 °C) for 20 days. After removing dust and contaminants, the dried plant was cut into smaller pieces. Then the essential oil was prepared by distillation method using clevenger at

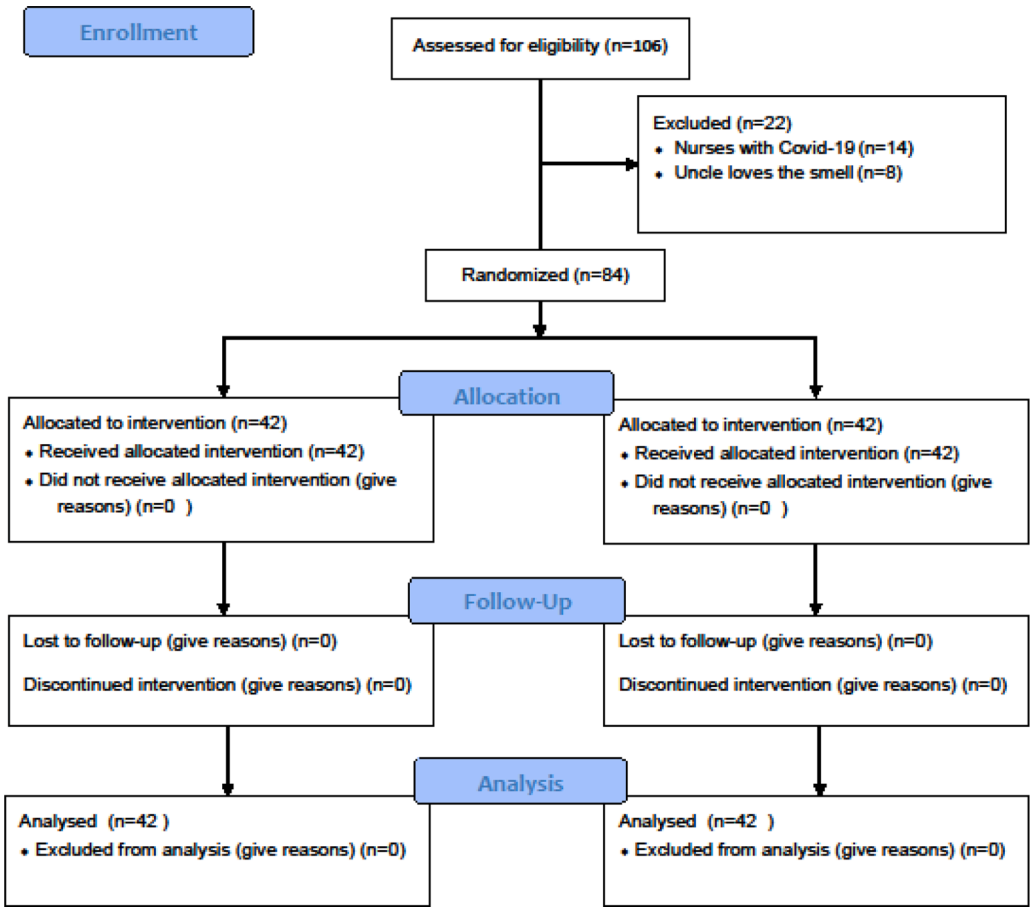

Fig. 1. Flow diagram.

250–70 °C for 5 to 8 h. The color of the obtained essential oil was yellowish-green, poured into dark glass bottles with drop caps, and stored in the refrigerator at a temperature of 4–8 °C. Pure *P. graveolens* is diluted in equal proportions with a base oil that has the same viscosity as geranium. The main constituents of essential oil were citronellol (27%), linalool (1.1%), geraniol (25%), and citronellyl formate (8.4%). Pure refined and odorless sunflower oil was also prepared for the placebo group. The essential oils were supplied by Shamim-Sabz Pharmaceutical Company, Alborz - Iran.

Intervention

Before data collection, the participants were asked to inhale a dark bottle containing lemon juice to ensure the health of the olfactory nerve. They were included in the study if the inhaled odor was reported accurately. The nurses were asked not to use perfume or cologne on the study days. Considering the concurrence of the study with the Covid-19 pandemic and the continuous use of personal protective face masks by nurses, the study process was considered as follows: during aromatherapy, participants put a simple surgical mask on their protective mask. In the intervention group, one drop of pure *P. graveolens* essential oil was, and in the placebo group, one drop of pure sunflower oil was poured on a dark linen pad and placed in the space between the two masks. The fragrance was inhaled for 20 min with normal breathing. Using a Visual Analog Fatigue scale, nurses determined the fatigue score 30 min before inhaling the scent, immediately, and 60 min after that. The used pads and masks were discarded after each aromatherapy session. Aromatherapy for 20 min twice in each shift, between 9 am and 1 pm (for the morning shift) and 3 pm to 7 pm (for the evening shift), with an interval of one hour between each step, was done. Aromatherapy was in three consecutive work shifts (morning or evening). In the morning of the intervention, the participants determined the quality of their sleep last night based on the VSH Sleep Scale. The researcher described the steps and methods of implementation individually and the first stage of aromatherapy for each participant; after ensuring the correct implementation, the nurse was asked to teach the intervention process to the researcher. In addition, how to perform aromatherapy and the exact time of completing the questionnaires were sent via text message with WhatsApp™ Messenger. The groups received fragrance at different times and places. Dark glass bottles with tight drop caps were used, so the oil had no contact with the air. Dark linen pads were also used to cover the essential oil color. During the study, participants in both groups were asked to report any side effects such as headaches, nausea, or other symptoms by telephone and WhatsApp™ Messenger. No side effects were observed according to the researcher's supervision and the participants' reports.

Data analysis

Data management and analysis were performed using SPSS, version 24. The results of qualitative data were reported as frequency (percentage) and quantitative data as (Mean ± SD). Chi-square was used to evaluate the homogeneity of qualitative variables between groups. To compare the mean score of quantitative variables, an independent *t*-test was used. To compare the changes of quantitative variables between two groups at different times, repeated measure ANOVA was used. A p-value less than 0.05 was considered significant.

Outcome measures and data collection

Data were collected using a demographic and professional Information questionnaire, the VAS-F, and the VSH Sleep Scale. On obtaining written informed consent from the participants, the contact numbers of the researcher and the participants became mutually available. The link to the data collection tool was sent to the participants via text message and WhatsApp™ Messenger. They were also reminded with auto-reminders to complete the questionnaires.

Demographic and professional information questionnaire

A demographic and professional information questionnaire was completed, including age, gender, marital status, BMI, level of education, work experience, work experience in the ICU Covid-19, and average night shifts per month.

The visual analog fatigue scale(VAS-F)

The present study assessed fatigue as the primary outcome by VAS-F. This scale is a continuous scale that consists of a 0 to 10-cm ruler. Participants were asked to report their perception of fatigue from 0 (no fatigue) to 10 (highest fatigue level). There are valid scales for measuring fatigue. Most fatigue scales retrospectively assess fatigue from the previous week. In contrast, VAS-F measures the severity of fatigue simultaneously. Therefore, the risk of bias in this tool is low.[29]

The Verran and Snyder-Halpern (VSH) Sleep Scale

Sleep quality as a secondary outcome was investigated. The VSH Sleep Scale was used. This 15-item visual analog instrument measures participants' perception of their previous night's sleep quality. The VSH Sleep Scale developed by Snyder-Halpern and Verran in 1987 includes "disturbance" (interruptions and sleep latency), "effectiveness" (rest upon awakening, subjective quality of sleep, and total sleep period), and "supplementation" (napping) subscales. The score of each section is 0 to 100 mm (with a distance of 5 mm). The participant determines their perception of sleep at this distance as self-reported. Its scores are 0 to 700 in the disturbance subscale, 0 to 500 in the effectiveness subscale, and 0 to 400 in the supplementation subscale. A total score that indicates sleep disturbance or improvement has not been determined. However, an increase of 15 mm in the score after intervention in the effectiveness subscale and a decrease of 15 mm in the subscales of the disturbance and supplementation is considered to improve sleep quality.[30] This tool has been translated into Persian, and its psychometric properties have been evaluated in the Iranian population. The VSH Sleep Scale had a reliability coefficient of 0.83 (Cronbach's alpha). The content and face validity of the instrument have been confirmed, and Construct validity was examined by factor analysis.[30]

Beck depression inventory

Depression was assessed as a confounding variable with Beck Depression Inventory short form (BDI-SF). Nurses in a room near the ward completed the scale before the intervention at a specific time (10 to 11 am and 4 to 5 pm). This scale contains 13 items. Each item consists of four phrases and is scored 0–3 on the likert scale. The minimum and maximum scores are 0 to 39. A score of 0–3 (normal), 4–7 (mild depression), 8–11 (mild to moderate depression), 12–15 (moderate depression), and a score of 16–39 are considered severe depression. The concurrent validity of the scale was measured using its long form (21 items) in Rajabi's study, and the correlation coefficient was 0.67. Also, its reliability has been confirmed with Cronbach's alpha of 89%.[31]

Ethical considerations

This clinical trial study was conducted in line with the Declaration of Helsinki. The code of ethics was obtained from the Deputy for Research and Technology of Lorestan University of Medical Sciences. (No = IR.LUMS.REC.1399.194). It is also registered in Iran Clinical Trial Center (No: IRCT20100609004129N5). Detailed information about the objectives and confidentiality of the research information was explicitly explained to all participants. Participants were reassured that they could leave the study at any stage. In addition, informed written consent was obtained before the start of the study.

Results

Baseline characteristics

In this clinical trial, 42 people from the Geranium group and 42 people from the placebo group completed the study, and their data were used in the final analysis (Fig. 1). Most participants were female (85.7%), married (56%), and had a bachelor's degree (94%). There was no significant difference between the participants of the two groups regarding demographic and professional characteristics ($P > 0.05$) (Table 1). Also, there was no significant difference in the severity of depression between the two groups.

Efficacy: P. graveolens versus placebo

The changes in mean fatigue scores of the two groups during different days and stages of aromatherapy are presented in Table 2. There was a significant difference between the mean fatigue scores of the two groups 30 min before aromatherapy on stage 1 of the first and second days and the second stage of the third day ($P < 0.05$). Therefore, comparing mean fatigue score changes of the two groups during different days and times of aromatherapy was done with repeated measures ANOVA. Due to the non-establishment of the sphericity assumption, the results were reported with the Greenhouse. There was a significant difference between the mean fatigue score changes of the two groups over time ($P < 0.05$). Therefore, a significant decrease in the mean fatigue score was reported in the *P. graveolens* group compared to the placebo group. During stage 1 of the first day, mean fatigue score changes of the two groups before (T1) and immediately after the intervention (T2) were not significant ($P < 0.208$). However, a significant decrease in the mean fatigue score of the *P. graveolens* group compared to the placebo group was reported one hour after the intervention (T3) compared to 30 min before (T2) ($P < 0.004$). On the following days and at different stages, the decrease in the mean fatigue

Table 1
Comparison of demographic and professional characteristics between two groups.

Variable		Geranium group ($n = 42$)		Placebo group ($n = 42$)		P-Value
		N	%	N	%	
Gender	Male	9	21.4	3	7.1	0.116
	Female	33	78.6	39	92.9	
Marital status	Single	18	42.9	18	42.9	0.6
	Married	24	57.1	23	54.8	
	Divorced	0	0	1	2.4	
Education level	Bachelor	39	92.9	40	95.2	0.99
	MSc	3	7.1	2	4.8	
		Mean	SD	Mean	SD	
Age (year)		31.6	6.43	31.14	5.81	0.73
BMI		23.56	3.1	23.73	2.56	0.79
Number of night shifts per month		5.83	1.96	5.86	1.77	0.95
Work experience (year)		7.65	5.09	7.12	5.18	0.63
Work experience in ICU (year)		4.87	3.38	3.75	2.55	0.08

Table 2
Comparison of changes in mean fatigue scores between two groups at different times.

Intervention Time			Assessment times (Mean ± SD)			Mean fatigue score changes (Mean ± SD)				P-value (time *group)
			30 min before the intervention (T1)	Immediately after the intervention (T2)	60 min after the intervention (T3)	T2 vs. T1	P-value	T3 Vs. T1	P-value	
First day	Stage 1	Geranium	4.29 ± 1.99	4.12 ± 1.95	3.9 ± 1.89	−0.16 ± 1.2	0.208	−0.38 ± 1.68	0.004	0.004 F*= 6.41
		Placebo	3 ± 1.12	3.1 ± 1.32	3.48 ± 1.31	0.09 ± 0.57		0.47 ± 0.86		
	Stage 2	Geranium	4.64 ± 1.8	3.81 ± 1.71	3.81 ± 2.01	−0.83 ± 0.96	< 0.001	−0.83 ± 1.24	< 0.001	< 0.001 $F = 17.38$
		Placebo	4.38 ± 1.28	4.38 ± 1.28	4.69 ± 1.35	0 ± 0.73		0.3 ± 0.74		
Second day	Stage 1	Geranium	4.21 ± 2.33	3.76 ± 2.01	3.64 ± 1.92	−0.45 ± 1.01	0.014	−0.57 ± 1.72	0.002	0.001 $F = 6.36$
		Placebo	3.14 ± 1.35	3.17 ± 1.44	3.55 ± 1.46	0.02 ± 0.68		0.4 ± 0.88		
	Stage 2	Geranium	4.29 ± 1.62	3.60 ± 1.83	3.69 ± 1.89	−0.69 ± 1.21	0.001	−0.59 ± 1.56	0.001	< 0.001 $F = 9.51$
		Placebo	4.62 ± 1.41	4.67 ± 1.42	4.93 ± 1.38	0.04 ± 0.53		0.3 ± 0.68		
Third day	Stage 1	Geranium	3.60 ± 2.04	3.26 ± 1.90	2.90 ± 1.69	−0.33 ± 0.9	0.029	−0.69 ± 1.09	< 0.001	< 0.001 $F = 20.31$
		Placebo	3.33 ± 1.28	3.36 ± 1.37	3.81 ± 1.53	0.02 ± 0.51		0.47 ± 0.8		
	Stage 2	Geranium	4.17 ± 1.49	3.74 ± 1.57	3.71 ± 1.75	−0.42 ± 0.73	0.001	−0.45 ± 0.99	0.001	< 0.001 $F = 8.85$
		Placebo	4.81 ± 1.40	4.88 ± 1.4	4.98 ± 1.40	0.07 ± 0.51		0.17 ± 0.62		

* Repeated Measures ANOVA.

scores T2 and T3 compared to T1 in the *P. graveolens* group was significant compared to the placebo group ($P < 0.05$).

The within-group comparison showed an increase in the *P. graveolens* group's mean sleep score in the disturbance subscale ($P = 0.029$). There is no significant difference between the two groups mean scores of the disturbance subscale over time ($P = 0.128$) (Table 3). The within-group comparison showed an increase in the mean sleep score in the subscale of effectiveness in the *P. graveolens* group ($P = 0.036$). Also, there was no significant difference between the changes in the mean sleep score in the effectiveness subscale of the two groups over time ($P = 0.219$) (Table 3). Based on the corrected Bonferroni comparisons between different times, from the second to the third day of the intervention, there was a significant difference between the changes in the mean sleep score in the supplementation subscale of the two groups ($P = 0.024$). Thus, an increase in the mean Supplementation score was observed in the *P. graveolens* group, and in the placebo group, a decrease was observed (Table 3).

Also, the results showed no significant difference between the nurses' mean total sleep quality score in the two groups ($P = 0.458$) (Table 3). According to the participants' self-report, we did not observe particular side effects induced by using *P. graveolens* and sunflower oils during the intervention.

Discussion

This study aimed to determine the effect of *P. graveolens* essential oil on the fatigue and sleep quality of nurses working in the ICU during the Covid-19 pandemic. According to the findings, aromatherapy with *P. graveolens* essential oil can reduce the perceived fatigue of critical care nurses. Despite its efficacy in fatigue, aromatherapy could not improve sleep quality.

In the present study, fatigue was measured immediately after aroma inhalation to understand the immediate effects of aromatherapy. The fatigue of the *P. graveolens* group showed a significant decrease

Table 3
Comparison of Sleep scores between two groups at different times.

Time Subscale		First day Mean ± SD*	Second day Mean ± SD	Third day Mean ± SD	Within-group effect	P-value (Time)	P-value (Group)	Effect of time *group
Disturbance	Geranium	73.43 ± 20.36	79.89 ± 15.12	81.97 ± 18.13	0.029 $F = 4.12$	0.017	0.575	0.128 $F = 2.12$
	Placebo	79.04 ± 16.31	80.74 ± 13.39	80.4 ± 12.9	0.575 $F = 0.56$			
Effectiveness	Geranium	80.52 ± 23.98	85.95 ± 19.99	90.33 ± 21.43	0.036 $F = 3.46$	0.021	0.137	0.219 $F = 1.53$
	Placebo	89.8 ± 13.6	90.8 ± 14.51	91.47 ± 13.48	0.536 $F = 0.63$			
Supplementation	Geranium	76.84 ± 21.99	78.86 ± 16.64	83.33 ± 15.37	0.075 $F = 2.68$	0.358	0.709	0.03 $F = 3.58$
	Placebo	81.01 ± 18.05	82.31 ± 13.69	79.28 ± 15.48	0.255 $F = 1.39$			
Total	Geranium	72.53 ± 18.66	77.58 ± 13.53	80.53 ± 16.09	0.25 $F = 4.4$	0.024	0.458	0.054 $F = 3.15$
	Placebo	78.23 ± 12.55	79.58 ± 11.8	78.57 ± 11.42	0.577 $F = 0.525$			

* Standard Deviation.

compared to the placebo group. Also, the delayed effects of aromatherapy were evaluated by measuring the fatigue score one hour after the intervention. The results showed that the fatigue of the *P. graveolens* group was reduced. These findings indicate that *P. graveolens* aromatherapy can effectively reduce the fatigue of ICU nurses under severe work pressure due to the outbreak of Covid-19 without the need for repeated repetition of intervention courses.

Essential oils have a refreshing effect, primarily with inhalation. The sense of smell activates the limbic system and hormones, reducing stress, depression, and fatigue by increasing mental and physical stability.[32] In the study, geranium was shown to be effective on the hypothalamic-pituitary-adrenal axis and has sedative effects by reducing glucocorticoid levels.[33] In addition, geranium can reduce anxiety, anger, restlessness, and emotional depression due to its antioxidant effects.[26] The antioxidant activity of *P. graveolens* essential oil can be attributed to the presence of monoterpene identified in its chemical composition including geraniol.[34] In another study, the effectiveness of aromatherapy massage with a combination of essential oils of lavender, *P. graveolens*, and chamomile in reducing anxiety and fatigue of nursing students was reported in the first clinical experience.[35] Another study showed reduced stress, fatigue, and improved mood in operating room nurses after inhaling aromatherapy with a mixture of lavender, *geranium*, and marjoram.[36] However, with a combination of essential oils, the difference between the benefits of each is still being determined. Therefore, more evidence is needed to reach a definitive conclusion about the effectiveness of *P. graveolens* essential oil aromatherapy in reducing fatigue.

Contradictory findings have been reported regarding the effect of aromatherapy on fatigue. In the study by Hatami et al. (2020), the ineffectiveness of inhaled aromatherapy with rosemary in reducing the fatigue of pre-hospital emergency personnel has been reported.[37]

Many essential oils can reduce sedation and excitement and soothe and improve sleep quality.[38] Therefore, aromatherapy is believed to effectively improve sleep quality by reducing stress, anxiety, fatigue, and pain, factors that cause insomnia.[39] The review of previous studies showed that, so far, no study has examined the effectiveness of aromatherapy in reducing nurses' fatigue and its effect on improving their sleep quality. Therefore, to overcome the knowledge gaps in this matter, relevant studies should be conducted to understand aromatherapy's efficacy better. Although, our results did not show an improvement in the sleep quality of the intervention group nurses. Nevertheless, we have introduced a path for new and potentially important research in nursing.

The present findings agree with the results of a study in 2021, which investigated four sessions of aromatherapy massage with lavender essential oil to improve the sleep quality of critical care nurses. This study showed no significant difference in the total subjective sleep quality and objective sleep parameters before and after the intervention. Nevertheless, a gradual improvement in the subjective sleep quality of nurses in the intervention group was reported.[40] A clinical trial showed improved sleep quality of intensive care unit nurses after aromatherapy with lavender 2%.[19] Yang et al. (2015) reported the effectiveness of 8 weeks of inhalation aromatherapy with lavender in improving the sleep quality of female nurses. Aroma inhalation was done before sleep, and the control group received no intervention.[41] Also, the study findings by Kim and Hur. (2016) showed an improvement in nurses' sleep quality after inhaling aromatherapy. In this study, nurses slept after the night shift by placing lavender essential oil at a distance of 30 cm.[42]

The effect of essential factors such as gender, lifestyle, emotional state, sleep hygiene, and type of work shift on the results should not be ignored.[40] A study found a significant relationship between depression and increased sleep disorders in female nurses.[43] Also, shift work changes the awake and sleep time in a 24 h cycle, harming the amount and quality of sleep.[44] Their mental and physical activities in this time interval affect the reported sleep quality. These findings recommended aromatherapy's more remarkable and comprehensive efficacy on nurses' sleep quality. Also, sleep disorder screening was not performed in this study. Future studies can screen the effectiveness of aromatherapy in improving the sleep quality of nurses with sleep problems.

The limitation of the study was the Covid-19 crisis, which caused nurses to become ill and participants not to complete the study. In addition, the intense emotional impact of intensive care unit nurses on observing the suffering and dire consequences of Covid-19 patients effectively reduced the desire to participate in the study, which was another study problem. Also, sampling in three consecutive shifts was a problem in the study due to the rotation of nurses' work shifts. There is no way to mask essential oil odors in aromatherapy studies, so another limitation is the difficulty of blinding. Based on the results, mixed-method research is recommended to determine the generalizability and application of aromatherapy in reducing nurses' problems during the Covid-19 crisis. Another limitation of the study was the lack of sampling in the night shift.

Conclusion

Considering the urgent need to support nurses during the epidemic of Covid-19 and other similar crises, the present study's findings suggest aromatherapy with *P. gravelens essential* oil to reduce fatigue and improve critical care nurses' sleep quality among nursing managers and leaders. Also, the findings of this study make nurses interested in using complementary medicine and aromatherapy as self-care methods.

Author contributions

The study conception/design: S.H, N.K, A.B, and M.G; The data collection. analysis and interpretation of data: N.K, S.H, and M.B; writing the manuscript and editing: S.H, N.K, A.B, M.G, and M.B

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