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# The Effect of Deep Breathing with Rosemary Essential Oil on the Sleep Quality of Patients Undergoing Upper Limb Orthopedic Surgery

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## ABSTRACT

**Background and Objective:** One of the important problems of hospitalized and orthopedic patients is sleep disorders and poor sleep quality. Considering the high rate of orthopedic and trauma operations in Iran and lack of studies in this area, the present study was conducted with the aim of comparing the effect of two methods of deep breathing with and without rosemary essential oil on the sleep quality of patients undergoing upper limb orthopedic surgery.

**Methods:** This clinical trial was conducted on 102 orthopedic surgery candidates in three groups of 34 people. The quality of sleep was checked the night before surgery and 7 days after surgery using the Petersburg Questionnaire. A score of 5 or more means poor sleep quality and less than 5 means good sleep. The group of deep breathing with rosemary used a necklace containing cotton soaked in rosemary essential oil; deep breathing was repeated twice a day and 12 times each time for up to 7 days. The group of deep breathing without rosemary used a necklace containing normal saline and the control group used necklace containing cotton without rosemary and normal saline. Then, the results were checked and compared in the groups.

**Findings:** The demographic characteristics of the three groups were similar. 97.1% of patients in the group of deep breathing with rosemary, 58.8% in deep breathing without rosemary, and 23.5% in the control group had good sleep quality until 7 days after surgery. Two days after the operation, the mean sleep score was 11.24±0.58 in the group of deep breathing with rosemary, 8.78±4.58 in the group of deep breathing without rosemary, and 9.43±0.58 in the control group (p=0.016). The quality of sleep in the group of deep breathing with rosemary was better and significant compared to the group without rosemary and the control group (p=0.027).

**Conclusion:** The results of the study showed that deep breathing with rosemary improves the sleep quality of patients undergoing upper limb orthopedic surgery. Therefore, this complementary method can be used to improve sleep in patients undergoing upper limb orthopedic surgery.

**Keywords:** *Breathing Exercises, Rosemary, Sleep Quality, Orthopedic Surgery, Rosmarinic Acid.*

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## Introduction

Sleep is a necessary part of physical health, mental comfort and energy storage. Comfortable and proper sleep accelerates the process of physical and mental recovery of patients (1). Sleep is one of the most basic human needs (2). Therefore, lack of sleep can have severe adverse effects on physical and mental health and as a result, cause an increase in care costs (3). Although surgery, the nature of the disease, and the complications caused by it can prevent adequate sleep and rest, but the concern about problems such as pain and discomfort after the operation, lack of ability to do physical activity after the operation, hospital environment, long-term care and staff activities can also reduce the quality of sleep and disrupt it in patients (4, 5). According to the report of the World Health Organization, almost 1 out of every 3 patients have problems sleeping at night, and most of the sleep problems in patients are caused by their hospitalization (6). In fact, the use of sedatives such as diazepam to get rid of insomnia problems due to drug side effects, such as weakened respiratory activity, complications, or unavailability, has drawn the attention of nursing systems to non-drug techniques to improve sleep (7).

One of these methods is deep breathing exercises that can reduce sleep disorders. Therefore, it is considered as an excellent tool to facilitate relaxation (8). With deep breathing, the time of inhalation and exhalation increases; as a result, the number of breaths decreases and the amount of oxygen in the blood is maximized. Thus, the extra pressure is removed from the vital organs and the physical and mental relaxation of the person increases (9). Previous studies have shown doing deep breathing in patients can improve the quality of people's sleep (8). In a study, deep breathing showed positive effects on the quality of sleep, and the use of this non-medicinal and uncomplicated method was suggested in order to maintain the mental and physical health of personnel and increase the safety and quality of the job (10).

Aromatherapy is the knowledge of using essential oils and aromatic plant oils to improve health and recovery (11). According to some researchers, the human brain gives an emotional response to any scent. Thus, when a scent is inhaled, the smell from the plant can activate the olfactory nerve cells and ultimately the limbic system. Depending on the type of scent, nerve cells also release different neurotransmitters such as enkephalin, endorphin, noradrenaline and serotonin, which can have an impact on the health, comfort and relaxation of patients (12). Therefore, aromatherapy ranks second among the most widely used nursing methods (13). Among different scents, rosemary plant is one of the most useful plants, whose essential oil contains rosmarinic acid, phenolic compounds and volatile oil, which relaxes and improves sleep disorders by stimulating the olfactory center in the brain. Rosemary belongs to the mint family and is cultivated in Iran for medicinal and ornamental purposes. This medicinal plant is widely used in food and cosmetics and it has no special side effects (14). Some studies have reported effects such as enhanced memory, reduced anxiety and depression, and improved sleep quality, besides the absence of side effects of rosemary plant (15).

Despite the advancement of technology in health care and considering the importance of sleep quality in improving the physical and mental health of patients, the usual pharmaceutical methods to improve the quality of sleep of patients are still insufficient. Therefore, there is a need for interventions and non-pharmacological treatments. Considering the high rate of orthopedic operations in Iran, and issues such as preoccupation, lack of necessary ability for physical activity in orthopedic patients in the post-operative stage to earn a living and have a normal social life, especially in upper limb surgery and given the lack of studies regarding the use of non-pharmacological and complementary methods instead of sleeping pills, this study was conducted to compare the effect of two deep breathing methods, with and without rosemary essential oil, on the sleep quality of patients undergoing upper limb orthopedic surgery.

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## Methods

This randomized clinical trial study was approved by the ethics committee of Mazandaran University of Medical Sciences with the code IR.MAZUMS.REC.1401.501 and registered in the Iranian clinical trial system with the code IRCT20230209057374N1. After making the necessary arrangements and obtaining written informed consent from the participants, it was conducted on upper limb orthopedic surgery candidates admitted to the operating room of 17 Shahrivar Hospital in Amol in 2022-2023. Patients over 18 years of age, the presence of any fractures and tears in the upper limbs, the duration of the operation from a minimum of 30 minutes to a maximum of 3 hours, full consciousness, not suffering from respiratory diseases such as asthma, bronchitis and emphysema, nervous and mental diseases, not smoking, absence of pregnancy and breastfeeding, insensitivity to medicinal plants, and anesthesia class I and II (ASA1 and ASA2) were included in the study. In case of withdrawal from the study, unwanted cardiovascular and respiratory complications during anesthesia and surgery, use of sedatives and psychoactive drugs, suffering from compartment syndrome and serious and simultaneous injuries in upper limbs and injuries of other organs were excluded from the study. 102 eligible patients were selected via convenience sampling and were randomly allocated into three groups of 34, including deep breathing with rosemary, deep breathing without rosemary, and the control group. Based on a previous similar study (10), using G-Power software with an average effect size of 0.3, 95% CI, a type I error of 5% and a type II error of 10%, sample size was determined as 29 people in each group. 15% was added to the sample size to increase the accuracy of the study and possible dropout, and 34 people were considered in each group.

In order to avoid selection bias, patients were randomly assigned to each group using six letter blocks BB, RR, CC; respectively to the control group (C), deep breathing with rosemary (R) and deep breathing without rosemary (B). 17 blocks of six were randomly selected according to the sample size, and then the order of six letters of each block was considered as six patients who visited continuously. Finally, a continuous order of 102 patients was determined according to the desired letters or groups. In order to hide the patient's entry number, the number of the patients was consecutively written on the envelope and the type of intervention inside the envelope.

Rosemary essential oil was purchased from Dr. Soleimani Plant Essential Oil Company, Golestan Province, Gorgan, Iran, and its ingredients include caffeic acid derivatives, diterpenes, flavonoids, triterpenes, and volatile oil (1,8-cineole, alpha-pinene, camphor, borneol, camphene, limonene, p-cymene, myrcene, linalool, alpha-terpineol).

After the introduction, the same explanation and the same training was given to each eligible patient on how to perform deep breathing. Questionnaires of demographic information (including: age, sex, BMI, marital status, employment status) and clinical variables such as duration and characteristics of surgery were extracted and recorded by asking the patients, and from the patient's file. Sleep quality as the main variable and primary outcome was completed through a standard questionnaire for patients by the researcher by asking the patient and from the patient's file. Deep breathing training was taught face to face by the researcher with the help of a guide note before surgery, and then its implementation was checked and approved. On the first day, the patient practiced deep breathing 12 times at the beginning of the day and 12 times in the evening before dinner, for 15 minutes and up to a week; 4 days in a lying position and 3 days in a sitting position. The implementation of breathing was as follows: when the patient was lying on his/her back in a comfortable position and had his/her legs hip-width apart and slightly bent at the knee, he/she placed his healthy hand on his/her stomach and took a slow and deep breath through his/her nose; while

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expanding the abdominal muscles, the patient held breath for 5 seconds and then exhaled all the air from his/her lungs through nose. During inhalation and exhalation, the patient's attention was on the expansion and movement of the abdominal muscles. The patient practiced breathing in a sitting position as well as in a lying position (10).

In order to keep the patient unaware of his/her groups, all patients in the three groups used a necklace containing cotton. The patients' rooms in the groups were separated as much as possible and they did not know each other after discharge. However, due to the aromatic nature of rosemary essential oil, it was not possible to completely blind the patients, and opaque envelopes were used for concealment in such a way that the number of the patients entering the study was on the envelope and the type of intervention inside was clear. In the group of breathing with rosemary, a necklace containing a cotton bag with three drops of non-alcoholic rosemary essential oil (at a concentration of 100%), prepared from an essential oil pharmaceutical company in Gorgan, was placed on the cotton and placed at a distance of 20 cm from the patient's nose, and its scent was inhaled by taking a deep breath. At each stage of the intervention, the patient soaked a new cotton with rosemary essential oil (the researcher delivered enough cotton and rosemary essential oil to the patient for 7 days) and the necessary training was given. The group of deep breathing without rosemary was similar to the deep breathing group with rosemary; however, only three drops of normal saline were used instead of rosemary. In the control group, necklaces with cotton without rosemary and normal saline were used for patients. In addition, all intervention and control groups received routine treatment and care methods in the operating room and ward.

The Pittsburgh Sleep Quality Index (PSQI) was used to evaluate sleep quality. This questionnaire is classified in 7 areas for which 9 questions were considered. Question 5 contains 10 sub-questions. Therefore, the whole questionnaire has 18 questions that measure the quality of sleep. The areas and questions related to each area include: 1) mental quality of sleep with question number 6, 2) delay in falling asleep with average of question number 2 and part A of question 5, 3) duration of sleep with question 3, 4) Effectiveness and efficiency of sleep as a percentage of the total hours of actual sleep divided by the total hours that the patient is in bed, 5) sleep disorders, which is determined by the average of ten sub-questions of number 5, 6) the amount of sleep-inducing drugs taken by question number 7, and 7) daily performance determined by the average of questions 8 and 9. The score of each field is between 0 and 3 and the score of each question is a maximum of 3. The sum of the average scores of these 7 fields constitutes the total score of the questionnaire. Therefore, the sleep quality score is between 0 and 21, and the higher the score, the lower the sleep quality, and the score less than 5 is defined as the unfavorable sleep quality (16, 17). This tool has been used in various studies in Iran to determine the sleep quality of patients and it was confirmed in terms of validity and correlation of questions with Cronbach's alpha. The reliability of this tool was confirmed above 70% (17-19).

To collect data related to the quality of sleep until hospitalization, the researcher asked the patients directly and face-to-face based on the questions of the questionnaire, and after discharge, it was done by phone and the quality-of-life questionnaire was completed. The data were analyzed using SPSS version 23. To classify and describe the data using mean and standard deviation for quantitative variables and frequency and frequency percentage for qualitative variables, tables were used and for data analysis for quantitative variables that had a normal distribution, one-way ANOVA statistical tests were used. For intragroup measurements, Repeated measures ANOVA was used. Kruskal-Wallis or Friedman's test was used to analyze quantitative variables and if they did not have a normal distribution. Qualitative variables were analyzed by chi-square tests and Fisher's exact test, and $p<0.05$ was considered significant.

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## Results

In this study, 102 candidates for upper limb orthopedic surgery were examined in three groups of 34 people: deep breathing with rosemary, deep breathing without rosemary, and the control group. The mean age of the participants in this study was 38.1±10.7 years and they were in the range of 18-62 years, of which 61 (59.8%) were men and 41 (40.2%) were women. There was no significant difference between the studied groups in terms of age, gender, weight, height, BMI and clinical variables such as surgery time and social characteristics (Tables 1 and 2). No intervention-related complications were observed or reported in the three groups of patients during the study.

**Table 1. Demographic information of people participating in the study in the three groups**

| Variable \ Group | Deep breathing with rosemary Mean±SD | Deep breathing without rosemary Mean±SD | Control Mean±SD | p-value* |
|---|---|---|---|---|
| Age (years) | 37.85±9.05 | 36.76±11.1 | 39.73±11.83 | 0.516 |
| Height (meters) | 1.7±0.094 | 1.7±0.108 | 1.7±0.063 | 0.985 |
| Weight (kg) | 79.35±11.00 | 78.7±11.3 | 78.47±16.87 | 0.961 |
| BMI | 27.39±3.92 | 27.29±4.63 | 27.07±5.43 | 0.958 |
| Duration of surgery | 56.47±11.38 | 57.05±11.35 | 57.94±11.22 | 0.865 |

***One-way analysis of variance**

**Table 2. Frequency distribution of social variables by groups**

| Variable \ Group | Deep breathing with rosemary Number(%) | Deep breathing without rosemary Number(%) | Control Number(%) | p-value* |
|---|---|---|---|---|
| **Gender** | | | | |
| Man | 20(58.8) | 19(55.9) | 22(64.7) | 0.757 |
| Woman | 14(41.2) | 15(44.1) | 12(35.3) | |
| **Marital status** | | | | |
| Single | 13(38.2) | 12(35.3) | 16(47.1) | 0.596 |
| Married | 21(61.8) | 22(64.7) | 18(52.9) | |
| **Occupation status** | | | | |
| Employee | 6(17.6) | 0(0.0) | 4(11.8) | 0.062 |
| Self-employed | 28(82.4) | 34(100) | 30(88.2) | |

***Chi-square test**

Among these people, 21 people had injuries in the fingers, 33 people in the forearm area, 16 people in the arm area and 32 people in the palm area. There was no significant difference between the studied groups in terms of surgical clinical variables and they were homogeneous (Table 3).

The mean scores of sleep quality were significantly different between the deep breathing groups with rosemary and without rosemary and the control group (p=0.000). There was no significant difference in the mean score of the area related to subjective sleep quality in the three studied groups the night before operation and 1 day after the operation. However, on 2, 4 and 7 days after surgery, this difference was

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significant (p<0.001) (Table 4). There was no significant difference in the score of delayed sleep phase in patients the night before the intervention, but there was a significant difference in the days after the operation; it was better in the group of deep breathing with rosemary (p=0.001).

**Table 3. Frequency distribution of variables related to surgery by groups**

| Group<br>Variable | Deep breathing with rosemary Number(%) | Deep breathing without rosemary Number(%) | Control Number(%) | p-value* |
|---|---|---|---|---|
| **History of surgery** | | | | |
| Yes | 14(41.2) | 17(50.0) | 17(50.0) | 0.708 |
| No | 20(58.8) | 17(50.0) | 17(50.0) | |
| **Systemic disease** | | | | |
| Yes | 12(35.3) | 12(35.3) | 10(29.4) | 0.842 |
| No | 28(64.7) | 22(64.7) | 24(70.6) | |
| **Cause of injury** | | | | |
| Accident | 15(44.1) | 11(32.4) | 12(35.3) | |
| Falls | 8(23.5) | 7(20.6) | 10(29.4) | 0.461 |
| Tools | 11(32.4) | 16(47.1) | 12(35.3) | |
| **Injured organ** | | | | |
| Finger | 5(14.7) | 6(17.6) | 10(29.4) | |
| Forearm | 12(35.3) | 10(29.4) | 11(32.4) | 0.315 |
| Arm | 5(14.7) | 6(17.6) | 5(14.7) | |
| Palm | 12(35.3) | 12(35.3) | 8(2.35) | |

*One-way analysis of variance

**Table 4. Comparison of the mean subjective score of sleep separately in three groups the days before the operation, and 1, 2, 4 and 7 days after the operation**

| Group<br>Variable | Deep breathing with rosemary Mean±SD | Deep breathing without rosemary Mean±SD | Control Mean±SD | p-value* |
|---|---|---|---|---|
| **Mental quality (score 0-3)** | | | | |
| The night before | 1.82±0.57 | 2.08±0.51 | 1.79±0.64 | 0.072 |
| 1 day later | 1.79±0.53 | 2.02±0.42 | 1.94±0.48 | 0.075 |
| 2 days later | 1.44±0.56 | 2.00±0.42 | 1.91±0.51 | 0.009 |
| 4 days later | 1.11±0.32 | 1.67±0.58 | 1.91±0.57 | 0.001 |
| 7 days later | 1.02±0.17 | 1.44±0.56 | 0.94±0.64 | 0.001 |
| **p-value**** | 0.001 | 0.001 | 0.003 | |

*one-way analysis of variance, **Repeated measures ANOVA

The length of sleep time in hours in the deep breathing group with rosemary was better than the other groups (Figure 1). The results showed that the actual length of sleep in the Rosemary group was better than the other two groups during the time after surgery (p<0.05).

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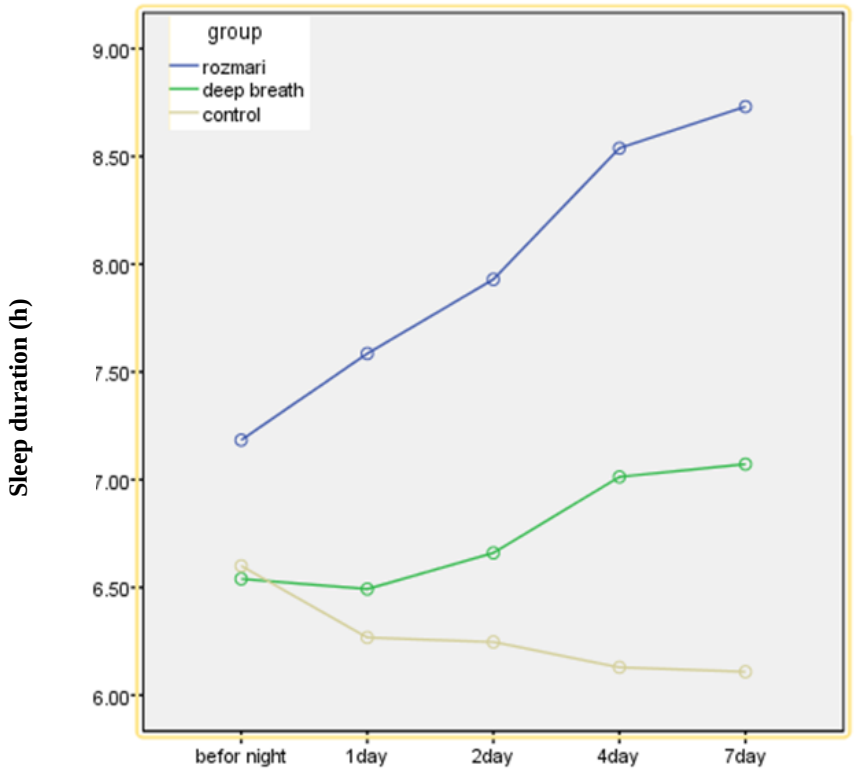



**Figure 1. The duration of night sleep (hours) the night before and 1, 2, 4 and 7 days after surgery separately in the three study groups**

The seven domains of Pittsburgh Sleep Quality Index showed that in addition to mental quality and the score of delayed sleep phase, other domains, such as daily dysfunction, were better in the Rosemary group. Table 5 shows the scores related to some other areas of sleep quality separately in the three studied groups before surgery, and 1, 2, 4 and 7 days after surgery. The results related to other indicators were shown in Table 5.

Also, the simultaneous effect of group and time on changes in sleep quality was shown in Table 6. In order to remove the effect of time interference with the intervention group, the effect of time on sleep quality was removed using analysis of covariance, and after removing the effect of time, the sleep quality was different in the three groups; the sleep quality in the group of deep breathing with rosemary was better than other groups.

The comparison of the mean scores of the seven domains of Pittsburgh Sleep Quality Index at different times of evaluation in three study groups is shown in Figure 2. Also, the sum of the scores of the seven sleeping areas of Pittsburgh at different times of evaluation in three groups is shown in Table 7. According to this table, lower scores indicate better sleep quality, which was significantly better in the rosemary group on the fourth day.

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**Table 5. Comparison of efficiency, sleep disorders, use of sleeping pills and daily dysfunction by groups**

| Variable / Group | Deep breathing with rosemary Mean±SD | Deep breathing without rosemary Mean±SD | Control Mean±SD | p-value* |
|---|---|---|---|---|
| **Efficiency of sleep (0-3)** | | | | |
| The night before | 2.23±0.85 | 2.97±1.1 | 2.56±1.7 | 0.018 |
| 1 day later | 1.79±1.11 | 2.06±1.67 | 1.94±1.91 | 0.033 |
| 2 days later | 1.44±0.56 | 2.0±0.42 | 1.91±0.51 | 0.06 |
| 4 days later | 1.12±0.33 | 1.68±0.59 | 1.91±0.57 | 0.386 |
| 7 days later | 1.1±0.17 | 1.44±0.56 | 1.94±0.65 | 0.402 |
| **p-value**** | 0.001 | 0.001 | 0.099 | |
| **Sleep disorders (0-3)** | | | | |
| The night before | 2.08±0.287 | 2.32±0.474 | 2.02±0.171 | 0.001 |
| 1 day later | 2.02±1.171 | 2.26±0.54 | 2.08±0.287 | 0.001 |
| 2 days later | 2.00±0.71 | 2.18±0.447 | 2.17±0.386 | 0.026 |
| 4 days later | 2.00±0.000 | 2.14±0.359 | 2.17±0.386 | 0.042 |
| 7 days later | 2.02±0.171 | 2.05±0.238 | 2.08±0.287 | 0.596 |
| **p-value**** | 0.022 | 0.064 | 0.065 | |
| **Amount of sleeping pills (0-3)** | | | | |
| The night before | 1.26±0.447 | 1.35±0.485 | 1.2±0.41 | 0.007 |
| 1 day later | 1.11±0.409 | 1.32±0.638 | 1.02±0.171 | 0.013 |
| 2 days later | 1.02±0.171 | 1.29±0.629 | 1.02±0.171 | 0.016 |
| 4 days later | 1.02±0.171 | 1.26±0.618 | 1.02±0.171 | 0.057 |
| 7 days later | 1.02±0.171 | 1.2±0.478 | 1.02±0.171 | 0.224 |
| **p-value**** | 0.001 | 0.001 | 0.156 | |
| **Daily dysfunction (0-3)** | | | | |
| The night before | 1.76±0.43 | 1.82±0.52 | 1.67±0.47 | 0.045 |
| 1 day later | 1.64±0.48 | 1.73±0.56 | 1.76±0.43 | 0.716 |
| 2 days later | 1.5±0.5 | 1.61±0.55 | 1.7±0.46 | 0.584 |
| 4 days later | 1.05±0.23 | 1.23±0.49 | 1.76±0.43 | 0.001 |
| 7 days later | 1.23±0.43 | 1.44±0.56 | 1.85±0.5 | 0.001 |
| **p-value**** | 0.001 | 0.001 | 0.001 | |

*one-way analysis of variance, **repeated measurement analysis of variance

**Table 6. Examining the effects of time and group on changes in sleep quality in different groups**

| Variable | The square of the square | Degree of freedom | Mean square | F | p-value |
|---|---|---|---|---|---|
| **Sleep quality** | | | | | |
| Time | 3.008 | 4 | 0.752 | 4.817 | 0.001 |
| Group | 93.635 | 2 | 46.818 | 23.644 | 0.001 |
| Time*Group | 9.169 | 8 | 1.146 | 7.341 | 0.001 |
| Error | 61.824 | 396 | 0.156 | - | - |

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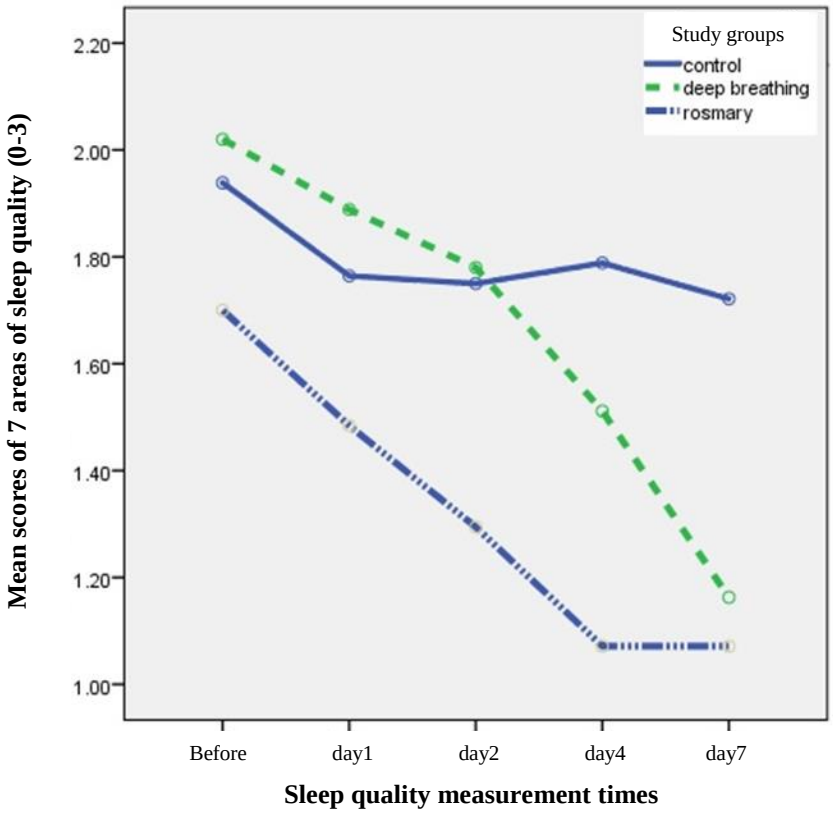



**Figure 2. Comparison of the mean scores of the seven domains of Pittsburgh Sleep Quality Index at different times of evaluation in the three study groups**

**Table 7. Total scores of seven areas of sleep quality before surgery, and 1, 2, 4, 7 days after surgery in rosemary, deep breathing and control groups (0 to 21 points)**

| Measurement steps | Rosemary | Deep breathing | Control |
|---|---|---|---|
| Before | 11.95 | 14.05 | 13.57 |
| End of the first night | 10.29 | 33.22 | 12.35 |
| End of the second night | 9.06 | 12.46 | 12.25 |
| End of the fourth night | 7.5 | 10.58 | 12.52 |
| End of the seventh night | 7.5 | 10.13 | 11.9 |

## Discussion

In this study, the group of deep breathing with rosemary had better sleep quality in all phases compared to the control group and deep breathing without rosemary, which shows the effectiveness of rosemary essential oil; in the group of deep breathing with rosemary on the first, second, fourth and seventh nights after the operation, more than 2 to 5 points of the 21-point sleep quality score of Pittsburgh Sleep Quality Index was higher than the control group, and the deep breathing group had relatively better sleep status compared to the control group. In the study of Nematolahi et al., the effect of rosemary capsules on the sleep quality of 68 students was investigated. The results showed that rosemary, as a traditional natural product, was effective in improving the sleep quality of students and the sleep quality improved after the intervention (15). In the study of Solhi et al., rosemary was used in the form of oral powder in people with opiate

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withdrawal syndrome. They reported that this method of use both improves sleep quality and reduces insomnia in people with opium withdrawal syndrome (20). These results show that not only the rosemary essential oil product is effective for increasing the quality of sleep through inhalation, but it is also effective when taken orally and digested. In a review article, Hamidpour et al. reviewed 80 articles and found that there are a wide range of therapeutic uses for rosemary. These results reported that rosemary compounds with antidepressant and sedative effects improve the sleep quality in patients (21). In an animal model, Alnamer et al. showed that rosemary essential oil has psychoactive activity, and with dopaminergic potentiation mechanisms, it can improve sleep onset latency and increase motor activity; the duration of sleep decreased from 34±0.2 minutes to 3±0.1 minutes (22). The results of this research are not consistent with the findings of the present study. Among the reasons for the contradiction in the results of two researches, it can probably be related to the dose-dependent effects and the use of a low dose of rosemary essential oil, the short duration of the intervention and the method of using rosemary essential oil and the studied population, which highly different between animals and humans.

In a review article, it was shown that the main compound of rosemary, which is rosmarinic acid, caused a reduction in mental pressure and relaxation and a good sleep (23). In this study, the word rosmarinic acid, which is the main ingredient of rosemary, was used for the search, and the word rosemary was not used for the search. However, the results of this study are consistent with the findings of the current research in terms of the presence of the main effective and soothing compound: rosmarinic acid. In their study, Khakha et al. also showed that deep breathing improved the sleep quality of the hospitalized elderly. Although these patients did not undergo surgery, they improved their sleep quality by performing deep breathing exercises, and in fact, the alignment of the results with the findings of the present study may be a basis for further research in determining the effectiveness of deep breathing on increasing relaxation and better sleep quality of patients (24). One of the possible reasons for the effects of deep breathing on improving sleep quality is related to focusing on how to breathe, moving away from other mental issues, as well as improving circulation and oxygenation in the organs and brain, reducing pain, and creating relaxation. In order to confirm this possible theory, other studies showed that performing deep breathing relaxes the person and reduces pain (10, 25).

In their study, Bloomer et al. investigated the effect of the combination of rosemary and Hemerocallis fulva on 32 people who had sleep disorders. They reported that the combination of rosemary essential oil and Hemerocallis fulva had no significant effect on the quality of sleep in people (26), and these findings are not consistent with the results of the present research. The difference in the results of two studies is probably related to the quality of Hemerocallis fulva temperament. In Iranian traditional medicine, the most important cause of sleep is the presence of wetness and coldness in the brain, and the more the brain becomes dry and warm, the sleep state will decrease and maybe the quality of sleep will change. Adding Hemerocallis fulva due to relatively hot and dry temperament has affected the mood quality of the brain, causing dryness and warmth to the brain and the expected effects to improve sleep of the participants did not happen. Furthermore, the difference in the sleep quality measurement tool in the two studies may be another reason for this difference.

The study by Tubbs et al. shows that rosemary essential oil improves sleep and daily activities in people with sleep disorders. In this study, it was reported that the compounds of rosemary improved the quality of daily sleep and reduced the intensity of insomnia (27). Kwon et al. investigated the sleep disorders caused by pentobarbital injection in mice; the results showed that rosmarinic acid improved the sleep disorders of mice and increased the total sleep time by 22.4%, and it was suggested to use rosmarinic acid to treat insomnia (28). The findings of various aligned studies in patients or participants in various studies who had sleep disorders indicate that the rosemary product, having effective and efficient compounds, is absorbed

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systemically through inhalation, digestion, and other methods. In addition to relaxing and improving the quality of sleep, it affects the central nervous system and may have other physiological properties, including the control of pain and anxiety in patients. Conducting more studies on other and unknown useful properties of rosemary product may provide novel strategies to reduce the problems of various patients who are candidates for surgery.

Deep breathing with rosemary improves the sleep quality of patients undergoing upper limb orthopedic surgery more than deep breathing without rosemary. Therefore, due to being native and availability of this natural product and the absence of any special complications in its use, as well as the convenience of its use, rosemary essential oil is recommended as a method to improve the sleep quality of patients by providing the necessary training to operating room staff, nurses and patients in this area. The present study was conducted only on patients undergoing upper limb orthopedic surgery, so the generalization of the results for other surgeries requires more studies.

One of the limitations of this study is the aromatic nature of rosemary essential oil, which made it difficult for the researcher to perform blinding, but efforts were made to keep the rooms of the patients of the groups separate as much as possible until the time of admission. According to the results of the study, sleep may be affected by some other factors, but by performing random block allocation and establishing uniform behaviors and similar conditions with patients of different groups, we can reduce the role of possible confounders.

**Conflict of interest:** The authors declare that there is no conflict of interest regarding the present study.

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