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The effect of postoperative back massage on pain, sleep outcomes and serum cortisol after open-heart surgery: A randomized controlled trial

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ABSTRACT

Background: Massage is widely recognized as an effective non-pharmacological intervention for reducing pain and anxiety after cardiac surgery. However, its effects on **sleep outcomes** and **biological stress markers** remain underexplored.
Aim: To evaluate the impact of back massage on postoperative pain, subjective and objective sleep outcomes, and serum cortisol levels in patients undergoing open-heart surgery.
Methods: A prospective randomized controlled trial was conducted with 72 patients scheduled for elective open-heart surgery. Participants were randomized (1:1) to an intervention group (back massage) or a control group (routine care with light touch). The intervention consisted of three standardized sessions (15–20 min each) on the first postoperative day. Outcomes included pain (Numeric Rating Scale-Pain), subjective sleep quality (Richard–Campbell Sleep Scale), objective sleep duration (smartwatch measurement), and serum cortisol levels. Data were analyzed using repeated-measures analysis of variance and Brunner–Langer tests in a per-protocol population ($n = 64$).
Results: Back massage was associated with significantly longer total sleep duration ($p = 0.037$) and greater reduction in pain scores, with significant group, time, and group × time effects ($p = 0.002$, $p < 0.001$, $p = 0.048$). Cortisol levels decreased over time in both groups ($p < 0.001$), but without significant between-group differences. Subjective sleep quality improved in both groups, and analgesic use declined, with no significant variation between groups. No adverse events were observed.
Conclusion: This randomized controlled trial demonstrates that back massage is a safe and feasible intervention after open-heart surgery, improving objectively measured sleep duration and reducing pain. By incorporating objective sleep measures and a biological stress marker (serum cortisol), this study provides novel insights that extend beyond the traditionally reported outcomes of pain and anxiety, supporting massage as a complementary strategy within multimodal nursing care.

What is already known

- Pain, sleep disturbances, and elevated stress responses are common complications after open-heart surgery.
- Massage therapy is known to reduce postoperative pain and anxiety, but its effects on sleep quality and physiological stress markers remain uncertain.

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- Few randomized trials have simultaneously examined pain, sleep outcomes, and cortisol levels in cardiac surgery patients.

What this paper adds

- Back massage improves postoperative pain and objectively measured sleep duration following open-heart surgery.
- The intervention is safe, feasible, and easily incorporated into early postoperative nursing care.
- No significant effects were found on subjective sleep quality or serum cortisol levels, identifying areas for future research.

1. Introduction

Sleep disturbance and postoperative pain are two major and closely interconnected clinical problems among patients undergoing cardiac surgery. Pain after sternotomy, chest tubes, restricted positioning, and surgical dressings is typically severe and affects nearly all patients in the early postoperative period, contributing substantially to autonomic activation, heightened stress, and impaired recovery (Liao et al., 2011; Bakry et al., 2022). At the same time, sleep—an essential determinant of physical and psychological well-being—is significantly disrupted in 48–90% of cardiac surgery patients and may remain poor for several postoperative days (Casida et al., 2018; Hweidi et al., 2024). Pain is one of the strongest predictors of postoperative sleep disruption, and disturbed sleep further exacerbates pain perception, amplifies inflammatory responses, and reduces melatonin secretion, creating a self-perpetuating "vicious cycle" that complicates recovery (O'Byrne et al., 2021). Addressing both pain and sleep together is therefore a nursing priority, as they represent fundamental and interdependent patient needs (Dağcan Şahin et al., 2024).

Pharmacological strategies to manage postoperative pain and sleep problems are widely used but have limitations, including diminished long-term effectiveness, risks of dependence, and potential for delirium (Soh et al., 2024; Liu et al., 2022). Non-pharmacological nursing interventions offer safer, evidence-supported alternatives that reduce adverse effects and complement routine perioperative care (Özkan and Bayrak, 2025). Approaches such as acupressure, eye masks, earplugs, music therapy, breathing exercises, and aromatherapy have been shown to alleviate both pain and sleep disturbance (Hweidi et al., 2024; Dağcan Şahin et al., 2024; Soh et al., 2024; Grafton-Clarke et al., 2019).

Massage is among the most widely practiced non-pharmacological nursing interventions and improves circulation, reduces muscle tension, and promotes relaxation (Liu et al., 2022; Özkan and Bayrak, 2025; Ozudi et al., 2023). Multiple trials and meta-analyses demonstrate its effectiveness in reducing postoperative pain and anxiety, including among cardiac surgery patients (Soh et al., 2024; Liu et al., 2022; Fazlollah et al., 2021). However, despite its established analgesic and anxiolytic effects, its impact on postoperative sleep—particularly when measured both subjectively and objectively—is less clearly understood.

Open-heart surgery also induces a pronounced neuroendocrine stress response, with serum cortisol levels remaining elevated for several days (Khoo et al., 2017). Evidence from oncology and cardiology populations suggests that massage may modulate cortisol responses (O'Byrne et al., 2021; Baek et al., 2022), but there is limited research exploring this effect in cardiac surgery patients.

Accordingly, the primary aim of this study was to evaluate the effect of back massage after open-heart surgery on postoperative pain and sleep outcomes, including both subjective and objective sleep measures. The secondary aim was to assess its effect on serum cortisol levels. By integrating patient-reported, objective, and biological outcomes, this study seeks to expand current understanding of massage beyond its known effects on pain and anxiety.

2. Objectives

The study aimed to evaluate the effectiveness of back massage on reducing postoperative pain measured by the Numeric Rating Scale, improving subjective sleep quality assessed by the Richard–Campbell Sleep Scale, increasing objective sleep duration measured by smartwatch, and influencing serum cortisol levels, compared with routine nursing care with light touch among patients undergoing elective open-heart surgery.

3. Methods

3.1. Study design

This study was assessor-blinded and a two-arm, parallel, randomized controlled trial with balanced randomization (1:1) conducted among patients undergoing elective open-heart surgery. The trial was prospectively registered at ClinicalTrials.gov (identifier: NCT06529471) prior to patient enrolment.

The hypotheses of the planned research were:

H1: Back massage reduces patients' postoperative pain level;
H2: Back massage improves patients' postoperative sleep score;
H3: Back massage reduces patients' postoperative serum cortisol levels.

3.2. Study setting, participants and randomization

Patients scheduled for elective open-heart surgery at the Cardiovascular Surgery Department of Kocaeli University Research and Practice Hospital were screened for eligibility between [September 2023 and July 2024].

Inclusion criteria were patients: (1) undergoing elective open cardiac surgery; (2) hospitalized in the cardiovascular surgery-intensive care unit ward for at least two nights postoperatively; (3) fully conscious; (4) willing to participate in the study. Exclusion criteria were patients: (1) taken to surgery in the middle of the day or in the afternoon; (2) undergoing minimally invasive cardiac surgery; (3) undergoing cardiac surgery without cardiopulmonary bypass; (4) presence of infection or physical disabilities such as scoliosis; (5) simultaneously undergoing another surgical intervention in the back region; (6) loss of any limb; (7) patients with neuromuscular dysfunction (paresthesia, plegia, Parkinson's disease). These exclusion criteria were selected because pain and relaxation levels may have affected sleep duration.

Although the protocol initially planned for 96 participants, recruitment concluded at 72 due to slower-than-expected postoperative admissions, strict exclusion criteria, and budget constraints. The Kocaeli University Scientific Research Project Unit funded the serum cortisol analyses, and the allocated budget limited the number of samples that could be processed, making further enrollment unfeasible.

A total of 78 patients were assessed; six were excluded (four did not meet the inclusion criteria and two declined to participate). The remaining 72 patients were enrolled and randomized. Eligible patients who expressed interest in the study met with a researcher to confirm eligibility, receive detailed information about the study procedures, and provide written informed consent. Sociodemographic and baseline clinical data were collected prior to randomization.

Randomization was performed by an independent statistician using a computer-generated allocation sequence with a 1:1 allocation ratio. Block randomization with a fixed block size of four was applied without stratification. Group assignments were concealed in sequentially numbered, opaque, sealed envelopes prepared by the statistician. Following confirmation of eligibility and baseline data collection, each participant was assigned the next envelope in sequence, which was opened to determine group allocation. Due to the behavioral nature of the intervention, blinding of participants and practitioners was not

feasible. However, allocation concealment was maintained throughout the enrollment process, and outcome assessment was partially blinded: biochemical analyses of serum cortisol were performed by a laboratory investigator (BYŞ) who remained blinded of group allocation. In addition, intervention fidelity was ensured using a standardized checklist, and random sessions were observed by an independent nurse educator (YÖ) to minimize performance bias. During follow-up, two patients were excluded due to inaccurate cortisol data, two patients withdrew from the final massage session, and four patients were excluded because of smartwatch malfunction. Ultimately, 64 patients (32 per group) completed the study and were included in the per-protocol approach (Fig. 1). Randomization was performed by an independent statistician who was not involved in the conduct of the trial, patient recruitment, or data collection. This statistician generated the allocation sequence and prepared the sequentially numbered, opaque, sealed envelopes. The statistician was not included in the authorship of this manuscript.

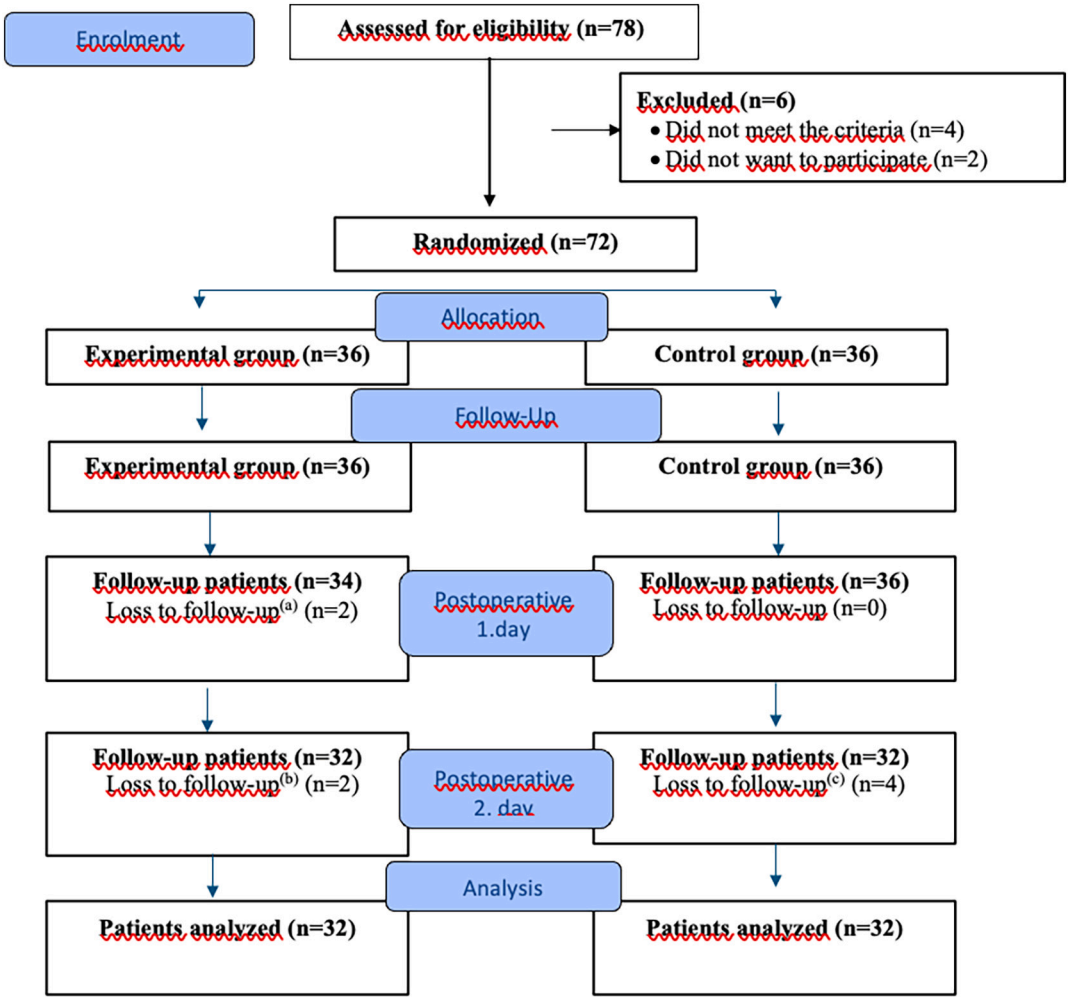
3.3. Study groups

3.3.1. Intervention group

All massage sessions were delivered in the cardiovascular surgery intensive care unit where privacy was ensured using bedside curtains and portable screens to create a visually and acoustically minimized treatment space. These semi-private areas provided controlled lighting, stable room temperature, and sufficient physical space for safe patient positioning and practitioner movement. No specialized equipment was required beyond standard intensive care unit infrastructure and odorless massage oil.

The massage protocol was developed based on the literature (Enriquez and Huang, 2022) and reviewed by two specialist nurses (SU, MK) and one physician (OO) to ensure clinical relevance. All massage sessions were delivered in the cardiovascular surgery intensive care unit, where patient privacy was maintained by using bedside curtains to create a visually isolated space. No modifications to the protocol occurred during the study.

The intervention was administered by two registered nurses (SU, MK) with prior training in Swedish massage techniques, which form part of the undergraduate nursing curriculum in Türkiye; therefore, no additional external certification was required. One practitioner was simultaneously enrolled in a graduate program in complementary therapies, and the other served as an in-service trainer within the hospital intensive care unit, ensuring familiarity with the clinical importance of massage-based interventions. This background minimized practitioner dependence and ensured consistent delivery of the



Loss to follow-up(a): Two patients were excluded from the study due to inaccurate cortisol results.
Loss to follow-up(b): Patient refused the last session of massage patient was excluded from the study.
Loss to follow-up(c): The smartwatch fitted to the patients did not measure sleep duration due to a technical glitch and the patients were excluded from the study.

Fig. 1. 2025 flow diagram.
*Smartwatch sleep time was measured between 00:00–08:00.

technique.

Before each session, practitioners assessed the patient's general condition and vital signs. Patients were positioned comfortably in an orthopneic posture with appropriate support, and only the back, shoulders, and neck were exposed to maintain privacy. Odorless oil was applied, and practitioners warmed their hands prior to starting. The standardized 15–20-minute protocol included the sequential use of Swedish massage maneuvers—effleurage, petrissage, friction, vibration, tapotement, and localized pressure—applied to the area between the cervical-3 and thoracic-12 vertebrae. Pressure level was maintained at a moderate intensity and could be slightly adjusted based on patient feedback, without altering the planned sequence or core components of the protocol.

If a patient requested to stop the procedure or if any clinical deterioration occurred, the session was immediately discontinued. To ensure intervention fidelity, practitioners followed a structured checklist, and random sessions were observed by an independent nurse educator (YÖ), who verified adherence to the established protocol.

No modifications were made to the massage protocol during the course of the study; the intervention was delivered exactly as originally planned in the trial protocol, with no changes to techniques, duration, or timing.

3.3.2. Control group

Participants in the control group received routine postoperative nursing care in accordance with institutional protocols. In addition, to simulate the interpersonal interaction and environmental conditions provided in the intervention arm, a standardized light touch was applied to the patient's back for 1–2 min. This procedure did not include any therapeutic massage techniques and was designed solely to control for the effects of attention and physical contact.

3.4. Data collection

Data were collected at three main time points during the early postoperative period. Baseline data were obtained after randomization and before the intervention (Postoperative 0:P0). These included sociodemographic information and baseline clinical variables, as well as initial assessments of sleep quality (Richard–Campbell Sleep Scale) and serum cortisol levels. On the postoperative-1's (P1) morning (08:00), participants underwent reassessment of sleep quality using the Richard–Campbell Sleep Scale and smartwatch-based sleep measurement. Baseline cortisol levels were collected at the same time point. In the intervention group, three standardized massage sessions were delivered at 08:00, 16:00, and 00:00. Serum cortisol was additionally measured at 08:30, immediately following the first massage session. Pain scores (Numeric Rating Scale-Pain) were recorded before and 10 min after each massage. On the postoperative-2's (P2) morning (08:00), data collection was repeated in both groups. This included reassessment of sleep outcomes (Richard–Campbell Sleep Scale and smartwatch data) and repeated measurement of serum cortisol at 08:00 and 08:30. The same measurement schedule was applied to the control group, who received routine care with standardized light touch instead of massage. Data collection was conducted by trained research staff (SU, MK, and OO) to ensure consistency across all measurement points (Fig. 2).

3.5. Outcomes

The Patient Information Form, developed by the research team based on a review of the relevant literatüre (Casida et al., 2018; Hweidi et al., 2024; Liao et al., 2011; Bakry et al., 2022), was used to collect baseline demographic and clinical data. This 10-item form included variables such as age, gender, presence of chronic disease, medical diagnosis, sleep frequency, and sleep interruptions.

The primary outcomes were postoperative pain and sleep quality. Pain intensity was assessed using the Numeric Rating Scale–Pain, which evaluates pain on a 0–10 scale, where higher scores indicate greater severity. The Turkish validation of the Numeric Rating Scale–Pain has demonstrated high reliability in surgical populations (Cronbach's $\alpha > 0.80$). Sleep quality was measured using the Richard Campbell Sleep Scale, a six-item instrument originally developed by Richards in 1987. The Turkish adaptation and validity were established by Karaman Özlü and Özer (2015). Each item is scored on a visual analogue format ranging from 0 to 20, yielding a total score of 0–100, with higher scores reflecting better sleep quality.

The secondary outcomes included objective sleep duration and serum cortisol levels. Objective sleep duration was monitored using a wrist-worn smartwatch, which provided continuous recording of sleep and wake patterns. Serum cortisol concentrations were measured via venous blood samples obtained in the early morning hours and analyzed

Time	Postoperative-0 day (P0)	Postoperative-1 day (P1)				Postoperative-2 day (P2)			
		Richards Cambell pre-test	Smartwatch sleep pre-test	Serum Cortisol	Pain	Richards Cambell last test	Smartwatch sleep post test	Serum Cortisol	Pain
08.00	Intraoperative time	✓	✓	✓	✓	✓	✓	✓	✓
08.10					✓				✓
08.30				✓	✓			✓	✓
16.00	The patient is under anesthesia.				✓				✓
16.10					✓				✓
00.00	Smartwatch applied to patient* Sociodemographic information and baseline clinical variables				✓				✓
00.10					✓				✓

Fig. 2. Data collection procedure.

in the hospital biochemistry laboratory according to standardized procedures. Levels were evaluated as continuous variables, and no cut-off value was applied. For contextual interpretation, typical reference morning cortisol level (5–25 mcg/dL) was considered.

3.6. Statistical analysis and sample size calculation

Sample size calculation was performed using G*Power version 3.1.9.7 (Kiel University, Kiel, Germany) (Faul et al., 2007). Power analysis was performed using the mean pain levels (Day 3) of the patients in the experimental and control groups in a similar study. (Dreyer et al., 2015). The sample size was calculated on the basis of 95% confidence interval, 90% power level, 0.05 error level, and 0.78 effect level. As a result of the power analysis, 36 patients were assigned to each group.

The study data were analyzed using IBM® SPSS® Statistics version 30 and R software. Continuous variables were summarized using mean ($\bar{x}$), standard deviation (SD), median (M), and interquartile range (IQR). Categorical variables were presented as frequencies (n) and percentages (%).

The assumption of normality for continuous dependent variables was evaluated using the Kolmogorov–Smirnov test (non-significant result indicating normality; $p > 0.05$), skewness and kurtosis values (expected to be close to 0 and within ±1.5), visual inspection of histogram plots for approximate bell-shaped distribution, and examination of Normal Q–Q plots for alignment of points along the 45-degree reference line (George and Mallery, 2010; Pallant, 2020; Tabachnick and Fidell, 2013). Since most continuous variables did not satisfy these criteria, non-parametric statistical tests were applied.

For comparisons of categorical variables between groups, the Chi-square test or Fisher's exact test was used as appropriate. For independent two-group comparisons of continuous variables, independent samples t-tests were used for parametric data, and the Mann–Whitney *U* test was applied for non-parametric data. For within-group comparisons of three or more repeated measures, the Friedman test was used. Additionally, non-parametric repeated-measures analyses were conducted using the Brunner–Langer method, which allowed testing of group effects (between-subjects), time effects (within-subjects), and group × time interactions.

These analyses were performed in R (RStudio environment) using the nparLD package, and the results were reported as ANOVA-Type Statistics (ATS) along with corresponding degrees of freedom (df) and p-values.

3.7. Ethical aspects

This study was conducted according to the Declaration of Helsinki. Approval was obtained from the Kocaeli University Interventional Research Ethics Committee (Project No: 2023/194, Decision No: KU-2023/11.26, Date: 15.06.2023). Written informed consent was obtained from all participants. Patients were informed they could withdraw at any time, and results would be published anonymously.

4. Results

4.1. Socio-demographic characteristics

The descriptive characteristics of the participants are presented in Table 1. No statistically significant differences were observed between the intervention and control groups with respect to age, body mass index, caffeine consumption prior to hospitalization, gender, marital status, educational level, smoking and alcohol use, presence of chronic disease, hospitalization history, daytime sleeping habits, pre-hospital sleep difficulties, and number of chest tubes (all $p > 0.05$).

Table 1
Descriptive characteristics of patients.

Descriptive	Experimental group	Control group		
	n = 32	n = 32		
	$\bar{X}$±SD	$\bar{X}$±SD	t; Z	p
Age	61.47 ± 13.53	63.50 ± 9.13	Z = -0.208	0.835
BMI	27.97 ± 4.8	28.24 ± 3.68	t = −0.267	0.790
Caffeine consumption prehospital* (n = 44)	5.32 ± 5.43	7.95 ± 7.26	Z = -1.207	0.228
	n (%)	n (%)	χ^2	p
Gender			χ^2 = 0.665	0.418[2]
Woman	12 (37.5)	8 (25.0)		
Male	20 (62.5)	24 (75.0)		
Marital status			–	0.672[3]
Married	28 (87.5)	30 (93.8)		
Single	4 (12.5)	2 (6.3)		
Education			χ^2 = 1.553	0.907[1]
Illiterate/reader author	3 (6.3)	2 (6.3)		
Primary education	15 (46.9)	13 (40.6)		
Middle school	3 (9.4)	3 (9.4)		
High school	6 (18.8)	7 (21.9)		
University	5 (15.6)	7 (21.9)		
Smoking use			χ^2 = 0.565	0.452[2]
Yes	13 (40.6)	17 (53.1)		
No	19 (59.4)	15 (46.9)		
Alcohol use				1.000[3]
Yes	3 (9.4)	2 (6.3)		
No	29 (90.6)	30 (93.8)		
Chronic disease			χ^2 = 0.696	0.404[2]
Yes	25 (78.1)	21 (65.6)		
No	7 (21.9)	11 (34.4)		
Hospitalization history				0.188[3]
Yes	31 (96.9)	24 (75.0)		
No	1 (3.1)	8 (25.0)		
Daytime sleeping habits			χ^2 = 1.001	0.317[2]
Yes	19 (59.4)	14 (43.8)		
No	13 (40.6)	18 (56.3)		
Prehospital sleep difficulties			χ^2 = 0.583	0.445[2]
Yes	15 (46.9)	11 (34.4)		
No	17 (53.1)	21 (65.6)		
Number of chest tubes			χ^2 = 0.000	1.000[1]
1	3 (9.4)	3 (9.4)		
2	25 (78.1)	25 (78.1)		
3	4 (12.5)	4 (12.5)		

[a]: Exact test değeri, $\bar{x}$: mean, SD: standard deviation, χ^2: Ki-kare test.
[*] Caffeine consumption data available for n = 44.
[1] Pearson ki-square test.
[2] Continuity correction test.
[3] Fisher's exact test. Z: Mann Whitney *U* test standardized Z-table value. t: Independent samples t test value.

4.2. Sleep duration and cortisol levels

Group comparisons for sleep-related outcomes are summarized in Table 2. Post-test total sleep duration, as measured by smartwatch, was significantly longer in the intervention group compared with the control group ($t = 2.306$, $p = 0.037$, one-tailed).

Regarding Richard–Campbell Sleep Scale scores, both groups demonstrated modest within-group improvements (intervention group $p = 0.045$; control group $p = 0.019$, one-tailed). However, between-group differences were not statistically significant at either pre-test ($p = 0.250$) or post-test ($p = 0.203$). These findings suggest that although both groups experienced improved subjective sleep quality, massage

Table 2
Comparison of sleep measurements and serum cortisol of patients.

	Measures	Experimental group (n = 32)	Control group (n = 32)	t; Z	p
		$\bar{x}$±SD	$\bar{x}$±SD		
Number of wake-up	Pre-test	5.69 ± 4.32	4.53 ± 5.07	Z = -1.670	0.095
	Post-test	4.59 ± 4.21	4.00 ± 1.93	Z = -0.750	0.453
Smartwatch total sleep time (min)	Pre-test	542.19 ± 198.31	457.53 ± 172.97	t = 1.820	0.074
	Post-test	508.56 ± 207.99	417.00 ± 122.96	t = 2.306	0.037
Total Richard–Campbell Sleep Scale	Pre-test	44.84 ± 24.69	40.47 ± 26.89	t = 0.678	0.250
	Post-test	52.76 ± 25.16	47.75 ± 22.78	t = 0.835	0.203

Cortisol (ng/mL)	Measures	$\bar{x}$±SD	$\bar{x}$±SD	Z	p
P1	Pre-test	23.33 ± 13.24	25.50 ± 18.37	Z = -0.087	0.465
	Post-test	20.26 ± 10.64	23.07 ± 16.06	Z = -0.134	0.447
P2	Pre-test	17.34 ± 6.99	17.27 ± 7.73	Z = -0.410	0.341
	Post-test	21.62 ± 33.31	13.91 ± 6.02	Z = -1.021	0.154
Cortisol (ng/mL)	Group: χ^2 (1) = 0.069, p = 0.366 Time: χ^2 (1.525) = 12.525, p < 0.001 Group × Time: χ^2 (1.525) = 0.288, p = 0.345				

All p values in the table are reported as one-tailed (p: one-tailed) in line with the hypotheses.
$\bar{x}$: Mean, SD: Standard deviation, min: minute, t: Independent samples t test, Z: Mann Whitney *U* test standardized Z-table value, P1: postoperative 1. day, P2: postoperative 2. day.
Note: For cortisol, nonparametric repeated measures analysis was performed using the Brunner-Langer method (nparLD package, R software). Results are reported with ANOVA-Type Statistic (ATS) values and corresponding degrees of freedom (df) and p-values.

therapy did not produce a superior effect relative to control.

As presented in Table 2, there was a significant main effect of time on serum cortisol levels (WTS = 12.525, p < 0.001), reflecting post-operative decline across both groups. Neither the group effect (p = 0.366) nor the group × time interaction (p = 0.345) reached statistical significance, indicating that massage did not differentially influence serum cortisol.

4.3. Pain level and analgesic use

Pain scores are reported in Table 3 and illustrated in Fig. 3. Brunner-Langer nonparametric repeated-measures analysis revealed significant main effects of group (p = 0.002) and time (p < 0.001), as well as a group × time interaction (p = 0.048). Although baseline pain scores were higher in the intervention group, a greater reduction in pain intensity was observed over time relative to the control group, supporting the analgesic effect of massage.

Analgesic usage is summarized in Table 4. Paracetamol and tramadol consumption decreased significantly over time in both groups (time effect p < 0.001), yet between-group comparisons at each postoperative day were not statistically significant (all p > 0.05). For dexketoprofen trometamol, a significant time effect was observed only in the control group (p = 0.040). Between-group comparisons were non-significant at both postoperative assessments (p > 0.05). Fentanyl use was minimal in both groups, with no significant within-group or between-group differences (all p > 0.05). These results indicate that massage contributed to subjective pain relief without substantially altering pharmacologic analgesic requirements.

4.4. Adverse events

No adverse events related to the massage intervention (e.g., skin irritation, hemodynamic instability) were observed. All sessions were terminated immediately if patients requested or if any clinical concerns arose.

5. Discussion

The quality and duration of postoperative sleep may be influenced by multiple factors including acute pain, treatment and care interventions,

Table 3
Comparison of pain means of patients in the experimental and control groups.

Day	Time	Measures	Pain		Z	p
			Experimental group (n = 32)	Control group (n = 32)		
			$\bar{x}$±SD	$\bar{x}$±SD		
P1	8.00	Pre-test	4.75 ± 2.98	3.13 ± 2.76	−2.215	0.014
		Post-test	3.03 ± 2.63	1.81 ± 2.39	−1.769	0.039
	16.00	Pre-test	4.00 ± 2.71	2.03 ± 2.38	−3.062	0.001
		Post-test	1.78 ± 2.07	1.25 ± 2.20	−1.362	0.087
	24.00	Pre-test	3.78 ± 2.76	2.03 ± 2.65	−2.764	0.003
		Post-test	1.91 ± 1.97	1.44 ± 2.50	−1.944	0.026
P2	8.00	Pre-test	3.19 ± 2.40	1.94 ± 2.82	−2.580	0.005
		Post-test	1.38 ± 1.68	1.34 ± 2.40	−1.083	0.140
	16.00	Pre-test	2.75 ± 2.40	1.03 ± 1.62	−3.077	0.001
		Post-test	1.09 ± 1.55	0.63 ± 1.31	−1.565	0.059
	24.00	Pre-test	3.00 ± 2.92	1.16 ± 2.05	−3.130	0.001
		Post-test	1.19 ± 1.82	0.66 ± 1.45	−1.691	p = 0.046
			Group: χ^2 (1) = 9.055, p = 0.002 Time: χ^2 (5.207) = 20.121, p < 0.001 Group × Time: χ^2 (5.207) = 1.858, p = 0.048			

All p values in the table are reported as one-tailed (p: one-tailed) in line with the hypotheses. $\bar{x}$: mean, SD: standard deviation, Z: Mann Whitney *U* test standardized Z-table value. P1: postoperative 1. day, P2: postoperative 2. day.
Note: Nonparametric repeated measures analysis was performed using the Brunner-Langer method (nparLD package, R software). Results are reported with ANOVA-Type Statistic (ATS) values and corresponding degrees of freedom (df) and p-values.

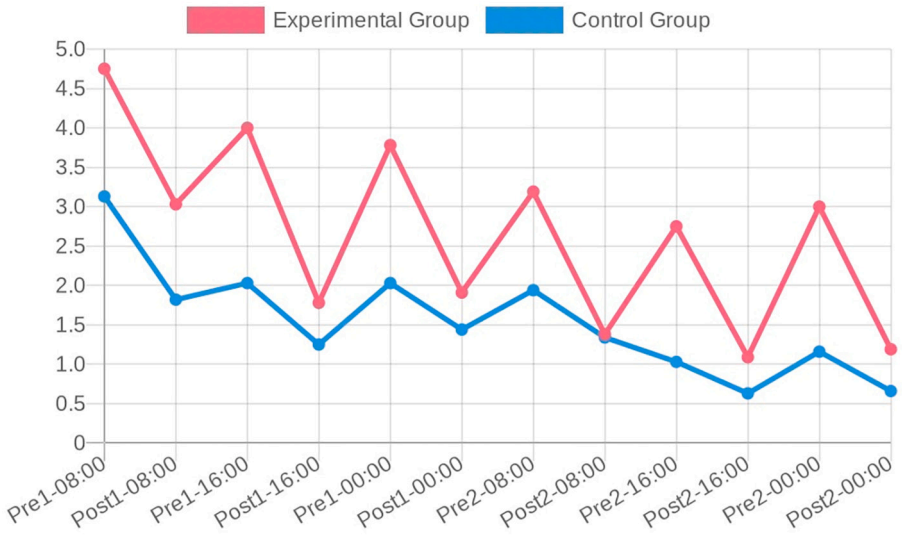


Fig. 3. Mean pain scores over time by group.

Table 4
Comparison of postoperative analgesic use of patients in the experimental and control groups.

Analgesic	Measures	Experimental Group (n = 32)	Control Group (n = 32)	Z^a	p
		$\bar{x}$±SD	$\bar{x}$±SD		
Paracetemol (mg)	P1	3.500.00 ± 1.191.37	3.875.00 ± 336.01	−1.106	0.135
	P2	1.718.75 ± 1.419.55	1.937.50 ± 1.625.16	−0.511	0.305
	Z^b	−4.175	−4.157		
	p	<0.001	<0.001		
Deksketoprofen trometamol (mg)	P1	8.44 ± 20.18	13.75 ± 31.39	−0.583	0.280
	P2	7.03 ± 21.28	3.13 ± 12.30	−0.850	0.198
	Z^b	−0.428	−2.049		
	p	0.669	0.040		
Tramadol (mg)	P1	179.69 ± 37.80	192.19 ± 28.71	−1.493	0.068
	P2	64.06 ± 62.52	73.44 ± 77.23	−0.244	0.404
	Z^b	−4.620	−4.325		
	p	<0.001	<0.001		
Fentanyl (mcg)	P1	0.00 ± 0.00	3.13 ± 12.30	−1.426	0.077
	P2	0.00 ± 0.00	0.00 ± 0.00	0.000	0.500
	Z^b	0.000	−1.414		
	p	1.000	0.157		

All p values in the table are reported as one-tailed (p: one-tailed) in line with the hypotheses. $\bar{x}$: mean, SD: standard deviation.
Z^a: Mann Whitney *U* test standardized Z-table value.
Z^b: Wilcoxon signed-rank test P1: postoperative 1. day, P2: postoperative 2. day.

and environmental conditions (Yang et al., 2025; Bahar et al., 2025). Massage is a basic nursing intervention for pain relief, relaxation, and sleep promotion after surgery. Evidence demonstrates that massage can improve sleep quality, reduce fatigue, and enhance sleep patterns, particularly among elderly patients (Bahar et al., 2025; Annisa and Kusuma Wati, 2024). In the present study, objective measurement with a smartwatch demonstrated significantly longer total sleep duration in the intervention group compared with controls. Richard–Campbell Sleep Scale scores improved modestly in both groups, but the between-group differences were not statistically significant. These findings suggest that massage may support relaxation and sleep, though its effect on subjective sleep quality requires further exploration. Prior studies have reported that longer massage interventions or extended follow-up may yield stronger improvements in sleep (Annisa and Kusuma Wati, 2024). In our study design, massage was administered for three sessions within one postoperative day; thus, limited exposure may explain the absence of more pronounced sleep benefits.

Thoracic surgery is one of the most painful surgical procedures. Inadequate pain management may hinder ambulation and increase the risk of complications such as prolonged intensive care unit stay, need for mechanical ventilation, pneumonia, and chronic postoperative pain (Schwarzova et al., 2024). Analgesic drugs alone are often insufficient and can be associated with side effects (Grafton-Clarke et al., 2019; Ozudi et al., 2023). Although baseline pain scores were higher in the intervention group, repeated-measures analysis showed a greater reduction in pain intensity over time compared with controls, supporting the analgesic benefit of massage. These results are consistent with literature indicating that individualized, multimodal approaches enhance postoperative pain management (Fernandes et al., 2024; Yerebakan et al., 2024; O'Neill and Lirk, 2022; Tian et al., 2020).

Contrary to the hypothesis, group differences in analgesic consumption were not statistically significant. Both groups exhibited significant reductions in paracetamol and tramadol use over time, whereas a significant difference in dexketoprofen trometamol consumption was seen only in the control group. This suggests that while massage may subjectively reduce pain, its impact on reducing pharmacologic analgesic requirements remains inconclusive.

Massage has been reported to modulate the postoperative stress response, including reductions in cortisol levels (Seo et al., 2020; Lee and Hur, 2022; Werthmann et al., 2025). In this study, cortisol levels

declined significantly over time in both groups, reflecting the expected postoperative trajectory, but no additional effect of massage was observed. These results align with prior studies indicating variability in cortisol outcomes and underscore the need for further trials with longer follow-up and standardized massage protocols.

6. Strengths and limitations

The findings of this study should be interpreted within the context of its design. The intervention was applied on the first postoperative day with three standardized massage sessions, and outcomes were assessed over a short follow-up period. This reflects the realities of the intensive care setting and provides important insights into the early postoperative phase; however, longer interventions and extended follow-up may yield further information about sustained effects. Blinding of participants and practitioners was not feasible due to the nature of the intervention, although serum cortisol analyses were conducted under blinded laboratory conditions to ensure objective evaluation. The sample size was calculated based on pain outcomes, which were the primary endpoint, while sleep and cortisol were evaluated as secondary outcomes. A limitation of this study is the use of a Per-Protocol analysis instead of a standard Intention-to-Treat approach. While PP analysis allowed us to evaluate the intervention's efficacy under optimal conditions and ensured the integrity of physiological data (cortisol and wearable sensor metrics), it may lead to an overestimation of the treatment effect and reduce the generalizability of the results to real-world settings where treatment adherence may vary. Finally, as a single-center study, the results are specific to the studied population and clinical context, yet they contribute meaningful evidence for integrating non-pharmacological interventions into postoperative care.

7. Conclusion

In conclusion, this randomized controlled trial demonstrated that back massage was associated with greater reductions in pain and longer objectively measured sleep duration, but did not significantly improve subjective sleep quality or cortisol levels. Analgesic consumption decreased over time in both groups without significant between-group differences. Future studies should examine longer intervention periods, alternative massage techniques, and larger multicenter samples. Incorporating massage into multimodal nursing care protocols may enhance patient comfort, facilitate recovery, and synergize with pharmacologic strategies for managing postoperative pain, sleep disturbance, and stress.

CRediT authorship contribution statement

Yasemin Özhanlı: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Ayşegül Güneş:** Writing – review & editing, Validation, Methodology, Conceptualization. **Nuray Akyüz:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Suna Uzun:** Investigation, Data curation. **Müşerref Kurt:** Investigation, Data curation. **Oğuz Omay:** Supervision, Resources, Data curation. **Berna Yıldırım Şık:** Investigation, Formal analysis, Data curation. **Şükriye Şahin:** Writing – review & editing, Writing – original draft, Formal analysis.

Informed consent

All patients provided written informed consent.

Ethical aspect of the study

Ethics committee permission (Project No: 2023/194 Decision No: KÜ GÖKAEK-2024/11.26 Date: 15.06.2023) was obtained from Kocaeli University Interventional Research Ethics Committee for the conduct of the study. Verbal and written informed consent was obtained from the patients, who were informed about the study in detail.

Trial registration

The trial was prospectively registered at ClinicalTrials.gov (identifier: NCT06529471) prior to patient enrolment.

Reporting statement

The study was reported in accordance with the CONSORT 2010 guidelines, and the intervention was described following the TIDieR checklist.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Note: This study has neither been published nor presented at any scientific meeting or conference.

Data availability

The data that support the findings of this study are available by email yasemin.ozhanli@kocaeli.edu.tr/yaseminozhanli@gmail.com upon reasonable request.

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