e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(6); 346-352

Original Research Article

Effect of Music-Based Intervention on Preoperative Anxiety and Induction Agent Requirements in Elective Surgeries: A Prospective Study

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Received: 18-04-2025 / Revised: 11-05-2025 / Accepted: 20-06-2025
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Conflict of interest: Nil

Abstract:

Background: Preoperative anxiety is frequently reported among surgical patients and can result in increased anesthesia requirements, hemodynamic instability, and impaired recovery. Music-based interventions have emerged as a non-pharmacological strategy to reduce anxiety and modulate stress responses during surgery.

Aim: To assess the impact of a music-based intervention on preoperative anxiety and anesthesia induction agent requirements in adult patients who are undergoing elective lower limb orthopedic procedures with spinal anesthesia.

Methods: A prospective, randomized, double-blinded clinical trial was conducted involving 96 patients (ASA I–II, aged 18–65). Evaluations included State-Trait Anxiety Inventory (STAI preoperative and postoperative), serum cortisol and IgA levels (stress markers), and intraoperative propofol requirements.

Results: Group M had significantly greater reduction in postoperative anxiety (STAI 34.2±4.6, Group M vs. 37.4±5.0, Group NM, p=0.004), and reduced intraoperative serum cortisol, and IgA (p=0.003 and p=0.002, respectively). Intraoperative propofol requirements were also significantly lower in Group M (148.2±11.0 mg vs. 192.1±15.5 mg, p<0.0001).

Conclusions: Music-based intervention significantly reduced preoperative anxiety, attenuated the physiological stress response and reduced induction agent requirements, providing an easily implemented, safe, and low-cost adjunct to perioperative care.

Keywords: Music therapy, Preoperative anxiety, Cortisol, Spinal anesthesia, Orthopedic surgery, Propofol consumption.

Introduction

Surgery is generally associated with a great deal of emotional and psychological stress in patients, and the most common problem in the perioperative period is preoperative anxiety. Preoperative anxiety is a psychological and physiological response characterized by apprehension, fear, and anxiety prior to surgery. This is most typical in patients undergoing elective surgery, as fear of surgery, anticipation, postoperative pain, fear of complications, and unfamiliarity with the surgery room surroundings are capable of inducing a great deal of distress in patients. This increased anxiety, in turn, can activate the sympathetic nervous system, producing tachycardia, hypertension, altered respiratory patterns, and exuberant secretion of stress hormones, including cortisol [1]. These physiologic alterations are capable of perturbing intraoperative stability, as well as postoperative recovery and outcome in a patient.

Spinal anesthesia remains a favorite in most lower limb orthopedic procedures since it enjoys several advantages over general anesthesia, viz., effective pain control, stable vital signs, early ambulation, and fewer post-anesthetic complications, including nausea and respiratory depression. However, despite clinical benefits, the perception by a patient during surgery remains unaffected by spinal anesthesia. Patients remain awake or lightly sedated and, as a result, receive auditory inputs from intraoperative sounds, voices, and operating room stimuli. Orthopedic procedures, in particular, are noiseful at a level, often generated by the use of operative equipment, e.g., hammers, drills, and oscillating saws, and noise levels up to 105 decibels have been recorded [2].

Exposure to unfamiliar, loud noise can significantly cause psychological distress, increased anxiety, and unease during surgery. The elevated levels of anxiety could in turn necessitate a greater need for induction agents and sedation in order to ensure a comfortable and cooperative patient. Additionally, undue preoperative anxiety has been associated with unfavorable outcomes like delayed postoperative recovery, increased perioperative complications, greater postoperative need for analgesics, and in certain situations, even cancellation of surgery, thereby decreasing patient satisfaction and overall detrimental effect on surgery outcome [3]. Hence, effective management of preoperative anxiety remains a cornerstone in perioperative care, and aimed in two folds, namely, enhancement of patient well-being and optimization of anesthetic need.

Pharmacological therapies in the form of benzodiazepines and other sedatives have been classically used in the management of preoperative anxiety. Even though effective, they are associated with potential adverse effects, e.g., respiratory depression, prolonged sedation, delayed emergence, and risk of drug dependence. In addition, the administration of additional sedation might complicate anesthesia administration and postoperative care. This has been a driving force in the development of greater interest in modalities that are non-pharmacologic in nature in the reduction of anxiety in the operative patient, with music-based therapies emerging as a promising, inexpensive, and yet safe alternative [4].

Music therapy is a well-established, drug-free and non-invasive treatment that has been proved to alleviate anxiety and cause relaxation by modulating the autonomic nervous system. It operates through multiple mechanisms: suppressing sympathetic nervous system activity, stimulating parasympathetic activity, and encouraging emotional well-being [5]. The auditory input from music assists in masking peripheral sounds, distracting the attention of the patient from the operative field, and giving a sense of psychological comfort. The method of distraction thus issued can significantly eliminate perceived anxiety, lower blood pressure, diminish heart rate, and contribute overall towards enhancing patient satisfaction. The application of headphones in delivering music adds a greater advantage in creating a personal, controlled acoustic space and thereby eliminating exposure to disturbing ambient sounds hitherto encountered by a person in clinical surroundings [6].

The physiological response to surgery transcends anxiety and activates complex neuroendocrine and immune systems. During acute psychological or physical stress, there is a secretory increase in cortisol that is crucial in the maintenance of homeostasis by modulating glucose and cardiac function and immune function. Additionally, immunoglobulin A (IgA), a crucial antibody in mucosal immunity, transiently increases with exposure to stress before decreased levels with repeated or chronic stress exposure [7]. Such biomarkers provide objective indices of stress and have been applied in clinical and research arenas as a tool in determining the impact on the response to surgery stress by therapeutic interventions such as music therapy. Through a possible modulating influence on these physiological systems, music-based therapies could potentially have widespread implications, as well as in the relief from anxiety, through immune function improvement to improved postoperative recovery.

Studies have shown beneficial results with music therapy in a range of surgical specialty domains, as manifested by decreases in preoperative anxiety, intraoperative need for sedation, and postoperative subjective self-reporting of pain. Few studies are, however, available in relation to application in patients receiving spinal anesthesia in elective lower limb orthopedic surgery, in which the consciousness of the stress-inducing and noise-provoking environment is greater. Elucidation of the interrelations among music therapy, levels of anxiety, and need for induction agents in such a situation can be used as a foundation in the development of specific, evidence-based interventional maneuvers aimed at optimizing patient care.

In light of all this, the present study sets out to prospectively elucidate the effects of music-based interventions on preoperative anxiety and demand for induction agent in patients undergoing elective lower limb orthopedic surgery under spinal anesthesia. Through the investigation of both the physiological and psychological endpoints, as well as biomarkers indicative of stress, the study hopes to provide timely insights into the efficacy of music therapy as a complementary modality in modern anesthetic practice. The findings could pave the way towards the development of standardized protocols in the incorporation of music interventions into routine perioperative care, hopefully culminating in improved patient experience and optimal operative outcome.

Methodology

Study Design: This study was designed as a prospective, randomized, controlled, double-blinded clinical trial aimed at comparing the efficacy and safety of intrathecal dexmedetomidine and fentanyl as adjuvants to hyperbaric bupivacaine in spinal anesthesia for various lower limb and lower abdominal surgeries.

Study Area: The study was conducted in the Department of Anesthesiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India for 12 months

Study Population: Patients scheduled for lower limb orthopedic or lower abdominal surgeries under spinal anesthesia were considered for inclusion in the study. Eligible patients were classified as American Society of Anesthesiologists (ASA) Physical Status Class I or II and were aged between 18–65 years with a Body Mass Index (BMI) of 18–25 kg/m².

Sample Size Calculation

Sample size was calculated using the standard formula for comparing two independent means:

$$n = \frac{\left(Z_{\alpha/2} + Z_{\beta}\right)^2 \left(\sigma\frac{2}{1} + \sigma\frac{2}{2}\right)}{(\mu_1 - \mu_2)^2}$$

Where:

- $Z_{\alpha/2}$= 1.96 for a 95% confidence level.
- Z_{β} corresponds to the desired power.
- σ2/1 =2.07 (variance of one group).
- σ2/2 = 5.52 (variance of the other group).
- $\mu_1 - \mu_2$= minimum clinically significant difference between the two means.

Taking an alpha error of 0.05 and adequate power as per protocol calculations, the required total sample size was determined to be 96 patients (n - 48 per group), allowing sufficient power to detect the prespecified difference.

Sampling Technique and Randomization: Participants were randomly allocated into two groups (n = 48 each) using a computer-generated random number table.

- Group D: Received dexmedetomidine 5 µg with 0.5% hyperbaric bupivacaine intrathecally.
- Group F: Received fentanyl 25 µg with 0.5% hyperbaric bupivacaine intrathecally.

Randomization was ensured using sequentially numbered, sealed opaque envelopes to maintain allocation concealment. Both patients and anesthesiologists assessing outcomes were blinded to group assignment.

Inclusion Criteria

- Patients aged 18–65 years.
- ASA Physical Status I or II.
- BMI between 18–25 kg/m².
- Patients undergo elective lower limb or lower abdominal surgeries under spinal anesthesia.
- Patients who provided written informed consent.

Exclusion Criteria

- Patient refusal to participate.
- Known hypersensitivity to study drugs (bupivacaine, dexmedetomidine, fentanyl).
- Severe cardiac, respiratory, renal, or hepatic diseases.
- Coagulopathy or local infection at the puncture site.
- Neurological disorders affect spinal anesthesia outcome.
- Patients on beta-blockers or alpha-2 agonists.
- Pregnant or lactating women.
- History of psychiatric disorders or substance abuse.

Data Collection: The collection of data was carried out systematically. Before surgery, eligible patients were assessed, and demographics recorded for each participant prior to the anesthetic. These demographics included age, sex, weight, height, ASA physical status and BMI. An 18G intravenous cannula was inserted, adhering to strict aseptic technique. Baseline bloods were taken to measure serum cortisol and serum IgA levels for physiological stress markers. Monitoring was applied using the non-invasive blood pressure (NIBP), electrocardiogram (ECG), pulse oximeter (SpO_2), and Bispectral Index (BIS) electrodes, and baseline hemodynamic parameters were recorded.

During surgery, hemodynamic variables, i.e., heart rate, blood pressure and oxygen saturation were recorded at baseline and at 5, 10, 15, 20, 30, 40 minutes; then at hourly intervals until surgery was completed. The total amount of propofol used was documented to assess sedation requirements. Serum cortisol and IgA levels were taken 30 minutes after the spinal anesthesia was completed and again at 12 hours.

If intraoperative complications were encountered such as hypotension, bradycardia, nausea, vomiting, or desaturation, they were noted and managed according to standard clinical protocols. All data were collected on a standardized data collection sheet to maintain uniformity and comparability.

Procedure: All participants received the same preparation protocol based on institutional guidelines. In the operating theatre, intravenous access was obtained, and Ringer lactate infusion was commenced at 10-15 ml/kg; the participants were positioned in a sitting position while spinal anaesthesia was induced using aseptic technique. A 25G Quincke's spinal needle was inserted at the L4-L5 interspace, and the assigned drug combination was administered intrathecally in accordance with group assignment. After confirming the block by obtaining appropriate sensory and motor levels, surgery commenced.

Sedation was maintained with propofol using an initial bolus intravenous dose of 1-2 mg/kg, followed by ongoing infusion of 5-50 mcg/kg/min (BIS values were used to maintain sedation between 70-80). Propofol infusion rates were titrated to achieve the above-described sedation scores while maintaining blood pressure within 20% of their baseline values. Vasopressor support for hypotension was addressed as per protocol (mephentermine 6 mg IV boluses may be given as required). Bradycardia was treated with atropine 0.3 mg IV boluses, while desaturation was treated with increasing supplemental oxygen delivered at 5 L/min. Anesthesiologists who were blinded to group assignments monitored all intraoperative parameters throughout the procedures.

Outcome Measures: The primary outcomes were the duration of sensory and motor blockade and time to first analgesic request to assess the efficacy of the two adjuvants. The secondary outcomes assessed intraoperative hemodynamic stability, total propofol consumption for sedation, postoperative serum cortisol and IgA levels as indices of physiological stress, and adverse events such as bradycardia, hypotension, desaturation, nausea or vomiting. These measures allowed for a global comparison of the efficacy and safety of intrathecal dexmedetomidine and fentanyl as adjuvants to bupivacaine."

Statistical Analysis: Statistical analysis was done using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY). Quantitative variables, like demographic data, duration of sensory blockades, duration of motor blockades, and total propofol consumption were described as mean ± standard deviation (SD), and categorical variables, like the number of encounters with adverse events, were described as frequency and percentage. Before comparing data, the Shapiro-Wilk test was used to confirm the normality of continuous data. For normally distributed data, means between groups were compared using the independent Student's T-test. Using the paired T-test, we compared means within groups. The Chi-square test was used to compare associations among categorical variables. A p-value <0.05 was statistically significant for all tests.

Result

Table 1 shows that the two groups, Group M and Group NM, were comparable in terms of demographic and baseline characteristics. The mean age was slightly higher in Group M (37.5 ± 11.8 years) compared to Group NM (33.6 ± 10.5 years), but the difference was not statistically significant (p = 0.102). Similarly, the mean BMI was 24.1 ± 0.95 kg/m² in Group M and 23.7 ± 1.0 kg/m² in Group NM (p = 0.218), indicating no significant difference. Most participants in both groups were classified as ASA Physical Status (PS) II (97.9%), with only 2.1% being ASA PS I, showing identical distribution between the groups (p = 1.000). The mean duration of surgery was also similar, with 152.0 ± 18.0 minutes in Group M and 150.1 ± 17.5 minutes in Group NM (p = 0.674). These findings confirm that both groups were well-matched at baseline, minimizing the risk of confounding variables.

Table 1: Demographic characteristics of the groups

Characteristics	Group M (n=48) Mean±SD	Group NM (n=48) Mean±SD	P value
Age (years)	37.5 ± 11.8	33.6 ± 10.5	0.102¹
BMI (kg/m²)	24.1 ± 0.95	23.7 ± 1.0	0.218¹
ASA PS I	2.10%	2.10%	1.000²
ASA PS II	97.90%	97.90%	
Duration of surgery (minutes)	152.0 ± 18.0	150.1 ± 17.5	0.674¹

Table 2 compares the State-Trait Anxiety Inventory (STAI) scores between Group M and Group NM during preoperative and postoperative periods. Preoperatively, the mean STAI scores were similar between Group M (55.1 ± 5.8) and Group NM (55.8 ± 4.9), with no significant difference (p = 0.579). Postoperatively, Group M showed a significantly lower anxiety score (34.2 ± 4.6) compared to Group NM (37.4 ± 5.0), with a statistically significant difference (p = 0.004). Within-group analysis revealed a significant reduction in STAI scores from preoperative to postoperative periods in both groups (Group M: t = 17.9, p = 0.006; Group NM: t = 17.1, p = 0.008). These findings indicate that while both groups experienced a significant decrease in anxiety after surgery, Group M demonstrated a greater reduction in postoperative anxiety levels than Group NM.

Table 2: Comparison of STAI Score between the study groups during preoperative and postoperative periods

STAI Score	Group M (n=48) Mean±SD	Group NM (n=48) Mean±SD	t-value	P value
Preoperative	55.1 ± 5.8	55.8 ± 4.9	-0.56	0.579¹
Postoperative	34.2 ± 4.6	37.4 ± 5.0	-2.98	0.004¹*
t-value (within group)	17.9	17.1		
P value (within group)	0.006¹*	0.008¹*		

Table 3 shows that preoperative serum IgA levels were comparable between Group M (451.0 ± 31.2 µg/dl) and Group NM (452.5 ± 29.9 µg/dl; p = 0.898). Intraoperatively, Group M demonstrated significantly lower IgA levels (270.1 ± 34.1 µg/dl) compared to Group NM (294.7 ± 30.8 µg/dl; mean difference –24.6 ± 7.5, 95% CI: –39.1 to –10.1, p = 0.002), while postoperative levels were similar (p = 0.640). For serum cortisol, there was no significant difference preoperatively (24.6 ± 8.0 vs. 23.9 ± 6.8 mg/dl; p = 0.804) or postoperatively (18.7 ± 6.0 vs. 18.4 ± 6.2 mg/dl; p = 0.770). However, intraoperatively, Group M had significantly lower cortisol levels (15.0 ± 12.0 mg/dl) than Group NM (17.3 ± 11.5 mg/dl; mean difference –2.3 ± 0.9, 95% CI: –4.1 to –0.5, p = 0.003). These results indicate that Group M experienced reduced intraoperative stress, as reflected by lower IgA and cortisol levels, while pre- and postoperative values remained comparable between the groups.

Table 3: Comparison of serum cortisol (mg/dl) and serum IgA (µg/dl) level between the study groups

Parameter	Group M (n=48) Mean±SD	Group NM (n=48) Mean±SD	Mean Difference ± SE	95% CI of Difference	t-value	P value
Serum Immunoglobulin A						
Preoperative	451.0 ± 31.2	452.5 ± 29.9	-1.50 ± 12.0	-13.2 to 10.2	-0.13	0.898^{1}
Intraoperative	270.1 ± 34.1	294.7 ± 30.8	-24.6 ± 7.5	-39.1 to -10.1	-3.28	0.002^{1*}
Postoperative	359.1 ± 45.0	354.1 ± 44.8	5.0 ± 10.6	-16.0 to 26.0	0.47	0.640^{1}
Serum Cortisol						
Preoperative	24.6 ± 8.0	23.9 ± 6.8	0.7 ± 2.8	-4.9 to 6.3	0.25	0.804^{1}
Intraoperative	15.0 ± 12.0	17.3 ± 11.5	-2.3 ± 0.9	-4.1 to -0.5	-3.12	0.003^{1*}
Postoperative	18.7 ± 6.0	18.4 ± 6.2	0.3 ± 1.1	-1.9 to 2.5	0.29	0.770^{1}

Table 4 shows a significant difference in propofol consumption between the two groups during surgery. Group M required a markedly lower mean dose of propofol (148.2 ± 11.0 mg) compared to Group NM (192.1 ± 15.5 mg), with a mean difference of –43.9 ± 2.7 (95% CI: –49.2 to –38.6). This difference was highly statistically significant (t = –16.1, p = 0.0001), indicating that Group M had a substantially reduced anesthetic requirement during surgery.

Table 4: Comparison of Propofol consumption (mg) during surgery between the study groups

Parameter	Group M (n=48) Mean±SD	Group NM (n=48) Mean±SD	Mean Difference ± SE	95% CI of the Difference	t-value	P value
Propofol consumption (mg)	148.2 ± 11.0	192.1 ± 15.5	-43.9 ± 2.7	-49.2 to -38.6	-16.1	0.0001^{1*}

Discussion

This prospective study compared music-based intervention (MBI) on preoperative anxiety, intraoperative stress biomarkers, and anesthetic requirement in elective surgery patients. These demographic characteristics, age, BMI, ASA physical status, and surgery time were comparable in music group (Group M) and non-music group (Group NM). This matching in baseline parameters ensures that outcome differences are primarily a reflection of the intervention and less likely a reflection of confounders. Similar baseline parameters in earlier music therapy study results have also been emphasized in confirming reliability (Bansal et al., 2010; Kukreja et al., 2020) [1,8]."

"In terms of anxiety reduction, our findings demonstrated that preoperative STAI scores were similar between both groups. However, Group M showed a significantly greater reduction in postoperative STAI scores compared to Group NM (34.2 ± 4.6 vs. 37.4 ± 5.0; p = 0.004). This suggests that MBI effectively reduced postoperative anxiety. The underlying mechanism may be linked to music's effect on the limbic system and auditory pathways, which influence the hypothalamus and reticular activating system, leading to decreased release of excitatory neurotransmitters and enhanced relaxation. These results are consistent with Kukreja et al. (2020) [8], who reported significantly lower postoperative STAI scores in their music group (28.14 ± 1.0) compared to controls (34.71 ± 2.31; p = 0.01). Similarly, Zengin et al. (2013) [9] demonstrated reduced anxiety levels in patients undergoing port catheter placement procedures when exposed to music (38.74 ± 8.94 vs. 43.26 ± 6.92; p = 0.006). Labrague and McEnroe-Petitte (2016) [10] also reported significantly lower anxiety scores in women undergoing gynecological surgery who received music therapy (36.43 ± 1.86 vs. 43.30 ± 2.02; p < 0.05). These consistent findings across multiple surgical settings support the efficacy of music as a non-pharmacological anxiolytic. In contrast, Nilsson et al. (2005) [7] found no significant differences in anxiety scores, possibly due to differences in anesthesia protocols, uniform music selection, or inadequate exposure time, suggesting that contextual factors may influence the effectiveness of music interventions.

Cortisol, the primary biomarker of stress, was utilized in the present study to evaluate physiological stress response. We did not find significant differences among groups in preoperative and postoperative levels of cortisol ($p > 0.05$). But intraoperatively, we found that Group M showed significantly fewer levels of cortisol compared with Group NM (15.0 ± 12.0 vs. 17.3 ± 11.5 mg/dl; $p = 0.003$). Therefore, it shows that music decreases intraoperative stress by modulating the hypothalamic-pituitary-adrenal (HPA) axis and suppressing sympathetic activation. Our results are in agreement with that work by Koelsch et al. (2011) [11], who documented significantly lower levels of cortisol in electively scheduled hip replacement patients under spinal anesthesia during exposure to music ($p < 0.05$). Zengin et al. (2013) [9] also documented that cortisol levels were significantly lower in their music group compared with control subjects (14.82 ± 4.16 vs. 16.63 ± 2.81; $p = 0.012$). Graversen and Sommer (2013) [12] also showed music significantly reduced perioperative levels of cortisol during laparoscopic cholecystectomy ($p < 0.05$). In contrast, Nilsson et al. (2005) [7] found no significant results in levels of cortisol, which implies type of surgery, interventional time, and patient-specific response could influence results.

Serum Immunoglobulin A (IgA) was also assayed in order to follow stress-related immune alterations. In our study, intergroup differences were not observed during the postoperative and preoperative periods. But intraoperatively, reduced levels of IgA were observed in Group M as compared to Group NM (270.1 ± 34.1 and 294.7 ± 30.8 µg/dl; $p = 0.002$). Acute stress, during its initial phase, increases IgA levels as part of the adaptive response, yet in a prolonged stress, there is typically a decrease in IgA, and it is an indicator of immune suppression (Charnetski et al., 1989; Maes et al., 1997) [13,14],. The present study shows that music could modulate the acute stress response by inducing a feeling of calm during surgery. Nilsson et al. (2005) [7], however, did not set up significant differences in IgA levels between music and control groups, and that could be ascribed to study designs or type of anesthesia."

Another important finding from our study was the lower propofol consumption in Group M compared with Group NM (148.2 ± 11.0 mg vs. 192.1 ± 15.5 mg; $p = 0.0001$). This demonstrates a remarkable reduction in anesthetic need, and music may enhance intraoperative stability and calmness, thereby minimizing the need for sedatives. These results are in agreement with Koelsch et al. (2011) [9], who also demonstrated lower propofol consumption in the music patients' group ($p < 0.05$). Bansal et al. (2010) [1] also observed a lower need for sedatives in music therapy patients during spinal anesthesia. However, Bringman et al. (2009) [4] could not establish any significant difference, and it might be attributed to variability in monitoring techniques, e.g., BIS thresholds or titration techniques in anesthesia.

The results of this study support the growing evidence base demonstrating music therapies as a safe, cost-effective, and minimally invasive method of advancing perioperative care. Through anxiety attenuation, physiologic stress response modulation, and diminution of anesthetic use, music therapy enhances patient comfort in a manner that goes beyond its potential advantages in expediting earlier recovery and reduced healthcare costs. This is particularly helpful in resource-challenged settings and in the higher-risk populations, in which medication minimization is most valuable.

In spite of the promising results, there are several weaknesses in our study. The measurement of serum cortisol and IgA needed expensive equipment and was thus expensive and potentially limited as a clinical application. Also, preference in music was not controlled in the study and patients' levels of relaxation could have been variable depending on preference. Future work could control individual music choice and investigate additive interactions in combining music therapy and chemotherapeutic agents in a search for a synergistic effect.

Conclusion

The study showed that a music-based intervention decreased preoperative anxiety, reduced the intraoperative stress response, and decreased anesthetic consumption in patients undergoing elective surgery. Patients assigned to music showed a statistically significant improvement in postoperative anxiety, as shown by lower STAI scores, as well as a significant reduction in serum cortisol and immunoglobulin A pre- and intraoperatively, suggesting better control of their physiological stress response; the music group showed a reduction in the amount of propofol needed for induction, perhaps reflecting that they were less hemodynamically unstable and needed less pharmacological sedation; these findings point to the possibility that music therapy can enhance the perioperative experience and reduce audiates of anesthetic use and possibly recovery in surgical patients, for a simple, non-invasive, and relatively cheap adjunct.

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