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The effectiveness of music in improving the recovery of cardiothoracic surgery: a systematic review with meta-analysis and trial sequential analysis

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Abstract

Aim This study aimed to compile data on the effectiveness of music therapy for patients undergoing cardiothoracic surgery.

Background After cardiac and thoracic surgery, patients often experience physiological and psychological complications, such as anxiety, pain, stress, depression and changes in vital signs, which have a great impact on prognosis.

Methods A systematic search of six databases was performed to identify randomized controlled trials investigating music therapy and cardiothoracic surgery. The data were extracted from the qualified research, the data without heterogeneity were analysed by random-effects model (REM) meta-analysis, and the data with heterogeneity were analysed by fixed-effects model (FEM) meta-analysis. We evaluated anxiety, pain, duration of mechanical ventilation, hospital length of stay, stress hormones, opioid consumption, and vital signs, including heart rate (HR), respiratory rate (RR), oxygen saturation (SpO2), diastolic blood pressure (DBP), and systolic blood pressure (SBP) after cardiothoracic surgery. The meta-analysis and sensitivity analysis were performed with RevMan 5.4 and Stata 14 software, and trial sequential analysis was conducted using TSA 0.9.5.10 Beta software. This study was conducted in accordance with the PRISMA guidelines and was registered with PROSPERO.

Results The study included 24 randomized controlled trials with a total of 1576 patients. Our analysis showed that music therapy can significantly reduce the anxiety scores (SMD= -0.74, 95% CI [-0.96, -0.53], $p < 0.01$) and pain scores (SMD= -1.21, 95% CI [-1.78, -0.65], $p < 0.01$) of patients after cardiothoracic surgery. Compared with the control group, music therapy dramatically raised postoperative SpO2 (SMD = 0.75, 95% CI [0.11, 1.39], $p = 0.02$). In addition, the

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experimental group had significant statistical significance in reducing HR, SBP and opioid consumption. However, there was no significant difference in respiratory rate, stress hormones, diastolic blood pressure, length of hospital stay, or the duration of mechanical ventilation between the two groups.

Conclusions Music therapy can significantly reduce anxiety, pain, HR, SBP, and postoperative opioid use and even improve SpO2 in patients who undergo cardiothoracic surgery. Music therapy has a positive effect on patients after cardiothoracic surgery with few side effects, so it is promising for use in clinics.

Trial registration RROSPERO (registration number: CRD42023424602).

Keywords Anxiety, Cardiothoracic surgery, Meta-analysis, Music, Postoperative

Introduction

Cardiac and thoracic surgery often have a great impact on the body and psychology of patients. After cardiothoracic surgery, patients often experience physiological and psychological complications such as anxiety, depression, pain, excessive stress and changes of vital signs, which seriously affect the prognosis of patients [1, 2]. The common clinical intervention is symptomatic drug treatment, but drug treatment increases the risks of drug dependence, renal function damage, and inhibition of other body systems. If long-term drug treatment is needed, the damage to the body will also be correspondingly worsened. In addition, the blood–brain barrier restricts the entry of most drugs into the brain, so the treatment of anxiety and depression is often unsatisfactory [3]. As early as the golden age in ancient Greece, Pythagoras et al. [4] first proposed that music could be used as a prescription to treat physical and mental illness. Over time, modern studies have shown that music can regulate changes in heart rate by interfering with the autonomic nervous system [5]. Some articles have shown that music can reduce the anxiety and stress of patients with cardiovascular and lung cancer diseases [5–8], but whether music can effectively improve the recovery of patients after cardiothoracic surgery is still unclear. Therefore, our goal is to use meta-analysis to evaluate the effects of music therapy on vital signs, pain, anxiety, and stress hormones in patients after cardiothoracic surgery. The results of our analysis will provide strong evidence supporting the use of music as a nondrug postoperative measure for patients who undergo cardiothoracic surgery.

Methods

The study was conducted in accordance with the PRISMA statement guidelines and registered on PROSPERO (registration number: CRD42023424602) [9].

Search strategy

Six electronic databases were examined (Embase, PubMed, Web of Science, Cochrane Library, the WHO International Clinical Trials Registry platform, and ClinicalTrials.gov) for articles written in English and published from their inception to April 21, 2023. The search terms were centred around "music" or "music therapy" and "cardiac surgery" or "thoracic surgery" and "studies" restricted to human subjects. Finally, we show the detailed search strategies in the supplementary material attachment (Supplementary Appendices 1–4).

Eligibility criteria

We used Endnote X9 software to manage the imported literature and to delete duplicate articles. We screened the relevant articles by browsing the title and abstract. Then, the relevant articles were evaluated by reading the full text. Two researchers (Li and Weng) independently completed the screening process for this study.

Based on the PICOS formula, studies that met the following criteria were included: (I) participants: patients undergoing any cardiothoracic surgery; (II) intervention: perioperative music therapy, independent of the type of music and form of administration; (III) control group: patients who did not receive music therapy or routine care. (IV) Outcome parameters: pain, anxiety, stress hormones, vital signs, time of mechanical ventilation, and postoperative use of opioids. (V) Study design: randomized controlled trials (RCTs).

For the following reasons, we excluded several studies: [1] animal studies [2], nonrandomized trials [3], articles published repeatedly or without quantitative results, and [4] unreliable data extraction and analysis.

Data extraction

Two researchers (Li and Weng) independently extracted relevant data, including research features and measurement results. The third investigator (Guo) was consulted in order to settle the disagreements. Inter-rater reliability between the top two researchers was assessed using Cohen's kappa coefficient. The characteristics of the study included the name of the first author, year of publication, study site, type of operation, intervention, sample size, average age, and sex. The measurement results included the mean and standard deviation (SD) of anxiety and pain scores, stress hormones, hospital length of stay, mechanical ventilation time, postoperative opioid consumption, and vital signs including diastolic blood pressure (DBP), systolic blood pressure (SBP), heart rate (HR), respiratory

rate (RR), and oxygen saturation (SpO2) after intervention. For the results of vital signs, we extracted the difference value between the experimental group and the control group before and after intervention.

Risk of bias assessment

We used the Cochrane risk of bias assessment tool [10] to assess the bias risk included in randomized controlled trials and to assess the methodological quality of the study. If all areas assessed were low-risk, the corresponding study had a low risk of bias. Conversely, if an area was not low-risk, then the corresponding study had a high risk of bias. Through discussion, disagreements were settled. When a result contained at least 10 studies, we used funnel charts to assess publication bias.

Statistical analysis

RevMan and Stata software were used for statistical analysis. The mean difference (MD) with 95% confidence intervals (CI) was computed for continuous outcomes. If the data included different evaluation scale scores at the same time, the standardized mean difference (SMD) was used to calculate the results with 95% CI. We calculated the risk ratio (RR) and the 95% CI for the dichotomous outcomes. Excluded from the quantitative analysis were studies with significant baseline differences in anxiety and pain levels. Meanwhile, heterogeneity among studies was assessed using the I^2 statistic and the chi^2 test. Significant heterogeneity was deemed to exist if the chi^2 test yielded a P value <0.10 and the I^2 statistic $>50\%$. When there was heterogeneity across studies, we used the random-effects model (REM) for meta-analysis. The fixed-effects model (FEM) was applied in situations where there was no significant heterogeneity. We conducted sensitivity analysis in an attempt to eliminate heterogeneity in different results. We expected to conduct subgroup analyses according to different pain assessment scales and different areas of the participants. Additionally, trial sequential analysis (TSA) using the TSA 0.9.5.10 Beta was performed in order to further corroborate the meta-analysis's findings and evaluate the required information size (RIS). We set the boundary value type of the hypothesis test to a two-sided test and set the probability of type I error to $\alpha=0.05$. A P value <0.05 was regarded as statistically significant.

Results

Results of the literature search

By searching PubMed, Embase, Cochrane Library, Web of Science, ClinicalTrials.gov, and WHO International Clinical Trials Registry platform, we found 352 articles. After 113 articles were excluded by Endnote X9, the titles and abstracts of the remaining 239 articles were further screened, and 60 articles were included in the full-text screening. We excluded 34 items according to the inclusion and exclusion criteria. Finally, 26 studies were included for qualitative analysis (1641 patients), of which 24 studies (1555 patients) were included in the meta-analysis. The flow chart of research and screening is shown in Fig. 1.

Characteristics of included studies

Finally, 24 randomized controlled trials were included [11–34], including 801 patients in the music treatment group and 754 patients in the control group. In the selected literature, one study was a nonemergency sternotomy procedure [16], two were thoracic surgeries [24, 32], and the rest were cardiac surgeries, including coronary artery bypass grafting (CABG), valve repair, or valve replacement. In the music therapy group, one study intervention was music video (MV) [19], two studies interventions were natural sounds [13, 14], and the remaining intervention was music in the traditional sense. The choices for playing music include natural sound, a unified music list preselected by the researchers, a unified music list chosen by the patients themselves, or their own favourite music. The form of listening to music was not fixed. Patients in the control group were allowed to rest and received standard nursing care, headphones without music playing, or a blank CD combined with standard nursing care after cardiothoracic surgery. The anxiety assessment scale after cardiothoracic surgery includes the Hospital Anxiety and Depression Score (HADS), State-Trait Anxiety Inventory (STAI), Visual Analogue Scale (VAS), and Numeric Rating Scale (NRS). The pain assessment scale includes the VAS, NRS, and Face, Legs, Activity, Cry, and Consolability (FLACC). The summarized data of the included studies are shown in Table 1.

Risk of bias assessment

The included randomized controlled trials were evaluated for deviation risk. Figure 2 shows a simplified deviation risk diagram (Fig. 2). Figure 3 shows the deviation risk details for each study (Fig. 3).

Outcomes

Anxiety

As shown in Fig. 4, the music therapy group was significantly better than the control group in terms of anxiety (SMD = -0.74, 95% CI [−0.96, 0.53], $p<0.01$) (Fig. 4a). There was high heterogeneity among the studies ($P=0.06$, $I^2=45\%$). To explore the potential sources of heterogeneity, we conducted meta-regression and subgroup analyses. The detailed results of these analyses can be found in the Supplementary Material (Supplementary Figs. 1–4). Sensitivity analysis was employed to evaluate the stability of the results (Supplementary Fig. 5). The models of the cumulative Z curve crossed the trial sequential

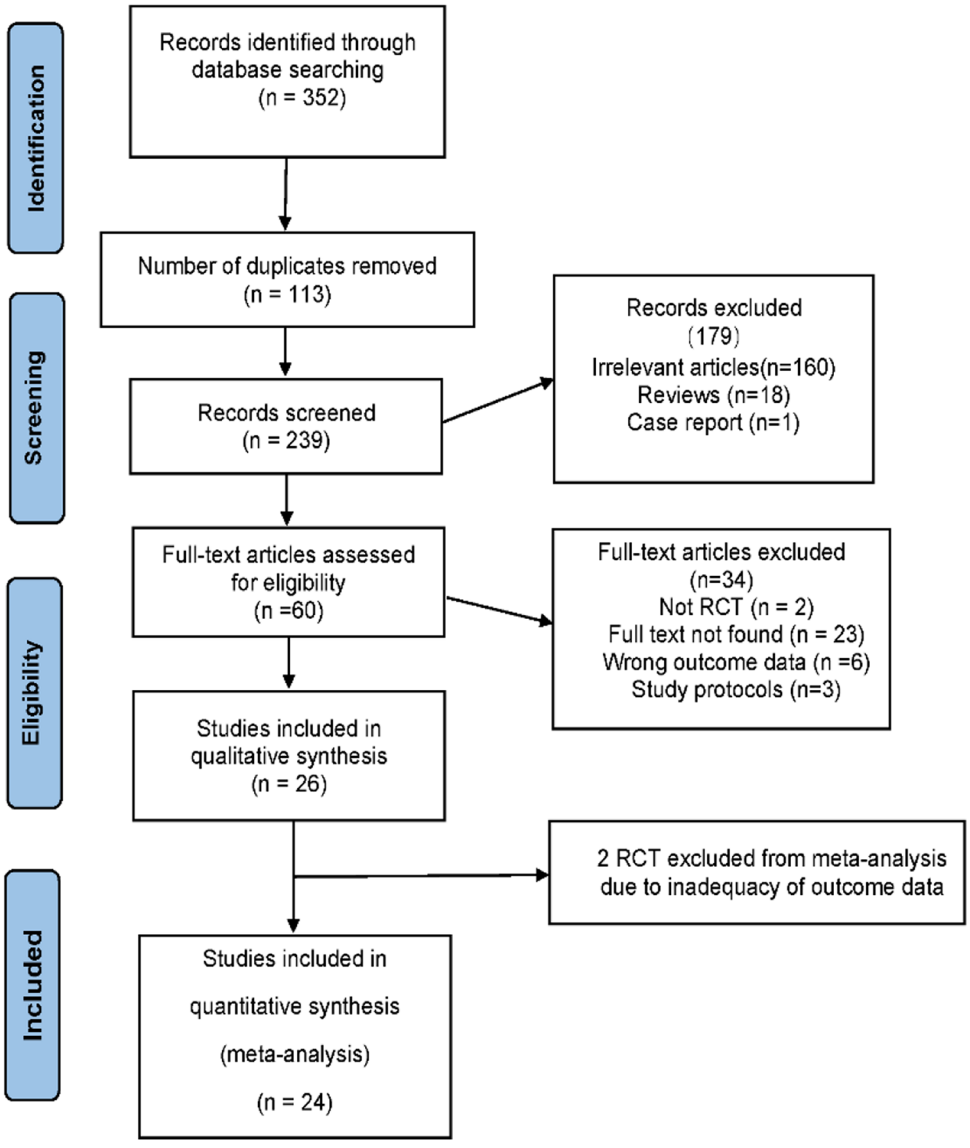


Fig. 1 Flow diagram of the study flow

monitoring boundary (TSMB) and arrived at the RIS. The TSA of this pooled meta-analysis provided conclusive evidence for the expected effect of music therapy (Fig. 4b).

Pain

As shown in Fig. 5, in terms of pain relief, the music therapy group was significantly better than the control group (SMD = -1.21, 95% CI [−1.78, 0.65], $p<0.01$) (Fig. 5a). The results of the TSA showed that the cumulative Z curve breached both the TSMB and the conventional boundary, and the sample size in reality also exceeded the expected sample size. This positive result showed that the result of the meta-analysis was robust and further confirms the efficacy of music therapy (Fig. 5b). The results of the meta-analysis were mostly unchanged when any one of these ten studies was eliminated, according to the sensitivity analysis. The funnel chart and the results of subgroup analysis are shown in the supplementary data. The NRS was employed in 4 out of 10 studies evaluating postoperative pain in patients. A subgroup analysis was performed based on various types of music to determine the potential influence of music preference on NRS pain score assessments. The findings indicated that interventions utilizing participant-selected music were more effective in reducing postoperative pain scores (Supplementary Figs. 6–10).

Stress hormone

The results of the meta-analysis showed that music therapy had no effect on stress hormones after cardiothoracic surgery (SMD=0.29, 95% CI [−0.11, 0.69], $p=0.15$)

Table 1 Characteristics of the studies

Author (year)	Coutry	Type of surgery	Groups of intervention	Sample (*n*)	Age (years) mean ± SD	Men, *n* (%)	Women, *n* (%)	Outcomes
Abd-Elshafy [11]	Egypt	Repair of congenital heart disease	Music therapy	25	7.02 ± 2.70	10	15	In children undergoing heart surgery, listening to favorable music can reduce stress and increase relaxation.
			Control	25	7.48 ± 2.48	9	16	
Ajorpaz [12]	Iran	CABG or valve replacement surgery	Music therapy	30	NA	12	18	Relaxing music can help with post-operative pain management.
			Control	30	NA	17	13	
Ashok [33]	India	CABG	Music therapy	20	60.8 ± 7.75	6	14	Music therapy is more effective in relieving anxiety than Phase I cardiac rehabilitation.
			Control	20	59.85 ± 7.92	6	14	
Chen [13]	China	CABG or valve replacement suegery	Music therapy	9	58.44 ± 10.06	6	3	Natural sounds have positive physiological effects and can reduce pain and anxiety in patients undergoing cardiothoracic surgery.
			Control	9	63.11 ± 11.80	8	1	
Cigerci [34]	Turkey	CABG	Music therapy	34	62.3 ± 11.3	25	9	Music reduces pain and the amount of analgesics during patients' stays in the ICU and surgical wards.
			Control	34	60.8 ± 10.3	27	7	
Cutshall [14]	USA	CABG or cardiac valve surgery	Music therapy	49	65.6 ± 12.9	37	12	Recorded music and natural sounds may provide a way for patients undergoing cardiovascular surgery to relax.
			Control	51	60.2 ± 12.4	40	11	
Dong [15]	China	Valve replacement surgery	Music therapy	43	57.6 ± 12.7	24	19	Music therapy can reduce anxiety and pain after cardiac surgery, as well as SBP, HR, and RR.
			Control	43	54.8 ± 11.4	26	17	
Ganesan [16]	India	Non-emergency sternotomy procedure	Music therapy	35	NA	22	13	They found that music was effective on anxiety, pain, DBP, and oxygen saturation among post-operative sternotomy patients.
			Control	35	NA	19	16	
Hatem [17]	Brazil	Pediatric cardiac surgery	Music therapy	61	NA	NA	NA	They found that music had a positive effect on some vital signs (HR and RR) in children after heart surgery.
			Control	18	NA	NA	NA	
Heidari [18]	Iran	CABG	Music therapy	30	56.33 ± 13.52	15	15	After CABG, music therapy is a useful non-pharmacological way to reduce anxiety.
			Control	30	60.91 ± 8.66	12	18	
Huang [19]	China	Pediatric cardiac surgery	Music therapy	58	5.02 ± 1.81	33	25	After cardiothoracic surgery, MV treatment can be a useful nonpharmaceutical intervention to reduce postoperative pain in children.
			Control	58	4.79 ± 1.74	36	22	
Huang [20]	China	Pediatric cardiac surgery	Music therapy	37	2.1 ± 1.33	20	17	MT in the ICU can shorten the time of mechanical ventilation and reduce the incidence of delirium after cardiac surgery.
			Control	37	2.4 ± 1.29	23	14	
Jafari [21]	Iran	CABG and valve replacement surgery	Music therapy	30	NA	14	16	After cardiac surgery, music therapy is an inexpensive, non-pharmacological, and side-effect-free way to successfully reduce pain.
			Control	30	NA	12	18	
Janardan [22]	India	Open heart surgery	Music therapy	30	NA	NA	NA	They discovered that breathing exercises combined with music therapy were more beneficial than breathing exercises alone.
			Control	30	NA	NA	NA	
			Control	51	63.5 ± 14.12	42	9	
Kshettry [23]	USA	Open heart surgery	Music therapy	53	62.8 ± 13.44	33	20	Music seems to relieve pain and tension during early recovery after open heart surgery.
			Control	51	63.5 ± 14.12	42	9	
Liu [24]	China	Thoracic surgery	Music therapy	47	54.45 ± 15.90	32	15	They found music can reduce postoperative pain and anxiety and lower SBP and HR in patients after thoracic surgery.
			Control	51	52.02 ± 15.62	33	18	
Luis [25]	Egypt	Elective septal myectomy, valve replacement, or CABG	Music therapy	6	NA	NA	NA	They found that live music therapy can relieve pain and anxiety as well as reduce stress in patients undergoing cardiac surgery.
			Control	6	NA	NA	NA	
Murrock [26]	USA	CABG	Music therapy	15	NA	5	10	When CABG patients exercise in Phase II of cardiac rehabilitation, music can improve their general mood.
			Control	15	NA	12	3	
Nilsson [27]	Sweden	CABG or valve replacement surgery	Music therapy	20	64 ± 10.0	17	3	After open heart surgery, listening to music while in bed has some effects on the levels of subjective relaxation and s-oxytocin.
			Control	20	67 ± 7.5	15	5	

Table 1 (continued)

Author (year)	Coutry	Type of surgery	Groups of intervention	Sample (*n*)	Age (years) mean ± SD	Men, *n* (%)	Women, *n* (%)	Outcomes
Nilsson [28]	Sweden	CABG or valve replacement surgery	Music therapy	28	64 ± 11.5	NA	NA	Patients who listened to music had significantly lower levels of s-cortisol.
			Control	30	69 ± 7.5	NA	NA	
Sendelbach [29]	USA	CABG and valve replacement surgery	Music therapy	50	62.3 ± 14.8	31	19	Patients recovering from cardiac surgery may benefit from music therapy.
			Control	36	64.7 ± 11.4	29	7	
Twiss [30]	USA	CABG or valve replacement surgery	Music therapy	42	72.6 ± 2.1	28	14	Listening to music during cardiovascular surgery decreased anxiety in older people compared to those who did not.
			Control	44	75.1 ± 3.4	29	15	
Voss [31]	USA	CABG and valve replacement surgery	Music therapy	19	NA	NA	NA	They discovered that during the first chair rest period following open-heart surgery, sedative music was more successful at reducing patients' anxiety and pain than scheduled rest and standard care.
			Control	21	NA	NA	NA	
			Scheduled rest	21	NA	NA	NA	
Wang [32]	China	Thoracic surgery	Music therapy	30	53.5 ± 10.7	17	13	Music therapy combined with sufentanil to improve the effect of patient-controlled intravenous analgesia.
			Control	30	53.8 ± 11.2	18	12	

CABG Coronary Artery Bypass Graft; *ICU* Intensive Care Unit; *SBP* systolic blood pressure; *HR* heart rate; *RR* respiratory rate; *DBP* diastolic blood pressure; *MV* Music Video; *MT* music therapy

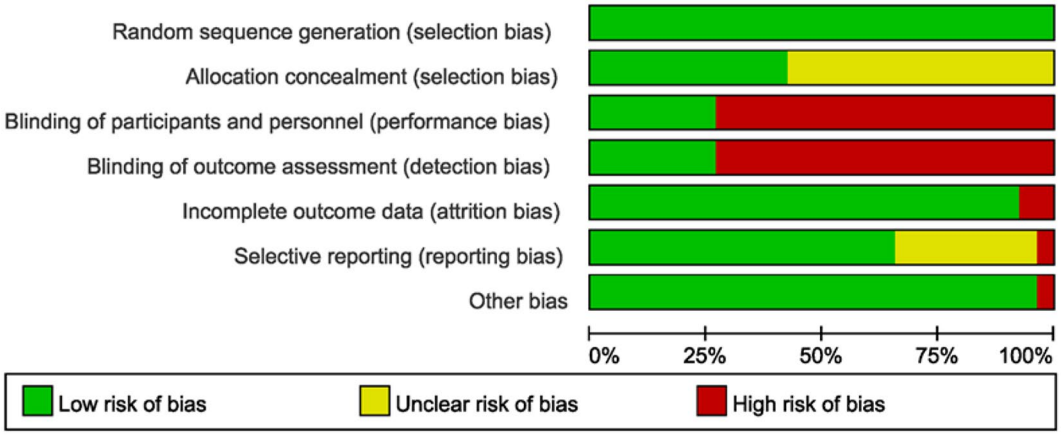


Fig. 2 Risk of bias graph

(Fig. 6). There was no significant heterogeneity between studies (P=0.40, I^2=0%).

SpO2

Six studies [11, 16, 19, 27, 28, 35] evaluated the effect of music therapy on SpO2 in patients after cardiothoracic surgery. The pooled analysis of these 6 studies showed that music therapy improved the Spo2 of postoperative patients (MD=0.75, 95% CI [0.11, 1.39], p=0.02) (Fig. 6). There was no significant heterogeneity among the studies (P=0.11, I^2=44%).

HR

Studies [11, 15, 16, 18, 19, 23, 24, 27, 28, 35] have evaluated the effect of music therapy on HR after cardiothoracic surgery. The pooled analysis found a significant difference between the music and control groups and indicated that music therapy effectively reduced HR (MD = -4.71, 95% CI [-7.05, -2.37], p<0.01) (Fig. 6). There was no significant heterogeneity among the studies (P=0.12, I^2=35%).

RR

Studies [15, 19, 24, 28, 35] have evaluated the effect of music therapy on RR changes after surgery. The pooled analysis of these 5 studies did not find any significant difference in RR between the music group and the control group (MD = -1.72, 95% CI [-3.98, 0.53], p=0.13) (Fig. 6). There was significant heterogeneity among the studies (P<0.01, I2=92%). After removing Huang et al. [19], we solved the heterogeneity (p=0.42, I^2=0%), which further supported our results (MD = -0.47, 95% CI [-1.19, 0.25], p=0.20) (Supplementary Fig. 11).

Fig. 3 Risk of bias summary

SBP

As shown in Fig. 7, based on the control group, music therapy significantly reduced SBP after cardiothoracic surgery (MD = -7.35, 95% CI [-10.43, -4.27], $p<0.01$). There was no heterogeneity among these studies ($P=0.43$, $I^2=0\%$) (Fig. 7).

DBP

Six studies [15, 16, 18, 23, 24, 35] evaluated the effect of music therapy on SpO2 in patients after cardiothoracic surgery. The pooled analysis of these 6 studies showed that music therapy had no significant effect on DBP (MD = -1.65, 95% CI [-3.76, 0.45], $p=0.12$) (Fig. 7). Among these studies, there was no heterogeneity ($P=0.84$, I2=0%).

Mechanical ventilation time

Studies [19, 20, 30] have evaluated the effect of music therapy on the duration of mechanical ventilation in patients after cardiothoracic surgery. The pooled analysis of the results of these three studies showed that there was no significant difference in the duration of mechanical ventilation between the two groups (SMD = -0.95, 95% CI [-2.24, 0.35], $P=0.15$) (Fig. 7).

Hospital length of stay

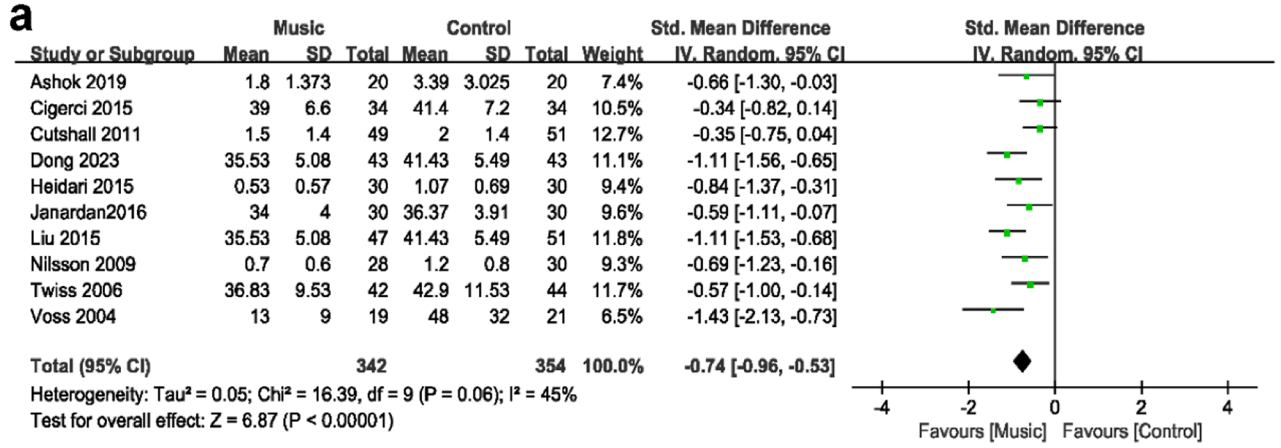
Studies [11, 20] evaluated the effect of music intervention on the hospital length of stay of patients undergoing cardiothoracic surgery. The pooled analysis of these two studies did not find any significant difference between the music and control groups regarding the hospital length of stay (SMD = -0.11, 95% CI [-0.84, 0.62], $P=0.77$) (Fig. 7).

Opioid consumption

With regard to the use of opioids in patients after cardiothoracic surgery, the pooled analysis of 5 studies [14, 19, 27, 32, 35] showed that music therapy could significantly reduce the amount of opioids used in postoperative patients (SMD = -1.46, 95% CI [-2.51, -0.42], $P<0.01$) (Fig. 7). The funnel plot and sensitivity analysis plots are presented in the supplementary materials (Supplementary Figs. 12, 13).

Discussion

Reasonable optimization of the treatment and management of patients after cardiothoracic surgery is very important to improve the prognosis of patients after surgery. Well-managed treatment may lead to lower postoperative anxiety, lower pain intensity, better sleep and rest quality, lower consumption of opioids and nonsteroidal anti-inflammatory drugs, even better vital signs, and lower morbidity and mortality rates [36–38]. Music therapy is considered one of the main complementary and alternative medical therapies in modern medicine [39].



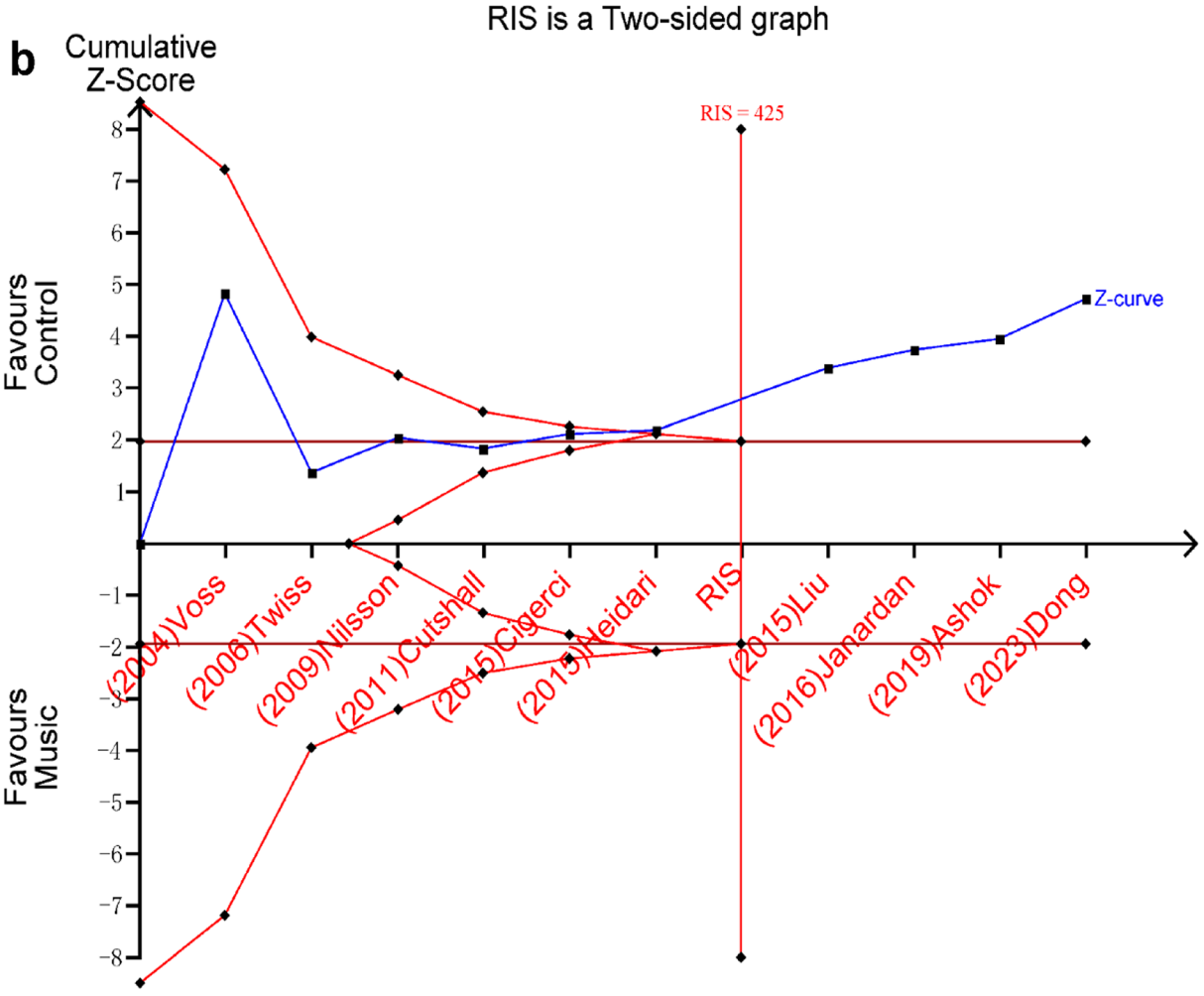


Fig. 4 (**a**) Forest plot for anxiety. (**b**) Trial sequential analysis of music therapy in improving postoperative anxiety in Cardiothoracic surgery. *CI* confidence interval; *RIS* required information size

Some studies have found that it can improve patients' sleep, relieve anxiety and stress, cure a variety of diseases, and improve their health. However, its exact mechanism is not clear [32, 35]. Previous studies have shown that music can be used to relieve chronic pain [40]. However, there is no strong evidence supporting that music can improve the prognosis of patients who undergo cardiac surgery or major chest surgery. To assess the impact of

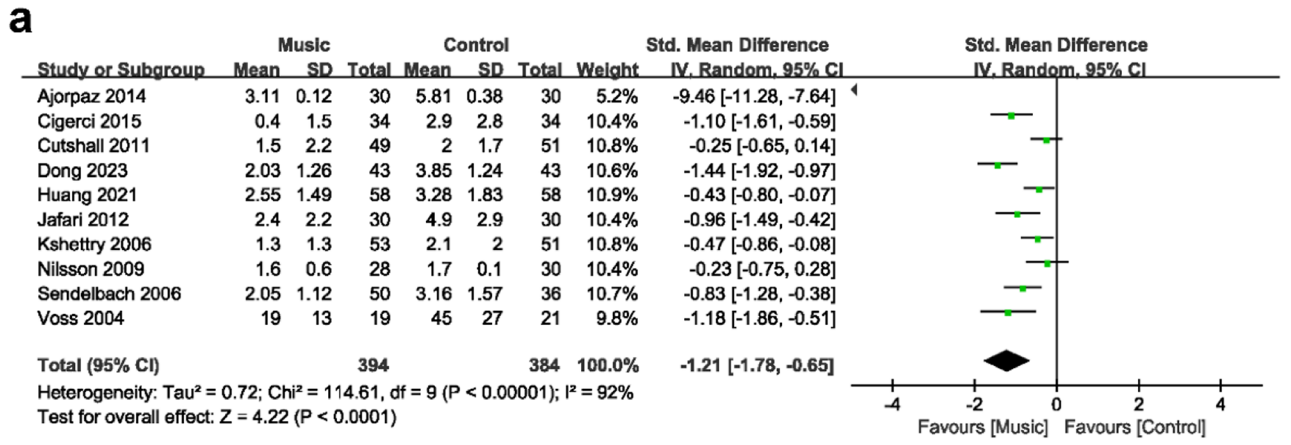


Fig. 5 (**a**) Forest plot for pain. (**b**) Trial sequential analysis of music therapy in improving postoperative pain in Cardiothoracic surgery. *CI* confidence interval; *RIS* required information size

music therapy on the prognosis of patients following cardiothoracic surgery, this systematic review used a meta-analysis of RCTs. The main purpose of this meta-analysis was to evaluate whether music therapy can improve the prognosis of patients after cardiothoracic surgery. The impact of music therapy on the prognosis of patients after cardiothoracic surgery was assessed in this systematic review by a meta-analysis of RCTs. The current evidence supporting the effectiveness of music therapy for patients undergoing cardiac and thoracic surgery was summarized by screening RCTs published before May 2023. The RCTs included in this meta-analysis included different countries, regardless of race and age.

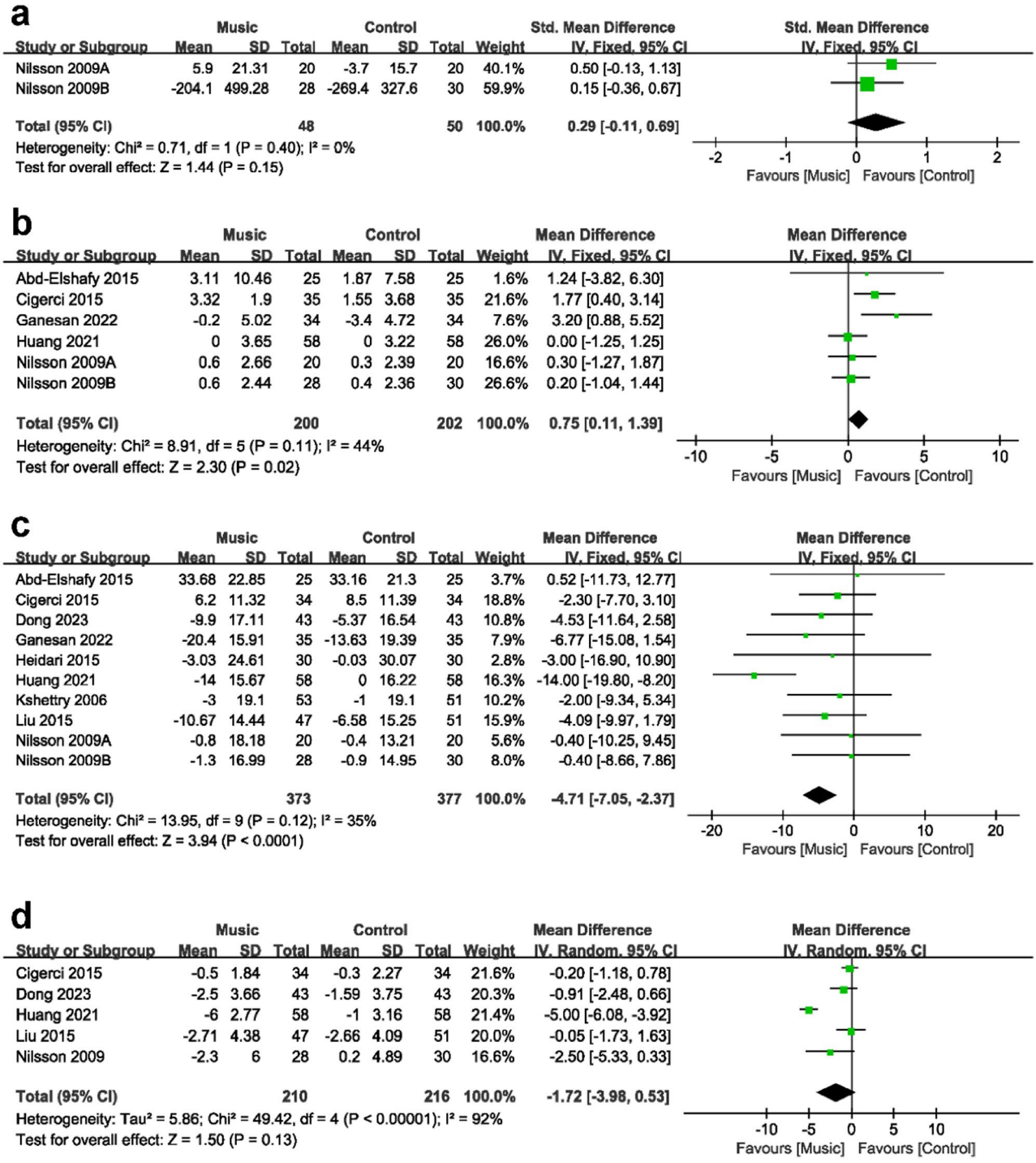


Fig. 6 Forest plot of the effect of music on patients after cardiothoracic surgery. (**a**) Stress hormone; (**b**) SpO2; (**c**) HR; (**d**) RR

Psychological outcomes

The systematic review included twenty-six trials, while the meta-analysis contained twenty-four randomized controlled trials. Our analysis revealed that among the 24 studies included, 12 utilized researcher-selected relaxing and soft music as the intervention, 9 employed patient-preferred music, 2 incorporated researcher-selected sedative music, and 1 utilized researcher-selected nature music as the intervention. The results of 10 studies ($N=696$) showed that music therapy can significantly reduce the anxiety level of patients after cardiothoracic surgery. However, there is heterogeneity in the results of different studies. To identify the sources of heterogeneity in this study, we conducted meta-regression

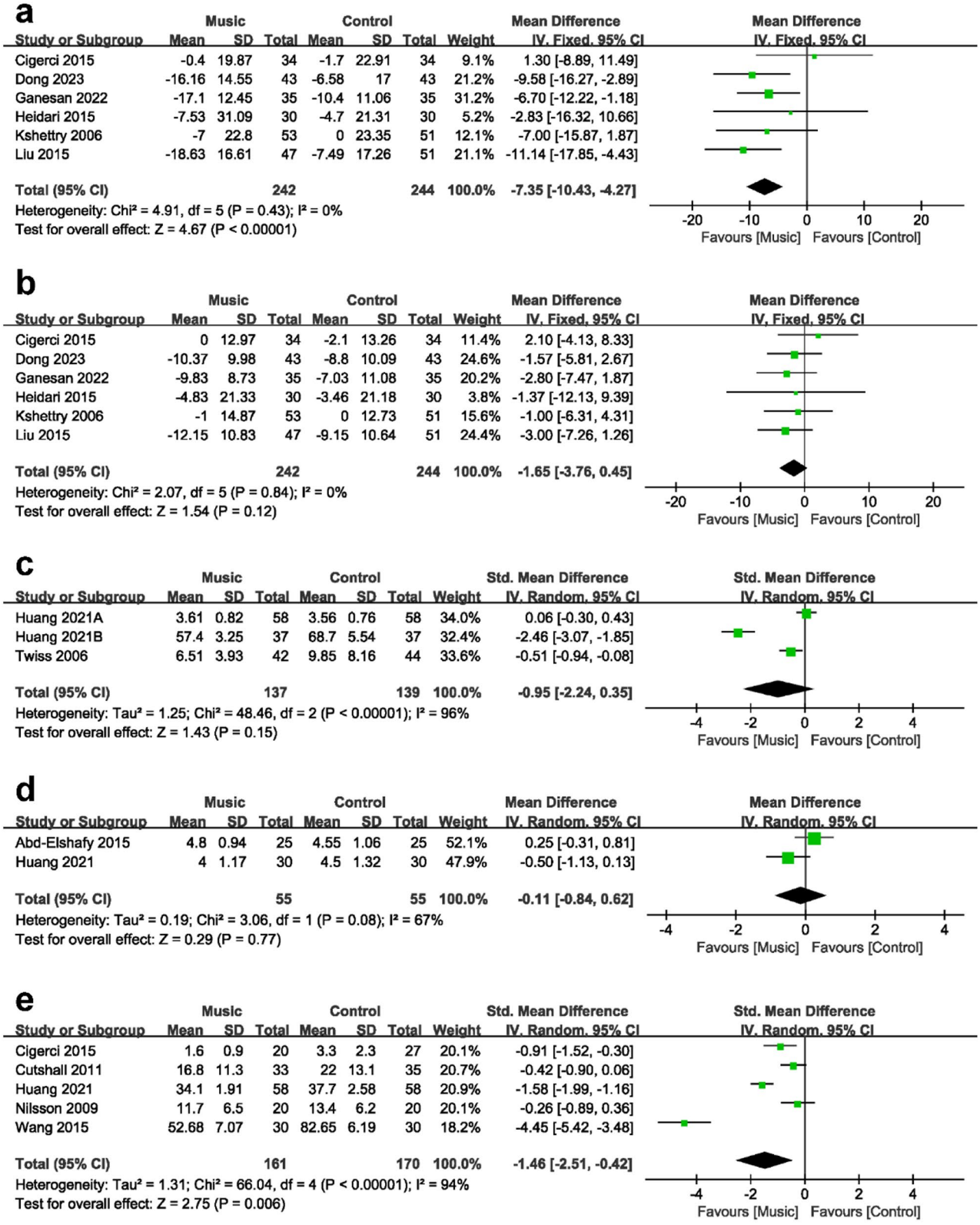


Fig. 7 Forest plot of the effect of music on patients after cardiothoracic surgery. (**a**) SBP; (**b**) DBP; (**c**) Mechanical ventilation time; (**d**) Hospital length of stay; (**e**) Opioid consumption

and subgroup analyses based on different anxiety rating scales and regional populations, respectively. Unfortunately, despite our efforts, we were unable to identify a specific source of heterogeneity in this study. However, it is important to note that our study did reveal statistically significant differences between the experimental and control groups within each of the analyzed subgroups. Then, we conducted a sensitivity analysis and identified that the study by Cutshall et al. [14] was a potential factor affecting heterogeneity. The above analysis enhances the robustness and adequacy of our results. Our results have a high level of evidence. The study by Ramesh et al. [41] on heart surgery and music is consistent with ours.

The results of 10 studies (N=778) showed that music therapy can reduce the degree of pain in patients after cardiothoracic surgery. However, there is a strong heterogeneity among these studies. The offset was found through the funnel chart, and the potential source of the offset could not be found despite the subgroup analysis. However, the results of the sensitivity analysis showed that excluding all the studies in turn did not affect the results, indicating that this study is still reliable. At the same time, we conducted a sequential analysis of pain; the cumulative Z curve breached both the trial sequential monitoring boundary and the conventional boundary, and the actual sample size also exceeded the expected sample size. The results of the trial sequential analysis further enhance the robustness of the meta-analysis results. Finally, to examine the impact of music preference on postoperative pain scores, we performed subgroup analyses based on music type. The findings indicated that interventions involving patient-preferred music were associated with a more significant reduction in postoperative pain scores.

Physiological outcomes

The results of this study suggested that music therapy can help slow the HR. Among the 10 studies (N=750) included, there was a difference between the results of one article and our conclusions, which may be related to different populations in different studies. However, there was no statistical heterogeneity in the results of the meta-analysis, which proved the reliability of the outcome. The results of six studies (N=402) showed that, compared with the standard nursing group, music had a positive effect on postoperative SpO2. In terms of blood pressure, the study found that music therapy can reduce the SBP (six studies, N=486) of patients after cardiothoracic surgery but has no significant effect on DBP (six studies, N=486). Only a few studies examined the effects of music on stress hormone levels (2 studies, N=98) and length of stay (2 studies, N=110) and found that music had no significant effect on stress hormones or length of stay. According to the use of opioid analgesics in patients after cardiothoracic surgery, six articles (N=331) were included. It was found that music therapy could significantly reduce the consumption of analgesics. For the observation of the time of postoperative mechanical ventilation, there was no evidence supporting that music can shorten the duration of mechanical ventilation (three studies, N=276).

Implications for research

This systematic review provides evidence supporting the idea that music therapy may be beneficial to the recovery of vital signs in patients after cardiothoracic surgery. This series of studies uses different kinds of music therapy, such as classical music, pop music, light music, and traditional Chinese medicine music. The study found that when music is used to relieve postoperative anxiety, soft, melodious music is preferred [15, 24]. In the future, more RCTs are still needed to further verify which types of music can have the best therapeutic effect on different diseases. It is also necessary to study the effects of different durations, time periods, and frequencies of music interventions on the therapeutic effect. Future research should combine different biomarkers with music therapy to clarify the specific mechanism of music therapy.

Strengths of the study

This study's strength is that it is the first meta-analysis to evaluate how music therapy affects patients' chances of recovering from cardiothoracic surgery. The previous systematic review and meta-analysis have some limitations. Previous studies have systematically reviewed the effects of music therapy on cardiovascular disease, but there are no further studies on the effects of music therapy on patients undergoing cardiac surgery [5, 6]. In the meta-analysis by Ramesh et al. [41], they only analysed the effects of music on pain and anxiety in patients after cardiac surgery but did not analyse the effects of music on patients after other thoracotomies, such as major thoracic surgery. This review not only addresses anxiety after cardiothoracic surgery but also analyses all postoperative outcomes, including anxiety, pain, vital signs, stress hormones, and consumption of analgesics. Compared with previous meta-analyses, our research includes more and higher-quality articles. More significantly, we also performed trial sequential analysis to further support the results of the meta-analysis. Consequently, compared to earlier meta-analyses, this review is more valuable.

Limitations

Additionally, this study has certain drawbacks [1]. The types of and methods of music therapy included in this study are different, and some studies have tested natural sound, combined sound, and so forth [2]. Only two or three studies came together to analyse stress hormones,

hospital length of stay, and the duration of mechanical ventilation in patients after cardiothoracic surgery, and more randomized controlled trials are needed to explore these outcome indicators [3]. The heterogeneity and source between the studies in Figs. 1 and 2 cannot be determined, although subgroup analysis and meta-regression are used [4]. The results section concerning the consumption of opioid medications demonstrated significant heterogeneity, and our sensitivity analysis and funnel plot indicated a potential presence of publication bias in relation to this specific outcome. To improve the stability and representativeness of our findings, it would be advisable to incorporate additional literature into future meta-analyses [5]. We did not extract the duration or start time of music therapy for statistical analysis, and the start and duration of music therapy in different studies were different. Therefore, the effectiveness of music therapy at different times cannot be evaluated.

Conclusion

Music therapy has shown a significant reduction in postoperative anxiety and pain scores among patients undergoing cardiothoracic surgery, exerting a positive influence on postoperative prognosis. Although music therapy has no significant effect on the length of hospital stay of patients, it can significantly improve the postoperative life signs of patients.

Abbreviations

CABG	Coronary Artery Bypass Graft
ICU	Intensive Care Unit
SBP	Systolic blood pressure
HR	Heart rate
RR	Respiratory rate
DBP	Diastolic blood pressure
MV	Music Video
MT	Music therapy
CI	Confidence interval
RIS	Required information size

Supplementary Information

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Supplementary Material 1

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Not applicable.

Author contributions

TYL and YNG contributed to data acquisition and drafted the manuscript. Screening the publications for our meta-analysis was done by XJ and DL, JYX and MWS carried out statistical analysis and drawing. LLJ made a summary of the tables. YLW, YQW and WLY contributed to the revision of the manuscript.

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Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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