Yan et al.
BMC Complementary Medicine and Therapies (2025) 25:72
https://doi.org/10.1186/s12906-025-04815-z

BMC Complementary Medicine and Therapies

SYSTEMATIC REVIEW

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Effects of music therapy on physiological response and anxiety in perioperative ophthalmic patients: a systematic review

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Abstract

Purpose The purpose of this study is to evaluate the effectiveness of music therapy on physiological response and anxiety in perioperative ophthalmic patients. Furthermore, to explore the differentiation of intervention effects based on different intervention timing and music types.

Methods Five databases including PubMed, Embase, Web of Science, the Cochrane library and CINAHL were adopted for comprehensive search, from the inception of the database to October 2024. Reported according to the PRISMA 2020 statement. Methodological quality was assessed using Version 2 of the Cochrane tool for assessing risk of bias in randomized trial (Rob2). Revman manager 5.4 software was used for meta-analysis.

Results Nine studies (1331 patients) were included. The meta-analysis results showed that the intervention effect of the music intervention group was better than that of the control group, which had positive effects on lower systolic blood pressure (SBP) [mean difference (MD)=-5.86, 95% confidence interval (CI)=-7.97~-3.74, Z = 5.44, $p < 0.001$], lower diastolic blood pressure (DBP) (MD=-3.57, 95%CI=-6.80~-0.35, Z = 2.17, $p = 0.03$) and reducing anxiety [standard mean difference (SMD)=-0.80, 95%CI=-0.94~-0.66, Z = 11.2, $p < 0.001$)], but not statistically significant for heart rate/pulse rate (HR/PR) change (MD=-1.08, 95%CI=-2.29 ~ 0.12, Z = 1.77, $p = 0.08$). The subgroup analysis results showed that music intervention before surgery, as well as before and during surgery, could reduce the function of SBP and DBP (p-values all less than 0.05); All types of music have significance in reducing SBP (p-values all less than 0.001); Better intervention effect in binaural beats music (BBM) group than control group in decreasing HR/PR ($p = 0.01$) can be found; Regardless of the timing of intervention (preopertive, $p < 0.001$; intraoperative, $p = 0.008$; preoperative and intraoperative, $p < 0.001$) or the type of music (BBM, $p < 0.001$; other types of music, $p < 0.001$), music therapy has a significant effect on reducing patient perioperative anxiety compared to the control group.

Conclusion Overall, music therapy contributes to reducing both SBP and DBP, and anxiety level for perioperative ophthalmic patients. The intervention timing of preoperative, or both in preoperative and intraoperative, as well as music type of binaural beats, may have better effects on clinical indicators.

PROSPERO registration This systematic review was registered a priori with PROSPERO in September 22, 2023. PROSPERO registration number: CRD42023465797.

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Keywords Music, Blood pressure, Heart rate, Anxiety, Ophthalmic surgery, Perioperative

Introduction

With the rapid progress in population aging, the morbidity rate of multiple ophthalmic diseases has increased in the last decade, especially with various retinal disorders. Some unhealthy routine habits (strong light stimulation, long time use of electronic devices, etc.) have led to an increase in ophthalmic diseases, including myopia, glaucoma and dry eye disease. These diseases resulted in visual impaired or disorder greatly affects the daily function and quality of life of patients [1]. The vision-related symptoms of ophthalmic diseases could be devastating and lead to functional and occupational disabilities. As estimated, annual global productivity loss from vision impairment is approximately $410.7 billion purchasing power parity [2]. Visual impairment, especially in older patients, increases the care burden on both the healthcare system and society as a whole [3, 4]. Therefore, it is important to adopt effective therapeutic interventions as early as possible, in order to delay the blindness, disability and severe dysfunction of daily life caused by ophthalmic diseases, especially in low-income and middle-income countries.

In the current state, over 90% of patients with vision impairment have a preventable or treatable cause with existing highly cost-effective interventions [2]. Ophthalmic surgery is such an important clinical treatment that can effectively cure or alleviate the eye diseases. However, concerns about improving surgical treatment effectiveness, as well as perioperative patient experience and safety, have become increasingly prominent. The eyes are considered to be one of the most intricate organs within the human body, as they are directly exposed to the external environment and contain abundant sensory nerve endings. The patient exhibits a reflexive defensive reaction to close or direct operations of the eyes. For instance, tension and anxiety could manifest in physical symptoms, such as elevated blood pressure and HR, even stress-induced reactions like arrhythmia [5–7]. Certain preoperative preparations and remaining conscious during surgery while under local anesthesia may potentially exacerbate these stress reactions. This may serve as potential risk factors for patient safety during the perioperative period. The increased HR, respiratory rate, and blood pressure indirectly cause elevated intraocular pressure, further leading to the compression of the optic nerve, and disruption of visual signal transmission [8]. During injection of anesthesia, hypertension and HR greater than 85 beats per minutes may increase the risk of orbital hemorrhage and perioperative suprachoroidal expulsive hemorrhage [9]. The prior exposure to surgical anxiety and stress experience could result in patients delaying, refusing, or failing to comply with surgery as recommended, ultimately impacting the clinical outcomes and recovery of patients [10–13]. However, such adverse impacts have been largely overlooked within the realm of clinical practice.

From the perspective of humanistic care, in order to relieve the mental and physical stress experienced by patients during perioperative ophthalmic surgery, the complementary medicine therapies have been widely noticed and discussed. The most commonly used approaches include music therapy, aromatherapy and mindfulness therapy, etc [14–16]. Notably, music therapy has shown its unique advantages in cost economy, accessibility and flexibility, and has been widely used with markable value in the adjuvant treatment of many diseases [17, 18]. Previous studies have proven that music therapy is facilitate to improve patients' physiological stress response and relax the mind [16, 19, 20]. As a non-pharmaceutical intervention, music therapy has a positive effect on reducing pain and anxiety, enhancing patients' comfort and promoting recovery. However, in the field of perioperative ophthalmic surgery, the discussion about music therapy as a complementary medicine approach is still insufficient. Existing studies have reported various subjects and evaluation indicators, and the quality of evidences is limited [5, 16, 21]. Meanwhile, the method of music therapy is not specified. There is no explicit consensus on the type, rhythm, timing and effect of music therapy during perioperative ophthalmic surgery.

Randomized controlled trials (RCTs) are adept at addressing the impact of intervention factors on outcomes, thus mitigating selection bias and other potential sources of bias. The meta-analysis results of high-quality RCTs, together with internationally recognized RCTs results based on large sample, are listed as the highest level of evidence [22]. It provides a more realistic scientific basis for clinical practice and health decision-making. Based on this, this study conducted a systematic review and meta-analysis of high-quality parallel RCT studies, which focus on the effects of music therapy on physiological responses and anxiety in ophthalmic perioperative patients. The purpose of this study is to summarize the effectiveness of music therapy on physiological response and anxiety for perioperative ophthalmic patients. In addition, explore the differences in intervention effects based on different intervention times and music types, to contribute evidence basis for complementary therapy to improve the psychosomatic response in the clinical practice.

Methods

This systematic review was registered a priori with the International Prospective Register of Systematic Reviews (PROSPERO) in September 22, 2023 (PROSPERO registration number: CRD42023465797). This study was conducted and reported according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 statement [23].

Search strategy

We conducted a comprehensive search across 5 databases, including PubMed, Embase, Web of Science, the Cochrane library and CINAHL. The search timeframe extends from the inception of the database to October 2024. Furthermore, for the purpose of identifying additional pertinent research, we conducted a thorough examination of the reference lists cited in the selected studies. In consistent with the PICO principle, an approach of combination of MESH terms and free text words was used. The main search terms were described as 'Ophthalmology' or 'Eye Diseases', 'Music' or 'Music Intervention' or 'Music Therapy', 'Surgery' or 'Operative'. For each database, the corresponding search mode has been settled, and the search strategy was shown in Appendix 1.

Study selection

We imported all the retrieved literature into EndNote 20.0, and the literature was screened independently by two researchers (J.L. and W.C.), and the duplicate literature were eliminated. Under reviewing the title and abstract of the literature, the irrelevant studies were removed. Afterwards, two researchers conducted to read the full text and make a decision whether to include the study according to the inclusion and exclusion criteria. Differences between the two researchers during the literature screening process were resolved through discussion or negotiation with the third researcher (J.Y.).

The inclusion criteria of this study were as followed: (1) Parallel randomized controlled trial; (2) The subjects were ophthalmic perioperative patients with aged elder than 18 years; (3) In the experimental group, music intervention was used in the perioperative period of ophthalmic surgery; (4) The control group was blank control, routine nursing or other therapy; (5) Main outcome indicators included pre- and post-intervention changes in blood pressure, HR/PR or anxiety assessment (such as anxiety scores and anxiety levels). (6) The language was English.

Meanwhile, the exclusion criteria were as followed: (1) The literature type was research proposal or conference abstract; (2) Repeated publication; (3) The original full text unobtained; (4) The study population was patients who received only intravitreal injection. (5)The specific music therapy intervention without details. (6) Research bias is considered high risk.

Methodological quality assessment

The quality of all included literature was critically assessed by two independent researchers (J.L. and W.C.), under the guideline of the RoB2 [24]. The domains of RoB2 are as follows: (1) Domain 1 (D1), bias during randomization; (2) Domain 2 (D2), bias from established interventions; (3) Domain 3 (D3), bias from missing outcome data; (4) Domain 4 (D4), bias from outcome measurement; (5) Domain 5 (D5), bias from selective reporting of results. the risk of bias in each domain can be classified into three levels: "low risk of bias", "some concerns" and "high risk of bias". An internal initial communication was conducted when inconsistent occurred during the quality assessment process. If the agreement could not be reached, the third researcher (J.Y.) would involve and make a final decision. If any domain of an RCT was assessed as "high risk", then the overall bias risk is "high risk". We excluded the study with high overall risk.

Data extraction

Literature data were extracted from the full text by two independent researchers (J.L. and W.C.), using a unified and standardized tool, including key information as author, publication year, study design, region, sample size, surgical method, gender of subjects, age of subjects, intervention start time, intervention duration, intervention method, outcome indicators, intervention effect, etc. When the extracted information is inconsistent, the final document extraction content is determined through negotiation.

Statistical analysis

The studies were grouped according to the outcome indicators of the included studies. The Review Manager (RevMan) Version 5.4 software was used for meta-analysis. MD or SMD was used to represent the effect size, and to present the result as a point estimate and 95% CI. The Chi-square tests were used to estimate heterogeneity. When $p \geq 0.1$ and $I^2 < 50\%$, homogeneity was assumed to be exist, and the fixed-effect model was used to calculate the effect size. Otherwise, when $p < 0.1$ and $I^2 \geq 50\%$, heterogeneity was considered and the random effects model was used. The publication bias was tested by funnel plot.

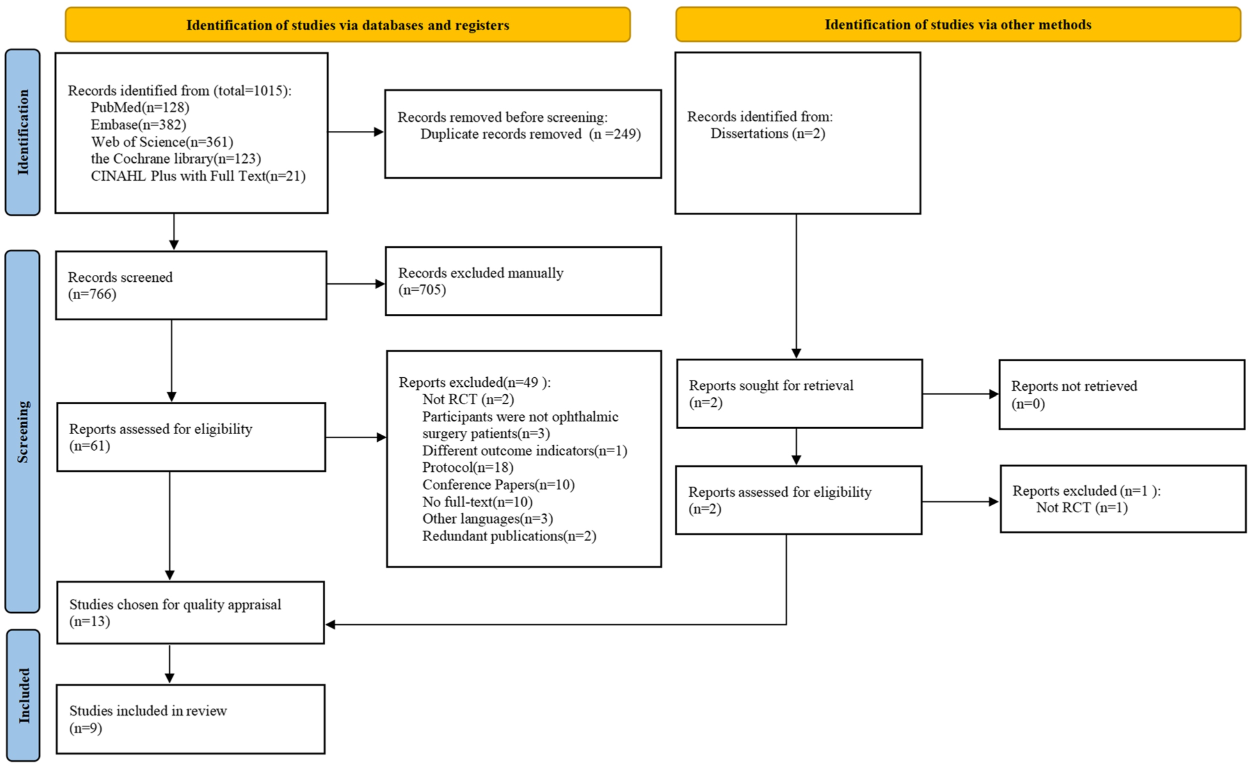

Fig. 1 Flow diagram of study searching and selection

Results

Selection results

The flow diagram of the study selection process was based on PRISMA (Fig. 1). We have identified total 1015 articles in the databases and one dissertation via other methods, and then removing of 249 duplicates. After an independent review of titles and abstracts, 705 irrelated articles were removed and 49 records were excluded for failing to meet the inclusion criteria. 13 studies were chosen for quality appraisal and then excluded four study due to the poor quality. A total of nine RCTs were included in the final review [21, 25–32]. The main characteristics of these eligible studies were extracted and summarized (Table 1).

Intervention and outcome characteristics

In our study, as interested in the characteristics of intervention, we conducted review by intervention timing, music types, application of sedatives, as well as the outcome evaluated for each study (Table 2). When included in the meta-analysis, we considered the music groups as the intervention group and the no music/operating room noise groups as the control group.

Risk of bias

Generally, the quality of studies included in RCTs was good from a data and design integrity perspective (Fig. 2). The methods of random sequence generation, concealment, and blinding in RCTs were less detailed reported. In light of the nature of music interventions, blinding researchers was difficult. Some studies were concerned because of the possibility of missing data. But the missingness may not depend so much on its true value. No bias on other items was found. Finally, four studies were eliminated due to high risk during the randomisation process [33–36]. More details about the risk assessment were shown in additional file 2.

Outcomes of meta-analysis

Effects of music therapy on physiological response and anxiety in all group

For all nine included studies, involving a total of 1332 patients. Seven studies reported the SBP change and DBP change [21, 25–27, 29, 31, 32], eight studies reported the HR/PR change [21, 25–27, 29–32], and six studies reported the anxiety change [21, 27–31]. Overall, based on the results of the meta-analysis, the music intervention group had better intervention effects than the control group, which had positive effects on lower SBP (MD=−5.86, 95%CI=−7.97~−3.74, Z=5.44, $p<0.001$, $I^2=0\%$), lower DBP (MD=−3.57, 95%CI=−6.80~−0.35, Z=2.17, $p=0.03$, $I^2=86\%$) and reducing anxiety (SMD=−0.80, 95%CI=−0.94~−0.66, Z=11.2,

Table 1 Characteristics of the included studies

Author (year)	Study design	Country	Sample size	Type of surgery	Mean age (Mean ± SD)	Gender (Male/Female)
Allen (2001) [25]	RCT	America	IG: 20 CG: 20	cataract extraction, glaucoma surgery	IG: 74 (SD not reported) CG: 77 (SD not reported)	IG: 5/15 CG: 5/15
Cruise (1997) [28]	RCT	Canada	IG: 32 CG: 89	cataract extraction	IG: 70.8 ± 2.0 CG: 70.1 ± 3.4	IG: 8/24 CG: 36/53
Guerrier (2020) [29]	RCT	France	IG: 154 CG: 155	cataract surgery	IG: 68.5 ± 11.2 CG: 69.2 ± 10.8	IG: 71/83 CG: 62/93
Guerrier (2021) [30]	RCT	France	IG: 119 CG: 124	cataract extraction	IG: 67.3 ± 10.4 CG: 68.5 ± 11.2	IG: 56/63 CG: 59/65
Loong (2022) [31]	RCT	Malaysia	IG: 31 CG: 30	phacoemulsification with intraocular lens implantation	IG: 67.7 ± 9.0 CG: 63.9 ± 6.2	IG: 14/17 CG: 29/11
Muddana (2021) [32]	RCT	Inida	IG: 165 CG: 165	phacoemulsification	IG: 57.8 ± 7.72 CG: 58.79 ± 7.57	IG: 75/90 CG: 83/82
Musa (2022) [26]	RCT	Malaysia	IG: 46 CG: 46	cataract surgery	IG: 69.04 ± 8.086 CG: 67.70 ± 7.760	IG: 25/21 CG: 20/26
Roshani (2019) [27]	RCT	Iran	IG: 30 CG: 30	ophthalmic ambulatory surgery	IG: 57.46 ± 4.26 CG: 57.56 ± 6.03	IG: 16/14 CG: 13/17
Wiwatwongwana (2016) [21]	RCT	Thailand	IC: 88 CG: 47	phacoemulsification with intraocular lens implantation	IG: 67.7 ± 8.0 CG: 69.0 ± 10.0	IG: 53/35 CG: 23/24

IG intervention group, *CG* control group, *NR* not reported

$p<0.001$, $I^2=11\%$), but not statistically significant for HR/PR change (MD=−1.08, 95%CI=−2.29 ~ 0.12, Z = 1.77, $p=0.08$, $I^2=43\%$) (Fig. 3).

Subgroup analysis

Effect on SBP Seven articles reported the effect of music therapy on SBP in patients undergoing different period of perioperative ophthalmic surgery, and involved different types of music [21, 25–27, 29, 31, 32]. Heterogeneity test results revealed that the existence of homogeneity ($I^2=0\%$, $p>0.1$), and fixed effect model was used for analysis. There was a better intervention effect in music group than control group, with the intervention timing for: (1) preoperative stage (MD=−5.00, 95%CI=−9.02~−0.98, Z = 2.44, $p=0.01$); (2)preoperative and intraoperative stage (MD=−6.75, 95%CI=−9.37~−4.13, Z = 5.05, $p<0.001$). While there was no significant difference during the intraoperative stage (MD=−1.36, 95%CI=−9.00 ~ 6.28, Z = 0.35, $p=0.73$). Regardless of the music types, intervention group showed more significance in lowering SBP, whether using BBM (MD=−8.99, 95%CI=−13.81~−4.18, Z = 3.66, $p<0.001$) or other types of music (MD=−5.37, 95%CI=−7.63~−3.11, Z = 4.66, $p<0.001$). As shown in Fig. 4.

Effect on DBP Seven articles reported the intervention effect of music therapy on DBP in patients under different intervention timing and different music types [21, 25–27, 29, 31, 32]. Heterogeneity test results indicated that both heterogeneity exists ($I^2=86\%$, $p<0.001$, $I^2=85\%$, $p<0.001$), thus the random effects models were used for meta-analysis. There was a better intervention effect in music group than control group, with the intervention timing for: (1)preoperative stage (MD=−11.00, 95%CI=−13.70~−8.30, Z = 7.98, $p<0.001$); (2)preoperative and intraoperative stage (MD=−2.42, 95%CI=−4.71~−0.13, Z = 2.07, $p=0.04$). While there was no significant difference during the intraoperative stage (MD=−0.96, 95%CI=−5.62 ~ 3.70, Z = 0.40, $p=0.69$). And the difference was no statistically significant for different music types, both in BBM (MD=−1,76, 95%CI=−5.34 ~ 1.82, Z = 0.96, $p=0.34$) and other types of music (MD=−3.51, 95%CI=−7.74 ~ 0.71, Z = 1.63, $p=0.10$). As shown in Fig. 5.

Effect on HR/PR Eight literatures reported the intervention effect of music therapy on HR/PR in patients undergoing different period of perioperative ophthalmic surgery and different music types [21, 25–27, 29–32]. Random effect models were used for analysis due to the existence of heterogeneity. The results of meta-analysis showed that there was no statistical significance in the intervention effect between the music intervention group and the control group under different intervention timing: (1) preoperative stage (MD=−0.31, 95%CI=−2.04 ~ 1.42, Z = 0.36, $p=0.72$); (2)intraoperative stage (MD = 0.72, 95%CI=−4.87 ~ 6.31, Z = 0.25, $p=0.80$); (3) preoperative and intraoperative stage (MD=−2.86, 95%CI=−5.81 ~ 0.10, Z = 1.89, $p=0.06$).

Table 2 Intervention and outcome characteristics of the included studies

Author (year)	Intervention of music type		Intervention timing	Duration	Follow-up time	Outcomes and measurement	Application of Sedatives	Conclusions
	Experimental group	Control group						
Allen (2001) [25]	Soft hits, classical guitar, chamber music, folk music, and popular singers from the 1940s and 1950s	No music	①②③	NR	①; Every 5 min	①②; Perceived stress; Coping levels	Midazolam hydrochloride; Alfentanil hydrochloride	Self-selected perioperative music can ameliorate clinical hypertension response.
Cruise (1997) [28]	Relaxing Music: Classical music accomparileed by soothing sounds of nature	Relaxing suggestions/ white noise/ operating room noise	②	NR	①③; At 15 min intervals	①②③⑥	Intravenous fentanyl or alfentanil and midazolam	Relaxing music can improve the satisfaction of the elderly patients undergoing cataract surgery.
Guerrier (2020) [29]	Music according to patient's preferences	Headphones with no music	①	20 min	①③; Before and after the music intervention	①②④; Hypertensive event	Oral midazolam for patients with anxiety before surgery; Selective injection of midazolam during surgery	Personalized music intervention before cataract surgery may be considered to lower anxiety levels and hypertension.
Guerrier (2021) [30]	Music according to patient's preferences	Headphones with no music	①	20 min	②③; Before and after music intervention; One week after surgery	②③⑤	Oral midazolam preoperative	Music intervention was effective in reducing anxiety level and self-reported pain both during surgery and in the early postoperative period.
Loong (2022) [31]	BBM	Earphones with no music	①②	NR	①②③	①②③⑤	None	BBM decreases operative pain, anxiety and the tachycardic response to stress in cataract surgery.
Muddana (2021) [32]	Relaxing classical instrumental or devotional music	Headphones with no music	①②	NR	①③; After initiation of capsulorhexis, and after implantation of the intraocular lens; After initiation of the capsulorhexis	①②④⑥; Follow verbal instructions	NR	Exposure to music before, during, and after surgery significantly reduced self-reported anxiety and lowered postoperative blood pressure
Musa (2022) [26]	A piano music (rhythm of < 70 beats/min, volume of ≤ 60 dB)	No music	②	NR	During administering local anesthesia; At first incision; During sculpting or at first phacoemulsification power used in cases of phaco-chop; During wound hydration	①②④; SAA	NR	A slow tempo music during cataract surgery was shown to significantly reduce several indicators for anxiety.
Roshani (2019) [27]	BBM	No music	①②	NR	①③; Before intervention; every five minutes during intervention and immediately and 30 min after intervention	①②③⑤⑥; Hemodynamic changes; Patient satisfaction; Surgeon satisfaction	Fentanyl injection; Midazolam and propofol injection if required in control group	BBM is effective in reducing anxiety and pain, controlling hemodynamic changes, and increasing patient satisfaction.

Table 2 (continued)

Author (year)	Intervention of music type		Intervention timing	Duration	Follow-up time	Outcomes and measurement	Application of Sedatives	Conclusions
	Experimental group	Control group						
Wiwatwongwana (2016) [21]	BBM/ a plain music	Earphones with no music	①②	> 30 min	①②③	①②③; Operative time	NR	Music both with and without binaural beat, was proven to decrease anxiety level and lower SBP.

Sequence number in intervention timing and follow-up time: ①The preoperative period; ②The intraoperative period; ③The postoperative period

Sequence number in outcomes and measurement: ①BP; ②HR or PR; ③Anxiety score; ④Anxiety level; ⑤Pain; ⑥Respiratory rate

NR not reported, *BBM* the binaural beats music

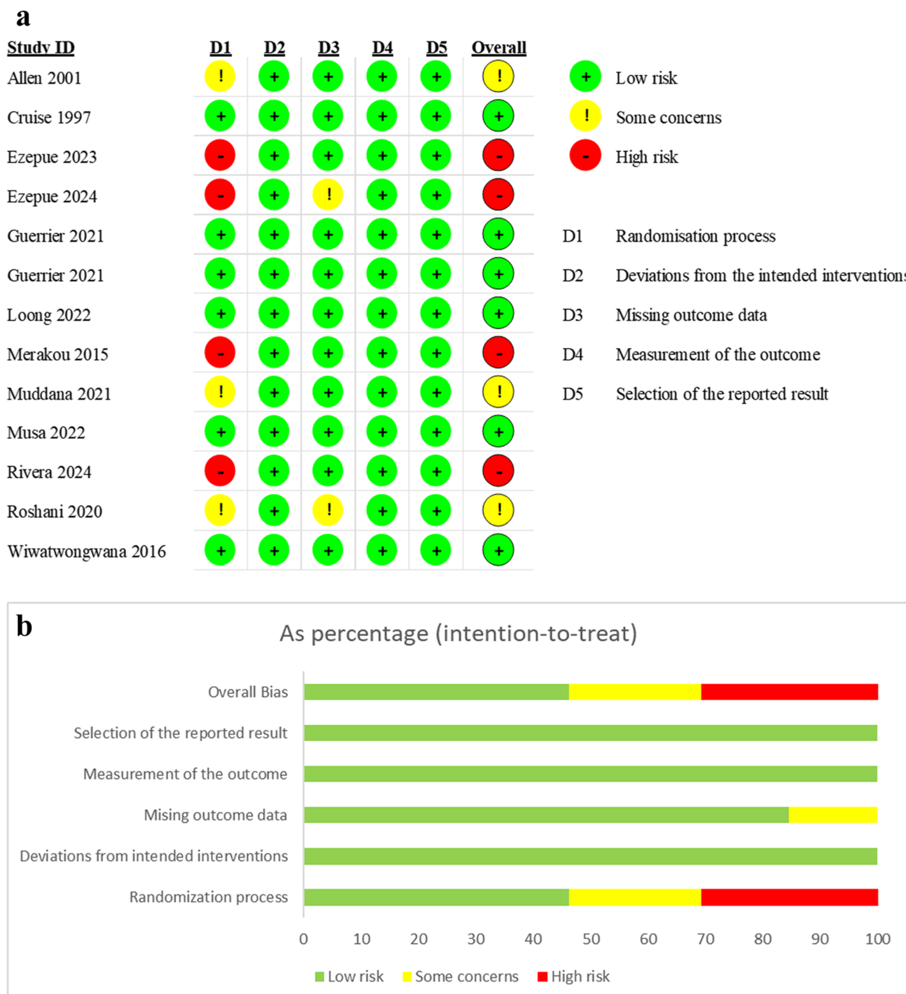

Fig. 2 **a** Results of bias risk assessments. **b** Proportion of bias risk

For the decrease in HR/PR, BBM intervention shows significant (MD=−4.75, 95%CI=−8.55~−0.94, Z=2.45, p=0.01) while other types of music not (MD=−0.57, 95%CI=−1.83 ~ 0.70, Z=0.88, p=0.38), compared with control group. As shown in Fig. 6.

Effect on anxiety Six articles reported the effect of music therapy on anxiety in patients undergoing different period of perioperative ophthalmic surgery and different types of music [21, 27–31]. Heterogeneity test results indicated the existence of homogeneity (I^2=11%, p=0.34, I^2=38%, p=0.14), and the fixed-effect model were used for meta-analysis. There was a better intervention effect in music group than control group for all intervention timing: (1)preoperative stage (MD=−0.73, 95%CI=−0.90~−0.56, Z=8.29, p < 0.001); (2)intraoperative stage (MD=−0.69, 95%CI=−1.21~−0.18, Z=2.64, p=0.008); (3)preoperative and intraoperative stage (MD=−0.98, 95%CI=−1.25~−0.72, Z=7.24, p < 0.001). Regardless of the music types, whether using BBM (SMD=−1.07, 95%CI=−1.36~−0.78, Z=7.23, p < 0.001) or other types of music (MD=−0.75, 95%CI=−0.90~−0.59, Z=9.56, p < 0.001) showed more significance in intervention group. As shown in Fig. 7.

Publication biases analysis

Due to the inclusion of only 9 articles (< 10 articles) in this study, the sensitivity of publication bias detection was low. Funnel plots for SBP, DBP, HR/PR and anxiety were shown in additional file 3.

Discussion

The utilization of the complementary medicine therapies in ophthalmic surgery has garnered increasing attention, particularly concerning its impact on patients' surgical experiences and postoperative recovery. This study presents a systematic review and

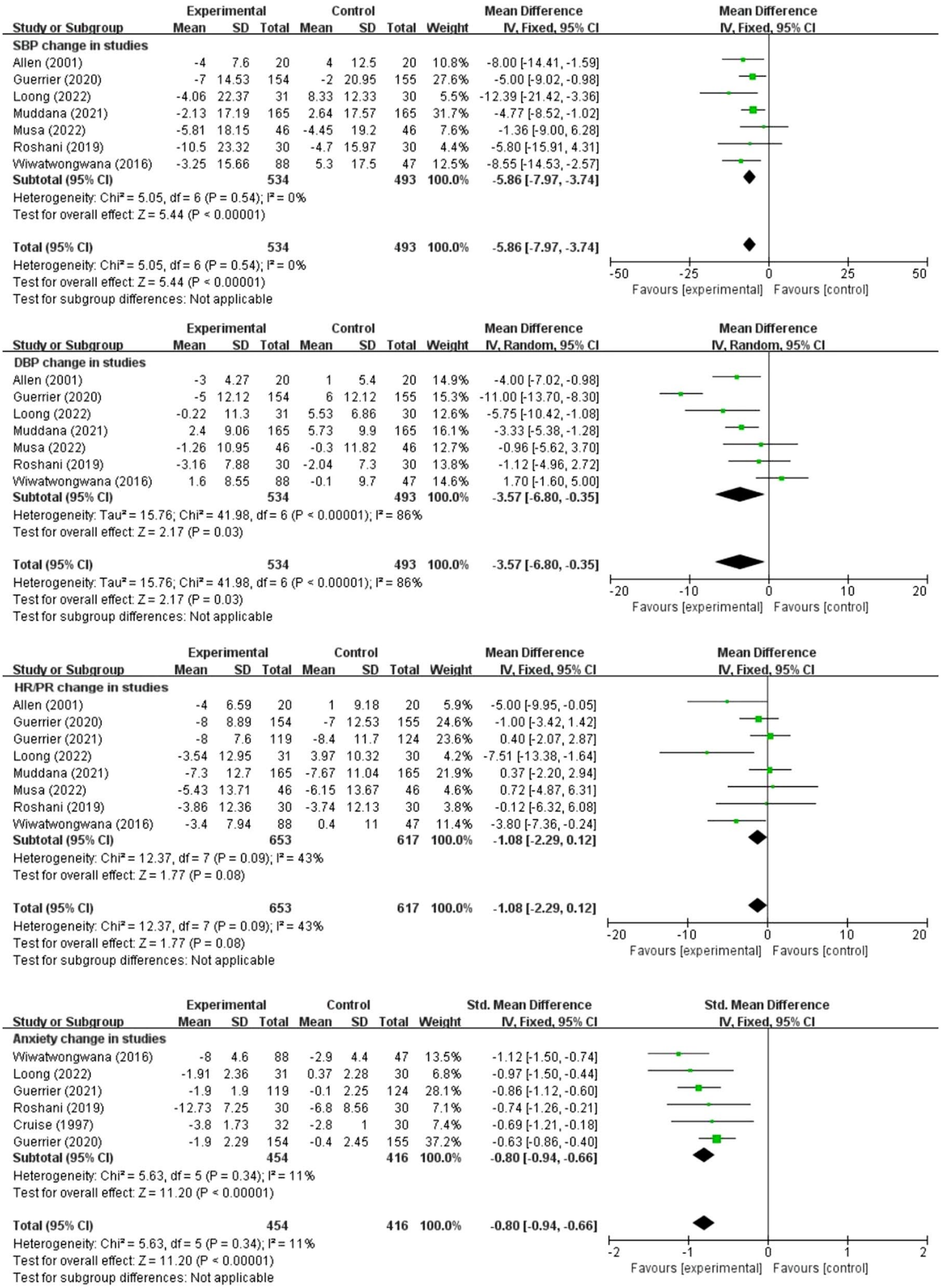

Fig. 3 Forest plot for physiological response and anxiety change under music intervention

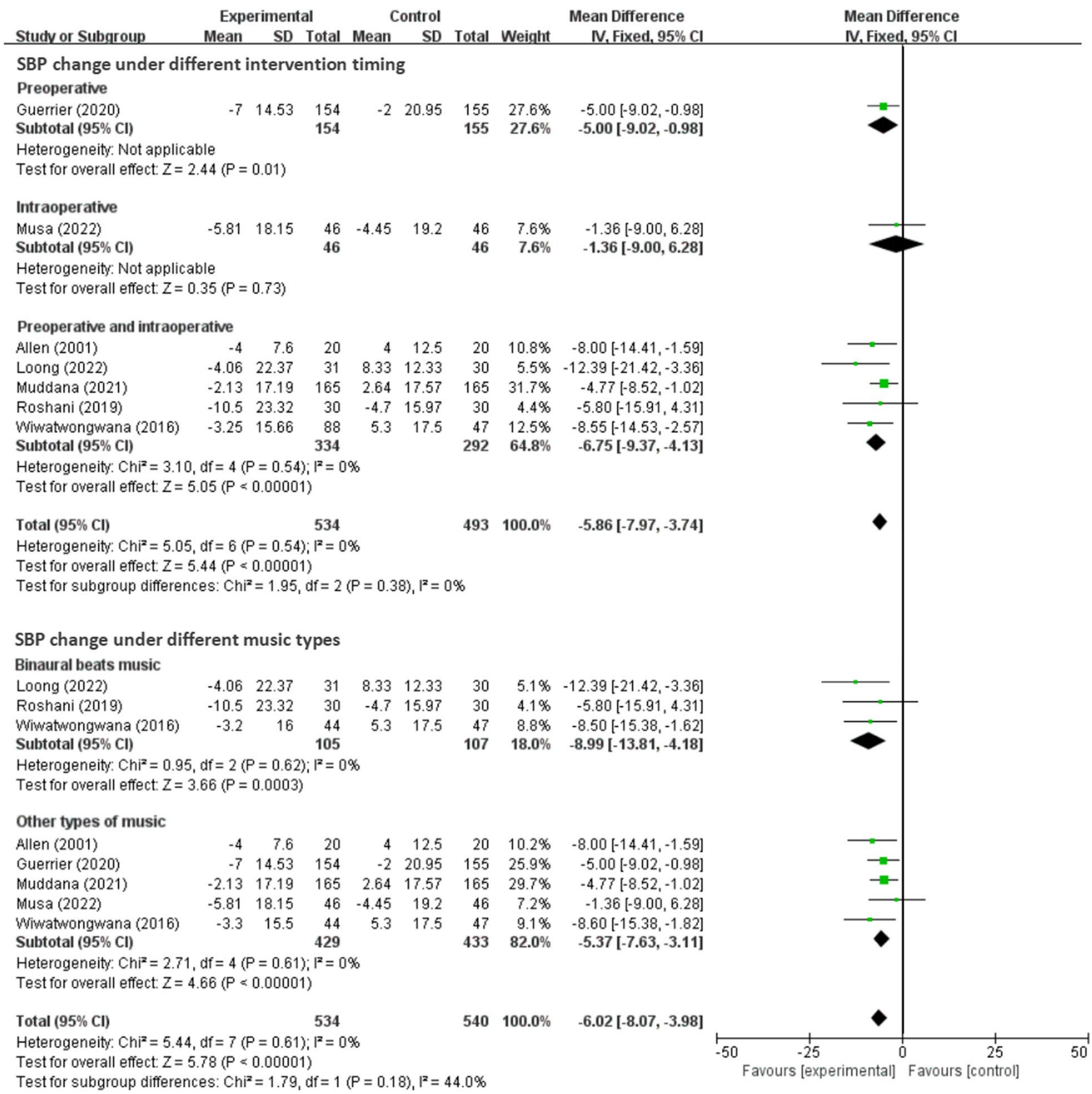

Fig. 4 Forest plot for SBP change under different intervention timing and different music types

meta-analysis of high-quality RCTs of the music therapy for patients undergoing ophthalmic surgery. We also explored the outcomes of two critical subgroups: the timing of intervention and the type of music employed. Our findings contribute to the existing practical evidence on the application of music therapy in perioperative ophthalmic patients. Overall, music therapy demonstrated significant positive effects on both physical and mental health outcomes in the perioperative ophthalmic period, in terms of reducing SBP, DBP, and anxiety. For anxiety, there were obvious improvement effects regardless of the intervention timing and type of music.

Numerous studies have demonstrated that music can positively influence various physiological markers, such as blood pressure, HR, pain perception, and cortisol levels, thereby contributing to overall health improvement [37–39]. Additionally, some studies indicate that music therapy is primarily effective in reducing SBP, with less pronounced effects on DBP [19]. The results

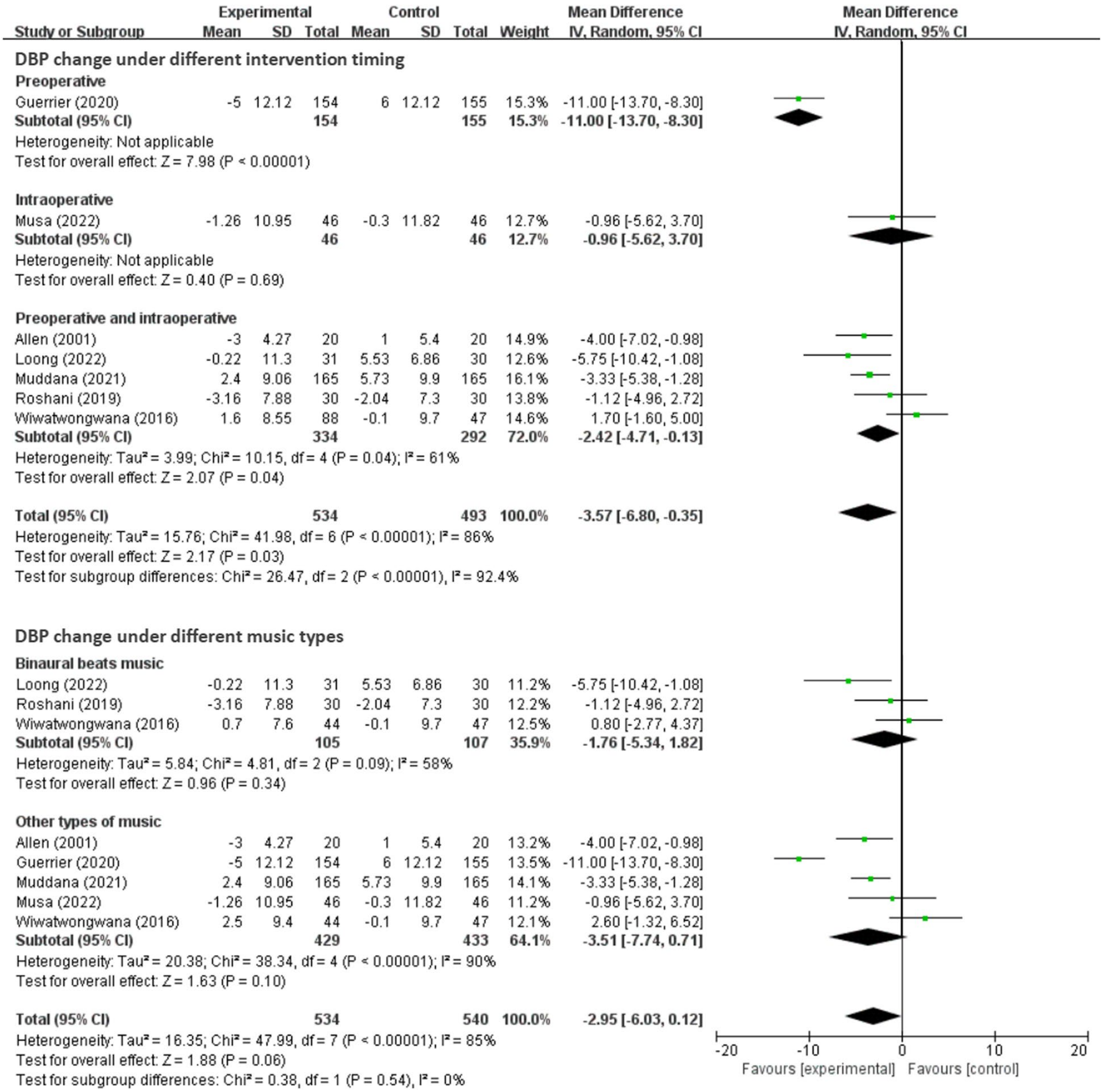

Fig. 5 Forest plot for DBP change under different intervention timing and different music types

of our research were similar to these findings, particularly highlighting a significant reduction in SBP. In this meta-analysis, we also found that music therapy is effective to relieve physiological response in perioperative ophthalmic patients. In our study, compared with the control group, the music intervention group had a mean reduction of 5.83mmHg in SBP and 3.67mmHg in DBP. It may provide good clinical significance, especially for patients whose blood pressure levels may exceed the safe range of ophthalmic surgery. Music intervention for cataract surgery can reduce anxiety related hypertension event and reduce the need for sedatives in patients during the surgery [29]. In addition, combined with other complementary therapies, music therapy may result in excellent anti-hypertensive effect.

It is also essential to acknowledge that the impact of music on HR remains less clearly defined. And in our study, the effect of different types of music on HR almost reached the threshold of statistical significance. At the same time, not all types of music showed significant effects on HR, which might be attributed to the

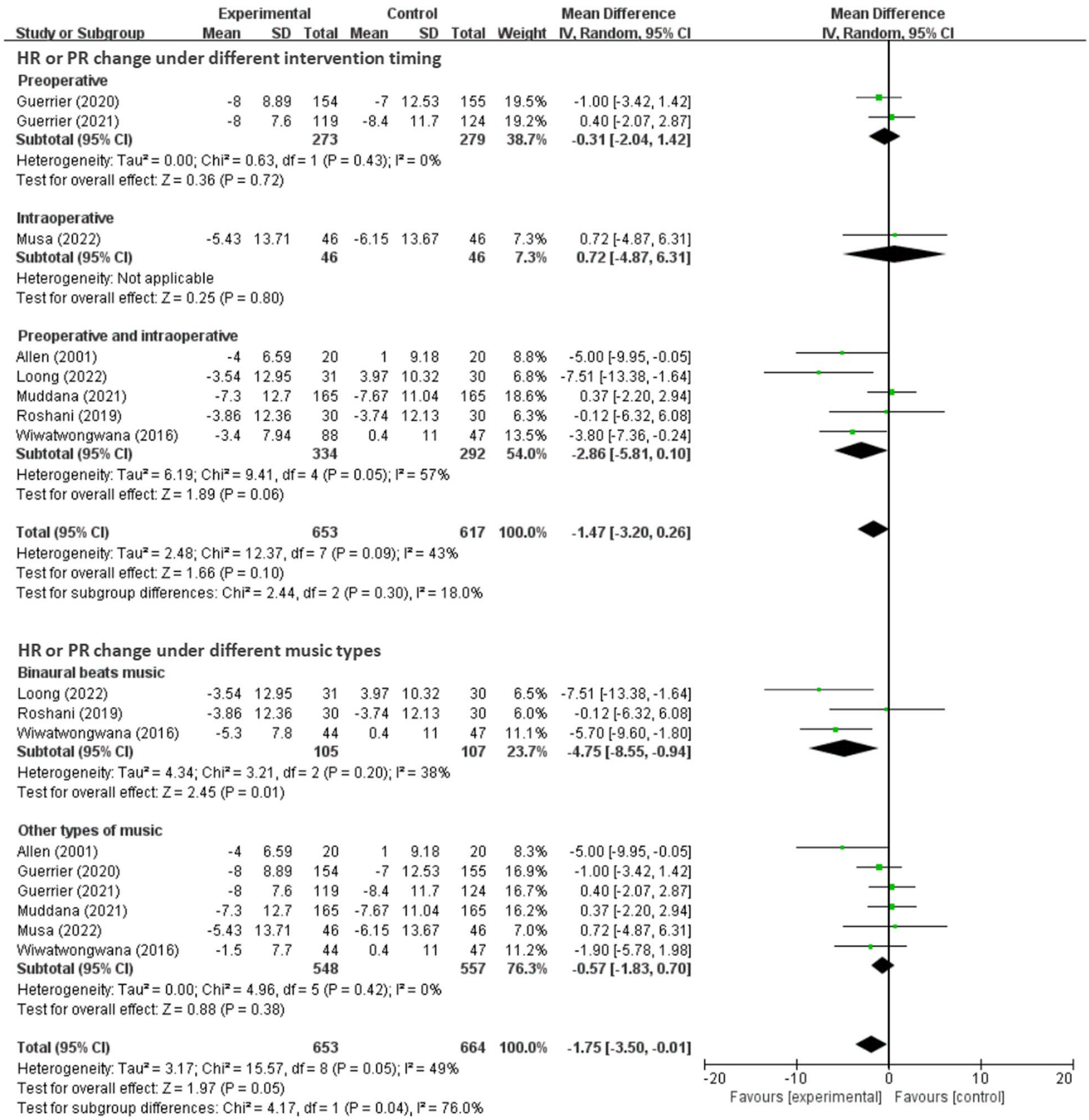

Fig. 6 Forest plot for HR/PR change under different intervention timing and different music types

specific rhythmic characteristics of the music. Binaural beats offer an external rhythmic stimulus that creates synchronized pulse frequencies through an auditory illusion [40]. Literature indicated that music embedded with binaural rhythms was associated with a diminished sympathetic response and an enhanced parasympathetic response in the cardiovascular system [41]. Although the repetitive and artificial sounds of binaural beats might elicit anxiety and discomfort when experienced in isolation, their integration with other auditory stimuli could facilitate anxiety reduction [42, 43]. In another study, statistically significant differences were found in resting, fast music, and slow music HR, SBP, and DBP [20]. One interesting thing is that, one study focused on patients' self-selected music without comparing the effects of different types of music on physiological responses [25]. Primarily because previous research supported the importance of self-choice,

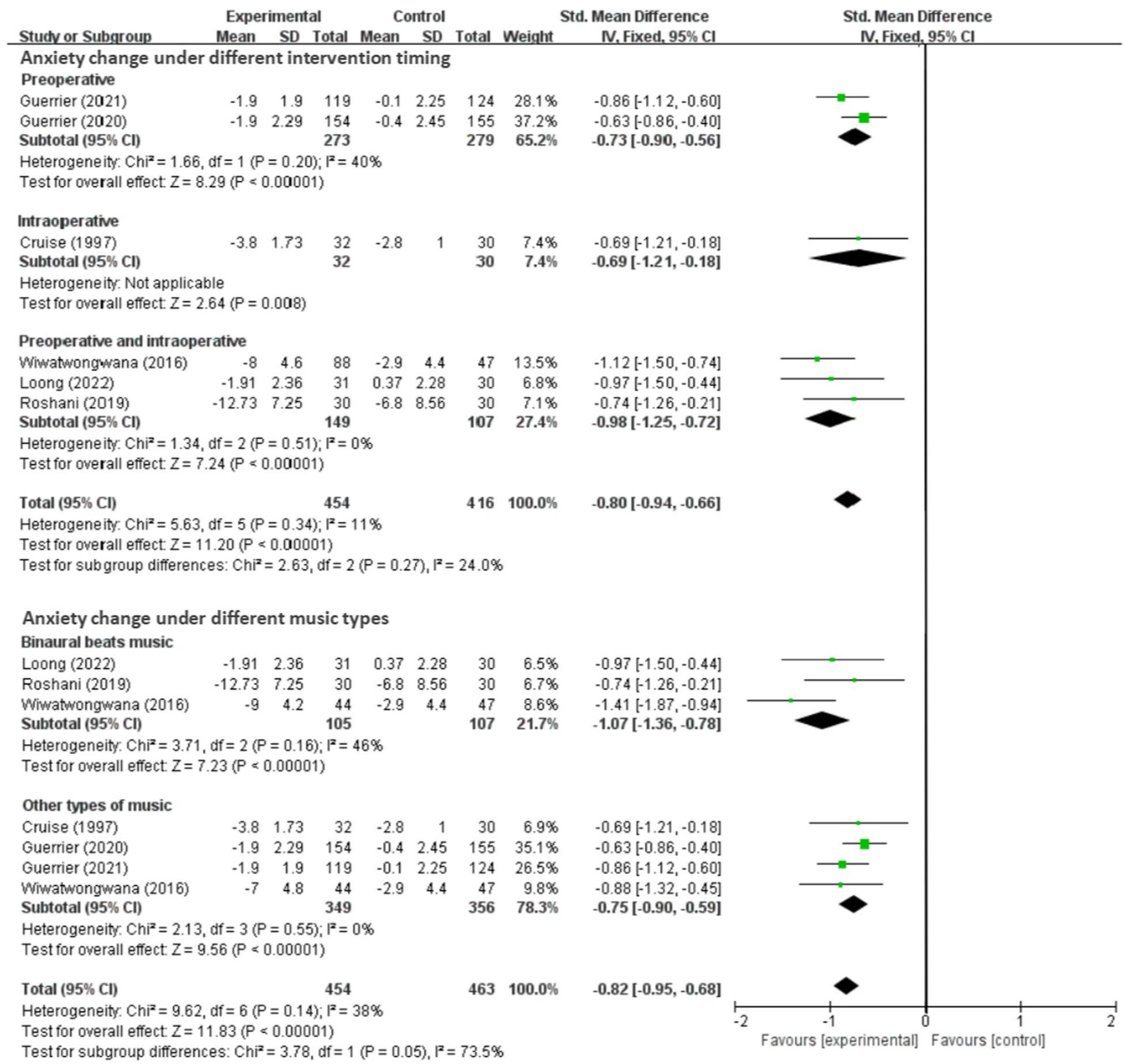

Fig. 7 Forest plot for anxiety change under different intervention timing and under different music types

patient control over music choice was more predictive of physiological responses than the type of music itself, and allowing patients to choose their preferred type of music was more practical and operative than forcing a specific type of music to be played in a clinical setting [25]. However, the difference in heart rate changes between the intervention group and the control group was relatively small. It is still remained uncertainty regarding the clinical application significance.

In all group and subgroup analysis, music therapy demonstrated efficacy in alleviating anxiety symptoms. Specifically, music serves as a cognitive distraction, redirecting patients' attention away from surgery-related fears and anxieties, which subsequently mitigates stress and pain while improving overall anxiety levels through nerve regulation mechanisms [44]. The application of music therapy in ophthalmic surgery patients has shown good clinical value.

Although we have conducted rigorous literature screening, heterogeneity in the included studies is still inevitable, which may be related to the diversity of interventions and the timing of outcome indicators evaluation, as shown in Table 2. We therefore performed a subgroup analysis to explore what intervention features led to the more significant effects. The heterogeneity may come from the following aspects. Firstly, as mentioned before, different types of music are expected to have well effects in anxiety reduction. Three studies used BBM, while it is difficult to classify other types of music. So, there may be heterogeneity when merging effect quantities. Secondly, the measurement of outcome indicators varies. The patient's vital signs will constantly fluctuate with the progression of the perioperative period. Therefore, when analyzing the effectiveness of music therapy, we try to choose indicators from the same time period for comparison. In the group where music was played both before and during surgery, the majority of studies reported indicator values at the beginning and end of the surgery. But some literature only reported intraoperative values. For the evaluation of anxiety, different evaluation tools were used within the same study or between different studies. To minimize heterogeneity, we chose the SMD approach. In addition, the application of sedative drugs in research varies. Sedatives are used in all patients, in certain specific situations, or not at all. These affects the outcome measures, which providing heterogeneity.

Although our study was conducted strictly, there were some limitations. First, when taking the assessment of quality, we carefully reviewed all literature that could be included. But some studies did not report in detail, such as the randomization method or the blind method, which will affect the reliability of the results. Secondly, the total sample size was small. While its appearance that some groups had fewer samples when conducting subgroup analysis. Moreover, several studies only present partial indicators relevant to our research.

This study has some implication in clinical. We found some application for RCTs related to music therapy in ophthalmic surgery patients when searching. We believe that it's still a topic worth exploring. In the future research, larger RCTs employing a blind design should be conducted, to further substantiate the efficacy of music therapy. On the other hand, it will provide more accurate indicators for evaluating the effectiveness of adjuvant therapy to pay attention to the fluctuations in physiological indicators. In addition, it is encouraged to explore the potential effects of music therapy in combination with other non-pharmacological interventions, as well as their impact on patients' postoperative recovery both in physiological and psychological, such as postoperative pain and duration required of stay.

Conclusion

In conclusion, music therapy is a safe, effective, and cost-effective non-pharmacological intervention of the complementary medicine. The intervention timing of preoperative, or both in preoperative and intraoperative, as well as music type of binaural beats, may have better effects on clinical indicators. Furthermore, aside from providing practical clinical treatment value, it also enhances medical humanistic care. More high-quality studies are needed in the future to further validate and optimize the use of music therapy, and to explore its use in combination with other non-pharmacological interventions.

Abbreviations

CI	Confidence interval
DBP	Diastolic blood pressure
HR	Heart rate
MD	Mean difference
NRS	Numeric Rating Scale
PR	Pulse rate
RCTs	Randomized controlled trials
SAS	Self-assessment Anxiety Scale
SBP	Systolic blood pressure
SMD	Standard mean difference
STAI	State-Trait Anxiety Inventory
VAS	Visual Analog Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12906-025-04815-z.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Acknowledgements
None.

Authors' contributions
J.H., J.L. and J.Y. conducted research design. J.L., W.C., J.Y. screened literature. J.Y., J.W. and J.L. analyzed data. All authors participated in writing the manuscript. J.H. revised the manuscript. J.Y. and J.L. contributed equally to this work and should be considered co-first authors.

Funding
None.

Data availability
The study data are included in the manuscript. Other information can be obtained from the corresponding author.

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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Received: 3 September 2024 Accepted: 6 February 2025
Published online: 22 February 2025

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