



Effectiveness of Non-pharmacological Interventions for Reducing Anxiety in Endoscopy and Colonoscopy Procedures: A Systematic Review and Network Meta-Analysis

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Abstract

Background Anxiety is a common concern among patients undergoing endoscopic procedures, affecting up to 70% of individuals. Increased anxiety can heighten pain perception, reduce procedural tolerance, and negatively impact patient satisfaction. Non-pharmacological interventions, such as music therapy, virtual reality, aromatherapy, relaxation techniques, and others, have been explored as alternatives to pharmacological anxiolytics. This systematic review and network meta-analysis (NMA) provides an evaluation of these interventions in reducing anxiety and their impact on secondary outcomes, including pain, patient satisfaction, and procedure duration.

Methods Following PRISMA guidelines, we systematically searched seven databases for randomized controlled trials (RCTs) evaluating non-pharmacological interventions for anxiety reduction in endoscopy and colonoscopy. A network meta-analysis was conducted using a random-effects model to compare intervention effectiveness, with standardized mean differences (SMDs) and 95% confidence intervals (CIs) calculated. Surface under the cumulative ranking (SUCRA) probabilities determined the rank order of interventions. Subgroup analyses were performed by type of procedure (upper vs. lower endoscopy) and sedation status.

Results A total of 48 RCTs comprising 6014 participants and evaluating 12 non-pharmacological interventions were included. In the network meta-analysis (NMA) for anxiety, Reiki (SMD = − 1.51, 95% CI − 3.01 to − 0.01, $p = 0.04$), aromatherapy (SMD = − 1.31, 95% CI − 2.47 to − 0.14, $p = 0.02$), and music therapy (SMD = − 1.09, 95% CI − 1.50 to − 0.67, $p < 0.01$) significantly reduced anxiety compared to standard care. These interventions also ranked highest in terms of SUCRA values Reiki (0.77), aromatherapy (0.73), and music therapy (0.67). The NMA for secondary outcomes showed that music therapy significantly improved patient satisfaction (SMD = 2.21, 95% CI 1.20 to 3.22, $p < 0.01$), while no intervention had a statistically significant impact on pain or procedure duration. Subgroup analyses showed that music therapy was most consistent in lower endoscopic and sedated procedures, while aromatherapy and Reiki demonstrated stronger effects in upper and non-sedated procedures.

Conclusion Music therapy demonstrated the strongest evidence for anxiety reduction, with potential benefits for patient satisfaction. Reiki and aromatherapy also ranked highly, though their significance varied. No intervention significantly influenced pain or procedure duration. Subgroup analyses suggested that effectiveness may vary by procedure type and sedation status, underscoring the importance of tailoring interventions to clinical context. Future research should prioritize direct intervention trials with standardized methodologies to enhance the robustness of findings and establish causal relationships.

Keywords Non-pharmacological interventions · Endoscopy · Colonoscopy · Music · Anxiety · Pain

Abbreviations

CI	Confidence Interval
CNKI	China National Knowledge Infrastructure
CSI	Corticosteroid Injection
DASS-21	Depression Anxiety Stress Scales-21
DBP	Diastolic Blood Pressure
FLACC	Face, Legs, Activity, Cry, Consolability Scale
I2	I-squared statistic (Heterogeneity measure)
MD	Mean Difference
NMA	Network Meta-Analysis
NRS	Numerical Rating Scale
OR	Odds Ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRO-STEP	Patient-Reported Scale for Tolerability of Endoscopic Procedures
PROSPERO	International Prospective Register of Systematic Reviews
PSSI	Patient Satisfaction with Sedation Instrument
RCT	Randomized Controlled Trial
REML	Restricted Maximum Likelihood
RR	Relative Risk
SAS	Zung Self-Rating Anxiety Scale
SBP	Systolic Blood Pressure
SD	Standard Deviation
SMD	Standardized Mean Difference
STAI	Spielberger State-Trait Anxiety Inventory
SUCRA	Surface Under the Cumulative Ranking Curve
VAS	Visual Analog Scale
WBFRS	Wong-Baker FACES Pain Rating Scale

Introduction

Anxiety is a state of heightened fear and worry that frequently occurs among patients undergoing endoscopy and colonoscopy, with up to 70% of individuals experiencing it before these procedures [1]. These essential diagnostic and therapeutic tools for managing gastrointestinal diseases frequently provoke apprehension, discomfort, and fear. Anxiety in this context increases the perception of pain and distress, negatively affecting physiological responses, patient cooperation, and procedural tolerability [2, 3]. Addressing procedural anxiety not only reduces discomfort but also aligns with global initiatives like patient-centered care, aimed at enhancing patient satisfaction, improving healthcare experiences, and optimizing overall outcomes. Pharmacological options, such as benzodiazepines or selective serotonin reuptake inhibitors (SSRIs), are used to manage procedural anxiety. However, these medications have limitations, including a

30–60-min onset for benzodiazepines and weeks for SSRIs, along with medication-related side effects. Importantly, the failure to address psychological aspects highlights the increasing need to incorporate non-pharmacological interventions. Methods like music therapy, guided imagery, aromatherapy, relaxation techniques, mindfulness, and virtual reality have surfaced as effective alternatives [4–6]. Smaller-scale reviews and pilot studies have suggested that methods leveraging sensory distraction, emotional modulation, and relaxation can significantly reduce anxiety and improve patient experiences [5, 7]. For instance, music therapy has shown effectiveness in lowering cortisol levels, and virtual reality offers immersive distractions to alleviate stress [4, 8].

The comparative effectiveness of these non-pharmacological interventions remains understudied. Current randomized controlled trials (RCTs) typically assess individual techniques without direct or indirect comparisons to standard care, placebo, or alternative interventions [9]. Additionally, secondary outcomes like patient satisfaction, measured by tools such as the Patient Satisfaction Instrument [10], and procedure tolerability, assessed by tools like the Patient-Reported Scale for Tolerability of Endoscopic Procedures (PRO-STEP) [11], are reported inconsistently. This gap highlights the need for systematic and meta-analytic methods to assess these interventions [2]. This systematic review and meta-analysis evaluate the effectiveness of non-pharmacological interventions in lowering anxiety in patients undergoing endoscopy and colonoscopy. The study will analyze evidence from RCTs to assess their effects on anxiety reduction and investigate secondary outcomes such as patient satisfaction, procedural tolerability, and adverse effects. The results will offer recommendations grounded in evidence to enhance patient-centered care during endoscopic procedures.

Methods

The meta-analysis followed the recommendations and criteria established by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guidelines [12, 13]. The protocol was pre-registered at the International Prospective Register of Systematic Reviews (PROSPERO) with the identifier code CRD42025645183.

Eligibility Criteria: Type of Study, Participants, and Intervention

We conducted a systematic review and meta-analysis of relevant studies published from the inception of the database to the present, including only randomized clinical trials (RCTs) in English. Studies were excluded if they were duplicates, if the necessary data could not be obtained, or if a response

from the original author could not be received. This study included participants of all ages undergoing endoscopy or colonoscopy procedures. Only studies that evaluated non-pharmacological interventions compared with standard care, placebo, or other non-pharmacological interventions for reducing anxiety levels were included.

Outcomes

The primary outcome assessed in this study is anxiety, which was measured using validated tools such as the Spielberger State-Trait Anxiety Inventory (STAI), the Zung Self-Rating Anxiety Scale, and the Depression Anxiety Stress Scales (DASS-21) in the included studies but not limited to them. Secondary outcomes include pain, patient satisfaction, and the duration of endoscopy. Pain assessment will be conducted but not limited to the use of the Visual Analog Scale (VAS) and the Numerical Rating Scale (NRS), with additional tools such as the Wong-Baker FACES Pain Rating Scale (WBFPRS), and the Face, Legs, Activity, Cry, and Consolability (FLACC) Scale, if applicable. Patient satisfaction will be evaluated using the Likert Scale and the Patient Satisfaction with Sedation Instrument. A summary of the primary and secondary outcomes with their corresponding measurement tools is provided in Supplementary Table 1.

Searching Methods

On 01/09/2025, a systematic search was initially conducted in PubMed, CINAHL, EMBASE, Cochrane, Web of Science, Scopus, and CNKI using the following terms: endoscopy, cognitive behavioral therapy, and anxiety. All detailed search strategies can be found in the supplementary material (Supplementary Tables 2–8).

Selection of Studies

Following an initial screening based on the title and abstract, two reviewers (MF, PG) independently selected trials for inclusion in this review using predetermined inclusion and exclusion criteria. This selection was performed using Rayyan [14]. Consensus and consultation with a third reviewer (EC) resolved disagreements about including the studies. Subsequently, a full-text analysis was conducted by two reviewers (LF, JA) independently selecting trials to be included in the review using predetermined inclusion and exclusion criteria. Consensus and consultation with a third review author (EC) resolved disagreements about including studies.

Data Extraction

Two independent reviewers extracted data from each included study using a standardized data extraction form. The following information was extracted: authors, year of publication, country of publication, study design, sample size (total number of cases and controls), participant characteristics (e.g., age, gender distribution, and comorbidities), intervention or exposure (specific non-pharmacological interventions used), comparison group (e.g., standard care, placebo, or other interventions), outcome measures of interest (e.g., anxiety levels, pain, patient satisfaction), and any relevant definitions and tools used (e.g., specific scales for anxiety and pain assessment such as the STAI, VAS, etc.).

Assessment of Risk of Bias in Included Studies

Two independent reviewers evaluated the risk of bias in each study, considering the specific criteria and guidelines provided by the Rob 2.0 tool for randomized controlled trials to assess the risk of bias [15]. Any reviewer discrepancies have been resolved through discussion with a third, blinded reviewer.

Statistical Analysis

A meta-analysis was performed using R version 3.4.3 [16]. The pooled effect of the outcomes was examined using a random-effects meta-analysis (DerSimonian-Laird approach) [17]. Whenever the number of studies reporting an outcome of interest was insufficient, only a qualitative analysis of the results was performed. Effect sizes were expressed as relative risk (RR) or standardized mean difference (SMD) and 95% CI. Using SMDs allowed researchers to combine results from studies that used different scales to measure the same outcome, such as anxiety, pain, or procedure time. This method helps ensure that differences in the scales themselves did not affect the overall results of the analysis. The I^2 statistic assessed heterogeneity, and the following cut-off values were used for interpretation: < 25, 25–50, and > 50% were considered small, medium, and large heterogeneity, respectively [18]. Network geometry and rankings were visualized using network plots, ranking probabilities expressed as P-scores or SUCRA, and forest plots showing multiple outcomes. For all outcomes, sensitivity analyses according to the leave-one-out method were performed to determine the influence of individual studies on the overall effect, using diagnostic plots proposed by Viechtbauer and Cheung [19]. Egger's regression test examined publication bias when ten or more reports with the same outcome were available [20]. Further statistical details are provided in Supplementary

Methods [21–25]. In addition, prespecified subgroup analyses were performed according to population (pediatric vs non-pediatric), type of endoscopy (upper vs lower), and sedation status (sedative vs non-sedative procedures). These were conducted to explore potential sources of heterogeneity and to assess whether intervention effects were consistent across different clinical contexts.

Results

Study Selection

Our initial search yielded 2396 potential articles across seven databases. After removing 893 duplicate articles, we conducted a title and abstract screening, resulting in the screening of 1503 articles. Of the 95 articles selected for full-text screening, 20 were excluded due to retrieval issues, 6 due to incorrect publication type, 17 for unpublished results, 2 for incorrect outcomes, 1 for wrong population, and 1 for duplication. Ultimately, 48 articles were included for analysis. This process is summarized in our PRISMA flow chart (Supplemental Fig. 1).

Study Characteristics and Participants

Of the 48 randomized controlled trials (RCTs) included in the analysis, the cumulative sample size was 6014 participants. Two studies were conducted with pediatric populations, while the remaining trials involved adults. The gender distribution across all studies was 52% female and 48% male. These RCTs originated from a geographically diverse range of countries, including Turkey (21%), the United States (13%), China (13%), and several other regions. The studies primarily focused on assessing the effectiveness of non-pharmacological interventions, such as music, virtual reality (VR), aromatherapy, and complementary therapies in managing anxiety, pain, and enhancing patient comfort during endoscopic procedures. In terms of procedure type, 27 studies assessed lower endoscopy, 15 upper endoscopies, and 6 included both. With respect to sedation, 18 studies used sedative procedures, 29 were performed without sedation, and 1 study did not clearly specify sedation status. Regarding anxiety, 56% of the studies used the Spielberger State-Trait Anxiety Inventory (STAI), 15% used the Visual Analog Scale (VAS), 4% used the Zung Self-Rating Anxiety Scale (SAS), 4% used the Depression Anxiety Stress Scales (DASS-21), 2% used the Numerical Rating Scale (NRS), 2% used the Likert Scale, 2% used vital signs as evaluation, and 15% of the studies did not assess anxiety. Among the included tools, STAI and DASS-21 were the most consistently reported

across studies, which is why they were considered as the primary endpoints for anxiety in this review. No restrictions were imposed on the selection of anxiety scales at the study level. For pain assessment, 46% of studies used the Visual Analog Scale (VAS), 8% used the Numerical Rating Scale (NRS), 2% used WBFPRS, 2% used the Face, Legs, Activity, Cry, Consolability (FLACC) Scale and WBFPRS scale simultaneously, 2% used a 26 question scale, 2% used the Likert scale, and 38% of the studies did not assess pain. Lastly, for patient satisfaction, 17% used the VAS, 6% used the Likert Scale, 2% used the NRS, 2% used the Patient Satisfaction with Sedation Instrument (PSSI), and 73% did not assess it. All data are summarized in Table 1 and supplemental Table 9 [26–73].

Risk of Bias Within Studies

We assessed the risk of bias using Cochrane's Risk of Bias 2.0 tool [74]. Overall, most studies presented low risk of bias or some concerns, while a smaller proportion showed high risk, mainly in randomization and outcome measurement. Detailed results for each endpoint are provided in Supplementary Figs. 2–5.

Meta-Analysis

Network Structure and Study Characteristics

The NMA included 27 studies ($k=27$) with 37 pairwise comparisons ($m=37$) across 12 distinct interventions ($n=12$), employing a random-effects model to account for between-study variability (Fig. 1). SMD relative to the control group was used to assess comparative effectiveness. Among the evaluated interventions, Reiki (SMD -1.52 , 95% CI -3.01 to -0.02 , $p=0.04$), aromatherapy (SMD -1.31 , 95% CI -2.47 to -0.54 , $p=0.02$), and music therapy (SMD -1.09 , 95% CI -1.50 to -0.67 , $p<0.01$) demonstrated a statistically significant reduction in the primary outcome (Fig. 1), whereas all other interventions, including audiovisual stimulation, electroacupuncture, guided imagery, massage, meditation, stress ball use, virtual reality, and visual distraction, did not exhibit significant efficacy compared to the control. The analysis indicated substantial heterogeneity ($I^2=92.7\%$ [90.3%; 94.6%]), with the Music vs Control comparison exhibiting the highest variability ($Q=257.29$, $df=12$, $p<0.01$), while Virtual Reality vs Control showed no significant heterogeneity ($Q=3.13$, $df=3$, $p=0.37$). Comparisons involving Music, Aromatherapy, Audiovisual, and Meditation contributed most to inconsistency, suggesting variability across studies assessing these interventions. However, adjusting for differences in treatment comparisons eliminated inconsistency ($Q=3.05$, $df=6$, $p=0.80$). All fitted models converged adequately,

Table 1 Characteristics of included studies

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Tekinsoy et al. 2017	Turkey	60	Non-pediatric	NA	34/26	Before and immediately after the colonoscopy	Meditation before colonoscopy Self-selected music during colonoscopy
El-Hassan et al. 2009	United Kingdom	180	Non-pediatric	59.97 $\pm$ 16.51	99/81	Before and immediately after the endoscopy	Self-selected music before endoscopy
Sogabe et al. 2018	Japan	206	Non-pediatric	51.8 $\pm$ 6.6	86/120	Before and immediately after the distraction period, and after the upper GI endoscopy procedure	Group 2: Auditory, music before endoscopy Group 3: Visual, Silent nature images (mountains, forest, water) before endoscopy Group 4: Combination, Nature images + music
Sun et al. 2023	China	224	Non-pediatric	NA	74/150	Immediately and 2 h after the procedure	Group 1: Classic music before colonoscopy Group 2: Popular music before colonoscopy
Muzzarelli et al. 2006	United States of America	118	Non-pediatric	52 $\pm$ 10.27	59/59	Immediately after the procedure	Aromatherapy: lavender oil
Shamali et al. 2024	Denmark	50	Non-pediatric	63.45 $\pm$ 9.96	27/20	Before and immediately after the procedure	Virtual reality before and during colonoscopy
Ovayolu et al. 2006	Turkey	60	Non-pediatric	NA	32/28	Before and immediately after the procedure	Music during colonoscopy
Shamekhi et al. 2019	Iran	102	Non-pediatric	40.08 $\pm$ 8.87	53/49	2–3 h before the procedure and after the procedure	Video group: Video clip before colonoscopy Guided imagery: Guided imagery audio file before colonoscopy

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Shaermoghadam et al. 2016	Iran	95	Non-pediatric	NA	NA	Before and immediately after the procedure	Hand reflexology massage before endoscopy Foot reflexology massage before endoscopy
Min et al. 2010	South Korea	104	Non-pediatric	NA	38/66	Before and immediately after the procedure	Music before esophago-gastroduodenoscopy
Padam et al. 2017	India	199	Non-pediatric	39.3 $\pm$ 11.3	65/134	Before and immediately after the procedure	Music: Vedic chants before endoscopy Music: Instrumental music before endoscopy
Kim et al. 2023	South Korea	40	Non-pediatric	58.15 $\pm$ 7.86	12/28	Before and immediately after the procedure	Virtual reality before endoscopy
Siripongsaporn et al. 2024	Thailand	107	Non-pediatric	58.09 $\pm$ 13.38	69/38	Before and immediately after the procedure	Virtual reality education before esophago-gastroduodenoscopy
Smolen et al. 2002	United States of America	32	Non-pediatric	59.85 $\pm$ 11.62	15/17	Before and immediately after the procedure	Self-selected music during colonoscopy
Martindale et al. 2014	Australia	34	Non-pediatric	52.01 $\pm$ 13.84	18/16	Immediately after the procedure	Music before and during colonoscopy
Tani et al. 2022	Italy	94	Non-pediatric	60.29 $\pm$ 11.3	40/50	Before and immediately after the procedure	Binaural beats before and during colonoscopy
Boonreunya et al. 2022	Thailand	64	Non-pediatric	61.1 $\pm$ 13.46	23/41	Immediately after the procedure	Group A: VR group during esophago-gastroduodenoscopy Group B: Sham VR group during esophago-gastroduodenoscopy

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Bashiri et al. 2018	Turkey	154	Non-pediatric	44.14 $\pm$ 8.77	97/54	Before and immediately after the procedure	Group 2, conscious sedation with music during endoscopy/colonoscopy Group 4, deep sedation with music during endoscopy/colonoscopy
Hirani et al. 2024	Pakistan	110	Non-pediatric	50.02 $\pm$ 16.14	41/69	Before and immediately after the procedure	Music: Non-lyrical soft music before and during the colonoscopy
Eberl et al. 2018	The Netherlands	153	Non-pediatric	NA	93/60	Before discharge and 24 h later by telephone	Electroacupuncture during colonoscopy Sham acupuncture during colonoscopy
Chuah et al. 2024	Malaysia	348	Non-pediatric	49.1 $\pm$ 15.7	212/128	Immediately after procedure	Transcutaneous electrical nerve stimulation of acupuncture points (Acu-TENS) before and during esophago-gastroduodenoscopy
Liu et al. 2022	China	120	Non-pediatric	NA	47/70	Immediately after procedure	Virtual reality before and during colonoscopy
Sabzevari et al. 2017	Iran	100	Pediatric	9.94 $\pm$ 2.9	55/49	Before and immediately after procedure	A classic musical piece by Clayderman was played during endoscopy (from the time of entering the endoscopy room to the end of the process) using a digital MP3 player and two speakers
Hayes et al. 2003	United States of America	198	Non-pediatric	61 $\pm$ 10.5	5/100	Before and immediately after procedure	Patients in the music group listened to self-selected music for 15 min before their procedure. They chose from five categories: classical, jazz, rock, country western, and easy listening

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Sun et al. 2022	China	216	Non-pediatric	44.84 $\pm$ 12.71	104/112	Before and immediately after procedure	Patients in the music group listened to randomly selected piano pieces of light music (no lyrics) through noise-reducing headphones during their colonoscopy procedure. The volume was adjustable by the patient, and the music was played continuously during the procedure
Ko et al. 2019	China	80	Non-pediatric	57.68 $\pm$ 11.43	39/41	At baseline and 30 min after the procedure	The intervention group received standard care plus easy listening music (a series of 15 popular non-rock Chinese songs) through earphones and an MP3 for 20 min before and during the colonoscopy procedure
Björkman et al. 2013	Sweden	120	Non-pediatric	NA	68/52	Immediately after procedure	This study consisted of 60 patients who listened to sedative instrumental music during their colonoscopy procedure
Stermer et al. 1998	Israel	199	Non-pediatric	NA	NA	Before and immediately after procedure	The intervention in this study focused on manipulating the background conditions in the endoscopy room during upper gastrointestinal endoscopy procedures. In four groups

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Walter et al. 2020	Germany	196	Non-pediatric	54.39 $\pm$ 16.17	95/101	After the procedure	The intervention group that received standard care plus the music intervention
Bay et al. 2021	Chile	100	pediatric	11.24 $\pm$ 4.11	63/37	Before and 40 min after the procedure	Listened to self-selected music via headphones. A nurse assisted them in choosing a song from a music application on an electronic device. If the randomization envelope indicated "yes," the music was played
Sobana et al. 2015	India	60	Non-pediatric	NA	NA	Before and 10 min after the intervention	Self-selected music before endoscopy
Smolen Hozumi et al. 2017	Japan	364	Non-pediatric	45.6 $\pm$ 5.4	0/364	Immediately after procedure	Vehicle group: essential-oil-less vapor, before colonoscopy Lavender group: lavender oil, before colonoscopy Grapefruit group: grapefruit oil, before colonoscopy Osmanthus group: Osmanthus fragrans oil, before colonoscopy
Aksu et al. 2023	Turkey	80	Non-pediatric	42.94 $\pm$ 17.15	33/47	Before and after Endoscopy	Music before endoscopy
Keşer et al. 2023	Turkey	100	Non-pediatric	38.04 $\pm$ 10.29	61/39	Before and immediately after procedure	Reiki session before endoscopy Aromatherapy: inhaled lavender essential oil before endoscopy
Karaveli et al. 2021	Turkey	60	Non-pediatric	56.27 $\pm$ 13.73	21/39	Before and immediately after the procedure	Virtual reality during colonoscopy

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Ko et al. 2017	Taiwan	138	Non-pediatric	48.0 $\pm$ 11.9	63/75	Immediately after the procedure	Music during colonoscopy by David Tolley
Teoh et al. 2021	China	128	Non-pediatric	62.67 $\pm$ 10.51	61/67	Before and after colonoscopy	Music during colonoscopy by Kevin Kern Electroacupuncture was performed at acupoints Hegu (LI-4), Neiguan (PC-6), and Zusanli (ST-36) using sterile acupuncture needles inserted to a depth of 15 mm. Regular electric stimulation was applied with a frequency of 2 Hz, pulse width of 200 μ s, and stimulation intensity "short of discomfort" for 45 min before and during EUS
Hu et al. 2010	Taiwan	27	Non-pediatric	52.26 $\pm$ 17.79	12/15	Before and immediately after procedure	One drop (50 ml) of Neroli oil was placed on the gauze in a hand-held nebulizer with an oxygen mask, which pneumatic pumps the oil into the mask. The oxygen masks were placed on the subjects nose to smell for five minutes

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Caner et al. 2023	Turkey	60	Non-pediatric	47.92 $\pm$ 14.10	30/30	Before, during, and after the procedure	Patients were told to count from 1 to 3, squeeze and release the stress ball once, and repeat this until the procedure was over. It was explained that they should focus their attention on the stress ball and squeeze the stress ball during the procedure. Patients were positioned for the procedure with their right side up, and they held the stress ball in their right hand. The stress ball used in the study was 6 cm in diameter, of medium hardness, and made of high-quality silicone

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Çelebi et al. 2019	Turkey	112	Non-pediatric	54.19 $\pm$ 13.92	56/56	Before and after the procedure	They were introduced to the MP3 player before the procedure and explained how to use it, and their questions were answered. Disposable headphones were applied to the patients, and the music therapy was started (music used was Ajam Ashiran maqam of Turkish Classical Music). They were able to adjust the volume, turn the sound on and off, stop the music, and start listening again. Music therapy was applied for 30 min during the procedure. In addition, 4L/h oxygen was given through the nasal cannula
Costa et al. 2010	Italy	109	Non-pediatric	51.31 $\pm$ 14.74	37/72	After procedure	Music was supplied through headphones connected to a portable compact disc machine located in a remote room. Headphones were of high quality, in order to ensure that music was not heard nearby by the endoscopist, and an independent observer ensured that this was true for each patient

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean $\pm$ SD	Gender distribution Female/Male (n)	Follow up	Intervention
Meeuse et al. 2010	The Netherlands	307	Non-pediatric	51.99 $\pm$ 17.00	160/147	Before and after sigmoidoscopy	In addition to the usual care, several CDs with classical music, English popular, Dutch popular, or jazz music were offered before the sigmoidoscopy. During the sigmoidoscopy, the patient listened to his or her preferred music, using headphones attached to a portable CD player. The personnel of the endoscopic unit could not hear the music
Bechtold et al. 2006	United States of America	167	Non-pediatric	56.35 $\pm$ 13.54	83/83	Before and after colonoscopy	The CD player was playing relaxing music upon the entrance of patient into the procedure room. We played the same music for all patients in the music group: "Watermark" by Enya (Reprise Records, a Time Warner Company, 1988), which contains 12 tracks (ranging from 1:59 to 4:25 in Length)
López-Cepero et al. 2004	Spain	118	Non-pediatric	47.40 $\pm$ 14.08	59/59	Before and after the procedure	The experimental group listened to classical music through personal headphones during the colonoscopy. The control group also used headphones

Table 1 (continued)

Study name	Country	Sample Size total	Population	Age total Mean ± SD	Gender distribution Female/Male (n)	Follow up	Intervention	
Barzegar et al. 2024	Iran	60	Non-pediatric	71.62 ± 7.14	25/35	Before and after the procedure	The intervention in this study involved the use of white noise to reduce anxiety in older adults undergoing colonoscopy; the experimental group listened to white noise via binaural headphones for 20 min	
Hulse et al. 2010	United States of America	21	Non-pediatric	58 ± 8.3	11/10	Before and after the procedure	The Reiki group received a 15-min modified Reiki intervention by a Reiki-trained nurse. She talked to the subject in a soft, soothing voice, placing her hands in a series of positions on or above strategic areas of the subject's body	
Xiaolian et al. 2015	China	180	Non-pediatric	38.83 ± 17.41	78/102	Before and after colonoscopy	Group A watched a soundless DVD with earphones on	
Umezawa et al. 2015	Japan	60	Non-pediatric	NA	19/38	Before and after the procedure	Group B watched a DVD with sound and wore earphones	
							Patients watched a silent movie using a head-mounted display	
Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean ± SD	Types of endoscopy procedures	Sedation	Drug
Tekinsoy et al. 2017	Standard care, no meditation/music	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	Yes	Meperidine midazolam
El-Hassan et al. 2009	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	No	—
Sogabe et al. 2018	Group 1: Standard care	Visual Analogue Scale (VAS)	NA	Visual Analog Scale (VAS)	NA	Upper	No	—

Table 1 (continued)

Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean $\pm$ SD	Types of endoscopy procedures	Sedation	Drug
Sun et al. 2023	Group 3: Standard care, no music	NA	NA	Visual Analog Scale (VAS)	Classic music: 8 ± 1.83 Popular music: 8 ± 1.80 Control: 7 ± 1.83			
Muzzarelli et al. 2006	Aromatherapy: Grapeseed oil/placebo	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	No	—
Shamali et al. 2024	Standard care, no VR	Spielberger State-Trait Anxiety Inventory (STAI)	Numerical Rating Scale (NRS)	Numerical Rating Scale (NRS)	Virtual Reality: 30.9 ± 12 Control: 31.3 ± 12	Lower	No	—
Ovayolu et al. 2006	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	Numerical Rating Scale (NRS)	Visual Analog Scale (VAS)	NA	Lower	No	—
Shamekhi et al. 2019	Control group: standard care	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	Yes	Meperidine & Midazolam
Shaermoghdam et al. 2016	Standard care, no massage	Depression Anxiety Stress Scales (DASS-21)	NA	NA	NA	Upper	No	—
Min et al. 2010	Standard care, no music	Visual Analogue Scale (VAS)	NA	NA	NA	Upper	No	—
Padam et al. 2017	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Upper	No	—
Kim et al. 2023	Standard care, no VR	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	Likert Scale	NA	Upper and Lower	Yes	Midazolam & Propofol
Siripongsaporn et al. 2024	Standard oral education	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Upper	No	Topical anesthesia
Smolen et al. 2002	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	Yes	Meperidine & Midazolam
Martindale et al. 2014	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	Yes	Midazolam & Fentanyl
Tani et al. 2022	Standard care plus white noise alone during the procedure	Visual Analogue Scale (VAS)	Visual Analog Scale (VAS)	NA	NA	Lower	No	—

Table 1 (continued)

Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean $\pm$ SD	Types of endoscopy procedures	Sedation	Drug
Boonreunya et al. 2022	Group C: control group, with standard EGD without wearing VR	NA	Visual Analog Scale (VAS)	Likert Scale	Virtual Reality: 9.2 ± 2.7 Control: 10.3 ± 3.3	Upper	No	Topical anesthesia
Bashiri et al. 2018	Group 1, conscious sedation without music during endoscopy/colonoscopy Group 3, deep sedation without music during endoscopy/colonoscopy	Spielberger State-Trait Anxiety Inventory (STAI)	Numerical Rating Scale (NRS)	NA	NA	Upper and Lower	Yes	Midazolam/Ketamine & Propofol
Hirani et al. 2024	Standard care with verbal teaching, pamphlets, and conscious sedation	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	Yes	Midazolam
Eberl et al. 2018	Standard care plus placebo acupuncture	NA	Visual Analog Scale (VAS)	NA	NA	Lower	Yes	Propofol
Chuah et al. 2024	Adhesive electrodes (the device remained inactive throughout the OGDS)	NA	NA	NA	Electroacupuncture: 6.0 ± 3.7 Control: 10.0 ± 3.7	Upper	No	—
Liu et al. 2022	Standard care plus VR and headphones were worn without any videos or sounds	Depression Anxiety Stress Scales (DASS-21)	Visual Analog Scale (VAS)	NA	Virtual Reality: 15.0 ± 3.05 Control: 16.0 ± 3.04	Lower	No	—
Sabzevari et al. 2017	Had an endoscopy done without music	Evaluating vital signs	FALCC scale and Baker-Wong pain scale	NA	NA	Upper	Yes	Midazolam
Hayes et al. 2003	Patients in the control group waited for 15 min in the procedure area before the GI procedure	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Upper and Lower	No	—

Table 1 (continued)

Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean $\pm$ SD	Types of endoscopy procedures	Sedation	Drug
Sun et al. 2022	Patients in the control group wore headphones during the colonoscopy, but no music was played	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	No	—
Ko et al. 2019	The control group received standard care only	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	Yes	Midazolam & Fentanyl
Björkman et al. 2013	Received the usual care during colonoscopy without music	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	NA	Lower	No	—
Stermer et al. 1998	The comparator in this study is the different background conditions in the endoscopy room	NA	26 questions scale, did not specify scale	NA	NA	Upper	Yes	Midazolam
Walter et al. 2020	A control group that received standard care	NA	NA	Patient Satisfaction with Sedation Instrument (PSSI)	NA	Lower	Yes	Propofol
Bay et al. 2021	Followed the routine procedure without music; if "no" appeared, headphones remained silent	Visual Analogue Scale (VAS)	Wong-Baker Faces Pain Rating Scale (WBFRS)	NA	NA	Upper	Yes	Midazolam
Sobana et al. 2015	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	No	—
Smolen Hozumi et al. 2017	Colonoscopy was done without any type of inhalation	Numerical Rating Scale (NRS)	Numerical Rating Scale (NRS)	NA	Vehicle group: 14.4 $\pm$ 3.3 Lavender group: 14.1 $\pm$ 3.7 Grapefruit group: 13.7 $\pm$ 2.8 Osmanthus fragrans group: 14.1 $\pm$ 3.7 Control: 15.3 $\pm$ 4.3	Lower	Yes	Meperidine & Midazolam

Table 1 (continued)

Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean $\pm$ SD	Types of endoscopy procedures	Sedation	Drug
Aksu et al. 2023	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	Visual Analog Scale (VAS)	NA	Lower	Yes	Propofol
Keşer et al. 2023	Standard care	Zung Self-Rating Anxiety Scale (SAS)	NA	NA	NA	Upper and Lower	Yes	Midazolam
Karaveli et al. 2021	Standard care, no VR	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	Virtual Reality: 7.36 ± 2.52 Control: 7.30 ± 2.45	Upper	No	—
Ko et al. 2017	Standard care, no music	Spielberger State-Trait Anxiety Inventory (STAI)	NA	Visual Analog Scale (VAS)	NA	Upper	No	Topical lidocaine
Teoh et al. 2021	Sham procedure with blunt-tip needles placed 15 mm from the acupoints, with simulated electrical stimulation by connecting the needle to the incorrect output socket of the electroacupuncture device	Visual Analogue Scale (VAS)	Visual Analog Scale (VAS)	Visual Analog Scale (VAS)	Electroacupuncture: 21.09 ± 15.69 Control: 14.93 ± 9.33	Upper	Yes	Propofol & Alfentanil
Hu et al. 2010	One drop (50 ml) of Sunflower oil was placed on the gauze in hand-held-nebulizer with an oxygen mask, which pneumatic pumps the oil into the mask. The oxygen masks were placed on the subjects nose to smell for five minutes	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	Aromatherapy: 19.08 ± 9.63 Control: 21.17 ± 8.15	Lower	No	—

Table 1 (continued)

Study name	Comparator	Anxiety Scale	Pain Scale	Satisfaction Scale	Duration Mean $\pm$ SD	Types of endoscopy procedures	Sedation	Drug
Caner et al. 2023	Did not receive any intervention during the endoscopy procedure	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	Visual Analog Scale (VAS)	NA	Upper	Yes	Propofol
Çelebi et al. 2019	Did not listen to the music, and routine procedures were undertaken in the unit without any additional intervention	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	Visual Analog Scale (VAS)	NA	Lower	No	—
Costa et al. 2010	Headphones given, but no music played (Mute headphones)	Zung Self-Rating Anxiety Scale (SAS)	Visual Analog Scale (VAS)	Likert Scale	Music: 23.30 $\pm$ 10.46 Control: 27.11 $\pm$ 11.94	Upper	Yes	Midazolam and Pethidine
Meeuse et al. 2010	Standard care	NA	Visual Analog Scale (VAS)	NA	NA	Lower	No	—
Bechtold et al. 2006	Standard care	Visual Analogue Scale (VAS)	NA	NA	NA	Lower	Yes	Meperidine & Midazolam
López-Cepero et al. 2004	Standard care	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	Music: 20.75 $\pm$ 13.42 Control: 18.16 $\pm$ 12.67	Lower	No	—
Barzegar et al. 2024	Standard care	Spielberger State-Trait Anxiety Inventory (STAI)	NA	NA	NA	Lower	No	—
Hulse et al. 2010	Standard care	Likert-type scale	Likert-type scale (0–10)	NA	NA	Lower	Yes	—
Xiaolian et al. 2015	Group C underwent routine care	Spielberger State-Trait Anxiety Inventory (STAI)	Visual Analog Scale (VAS)	NA	Visual: 5.96 $\pm$ 2.65 Audio and visual: 6.00 $\pm$ 2.34 Control: 5.73 $\pm$ 2.80	Lower	No	—
Umezawa et al. 2015	Routine care	Visual Analogue Scale (VAS)	Visual Analog Scale (VAS)	NA	Visual: 6 $\pm$ 2.34 Control: 7 $\pm$ 3.11	Lower	No	—

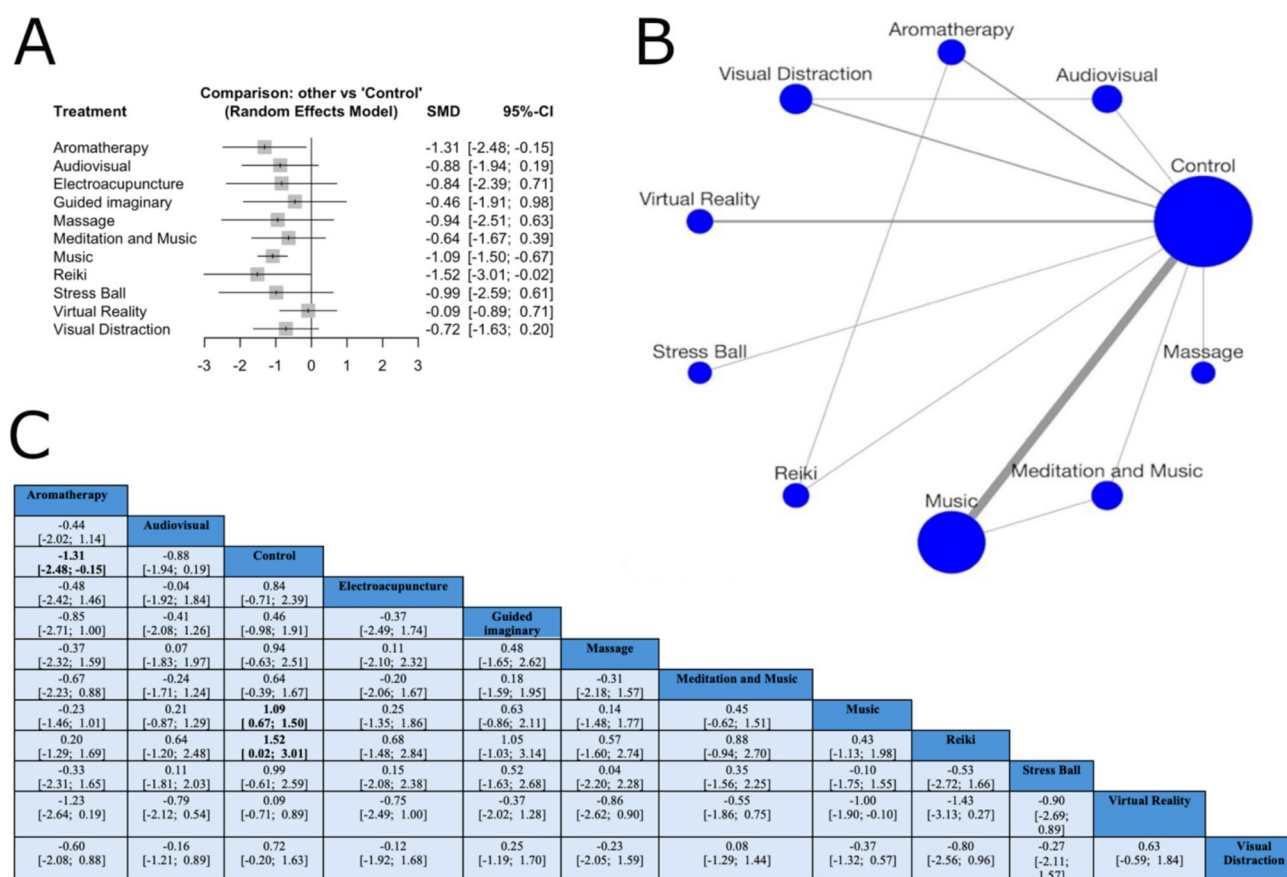


Fig. 1 Summary of network meta-analysis for anxiety outcomes. **A** Forest plot showing standardized mean differences (SMDs) with 95% confidence intervals for each intervention compared with control using a random-effects model. Negative SMDs indicate greater anxiety reduction versus control. **B** Network plot depicting direct and indirect comparisons among non-pharmacologic interventions. Each node (blue circle) represents a treatment, with larger nodes indicating a greater number of participants. Connecting lines (gray edges)

indicate direct head-to-head comparisons, and line thickness corresponds to the number of included studies. **C** League table summarizing pairwise standardized mean differences (SMD [95% CI]) between all interventions. Values below the diagonal indicate the estimated effect of the row-defining treatment versus the column-defining treatment. Negative values favor the row-defining intervention for anxiety reduction

and no statistical evidence of inconsistency was detected in the NMA. Node-split analysis showed no significant differences between direct and indirect estimates across comparisons ($p > 0.05$; Supplementary Figs. 6–7 and Supplementary Table 10), indicating overall consistency. The relative treatment estimates remained consistent across the network. The SUCRA values indicate the relative probability of each intervention being among the most effective across the assessed outcomes. For anxiety, Reiki (SUCRA = 0.67), Aromatherapy (SUCRA = 0.64), and Music (SUCRA = 0.65) ranked highest, suggesting superior efficacy in reducing anxiety symptoms. Regarding pain, Electroacupuncture (SUCRA = 0.67), Meditation and Music (SUCRA = 0.56), and Stress Ball (SUCRA = 0.55) showed the most favorable rankings. For patient satisfaction, the control group

(SUCRA = 0.73), Virtual Reality (SUCRA = 0.67), and Stress Ball (SUCRA = 0.62) obtained the highest probabilities, while Music (SUCRA = 0.29) and Audiovisual (SUCRA = 0.27) ranked lowest. Finally, in terms of procedure time, Electroacupuncture (SUCRA = 0.70), Aromatherapy (SUCRA = 0.66), and Virtual Reality (SUCRA = 0.58) ranked highest, whereas Music (SUCRA = 0.26) and Audiovisual (SUCRA = 0.41) were less effective (Table 2). The rank probability distributions (Supplementary Fig. 8) further illustrate treatment rankings, with Reiki demonstrating the highest probability of being the most effective, while Control was most frequently ranked among the least effective. The league table of SMDs (Fig. 1 and Supplementary Table 11) provides comparative treatment effects with 95% confidence intervals. The **Reiki vs Control** comparison demonstrated the most significant reduction in anxiety, while other interventions showed variable efficacy with overlapping

Table 2 Surface Under the Cumulative Ranking Curve (SUCRA) Scores for non-pharmacological interventions across anxiety, pain, satisfaction, and time of procedure

Intervention	Anxiety	Pain	Satisfaction	Time of Procedure
Aromatherapy	0.6471	0.4787	–	0.6604
Audiovisual	0.5433	0.477	0.2789	0.4175
Control	0.2102	0.4085	0.7387	0.3684
Electroacupuncture	0.5141	0.6750	0.5502	0.7021
Guided Imagery	0.4178	–	–	–
Massage	0.5375	–	–	–
Meditation and Music	0.4644	0.5688	–	–
Music	0.6542	0.3980	0.2908	0.2636
Reiki	0.6788	–	–	–
Stress Ball	0.5412	0.5571	0.6249	–
Virtual Reality	0.299	0.5049	0.6718	0.5822
Visual	0.4923	0.432	0.3447	0.5058

Bold values denote the top-ranked intervention in each category. "–" indicates that the intervention was not assessed for that outcome

confidence intervals. The funnel plot (Supplementary Fig. 9) assesses small-study effects and potential publication bias in the NMA. Visual inspection suggests asymmetry, with studies dispersed unevenly around the central effect estimate, particularly in comparisons involving **Control, Music, and Reiki**. Egger's test confirmed significant small-study effects ($p < 0.01$), indicating possible publication bias.

Secondary Outcomes

The NMA for pain included 21 studies ($k = 21$) with 23 pairwise comparisons ($m = 23$) across 9 distinct

interventions ($n = 9$; Fig. 2A). The NMA for patient satisfaction included 13 studies ($k = 13$) with 15 pairwise comparisons ($m = 15$) across 7 distinct interventions ($n = 7$; Fig. 2B). The NMA for time of procedure included 13 studies ($k = 13$) with 15 pairwise comparisons ($m = 15$) across 7 distinct interventions ($n = 7$; Fig. 2C). SMDs were calculated across all the interventions for the secondary outcomes (Fig. 3). For patient satisfaction, music therapy significantly improved satisfaction (SMD = 2.22, 95% CI 1.21 to 3.23, $p < 0.01$), while all other interventions did not exhibit significant efficacy compared to the control. For pain and time of procedure, none of the interventions had a statistically significant effect. All analyses showed substantial heterogeneity. Pain ($I^2 = 94.5\%$ [92.4%; 96.0]), patient satisfaction ($I^2 = 97.1\%$ [95.8%; 97.9]), and time of procedure ($I^2 = 88.8\%$ [80.9%; 93.4%]). Consistency analysis was performed for all variables (Supplementary Figs. 10–14, Supplementary Tables 12 and 13). For pain and time of procedure, with no statistically significant differences observed between direct and indirect estimates ($p > 0.05$) across all comparisons, indicating overall consistency in the network. For patient satisfaction, node-splitting analysis was not performed because no interventions had both direct and indirect evidence available for comparison. The SUCRA values indicate that, for pain, Electroacupuncture (SUCRA = 0.82), Meditation and Music (SUCRA = 0.64), and Stress Ball (SUCRA = 0.61) ranked highest, while visual (SUCRA = 0.34) and Control (SUCRA = 0.27) ranked lowest (Table 2 and Supplementary Fig. 15). For patient satisfaction, Audiovisual (SUCRA = 0.82), Music (SUCRA = 0.75), and Electroacupuncture (SUCRA = 0.43) ranked highest, while control (SUCRA = 0.18) and virtual reality (SUCRA = 0.25; Supplementary Fig. 16) ranked lowest. For the time of procedure, Electroacupuncture

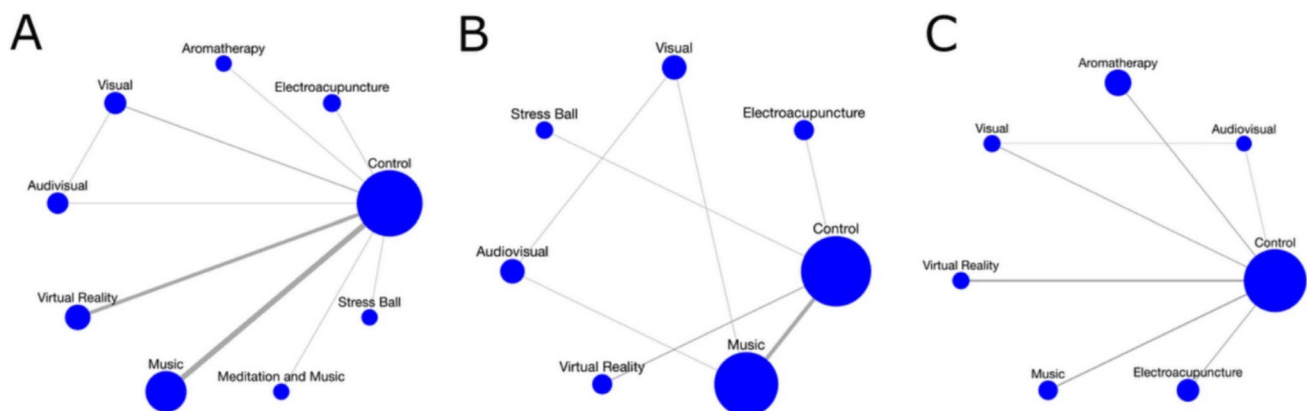


Fig. 2 Network plot of treatment comparisons in the network meta-analysis. The network plot illustrates treatment comparisons in the meta-analysis. Nodes (blue circles) represent interventions, with larger nodes indicating more participants. Edges (gray lines) denote direct comparisons, where thicker lines reflect a higher number of

studies. The largest node represents the most frequently studied intervention, often the reference treatment. This visualization highlights the structure of available evidence, showing how treatments are connected and where direct comparisons exist **A** Pain, **B** Satisfaction, **C** Time of procedure

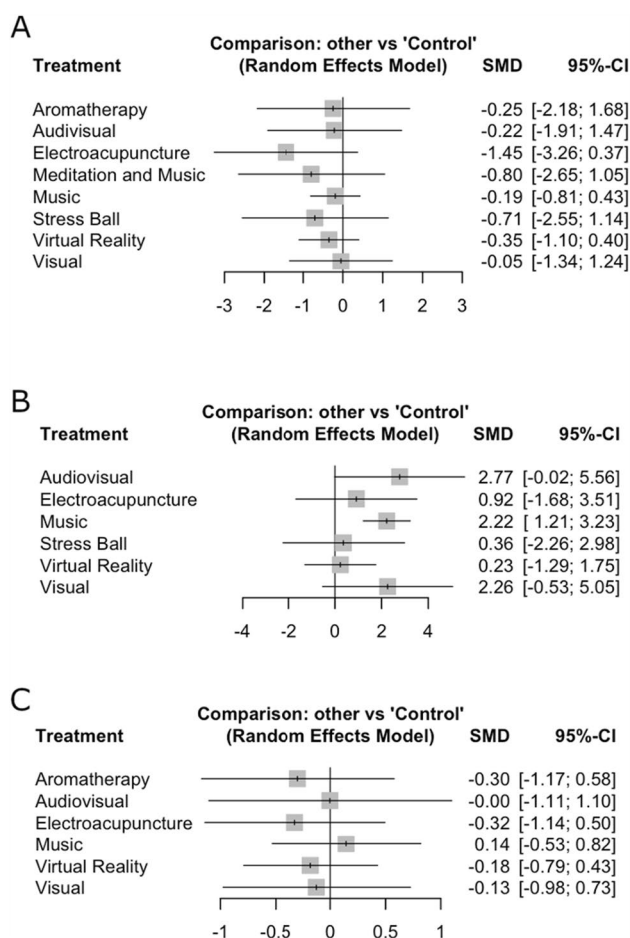


Fig. 3 Network meta-analysis of non-pharmacological interventions. Forest plot showing standardized mean differences (SMD) with 95% confidence intervals for non-pharmacological interventions versus control in reducing anxiety. Negative SMD favors the intervention. Squares represent effect sizes, and horizontal lines indicate confidence intervals. **A** Pain, **B** Satisfaction, **C** Time of procedure

(SUCRA = 0.66), Aromatherapy (SUCRA = 0.63), and Virtual Reality (SUCRA = 0.57) ranked highest, while Music (SUCRA = 0.29) and Control (SUCRA = 0.38) ranked lowest (Table 2 and Supplementary Fig. 17). The league table of SMDs (Supplementary Tables 14–16) provides comparative treatment effects with 95% confidence intervals for all secondary outcomes. Funnel plots for all outcomes showed asymmetry (Supplementary Figs. 18–20). However, only the Egger's test for patient satisfaction revealed significant small-study effects ($p < 0.01$), suggesting potential publication bias. Egger's test for pain ($p = 0.31$) and time of procedure ($p = 0.37$) did not detect significant small-study effects, indicating a low risk of publication bias.

Sensitivity Analysis

Anxiety In studies with low or some concerns for risk of bias ($k = 20$; Supplementary Fig. 21), aromatherapy (SMD = 1.76; 95% CI = -3.25 to -0.27; $p = 0.02$), Reiki (SMD = 1.75; 95% CI = -3.23 to -0.26; $p = 0.02$), and music therapy (SMD = 0.99; 95% CI = -1.44 to -0.54; $p < 0.01$; Supplementary Fig. 22) demonstrated significant reductions in anxiety. The overall network showed substantial heterogeneity ($I^2 = 92.2\%$). SUCRA rankings placed aromatherapy (0.83), Reiki (0.82), and music therapy (0.60; Supplementary Table 17), with pairwise effects detailed in the league table (Supplementary Table 18). For lower procedures ($k = 13$), music therapy was the only intervention with significant benefit (SMD = 1.80; $p < 0.01$; Supplementary Figs. 23–24); the overall network displayed very high heterogeneity ($I^2 = 96.5\%$), with music ranked highest (SUCRA = 0.86; Supplementary Tables 19–20). In upper procedures ($k = 10$), aromatherapy, Reiki, music, audiovisual distraction, and massage were significant, with overall heterogeneity remaining substantial ($I^2 = 80.8\%$; Supplementary Figs. 25–26); aromatherapy (0.90) and Reiki (0.90) achieved the top rankings (Supplementary Tables 21–22). In sedated patients ($k = 9$), only music therapy was effective (SMD = 1.58; $p = 0.0047$; Supplementary Figs. 27–28), with the network showing high heterogeneity ($I^2 = 95.8\%$) and music achieving the highest ranking (SUCRA = 0.83; Supplementary Tables 23–24). Among non-sedated patients ($k = 18$), aromatherapy, Reiki, and music therapy were significant (Supplementary Figs. 29–30), overall heterogeneity was high ($I^2 = 92.1\%$), and Reiki (0.82) and aromatherapy (0.78) ranked highest (Supplementary Tables 25–26).

Pain In network meta-analysis restricted to studies at low or some concerns for risk of bias ($k = 7$), electroacupuncture (SMD = 1.45; 95% CI = 1.83 to -1.06; $p < 0.01$) and music therapy (SMD = -1.09, 95% CI = -1.50 to -0.67, $p < 0.01$) significantly reduced pain (Supplementary Figs. 31–32, Supplementary Table 27), with no overall network heterogeneity ($I^2 = 0.00\%$). The highest SUCRA values were observed for electroacupuncture (1.00) and music (0.85; Supplementary Table 28). In subgroup analyses, lower procedures ($k = 15$) showed no significant interventions with high heterogeneity ($I^2 = 95.50\%$; Supplementary Figs. 33–34, Supplementary Tables 29–30), whereas upper procedures ($k = 5$) identified electroacupuncture (SMD = 1.45; $p < 0.01$), music therapy (SMD = 1.51; $p < 0.01$), and stress ball (SMD = 0.71; $p = 0.01$) as effective, with highest SUCRA values for music (0.89) and electroacupuncture (0.85; Supplementary Figs. 35–36, Supplementary Tables 31–32). Among sedation subgroups, music therapy was effective in non-sedated patients (SMD = 0.89; $p = 0.01$; Supplementary Figs. 37–38), with overall heterogeneity high ($I^2 = 92.50\%$).

and the highest SUCRA for music (0.82; Supplementary Tables 33–34), while no significant effects were observed in sedated patients ($I^2=97.30\%$; Supplementary Figs. 39–40, Supplementary Tables 35–36). League tables of pairwise comparisons are provided in the Supplementary.

Duration In studies with low or some concerns for risk of bias ($k=5$), no interventions significantly reduced procedure duration. Overall network heterogeneity was very high ($I^2=98.10\%$). The highest SUCRA values were for virtual reality (0.60) and visual distraction (0.59; Supplementary Figs. 41–42, Supplementary Tables 37–38). In subgroup analyses, upper procedures ($k=3$) showed no significant effects, with very high heterogeneity ($I^2=98.10\%$) and the highest SUCRA values for electroacupuncture (0.57) and virtual reality (0.57; Supplementary Figs. 43–44, Supplementary Tables 39–40). Lower procedures ($k=10$) also showed no significant effects, with moderate heterogeneity ($I^2=65.40\%$) and the highest SUCRA for aromatherapy (0.79; Supplementary Figs. 45–46, Supplementary Tables 41–42). The upper procedures and sedated procedures analysis were not performed due to the low number of studies. In non-sedated patients ($k=11$), electroacupuncture (SMD -1.08 ; 95% CI -1.33 to -0.84 ; $p<0.01$), aromatherapy (SMD -0.33 ; 95% CI -0.59 to -0.07 ; $p=0.01$), and music therapy (SMD 0.42 ; 95% CI 0.18 to 0.65 ; $p<0.01$) were effective (Supplementary Figs. 47–48), with low heterogeneity ($I^2=4.90\%$) and highest SUCRA values for electroacupuncture (1.00) and aromatherapy (0.77; Supplementary Tables 43–44).

Satisfaction In studies at low or some concerns for risk of bias ($k=11$), music therapy significantly improved satisfaction (SMD 1.38 ; 95% CI 0.47 to 2.29 ; $p<0.01$; Supplementary Figs. 49–50), with overall heterogeneity high ($I^2=96.70\%$). The highest SUCRA values were observed for control (0.82) and virtual reality (0.67; Supplementary Tables 45–46). In subgroup analyses, music therapy remained effective in lower procedures ($k=7$; SMD 1.97 ; 95% CI 0.90 to 3.05 ; $p<0.01$; Supplementary Figs. 51–52, Supplementary Tables 47–48) and sedated patients ($k=6$; SMD 3.20 ; 95% CI 1.15 to 5.25 ; $p<0.01$; Supplementary Figs. 53–54), both with high heterogeneity ($I^2=97.60\%$ and $I^2=98.40\%$), and the highest SUCRA consistently for music (>0.90 ; Supplementary Tables 49–50). Analysis for upper procedures was not performed due to the low number of studies available. In non-sedated patients ($k=7$), music therapy did not reach statistical significance (SMD 1.30 ; 95% CI -0.03 to 2.63 ; $p=0.06$; Supplementary Figs. 55–56), with high heterogeneity ($I^2=96.40\%$) and the highest SUCRA values for audiovisual distraction (0.78) and music (0.67; Supplementary Tables 51–52).

Discussion

This systematic review and meta-analysis provide a comprehensive evaluation of non-pharmacological interventions in patients undergoing endoscopy and colonoscopy. This study addresses several methodological limitations of earlier reviews by strictly adhering to PRISMA guidelines, employing dual independent data extraction, and conducting rigorous quality assessments of included studies.

Anxiety is a significant concern in medical and procedural settings, often leading to increased physiological stress, discomfort, and non-compliance with medical interventions [2]. Non-pharmacological strategies, such as aromatherapy, Reiki and music therapy, have gained attention as effective methods for reducing anxiety without the side effects of sedative medications [8]. The results of our analysis demonstrate that Reiki, aromatherapy, and music therapy are associated with a significantly lower incidence of anxiety compared with control groups, reinforcing their effectiveness in anxiety management. In contrast, other interventions, such as stress balls and visual distraction, show a more evenly distributed ranking, suggesting lower consistency in their effectiveness. The distribution of music therapy aligns with previous findings demonstrating its ability to modulate physiological stress responses, reduce cortisol levels, and promote relaxation [2, 3]. In the rank probability distribution, music therapy (SUCRA = 0.67) ranks among the more effective interventions for anxiety but is slightly lower than Reiki (SUCRA = 0.78). A higher SUCRA value for Reiki may reflect favorable point estimates across multiple comparisons. However, music still outperforms interventions such as stress balls, visual distraction, and electroacupuncture, suggesting that its effectiveness is well-supported compared to commonly used relaxation techniques. This aligns with previous findings showing that music therapy significantly reduces anxiety symptoms, stress hormone levels, and physiological markers of distress [8]. Given its ease of implementation, lack of adverse effects, and demonstrated efficacy, music therapy represents a viable option for reducing anxiety in clinical and everyday contexts. Classical music, with its structured harmonies and slow tempos, is widely used in music therapy for anxiety [9]. Meditation music, including Tibetan singing bowls and binaural beats, also promotes relaxation. Additionally, patient-selected music enhances therapy effectiveness by aligning with personal emotional responses [5]. Music has also been used effectively in other settings, such as Reiki and guided meditation, where it helps facilitate deep relaxation and energy balance. Moreover, the SUCRA value of 0.67 for music therapy suggests a high probability of being among the most effective interventions. Reiki, with a SUCRA value of 0.78, demonstrates a higher probability of ranking among the top interventions for anxiety, suggesting that Reiki may have a greater overall impact on anxiety reduction compared to music

therapy. Reiki has demonstrated effectiveness in reducing anxiety across various settings. In postoperative care, some studies suggest that Reiki helps lower anxiety levels and enhances relaxation following surgery, though findings remain mixed due to differences in study methodologies [64]. While in oncology settings, Reiki has been used to support cancer patients undergoing chemotherapy and radiation therapy, helping to alleviate treatment-related anxiety and promote emotional well-being [64]. Additionally, Reiki has been applied in chronic pain management, where it has shown potential in reducing anxiety by inducing deep relaxation and decreasing stress-related physiological responses [64]. It should also be noted that interventions supported by only limited or indirect evidence, such as virtual reality and guided imagery, should not be regarded as ineffective. Their lower ranking reflects the small number of available studies, and further research is needed to establish their efficacy.

Despite the evaluation of numerous non-pharmacological interventions, our analysis did not identify any significant impact of these strategies on pain reduction during endoscopic procedures. Electroacupuncture, meditation combined with music, and the use of stress balls achieved the highest rankings in the SUCRA scores for pain management. However, none of the interventions demonstrated statistically significant superiority compared to the control group. This indicates that although these interventions might offer a certain level of comfort, their efficacy in directly reducing procedural pain is still uncertain. These findings contrast with recent research that demonstrated meditation and electroacupuncture could affect pain perception through physiological and neurological mechanisms, such as endorphin release and autonomic modulation [45, 61]. However, the considerable variability noted in the studies included, along with the differences in pain assessment methodologies, procedural contexts, and sample size, may explain the absence of significant results in our meta-analysis. Previous research has shown mixed results regarding the use of music therapy for pain relief, with some studies indicating minor benefits and others reporting no significant effects. These findings highlight its potential role in other procedures beyond endoscopy [43, 48, 64], as previous studies have suggested that electroacupuncture may reduce sedation requirements in endoscopic procedures [45]. However, its direct impact on pain perception remains uncertain. Given its potential role in modulating physiological and neurological responses, further research is needed to explore its efficacy in other medical procedures.

Patient satisfaction plays a crucial role in the success of medical interventions such as colonoscopies and endoscopies, influencing both procedural outcomes and patient adherence to follow-up care [25]. Aksu et al. reported that high levels of satisfaction lead to better patient outcomes overall, decreased anxiety, and a greater disposition to undergo procedures in the future [51]. Numerous methods have been investigated to increase satisfaction; music therapy is a particularly successful and non-invasive strategy. According to Sun et al., adding

music before endoscopic treatments considerably improves patient satisfaction levels [23]. This is consistent with our findings that overall satisfaction increased significantly as a result of music therapy. Similar findings from additional studies have shown that music not only reduces the discomfort during the process but also enhances the patient experience by creating a calmer environment [29]. Music acts as a therapeutic distraction by modulating the limbic system, which is responsible for emotional processing and stress regulation, thereby enhancing the overall patient experience [29].

Another important factor that impacts patient experience is procedural duration. Although anxiety and pain have been shown to increase procedure duration [21, 28], none of the interventions in our analysis showed a statistically significant impact on the duration to complete the procedures, indicating that external factors might be more crucial. These results are consistent with previous studies that found little to no effect on the length of the process [36, 53]. A possible explanation is that although these methods could lead to less anxiety, they have no direct impact on the efficiency of the procedure.

Subgroup analyses further contextualize these findings. In patients undergoing lower endoscopic procedures, music therapy showed the most consistent benefit for anxiety reduction, while aromatherapy and Reiki were particularly effective in upper procedures. In sedated patients, music therapy significantly improved both anxiety and satisfaction, whereas in non-sedated patients aromatherapy and Reiki also demonstrated robust effects. For pain, electroacupuncture and music therapy appeared effective in upper procedures but not in lower ones. Subgroup analyses for procedural duration confirmed the overall results, with no intervention showing a consistent reduction in completion time. These findings suggest that while specific interventions may provide benefit depending on procedural context or sedation status, the heterogeneity of results highlights the importance of tailoring non-pharmacological strategies to individual settings.

Limitations and Practical Implications

Although our meta-analysis yielded significant findings, it presents certain limitations. Over 50% of the 48 studies demonstrated a low risk of bias, offsetting the 20% that reported a high risk of bias in critical areas such as randomization processes and outcome measurements. Additionally, the language restriction to English publications may have excluded relevant studies, limiting the scope of our review. Nevertheless, the analysis incorporated studies from a geographically diverse range of countries, offering cultural variety. A further limitation was the lack of direct comparisons between interventions, as most studies assessed interventions against control. This constrained our ability to evaluate comparative efficacy. Moreover, most interventions involved small sample sizes, and the number of

studies per intervention was limited. The music versus control intervention emerged as the most studied and had the largest sample size, ultimately being the only comparison that demonstrated statistically significant results. Substantial heterogeneity was also observed across analyses ($I^2 > 90\%$).

Another important limitation relates to the variability in intervention protocols. For example, studies on music therapy differed in music genre, delivery method (headphones vs. ambient), timing (pre-, intra-, or post-procedure), and duration, making it difficult to establish standardized recommendations. Similarly, interventions such as virtual reality demonstrated variability in immersion level and equipment used, which may influence patient outcomes. Additionally, variability in outcome measurement tools (e.g., different anxiety and pain scales) may have contributed to heterogeneity, further limiting comparability across studies. Despite these limitations, the findings carry meaningful clinical implications. Music therapy is feasible, low-cost, and easy to implement in endoscopy suites. Clinicians could integrate it by providing patients with headphones and curated playlists before and during the procedure, ensuring minimal disruption to workflow. Practical guidelines should focus on selecting calming, patient-preferred music, standardizing delivery duration, and incorporating staff training to optimize effectiveness. Another limitation is that some included studies involved pediatric patients. However, the number of pediatric participants was too small and data presentation too limited to allow for a separate analysis. Therefore, our findings mainly reflect adult populations.

Future research should prioritize large-scale direct intervention trials with standardized methodologies to enhance reliability and establish causal relationships. Additionally, exploring multimodal approaches such as combining music therapy with relaxation techniques or virtual reality in diverse clinical settings may further advance patient-centered care during endoscopic procedures.

Conclusion

Our systematic review and meta-analysis provide a thorough assessment of non-pharmacological strategies aimed at reducing anxiety in patients undergoing endoscopy and colonoscopy. Of the 12 approaches evaluated, Reiki, aromatherapy, and music therapy demonstrated the most consistent and statistically significant reductions in anxiety, with music additionally associated with improved patient satisfaction. The remaining interventions did not consistently outperform standard care. Secondary outcomes showed no significant effects on pain, overall satisfaction, or procedure duration. Subgroup analyses indicated that music therapy was most effective in sedated and lower

endoscopic procedures, while Reiki and aromatherapy showed greater benefits in non-sedated and upper procedures. These findings suggest that tailoring interventions to procedural context and patient characteristics may maximize clinical benefit. To strengthen the evidence base, greater standardization of outcome measures and study designs will be essential. Given the promising results observed, incorporating non-pharmacological approaches, particularly music therapy, into routine clinical practice may enhance patient-centered care during endoscopic procedures. Future research should prioritize direct intervention studies and allow for stronger conclusions regarding the comparative effectiveness of these approaches.

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Data Availability All the data used to perform this analysis are publicly available in the referenced articles. The rest of the material is at the author's disposal upon reasonable request.

Declarations

Competing interests The authors declare that they have no competing interests.

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