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MAGNETIC RESONANCE

# Effects of aromatherapy and music therapy on patients' anxiety during MRI examinations: a randomized controlled trial

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## Abstract

**Objectives** Many patients experience anxiety during MRI examinations. However, little attention has been focused on decreasing patient anxiety and minimizing on-site cancellations. Here, we aimed to investigate the effects of aromatherapy and music therapy on alleviating anxiety during MRI examinations.

**Methods** This single-center, double-blinded, randomized control trial was conducted between November 1, 2021, and January 10, 2022. Patients undergoing MRI examinations were assigned randomly into either the aromatherapy group (AG), music therapy group (MG), aromatherapy plus music therapy group (AMTG), or routine care group (RG) at a ratio of 1:1:1:1. Aromatherapy was conducted through inhalation of *lavender oil*. Music therapy was performed using *Pachelbel's Canon in D major*. The primary outcome was the change in anxiety before and after the MRI scan, assessed using both the State–Trait Anxiety Inventory form 1 (STAI-1) and Self-Rating Anxiety Scale (SAS). The second outcome was the participant's comfort, measured using Kolcaba's General Comfort Questionnaire (GCQ).

**Results** A total of 200 participants (mean age: 48.3 ± 14.9 years; 126 [63.0%] females) were enrolled, with 50 per group. The mean anxiety scores of the AMTG showed greater reduction compared with the AG, MG, and RG (ΔSTAI-1: 6.5 vs 2.6 vs 2.7 vs 1.9, $p < 0.001$; ΔSAS: 4.0 vs 1.4 vs 1.7 vs 0.6, $p < 0.001$). The mean GCQ score of the AMTG was higher compared with the AG, MG, and RG (98.0 vs 92.6 vs 91.2 vs 89.2, respectively, $p < 0.001$).

**Conclusion** Aromatherapy combined with music therapy is effective for reducing patients' anxiety and improving their comfort level during MRI scans.

**Key Points**

- *In this randomized control trial of 200 participants undergoing MRI scans, aromatherapy plus music therapy is effective in reducing STAI-1 and SAS, as well as improving GCQ scores.*
- *Although there was a significant difference between the aromatherapy plus music therapy and the single-intervention modalities, no significant differences were observed between the aromatherapy and music therapy themselves for state anxiety and comfort score.*
- *Aromatherapy plus music therapy is a safe, non-invasive, nonpharmacological, and inexpensive patient-centered intervention for reducing anxiety and improving comfort in adults undergoing MRI examinations.*

**Keywords** Aromatherapy · Music therapy · Anxiety · Magnetic resonance imaging · Randomized controlled trial

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**Abbreviations**

| | |
|---|---|
| AG | Aromatherapy group |
| AMTG | Aromatherapy combined with the music therapy group |
| CI | Confidence interval |
| GCQ | Kolcaba's General Comfort Questionnaire |
| MD | Mean difference |
| MG | Music therapy group |
| MRI | Magnetic resonance imaging |
| RG | Routine care group |
| SAS | Self-Rating Anxiety Scale |
| STAI-1 | State–Trait Anxiety Inventory form 1 |

## Introduction

Magnetic resonance imaging (MRI) is a common non-invasive imaging technology used for disease detection, diagnosis, and treatment monitoring. However, up to 51% of patients are exposed to anxious experiences prior to and during MRI scans [1]; reported causes include long wait periods, the enclosed space, loud noise, contrast-media injection, worry about the results, and having to remain still for a long time [1, 2]. This negative perception affects workflow, limits patient acceptance of MRI, affects image quality, and wastes scanning time [3].

Patients tend to have limited knowledge about imaging procedures, which increases their fear and uncertainty [4]. The manner in which patients experience healthcare depends largely on the attitudes and actions of the healthcare providers they encounter [5]. Patient education, pre-scan communication, and other interpersonal interactions represent useful approaches for increasing patients' awareness of expectations during MRI; this improves their ability to cooperate during the MRI scanning process and mitigates anticipatory anxiety [6]. However, in many radiology practices, radiographers are under pressure to complete scans quickly to reach productivity targets and control costs; this results in less face-to-face interaction with patients compared with other medical specialists and, thus, less individual attention to a patient's experience [7, 8]. Patient care is often neglected as radiographers focus more on the scanning than on the patient [9]. Therefore, as workloads increase, radiology managers and healthcare providers should consider how to decrease patient anxiety and minimize on-site cancellations.

Patient-centered interventions that employ complementary and alternative methods for alleviating negative emotions are attracting increasing attention [10]. Among these, aromatherapy has been shown to have significant clinical benefits for anxiety and comfort, and it is relatively free of adverse events [11, 12]. It involves the use of aromatic oils with relatively small volatile molecules that are inhaled easily and rapidly through the nose and pass through the blood–brain barrier to affect the central nervous system directly [13, 14]. Music therapy is another promising therapeutic strategy; listening to calm and slow-paced music can reduce anxiety and enhance comfort by affecting the limbic system, which is primarily responsible for controlling emotional states [15–17]. However, the anxiety-reducing effects of aromatherapy, music therapy, or their combination in patients undergoing MRI examinations have not yet been elucidated. We investigated the hypothesis that aromatherapy and music therapy conducted in the MRI waiting room would reduce patient anxiety, and compared the effectiveness of different interventions. We hope that this work can be beneficial for radiographers, radiologists, health care managers, and patient advocates.

## Materials and methods

Our institutional review board approved this study (registration number: ZY-20200042); all procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from each participant. The participants were informed that the collected data would not be used for any other purpose. The anonymity, confidentiality, and destruction of the data after the trial were guaranteed. Their participation in this trial was based on voluntary principle and they could withdraw from the study at any time. The study was registered at ClinicalTrials.gov before beginning (ChiCTR2200059071). This trial adhered to the applicable Consolidated Standards of Reporting Trials (CONSORT) guidelines [18].

### Trial design

This was a single-center, randomized, controlled, double-blind trial conducted in the Radiology department of our hospital. Four parallel groups with a 1:1:1:1 allocation ratio were compared: aromatherapy combined with music therapy (AMTG), aromatherapy (AG), music therapy (MG), and routine care (RG) groups. The study design is shown in Fig. 1.

### Participants

Adult inpatients who required MRI examinations at our institution were randomly invited to participate in the study. Participants underwent MRI examinations for the first time on a 3.0 T unit (Skyra, Siemens Medical Systems) between November 1, 2021, and January 10, 2022.

Each participant provided consent; participants who failed to provide consent were excluded from the study. Other exclusion criteria were having a hearing or smell impairment, having absolute or relative contraindications to MRI, receiving psychoactive medication, pregnancy or lactation, previous

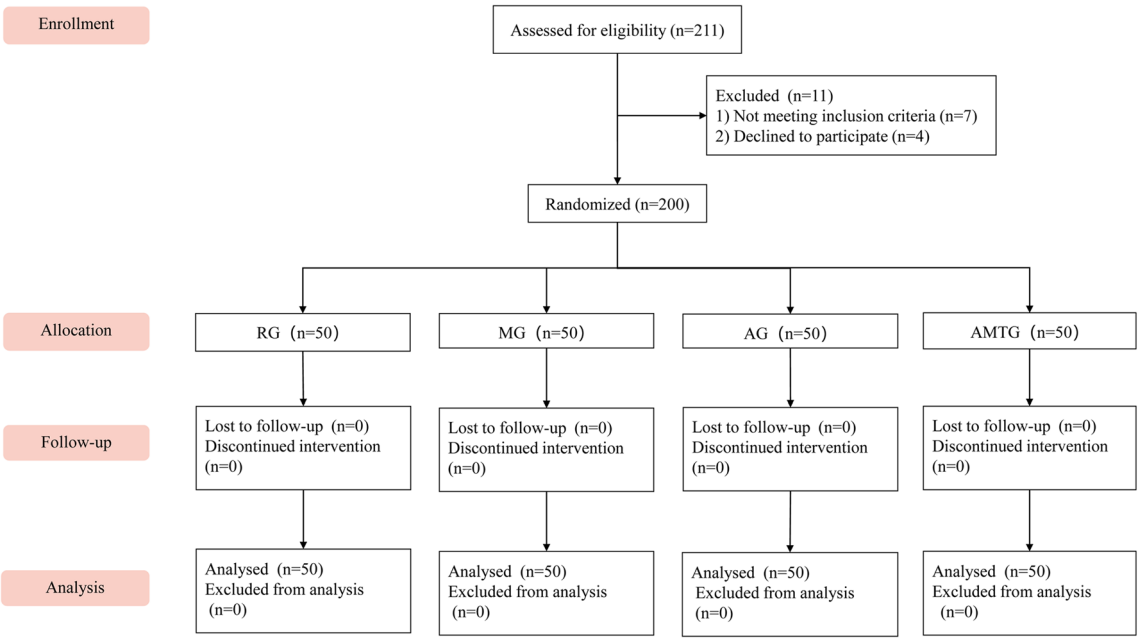


**Fig. 1** The CONSORT diagram of the study. AG, aromatherapy group; MG, music therapy group; AMTG, aromatherapy combined with music therapy group; RG, routine care group

participation, inability to cooperate with the investigator, or refusal to participate.

The sample size was set at a significance level of 0.05, a power of 0.95, and effect size of 0.25. The calculated minimum number of participants required for each of the four groups for one-way analysis of variance was 45 per group using G*Power software 3.1.5 (Heinrich–Heine University). The sample size was increased by applying a 10% drop and noncooperation, the sample size was increased to 50 participants in each group.

## Randomization and blinding

An independent clinical research assistant not involved in the study randomized the participants, using the Research Randomizer (https://www.randomizer.org/). A card with a randomly assigned number indicating the group assignment was placed in an opaque envelope and sealed. The research assistant opened an envelope for each participant in the order of their arrival and confirmed the group assignment. The double-blinded method was used to ensure that neither the evaluators nor the participants knew the group assignments.

## Interventions

For aromatherapy, the essential oils used in the intervention were chosen after consultation with an aromatherapy expert together with a review of previous literature. Based on the consultation and review, we selected lavender essential oil, one of the gentlest essential oils, which is proven effective in relieving stress, soothing, and emotional relaxation [19]. Eight drops of *lavender oil* were added to 300 ml of water and diffused into the air using an essential oil diffuser. The diffused oil is inhaled and spreads through the body, reaching peak levels within 20 min [14]. Therefore, aromatherapy was conducted for 20 min. The research assistants receiving aromatherapy checked whether the aroma oil had been diffused into the air. They replenished the water in the lamp when it was depleted and refreshed the prepared aroma oil.

For music therapy, *Pachelbel's Canon in D major* was played; it was selected after consultation with a licensed music expert who has been teaching a music training course for more than 13 years, together with a review of previous literature. Based on this consultation and review, we selected this *piece,* which was proven effective for improving stress levels, blood pressure, pulse, and body temperature [20]. The music was played continuously in a room equipped with speakers, so that participants could listen without earphones. The research assistants receiving music therapy ensured that music played continuously and insured that sound fidelity was adequate.

*Pachelbel's Canon in D major* was repeated three times (6 min 40 sec per time), which therefore lasted for 20 min.

The interventions for each group are shown in Fig. 2. Participants were told to arrive at the intervention site 40 min prior to the scheduled test. A research assistant assigned each participant randomly to a group before the MRI examination and then immediately guided the participants to separate, but similar, intervention rooms. Each intervention room was maintained at 26–27° C and medium-level lighting to eliminate extraneous factors. Windows were


**Fig. 2** Schematic plot of the study procedure. AG, aromatherapy group; MG, music therapy group; AMTG, aromatherapy combined with music therapy group; RG, routine care group; STAI-1, State–Trait Anxiety Inventory form 1; SAS, Self-Rating Anxiety Scale; GCQ, Kolcaba's General Comfort Questionnaire

covered to control lighting and prevent participants from looking outside. In addition to the participant–staff interaction, the interventions of the four groups were as follows:

*RG*: Participants received a 5-min video education and 5 min of a breathing–relaxation technique, followed by 20 min of waiting for the examination. The 20-min delay in this group is routine, which allows for adequate preparation for pre-inspection and adaptation to the new environment. The video education involved MRI safety, check-ups, and verbal information, including the duration of the examination, the importance of lying still, and the loud noise generated when images are taken. The breathing–relaxation technique involved alternating deep inhalation and exhalation for 5 min.

*AG:* Participants received a 5-min video education and 5 min of progressive relaxation, followed by 20 min of aromatherapy.

*MG:* Participants received a 5-min video education and 5 min of progressive relaxation, followed by 20 min of music therapy.

*AMTG:* Participants received a 5-min video education and 5 min of progressive relaxation, followed by 20 min of simultaneous aromatherapy and music therapy.

## Outcomes and measurements

The primary study outcome was the change in anxiety assessed using the Spielberger State–Trait Anxiety Inventory form 1 (STAI-1) and the Zung Self-Rating Anxiety Scale (SAS), before and after the MRI examination (ΔSTAI and ΔSAS, respectively). The secondary outcome was comfort scores measured by Kolcaba's General Comfort Questionnaire (GCQ).

The STAI-1 [21] was used to measure each participant's state of anxiety before the interventions and immediately after the MRI scan (STAI-before and STAI-after, respectively). The STAI score has 20 items, for which a person rates anxiety on a 0–4 scale ("nothing at all" to "very obvious"); the total score is 20–80 ("no anxiety" to "maximum anxiety"). Cronbach's alpha for this scale was 0.87.

The SAS [22] is a self-reported 20-item tool that measures a participant's psychological and somatic anxiety before the interventions and immediately after the MRI scan (SAS-before and SAS-after, respectively). Each item has a 1–4-point Likert scale ("no or little time" to "most or all of the time"); the item scores are summed and multiplied by 1.25. Higher scores indicate greater levels of anxiety. The SAS has a Cronbach alpha coefficient of 0.96.

Kolcaba's GCQ [23] includes 28 items concerning physiological, psychological, spiritual, social/cultural, and environmental aspects. Participants rate comfort on a 1–4-point Likert-type scale ("strongly disagree" to "strongly agree"). Negatively worded items were coded inversely; therefore, higher scores indicate greater comfort levels.

### Statistical analysis

Categorical variables are expressed as numbers (percentage); continuous variables are expressed as mean ± standard deviation or median (interquartile range), depending on the normality of their distribution. Comparisons of baseline characteristics of participants of each group consisted of the Chi-square test or one-way ANONA. One-way analysis of variance was used to determine whether there were significant differences in the scores of STAI-before, SAS-before, ΔSTAI-1, ΔSAS, and GCQ; a least significant difference post hoc analysis was used for pairwise comparisons. The data analyses followed the intention-to-treat principle. All statistical analyses were performed using SPSS Statistics version 23.0 (IBM Corp.). Statistical significance was set at $p < 0.05$.

## Results

Finally, 200 participants (126 [63.0%] females; mean age: 48.3 ± 14.9 years) were enrolled, with 50 per group. None of the participants withdrew from the trial; all participants completed and returned the questionnaires (100% response rate). Thus, all participants were analyzed for their primary and secondary outcomes. The baseline participant characteristics are shown in Table 1. There were no significant differences among the four groups (all $p > 0.05$). Notably, the baseline anxiety scores, including STAI-before ($F = 0.1$, $p = 0.935$) and SAS-before ($F = 0.5$, $p = 0.721$), did not differ among the groups before the interventions. The most frequent MR scanning site was the abdomen (118/200, 59.0%), followed by the head and neck (53/200, 26.5%), chest (29/200, 14.5%), and limbs (15/200, 7.5%). The mean scanning time of AMTG was slightly longer than that of AG, MG, and RG (25.3 ± 3.1, 23.0 ± 3.0, 22.6 ± 4.0, 22.3 ± 4.7, $p \leq 0.003$), whereas there were no significant differences between AG, MG, and RG (all $p > .05$). No repeated examinations occurred in the four groups. No therapy-related adverse events such as allergies were observed.

The effects of the various interventions are shown in Table 2. The differences in ΔSTAI-1 among the four groups were statistically significant ($F = 20.6$, $p < 0.001$). The pairwise comparison tests indicated that the ΔSTAI-1 value in the AMTG (6.5 ± 5.4) was significantly greater than those in the MG (2.7 ± 2.5), AG (2.6 ± 1.6), and RG (1.9 ± 1.9) (all $p < 0.001$), with mean differences (MD) of 3.8 (95% confidence interval [95% CI]: 2.5–5.1), 3.9 (95% CI: 2.7–5.2), and 4.6 (95% CI: 3.3–5.9), respectively. However, there were no significant differences in ΔSTAI-1 values among the AG, MG, and RG (all $P > 0.05$). Similarly, ΔSAS was significantly different among the four groups ($F = 250.4$, $p < 0.001$). The ΔSAS was significantly greater in the AMTG (4.0 ± 1.0) than in the MG (1.7 ± 0.5), AG (1.4 ± 0.5), and RG (0.6 ± 0.5) (all $p < 0.001$), with MDs of 2.3 (95% CI: 2.1–2.6), 2.7 (95 % CI: 2.4–2.9), and 3.4 (95% CI: 3.2–3.7), respectively. Furthermore, the MG has a greater ΔSAS than the AG (MD = 0.4, 95% CI: 0.1–0.6, $p = 0.007$) and RG (MD = 1.1, 95% CI: 0.8–1.4, $p < 0.001$).

GCQ scores were significantly different among the four groups ($F = 14.1$, $p < 0.001$). The GCQ score was significantly greater in the AMTG (98.0 ± 6.9) than in the MG (91.2 ± 6.3), AG (92.6 ± 6.6), and RG (89.2 ± 8.5) (all $p < 0.001$), with MDs of 6.8 (95% CI: 4.0–9.6), 5.4 (95% CI: 2.6–8.2), 8.8 (95% CI: 6.0–11.7), respectively. The GCQ score of the AG was similar to that of the MG (MD = 1.4, 95% CI: −1.4 to 4.2, $p = 0.328$) but greater than that of the RG (MD = 3.4, 95% CI: 0.6–6.2, $p = 0.017$).

## Discussion

This study evaluated the effects of aromatherapy and music therapy on reducing patient anxiety during MRI examinations when applied separately and in combination. This randomized study used interventions with high reproducibility, which could be utilized by patients before an MRI examination. The results show that the combination of aromatherapy with music therapy can further reduce a patient's anxiety and improve their comfort level during the MRI examination.

Routine MRI preparation does not contain enough information about MRI procedures to satisfy most patients, which strongly suggests a change in current practice is necessary [1]. Some attempts have been made to relieve anxiety before and during MRI scans, with mixed results. Tugwell et al [1] showed that video demonstrations or telephone conversations could significantly reduce pre-MRI anxiety; the video intervention performed slightly better than the phone call. However, Törnqvist et al [24] found that increased written information that contained procedural, sensory, and temporal information about MRI did not decrease patient anxiety, or increase patient satisfaction regarding the information, compared to patients receiving the routine basic written

**Table 1** Baseline characteristics of participants

| Characteristics | | RG ($n$ = 50) | MG ($n$ = 50) | AG ($n$ = 50) | AMTG ($n$ = 50) | $p$ value |
|---|---|---|---|---|---|---|
| Age, years | | 51.0 ± 16.2 | 47.1 ± 14.2 | 47.2 ± 14.5 | 48.3 ± 14.9 | 0.522 |
| Gender | | | | | | |
| | Male | 23 (46.0) | 14 (28.0) | 17 (34.0) | 20 (40.0) | 0.277 |
| | Female | 27 (54.0) | 36 (72.0) | 33 (66.0) | 30 (60.0) | |
| BMI[a], kg/m$^2$ | | | | | | |
| | Underweight | 3 (6.0) | 1 (2.0) | 7 (14.0) | 4 (8.0) | 0.056 |
| | Normal weight | 19 (38.0) | 29 (58.0) | 30 (60.0) | 28 (56.0) | |
| | Pre-obesity | 26 (52.0) | 17 (34.0) | 10 (20.0) | 16 (32.0) | |
| | Obesity | 2 (4.0) | 3 (6.0) | 3 (6.0) | 2 (4.0) | |
| Marital status | | | | | | |
| | Single | 4 (8.0) | 5 (10.0) | 5 (10.0) | 2 (4.0) | 0.181 |
| | Married | 40 (80.0) | 45 (90.0) | 40 (80.0) | 44 (88.0) | |
| | Divorced | 2 (4.0) | 0 | 3 (6.0) | 0 | |
| | Widowed | 4 (8.0) | 0 | 2 (4.0) | 4 (8.0) | |
| Insurance | | | | | | |
| | Yes | 50 (100.0) | 50 (100.0) | 48 (96.0) | 50 (100.0) | 0.246 |
| | No | 0 | 0 | 2 (4.0) | 0 | |
| Education level | | | | | | |
| | Primary education | 13 (26.0) | 15 (30.0) | 11 (22.0) | 18 (36.0) | 0.216 |
| | Lower secondary education | 15 (30.0) | 18 (36.0) | 26 (52.0) | 18 (36.0) | |
| | Upper secondary education or higher | 22 (44.0) | 17 (34.0) | 13 (26.0) | 14 (28.0) | |
| Smoking status[b] | | | | | | |
| | Currently smoking | 12 (24.0) | 4 (8.0) | 8 (16.0) | 6 (12.0) | 0.233 |
| | Ex-smoking | 11 (22.0) | 8 (16.0) | 10 (20.0) | 7 (14.0) | |
| | Never smoked | 27 (54.0) | 38 (76.0) | 32 (64.0) | 37 (74.0) | |
| Drinking status[c] | Heavy | 5 (10.0) | 2 (4.0) | 3 (6.0) | 1 (2.0) | 0.350 |
| | Light | 16 (32.0) | 13 (26.0) | 13 (26.0) | 9 (18.0) | |
| | Never | 29 (58.0) | 35 (70.0) | 34 (68.0) | 40 (80.0) | |
| Baseline anxiety measurements | | | | | | |
| | STAI-I | 48.1 ± 6.0 | 47.6 ± 6.1 | 47.9 ± 5.0 | 48.4 ± 6.8 | 0.935 |
| | SAS | 55.5 ± 3.6 | 55.0 ± 2.6 | 54.8 ± 4.4 | 54.7 ± 3.2 | 0.721 |
| Contrast injection | Yes | 23 (46.0) | 28 (56.0) | 30 (60.0) | 32 (64.0) | 0.300 |
| | No | 27 (54.0) | 22 (44.0) | 20 (40.0) | 18 (36.0) | |

Note.–Unless otherwise indicated, Continuous variables were presented as mean ± SD, and categorical variables were presented as number (%)

*RG*, routine care group; *MG*, music therapy group; *AG*, aromatherapy group; *AMTG*, aromatherapy combined with music therapy group; *BMI*, body mass index; *STAI-I*, State–Trait Anxiety Inventory form 1; *SAS*, Self-Rating Anxiety Scale

[a] BMI categories: underweight (BMI < 18.5), normal weight (BMI ≥ 18.5 and < 24.0), pre-obesity (BMI ≥ 24 and < 28), and obesity (BMI ≥ 28)

[b] 'Currently smoking' refers to someone who has smoked more than 100 cigarettes (including hand-rolled cigarettes, cigars, cigarillos, etc.) in their lifetime and has smoked in the last 28 days. 'Ex-smoking' refers to someone who has smoked more than 100 cigarettes in their lifetime but has not smoked in the last 28 days. 'Never smoked' is someone who has not smoked more than 100 cigarettes in their lifetime and does not currently smoke

[c] Heavy drinkers were defined as individuals who consume ≥ 21 and ≤ 50 units per week for males and ≥ 15 and ≤ 35 units per week for females (where 1 unit is equivalent to 8 g of ethanol). Light drinkers were defined as individuals who consume ≥ 10 and ≤ 20 units of alcohol per week for males and ≥ 5 and ≤ 14 units of alcohol per week for females

information. Shimokawa et al [25] conducted a non-randomized controlled trial to evaluate the efficacy of a patient-friendly audiovisual system in the MRI scanning room for reducing patients' anxiety; they found that the audiovisual system did not significantly reduce anxiety compared to the standard system. Further research is needed to evaluate the effects of other interventions on patient anxiety during MRI scans.

**Table 2** Comparison of anxiety and comfort level among groups

| Scores | Groups | Pre-test | Post-test | Difference (pre-post) | F-statistic | *p* value | Post hoc analysis |
|---|---|---|---|---|---|---|---|
| STAI-1 | RG (*n* = 50) | 48.1 ± 6.0 | 46.2 ± 5.5 | 1.9 ± 1.9 | 20.6 | < .001 | AMTG > MG = AG = RG |
| | MG (*n* = 50) | 47.6 ± 6.1 | 44.9 ± 4.7 | 2.7 ± 2.5 | | | |
| | AG (*n* = 50) | 47.9 ± 5.0 | 45.3 ± 4.3 | 2.6 ± 1.6 | | | |
| | AMTG (*n* = 50) | 48.4 ± 6.8 | 41.9 ± 3.3 | 6.5 ± 5.4 | | | |
| SAS | RG (*n* = 50) | 55.5 ± 3.6 | 54.9 ± 3.6 | 0.6 ± 0.5 | 250.4 | < .001 | AMTG > MG > AG = RG |
| | MG (*n* = 50) | 55.0 ± 2.6 | 53.3 ± 2.6 | 1.7 ± 0.5 | | | |
| | AG (*n* = 50) | 54.8 ± 4.4 | 53.5 ± 4.4 | 1.4 ± 0.5 | | | |
| | AMTG (*n* = 50) | 54.7 ± 3.2 | 50.7 ± 3.3 | 4.0 ± 1.0 | | | |
| GCQ | RG (*n* = 50) | | 89.2 ± 8.5 | | 14.1 | < .001 | AMTG > AG = MG > RG |
| | MG (*n* = 50) | | 91.2 ± 6.3 | | | | |
| | AG (*n* = 50) | | 92.6 ± 6.6 | | | | |
| | AMTG (*n* = 50) | | 98.0 ± 6.9 | | | | |

Note: Values are expressed as mean ± standard deviation. *RG*, routine care group; *MG,* music therapy group; *AG*, aromatherapy group; *AMTG*, aromatherapy combined with music therapy group; *STAI-I*, State–Trait Anxiety Inventory form 1; *SAS*, Self-Rating Anxiety Scale.

Complementary and alternative therapies, such as music therapy and aromatherapy, offer a method of anxiety reduction in patients undergoing MRI. Music therapy is an inexpensive, safe, non-invasive, and effective nonpharmacological intervention that can regulate a patient's heart rate, blood pressure, and respiratory rate [20]. Music therapy has been demonstrated to be effective for the management of negative symptoms, including anxiety, stress, insomnia, agitation, depression, fatigue, and pain, and can improve mental health, and dementia behaviors [26]. Aromatherapy stimulates the parasympathetic nervous system via the hypothalamus, thereby reducing a patient's heart rate, blood pressure, respiratory rate, oxygen consumption, and metabolism; this relaxes patients, alleviates pain, and reduces stress and anxiety [27]. Inhalation aromatherapy has been used as a symptomatic therapy for preoperative anxiety, postoperative nausea and vomiting, depression, stress, insomnia, pain, and dementia [11, 12, 28–30]. This intervention is also applicable to patients preparing for MRI scans, because of its low cost, safety, and ease of implementation in clinical settings.

This study explored the effects of aromatherapy plus music therapy and compared the effects with individual interventions. We attempted to mitigate the influence of extraneous variables by regulating the temperature and lighting in the intervention room. The effective use of these therapies requires a suitable physical space to administer the aroma and music therapies comfortably. If it is not possible to prepare such an intervention room, it may be better to control the environment through other means, since the surrounding environment might affect the therapeutic efficacy. The results showed that the combined use of the two types of interventions was associated with a synergistic effect for reducing anxiety and improving comfort levels. Aromatherapy and music therapy may interact together to produce an effect that was greater than the cumulative effect that the two therapies produce when used individually. We found that the aromatherapy plus music therapy was superior to the single-intervention modalities even though the former had a slightly longer scanning time due to a higher rate of intravenous contrast rather than other reasons such as repeated sequences or movement artifact; yet, there were no significant differences between the aromatherapy and music therapy interventions themselves for state anxiety and comfort score; this is consistent with previous studies [13, 31, 32]. This may be because both aromatherapy and music therapy reduce negative emotions, such as anxiety or stress, among subjects who perform demanding cognitive tasks.

This study had some limitations that should be acknowledged. First, since this study was conducted with inpatients at a single center, the findings of the study cannot be generalized too widely. Further studies are needed that include outpatients and consider more personal and social factors that can affect anxiety. Second, this study focused on adult participants and did not include pediatric participants, who were often administered sedation or anesthesia. Third, this study did not compare the effects of different music therapy methods and types, or test different essential oils, for alleviating participants' anxiety levels. In real-world settings, patients can choose the type of music and aroma based on their preferences. We can anticipate that aromatherapy and music therapy will be more personalized and effective in daily routines. Fourth, the intravenous contrast rate of AMTG was higher than other groups, principally RG. Given the contrast agent injection may increase patient anxiety, the effects of aromatherapy plus music therapy may be underestimated in this trial. Fifth, the effect of aromatherapy and music therapy on reducing movement artifacts was not investigated because this is not the goal of this

present study and the confounding factors were not well controlled. Additionally, a prior study [33] showed that there is little evidence for the assumption that anxiety increases motion and decreases image quality during an MR examination. Finally, while this study used self-reported questionnaires to measure anxiety and comfort, future research should also measure physiological variables to enhance the objectivity of the study results.

In conclusion, the current study demonstrates that aromatherapy plus music therapy is a safe, non-invasive, nonpharmacological, and inexpensive patient-centered intervention for reducing anxiety and improving comfort in adults undergoing MRI examinations. While this study examined the effects of combining aromatherapy with music therapy and highlighted advances in patient care in the radiology department except for advances in imaging technologies, there are several avenues of future research that can continue to advance our study, including varying the types of participants and therapy parameters and including objective physiological measurements and movement artifact to complement our participant-based data.

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## Declarations

**Guarantor** The scientific guarantor of this publication is Bin Zhang.

**Conflict of interest** The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

**Statistics and biometry** Bin Zhang performed the statistical analysis.

**Informed consent** Written informed consent was obtained from each participant.

**Ethical approval** This trial was approved by the institutional Ethics Committees of the First People's Hospital of Zunyi (the Third Affiliated Hospital of Zunyi Medical University) (registration number: ZY-20200042).

**Methodology**
- prospective
- randomised controlled trial
- performed at one institution

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