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ARTICLE

The Impact of Music Education Intervention on Anxiety Symptoms among Non-Music Major University Students: A Quasi-Experimental Study

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ABSTRACT: Backgrounds: Anxiety symptoms represent a prevalent mental health challenge among university students, yet accessible and scalable intervention approaches remain limited. This study examined the effectiveness of a structured music education intervention in reducing anxiety symptoms among non-music major university students in China. **Methods:** Using a quasi-experimental design with a non-equivalent control group, 110 participants experiencing anxiety symptoms were allocated to either an intervention group (n = 55) receiving a 12-week music education program comprising two 90-min sessions weekly, or a control group (n = 55) continuing regular academic activities. Assessments were conducted at baseline (T0), post-intervention (T1), and one-month follow-up (T2) using validated instruments including the Generalized Anxiety Disorder-7 (GAD-7), Patient Health Questionnaire-9 (PHQ-9), Connor-Davidson Resilience Scale-10 (CD-RISC-10), WHOQOL-BREF, and Social Support Rating Scale (SSRS). **Results:** The intervention group demonstrated significant anxiety reduction from baseline (GAD-7: 11.8 ± 3.2) to post-intervention (7.3 ± 2.8) and follow-up (7.8 ± 2.9), yielding large effect sizes (Cohen's d = 1.47 and 1.32, respectively), while the control group showed minimal change. Clinically, 68.1% of intervention participants achieved significant anxiety reduction compared to 12.0% of controls. Secondary outcomes including depression, psychological resilience, and quality of life showed significant improvements with medium-to-large effect sizes (Cohen's d = 0.43–0.68). A dose-response pattern indicated that higher session attendance predicted better outcomes (r = 0.36, $p < 0.001$). **Conclusions:** These findings provide preliminary evidence suggesting that music education may represent a feasible and potentially effective approach for anxiety management in university settings. Given the quasi-experimental design, results should be interpreted cautiously, and randomized controlled trials are needed to establish causal efficacy.

KEYWORDS: Music education intervention; university students; anxiety symptoms; quasi-experimental design; mental health; quality education

1 Introduction

The mental health of university students has become a pressing global concern, and the symptoms of anxiety are among the most prevalent psychological problems for students of higher education institutions. Recent evidence has identified music education interventions as a potentially promising avenue of approach in trying to respond to this need, particularly through their potential to enhance emotional intelligence and psychological resilience [1]. Within the Chinese higher education context, systematic evaluations have indeed highlighted the potential of structured music education programs in alleviating symptoms of mental health problems in university students, although methodological rigor is still an ongoing source of concern [1]. Epidemiological evidence suggests that symptoms of depression and anxiety affect a substantial proportion of college students worldwide, with prevalence rates sometimes reaching alarming

levels and thus calling for innovative and easily accessible methods of intervention [2–4]. Classic forms of psychological interventions have some barriers linked to stigma, resource limitation, and scalability; therefore, researchers and practitioners have started exploring additional options that can complement standard interventions within the existing educational frameworks.

Music-based therapeutic approaches have received significant interest and recognition with respect to their potential benefits in emotional regulation and mental well-being. Clinical research involving medical students has found that organized music interventions can positively impact one's skills in emotional regulation and decrease mental distress, providing explicit insights into therapeutic processes mediated by music participation and activity [5]. Within times of increased stress, such as those recently faced with the COVID-19 crisis, organized music interventions led to significant reduction of anxiety symptoms in students at colleges, underlining the applicability of such approaches under conditions of crisis and stress [6]. The specific role of group music therapy has demonstrated its potential in proactive stress and anxiety management, providing preventive and therapeutic benefits with respect to combined musical experiences [7]. Systematic reviews have established a theoretical foundation linking music engagement to psychological well-being across diverse populations [8,9]. The applicability of music therapy regarding stress reduction has already found support by meta-analysis, showing favorable effect size values concerning its efficiency and applicability with respect to diverse populations and approaches under diverse methodological designs [10,11], with longitudinal evidence further documenting associations between arts engagement and long-term health outcomes [12].

The theoretical underpinnings of interventions conducted in music education with regard to mental health include established theories that originate from psychology and cognitive science. Social cognitive theory highlights self-efficacy and outcome expectations as theoretical mechanisms through which music education may broadly influence mental health [13]. The concept of emotional intelligence has similarly been proposed as a distal theoretical pathway linking music education to well-being outcomes [14]. Building on these frameworks, the present study focuses on the proximal, measurable outcomes of this process—specifically anxiety symptoms, psychological resilience, quality of life, and social support—which are directly assessed. Research on music and socioemotional learning demonstrates that musical training fosters emotional skills extending beyond technical musical competence [15].

Individual as well as contextual factors may influence the effects of music-focused interventions, and they should be examined. Longitudinal studies identified sex differences in anxiety and depression in university student populations, suggesting individual factors as potential moderators of intervention effects [16]. Emotional regulation skills were identified as a potential mediator between music participation and mental health outcomes [17]. In terms of empirical studies on instrument-based music interventions, emotional intelligence and reduction of anxiety were found in youth populations [18].

Despite an ever-expanding literature base documenting the effectiveness of interventions incorporating music in mental health, research in this area has been characterized by several limitations [8,10]. The majority of research has addressed interventions offered by qualified therapists, raising questions concerning the effectiveness of interventions implemented by credentialed educators within an academic institution [6,7]. The majority of research has evaluated interventions with either music major participants, participants with prior music experience, or groups of participants with undefined prior experience, raising questions concerning interventions conducted with students not majoring in music, which comprise virtually all participants within an institution of higher learning. Variability in research methodologies, particularly concerning the parameters of interventions, has characterized research in this area, making it problematic to generally conclude what parameters comprise effective interventions [6]. Theoretically, intervening outcomes can be clarified only partially, with minimal research concerning myriad mediators including emotional regulation, self-efficacy,

and social support [12]. The majority of research has taken place in Western institutions, making problematic assuming transportability into differing cultural institutions of higher learning [1].

Furthermore, it is necessary to distinguish between music education and music therapy, as the two are conceptually different practices. In the case of music therapy, it is a clinical practice carried out by licensed therapists with diagnosed populations, while music education is a structured educational experience with a curriculum, carried out by qualified educators in an institutional setting. Even though the current study is underpinned by theoretical insights from the field of music therapy studies, it is necessary to note that the current study is not a clinical intervention, as is the case with music therapy, but an educational intervention aimed at prevention.

The current study attempts to bridge this gap with an evaluation of a structured music education intervention with non-music major university students experiencing anxiety symptoms in a Chinese higher education setting. A quasi-experimental study design was employed with the following objectives: (1) examine the effects of the 12-week music education intervention on anxiety symptoms as the primary outcome measure; (2) examine the effects of the music education intervention on secondary outcome measures, such as depression, psychological resilience, quality of life, and social support; and (3) examine potential moderators such as sex, severity of anxiety symptoms at baseline, and attendance at the music sessions. It was hypothesized that the intervention group participants would report greater reductions in anxiety symptoms than the control group at post-intervention and one-month follow-up.

2 Data and Methods

2.1 Research Design

This study employed a quasi-experimental design with a non-equivalent control group to evaluate the effectiveness of a music education intervention for reducing anxiety symptoms among non-music major university students at Zhejiang Shuren University. The participants were assigned to either the intervention group, which was given a structured music education program, or the control group, which continued with their normal academic activities, according to their class section enrollment, following the quasi-experimental design. The research protocol encompassed three primary measurement points: baseline assessment (T0) conducted before intervention initiation, post-intervention assessment (T1) immediately following the completion of the program, and follow-up assessment (T2) conducted one month after intervention completion to examine effect maintenance. As illustrated in Fig. 1, the study proceeded through systematic phases including participant recruitment and screening, informed consent procedures, baseline data collection, group allocation, intervention implementation spanning twelve weeks with two sessions per week, and sequential outcome assessments. The intervention group received ninety-minute music education sessions incorporating music appreciation, basic music theory, vocal training, and collaborative musical activities, while the control group maintained standard coursework without additional interventions. This study received ethical approval from the Institutional Review Board at Zhejiang Shuren University (approval number: IRB-2024-043), with all participants providing written informed consent. Confidentiality protections included data anonymization and secure storage protocols, and participants retained the right to withdraw at any time without penalty. The control group was offered access to the music education program following study completion as ethical compensation.

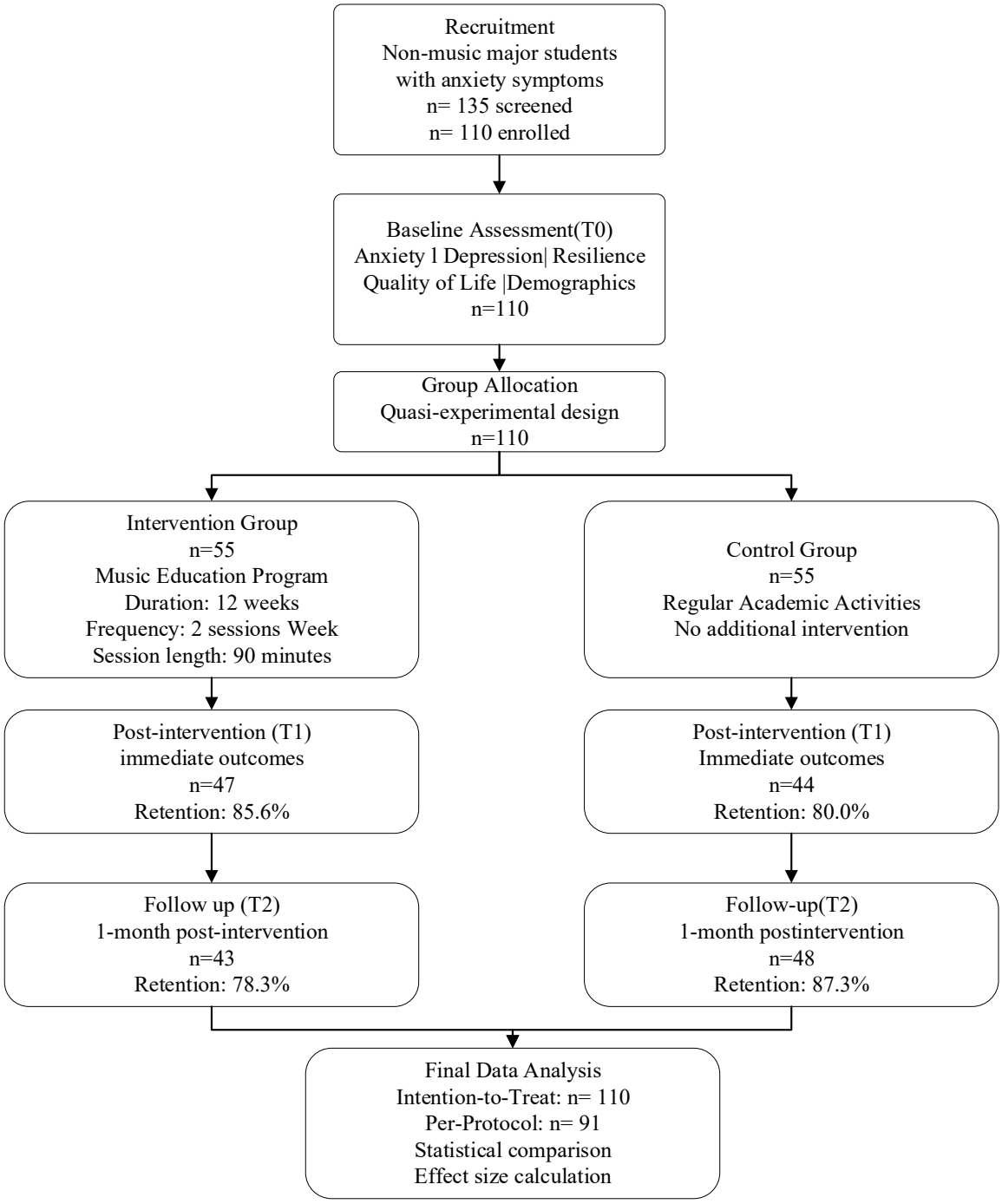

Figure 1: Participant flow diagram.

2.2 Setting and Participants

This study was conducted at Zhejiang Shuren University, a comprehensive private university located in Hangzhou, Zhejiang Province, China, with an enrollment of approximately 17,000 full-time undergraduate students across multiple disciplines. The target population was undergraduate students, non-majors in music, experiencing symptoms of anxiety, recruited by university announcements and by referral through various academic departments. The criteria for participants' inclusion included students' undergraduate

status, ages 18–25 years, absence of formal background in music, scores above the clinical threshold on controlled anxiety assessment instruments, and voluntary and signed consent. The criteria for exclusion included students' enrollment in academic courses in music, serious mental illnesses necessitating specialized interventions, present psychotropic drug usage, and concurrent involvement in any form of psychological interventions. Following recruitment and eligibility screening, 110 participants were enrolled and allocated to intervention (n = 55) and control (n = 55) groups, with demographic characteristics including age, sex, academic year, major discipline, family background, and prior informal music exposure documented at baseline to ensure comparability between groups.

2.3 Music Education Intervention Program

The music education program was designed with experiential involvement and emotional skills development, and it was founded with principles of social cognitive theories and constructivism. The program was conducted over 12 weeks, with bi-weekly 90-min sessions, amounting to 24 sessions and 36 h of class time. Each session combined numerous instructional elements, focusing on fostering psychological well-being and skills development in music. The main contents included introductory lessons to basic theories of rhythm, melodies, and harmony; guided appreciation lessons with diverse styles and emotional expressions of music; vocal development lessons with group collaboration, focusing primarily on controlled breathing and tone development; group performance lessons, with ensemble and team-building aspects; personal creative composition lessons, promoting personal expressions and imagination; and advanced listening skills with relaxation responses, founded with mindfulness and relaxation responses. The lessons were designed with significant experiential involvement and participation, along with technology integration and usage of various digital tools and software in music. The 90-min sessions were designed with a three-phase structure: an opening phase (15 min) that included guided breathing and listening to music for relaxation; an instructional phase (60 min) that included the main content of the week; and a closing phase (15 min) that included listening and creative activities. The sessions were allocated as follows: educational instruction (40%), expressive and performance activities (35%), and relaxation listening (25%). The repertoire included classical Western music, traditional Chinese folk music, and popular music. All aspects of the main content were standardized in an instructor manual developed in collaboration with music education and psychology faculty. Genre selection in relaxation listening was at the discretion of the instructors. Instructors were qualified in both music education and psychology and underwent two days of training in the protocol before the start of the study. Data on fidelity were obtained with weekly checklists completed by instructors and weekly, unannounced observation of instructors by a supervisor unaware of outcome data.

2.4 Measurement Instruments and Variables

The main outcome measure evaluated symptoms of anxiety based on scores obtained from the Generalized Anxiety Disorder-7 item scale, GAD-7, which has been found to be valid and has excellent psychometric properties with Cronbach's alpha values above 0.85 in Chinese university students. Secondary outcomes included Patient Health Questionnaire-9, PHQ-9, which has been validated and offers excellent psychometric standards with alpha values above 0.85, Connor-Davidson Resilience Scale-10, CD-RISC-10, and World Health Organization Quality of Life BREF, WHOQOL BREF, which has also shown excellent psychometric performance with alpha values above 0.85. Another secondary outcome measure was assessment of perceived and received support networks, which was based on Social Support Rating Scale, SSRS. Process measures included assessment of participants' engagement with interventions in terms of class attendance, class rating, and course evaluation, which was conducted after the interventions. The instruments used,

including all secondary outcomes, were all validated Chinese versions, which displayed excellent psychometric standards with alpha values above 0.85 and were administered at three time points: baseline (T0), immediate post-intervention (T1), and one-month follow-up (T2).

2.5 Data Collection Procedures

Participants were recruited through campus electronic notifications and collaborative efforts with academic school departments, with prospective participants completing initial online screenings including preliminary measures of anxiety symptoms and criteria eligibility. Interested and potentially qualified candidates then attended information sessions outlining research purposes, methods, and potential risks and benefits, along with arrangements protecting confidentiality, prior to obtaining written informed consent. Initial baseline measurements (T0) were obtained within one week after participant recruitment, with all research participants completing comprehensive individual measures through a secure online platform assessing anxiety, depression, resilience, quality of life, social support, and demographic information. Throughout the course of the 12-week research interventions, research assistants documented systemic recordings of participants' attendance and level of engagement, along with recording adverse events according to structured observation instruments. Post-intervention testing (T1) was conducted within three days after program completion, with all research measures administered identically at baseline testing times. The one-month post-intervention assessment (T2) was conducted via online research instruments with supplementary reminders and follow-up phone communications to reduce attrition potential, with all testing conducted by research assistants blind to the participants' group structure through standardized testing scripts. Data measures included double-data entry, logic consistencies checking research response for potential impossible response combinations, with immediate research response follows-up regarding ambiguous and incomplete responses, and with all participants' research responses kept anonymous with secured code-name identity entries stored within formally protected and secured servers under assigned federal and local regulations regarding protected research and personal institution-related and individual human biomedical research and personal identifiable information.

2.6 Data Analysis

For analyzing the data collected, the software used was SPSS 27.0 (IBM Corp., Armonk, NY, USA), with the significance level of the tests set at $\alpha = 0.05$, i.e., $p < 0.05$ was the criterion of statistical significance, while $p < 0.01$ and $p < 0.001$ were highly statistically significant, as indicated in the results. To describe participants' demographic and initial variable measures, descriptive statistics analysis was conducted, with continuous variables expressed as Mean ± Standard Deviation (M ± SD) and categorical variables expressed as frequencies and percentages. To determine if initial variable measures were equivalent between groups, independent samples *t*-tests and chi-square tests were used. The method used to replace missing values was multiple imputations by chained equation, assuming missing at random values. The main analysis conducted was repeated measures analysis of variance (RM-ANOVA), examining interaction effects of time and group over three time points (T0, T1, and T2). ANCOVA analysis was also used to control initial variable measures as covariates. To analyze clinical significance, effect size was calculated by Cohen's d with 95% confidence intervals. To find potential moderation variables, stratification analysis was conducted, dividing participants into sub-group categories by sex, initial severity of anxiety symptoms, and prior experience with music. The per protocol analysis, which only included the participants who attended all three assessment points, was defined as the main analysis. In addition, an intention-to-treat analysis was performed, including all the participants, with multiple imputation by chained equations used to account for missing data.

Sensitivity analysis was used to examine the robustness of the results by comparing them with alternative strategies for dealing with missing values. To extend the analysis beyond RM-ANOVA, linear mixed effects models (LME) were computed using restricted maximum likelihood estimation with time, group, their interaction, and participant as fixed effects, as well as participant as a random intercept. The consistency of results using RM-ANOVA and LME is described in Section 3.5. For graphical presentation of longitudinal trajectories, data are displayed as Mean ± Standard Error (Mean ± SE).

3 Results

3.1 Participant Characteristics and Baseline Comparability

The selection process involved screening 135 potential participants, with 110 non-music major undergraduate students who met the eligibility criteria and giving their consent to participate in the study. The 25 excluded participants included 18 students not fulfilling the inclusion criteria regarding enrollment in present music courses, psychotropic drug intake, and degree of anxiety symptoms, and 7 students not willing to participate regarding time constraint and personal reasons. The remaining 110 subjects were allocated to intervention and control groups through non-random assignment based on class section enrollment, each group consisting of 55 individuals, with 91 participants completing all research assessment instruments up to one-month post-testing, providing an overall retention rate of 82.7%. The demographic and clinical characteristics of participants, shown in Table 1, were satisfactory and comparable between groups at baseline. Demographic characteristics were well balanced between groups. The intervention group comprised 23 males and 32 females (mean age 20.4 ± 1.3 years), and the control group comprised 25 males and 30 females (mean age 20.6 ± 1.4 years), with no significant differences in sex (χ^2 = 0.163, p = 0.686) or age (t = 0.823, p = 0.412) between groups. Academic year distribution spanned from freshmen to seniors in both groups without significant disparity (χ^2 = 2.147, p = 0.542). Regarding baseline clinical measures, the intervention and control groups demonstrated comparable anxiety symptom severity (GAD-7: 11.8 ± 3.2 vs. 11.5 ± 3.4, t = 0.493, p = 0.623), depressive symptoms (PHQ-9: 10.2 ± 4.1 vs. 9.9 ± 4.3, t = 0.384, p = 0.702), psychological resilience (CD-RISC-10: 23.7 ± 5.8 vs. 24.1 ± 6.2, t = −0.356, p = 0.722), quality of life (WHOQOL-BREF: 88.3 ± 12.6 vs. 89.1 ± 13.2, t = −0.331, p = 0.741), and social support (SSRS: 38.6 ± 7.4 vs. 39.2 ± 7.8, t = −0.421, p = 0.674). These non-significant differences across all demographic and clinical variables confirmed adequate baseline equivalence, indicating that observed outcome differences could be attributed to intervention effects rather than pre-existing group disparities.

Table 1: Baseline demographic and clinical characteristics by group.

Characteristic	Intervention Group (n = 55)	Control Group (n = 55)	Test Statistic	*p*-Value
Demographics				
Age (years), M ± SD	20.4 ± 1.3	20.6 ± 1.4	t = 0.823	0.412
Sex, n (%)			χ^2 = 0.163	0.686
Male	23 (41.8%)	25 (45.5%)		
Female	32 (58.2%)	30 (54.5%)		
Academic Year, n (%)			χ^2 = 2.147	0.542
Freshman	15 (27.3%)	13 (23.6%)		
Sophomore	18 (32.7%)	16 (29.1%)		
Junior	14 (25.5%)	18 (32.7%)		
Senior	8 (14.5%)	8 (14.5%)		
Prior Music Experience, n (%)	12 (21.8%)	14 (25.5%)	χ^2 = 0.201	0.654

Table 1: *Cont.*

Characteristic	Intervention Group (n = 55)	Control Group (n = 55)	Test Statistic	*p*-Value
Clinical Measures				
GAD-7 Score, M ± SD	11.8 ± 3.2	11.5 ± 3.4	t = 0.493	0.623
PHQ-9 Score, M ± SD	10.2 ± 4.1	9.9 ± 4.3	t = 0.384	0.702
CD-RISC-10 Score, M ± SD	23.7 ± 5.8	24.1 ± 6.2	t = −0.356	0.722
WHOQOL-BREF Score, M ± SD	88.3 ± 12.6	89.1 ± 13.2	t = −0.331	0.741
SSRS Score, M ± SD	38.6 ± 7.4	39.2 ± 7.8	t = −0.421	0.674

Note: M = Mean; SD = Standard Deviation; GAD-7 = Generalized Anxiety Disorder-7; PHQ-9 = Patient Health Questionnaire-9; CD-RISC-10 = Connor-Davidson Resilience Scale-10; WHOQOL-BREF = World Health Organization Quality of Life-BREF; SSRS = Social Support Rating Scale. All *p*-values > 0.05 indicate non-significant baseline differences between groups.

3.2 Primary Effects of Music Education Intervention on Anxiety Symptoms

The music education intervention demonstrated significant efficacy in reducing anxiety symptoms among non-music major university students. As shown in Table 2, baseline GAD-7 scores were comparable between intervention (11.8 ± 3.2) and control (11.5 ± 3.4) groups (p = 0.623). Following the 12-week intervention, the intervention group exhibited substantial anxiety reduction at post-test (T1: 7.3 ± 2.8) and sustained improvement at one-month follow-up (T2: 7.8 ± 2.9), whereas the control group showed minimal change (T1: 10.9 ± 3.3; T2: 10.6 ± 3.2). Repeated measures ANOVA revealed significant main effects of time (F = 42.37, $p < 0.001$, partial $\eta^2 = 0.32$) and group (F = 28.51, $p < 0.001$, partial $\eta^2 = 0.24$), with a crucial time × group interaction effect (F = 35.68, $p < 0.001$, partial $\eta^2 = 0.29$), indicating differential intervention responses. Paired t-tests demonstrated significant within-group anxiety reduction in the intervention group from baseline to post-test (t = 9.87, $p < 0.001$, Cohen's d = 1.47) and from baseline to follow-up (t = 8.93, $p < 0.001$, Cohen's d = 1.32), reflecting large effect sizes. Conversely, the control group exhibited non-significant changes across time points ($p > 0.05$). Between-group comparisons using ANCOVA controlling for baseline scores revealed significantly lower anxiety in the intervention group at both T1 (F = 31.24, $p < 0.001$, adjusted Cohen's d = 1.21, 95% CI [0.82, 1.60]) and T2 (F = 26.89, $p < 0.001$, adjusted Cohen's d = 1.08, 95% CI [0.70, 1.46]). Clinically, 68.1% of intervention participants achieved ≥30% anxiety reduction compared to 12.0% of controls ($\chi^2 = 35.42$, $p < 0.001$), with 55.3% reaching subclinical anxiety levels versus 18.0% in controls ($\chi^2 = 16.87$, $p < 0.001$). As illustrated in Fig. 2, these patterns confirm robust and sustained intervention effects on anxiety symptom alleviation.

Table 2: Changes in anxiety symptoms across time points by group.

Measure	Intervention Group (n = 47)	Control Group (n = 44)	Between-Group Comparison
GAD-7 Score, M ± SD			
Baseline (T0)	11.8 ± 3.2	11.5 ± 3.4	t = 0.493, p = 0.623
Post-test (T1)	7.3 ± 2.8	10.9 ± 3.3	t = 6.12, $p < 0.001$
Follow-up (T2)	7.8 ± 2.9	10.6 ± 3.2	t = 5.04, $p < 0.001$
Within-Group Change			
T0 to T1	−4.5 ± 2.7***	−0.6 ± 1.9	ANCOVA: F = 31.24, $p < 0.001$
-Cohen's d	1.47 (large)	0.18 (trivial)	Adjusted d = 1.21 [0.82, 1.60]
T0 to T2	−4.0 ± 2.8***	−0.9 ± 2.1	ANCOVA: F = 26.89, $p < 0.001$
-Cohen's d	1.32 (large)	0.28 (small)	Adjusted d = 1.08 [0.70, 1.46]

Table 2: *Cont.*

Measure	Intervention Group (n = 47)	Control Group (n = 44)	Between-Group Comparison
Repeated Measures ANOVA			
Time effect	—	—	$F = 42.37$, $p < 0.001$, $\eta^2 = 0.32$
Group effect	—	—	$F = 28.51$, $p < 0.001$, $\eta^2 = 0.24$
Time × Group interaction	—	—	$F = 35.68$, $p < 0.001$, $\eta^2 = 0.29$
Clinical Significance, n (%)			
≥30% anxiety reduction	32 (68.1%)	6 (12.0%)	$\chi^2 = 35.42$, $p < 0.001$
Subclinical level (GAD-7 < 10)	26 (55.3%)	9 (18.0%)	$\chi^2 = 16.87$, $p < 0.001$

Note: M = Mean; SD = Standard Deviation; GAD-7 = Generalized Anxiety Disorder-7 (range 0–21); ANCOVA = Analysis of Covariance controlling for baseline scores; η^2 = partial eta squared. ***$p < 0.001$ for within-group paired t-tests. Negative change values indicate anxiety reduction (clinical improvement).

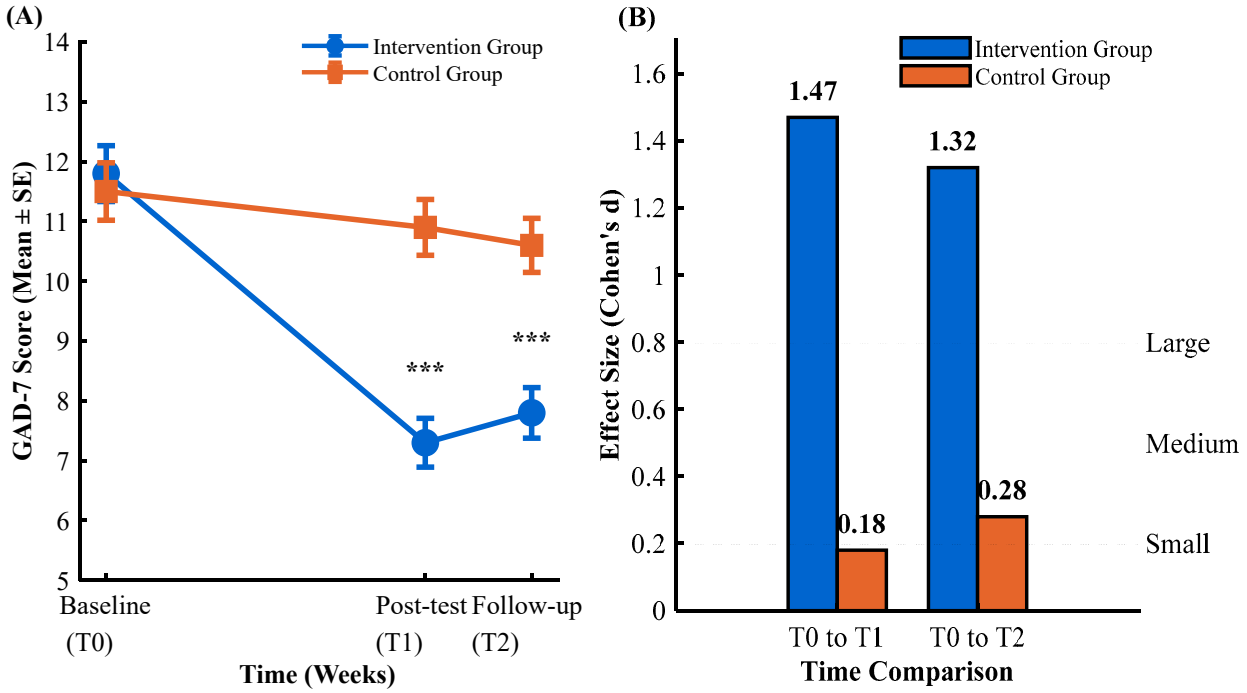

Figure 2: Effects of music education intervention on anxiety symptoms. (**A**) GAD-7 score trajectories across T0, T1, and T2. (**B**) Within-group effect sizes at T0→T1 and T0→T2. Note: (**A**) GAD-7 score trajectories across T0, T1, and T2 for the intervention (blue) and control (orange) groups (Mean ± SE; ***$p < 0.001$ for between-group differences). (**B**) Within-group effect sizes (Cohen's d) at T0→T1 and T0→T2; dashed lines indicate small (0.2), medium (0.5), and large (0.8) thresholds.

3.3 Intervention Effects on Secondary Outcomes

Beyond anxiety reduction, the music education intervention demonstrated significant beneficial effects across multiple secondary psychological outcomes, as shown in Table 3. Regarding depressive symptoms measured by PHQ-9, the intervention group exhibited substantial improvement from baseline (10.2 ± 4.1) to post-test (6.8 ± 3.5) and follow-up (7.1 ± 3.6), whereas the control group showed minimal change (T0: 9.9 ± 4.3; T1: 9.2 ± 4.2; T2: 8.9 ± 4.1). Between-group comparisons revealed significant differences at both T1 (adjusted Cohen's d = 0.68, 95% CI [0.32, 1.04], $p < 0.001$) and T2 (adjusted Cohen's d = 0.58, 95%

CI [0.22, 0.94], $p = 0.002$), reflecting medium effect sizes. Psychological resilience assessed by CD-RISC-10 increased significantly in the intervention group (T0: 23.7 ± 5.8; T1: 28.4 ± 6.1; T2: 27.9 ± 6.3) compared to controls (T0: 24.1 ± 6.2; T1: 24.8 ± 6.4; T2: 25.2 ± 6.5), with between-group effect sizes of d = 0.56 ($p = 0.001$) and d = 0.43 ($p = 0.008$) at respective time points. Quality of life measured by WHOQOL-BREF demonstrated significant enhancement in the intervention group (T0: 88.3 ± 12.6; T1: 98.7 ± 13.2; T2: 97.1 ± 13.8) versus controls (T0: 89.1 ± 13.2; T1: 90.5 ± 13.6; T2: 91.2 ± 13.9), yielding medium effect sizes (T1: d = 0.61, $p < 0.001$; T2: d = 0.44, $p = 0.006$). Social support scores on SSRS increased in the intervention group (T0: 38.6 ± 7.4; T1: 43.2 ± 7.8; T2: 42.5 ± 8.1) compared to controls (T0: 39.2 ± 7.8; T1: 40.1 ± 8.2; T2: 40.6 ± 8.3), with small-to-medium effects (T1: d= 0.39, $p = 0.018$; T2: d = 0.24, $p = 0.142$). As illustrated in Fig. 3, these patterns indicate that music education intervention produced broad positive psychological effects extending beyond primary anxiety outcomes, though effect magnitudes varied across domains with strongest impacts observed for depression and resilience, followed by quality of life and social support.

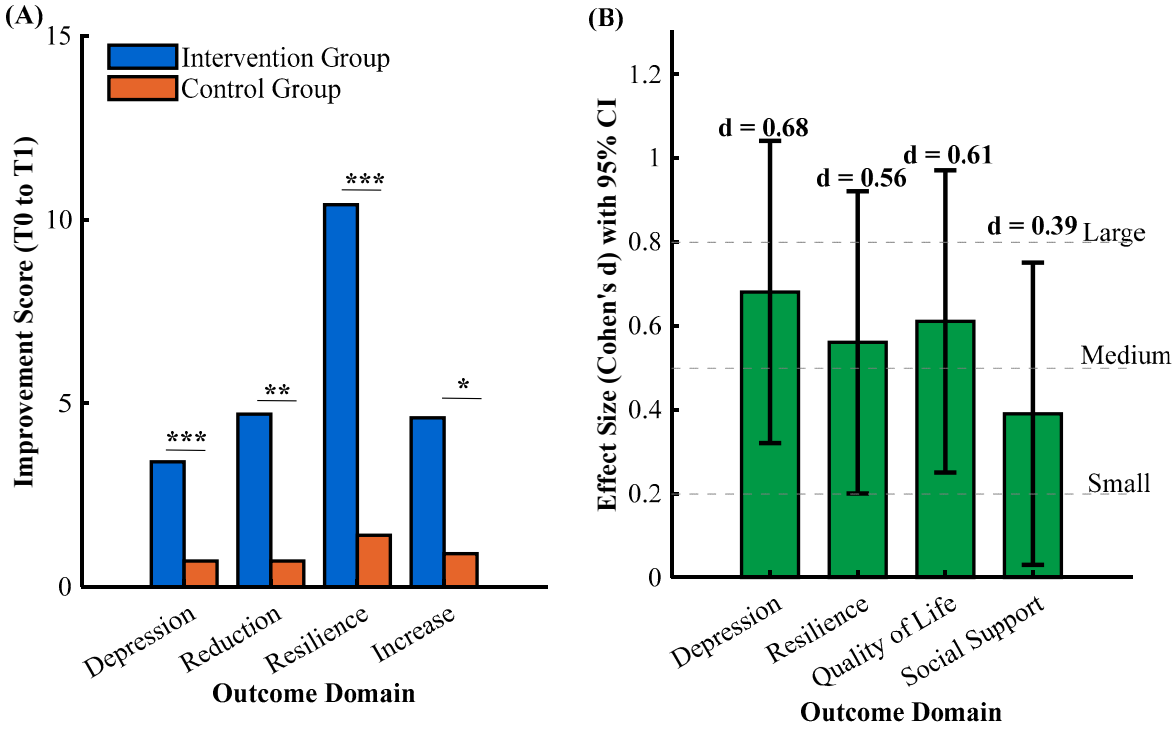

Figure 3: Secondary outcome measures: clinical improvements and effect sizes. (**A**) Clinical improvement across domains; (**B**) Between-group effect sizes at post-test. Note: (**A**) Mean improvement scores (T0 to T1) for the intervention (blue) and control (orange) groups across four secondary outcome domains (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ for between-group differences). (**B**) Between-group effect sizes (Cohen's d with 95% CI) at post-test (T1); dashed lines indicate small (0.2), medium (0.5), and large (0.8) thresholds.

Table 3: Secondary outcome measures across time points by group.

Outcome Measure	Time	Intervention (n = 47) M ± SD	Control (n = 44) M ± SD	Change Score (Intervention)	ANCOVA Results	Effect Size [95% CI]
Depression (PHQ-9)	T0	10.2 ± 4.1	9.9 ± 4.3	–	–	–
	T1	6.8 ± 3.5	9.2 ± 4.2	−3.4 ± 2.8***	F = 18.47***	d = 0.68 [0.32, 1.04]
	T2	7.1 ± 3.6	8.9 ± 4.1	−3.1 ± 2.9***	F = 12.34**	d = 0.58 [0.22, 0.94]

Table 3: *Cont.*

Outcome Measure	Time	Intervention (n = 47) M ± SD	Control (n = 44) M ± SD	Change Score (Intervention)	ANCOVA Results	Effect Size [95% CI]
Resilience (CD-RISC-10)	T0	23.7 ± 5.8	24.1 ± 6.2	–	–	–
	T1	28.4 ± 6.1	24.8 ± 6.4	+4.7 ± 3.2***	F = 14.23**	d = 0.56 [0.20, 0.92]
	T2	27.9 ± 6.3	25.2 ± 6.5	+4.2 ± 3.4***	F = 9.78**	d = 0.43 [0.07, 0.79]
Quality of Life (WHOQOL-BREF)	T0	88.3 ± 12.6	89.1 ± 13.2	–	–	–
	T1	98.7 ± 13.2	90.5 ± 13.6	+10.4 ± 8.3***	F = 16.89***	d = 0.61 [0.25, 0.97]
	T2	97.1 ± 13.8	91.2 ± 13.9	+8.8 ± 9.1***	F = 10.52**	d = 0.44 [0.08, 0.80]
Social Support (SSRS)	T0	38.6 ± 7.4	39.2 ± 7.8	–	–	–
	T1	43.2 ± 7.8	40.1 ± 8.2	+4.6 ± 4.2***	F = 6.89*	d = 0.39 [0.03, 0.75]
	T2	42.5 ± 8.1	40.6 ± 8.3	+3.9 ± 4.5**	F = 2.81	d = 0.24 [−0.12, 0.60]

Note: M = Mean; SD = Standard Deviation; T0 = Baseline; T1 = Post-intervention; T2 = 1-month follow-up; ANCOVA = Analysis of Covariance controlling for baseline scores; PHQ-9 = Patient Health Questionnaire-9 (range 0–27, higher scores indicate more severe depression); CD-RISC-10 = Connor-Davidson Resilience Scale-10 (range 0–40, higher scores indicate greater resilience); WHOQOL-BREF = World Health Organization Quality of Life-BREF (range 0–130, higher scores indicate better quality of life); SSRS = Social Support Rating Scale (range 12–66, higher scores indicate stronger social support). Change scores represent within-group differences from baseline. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

3.4 Subgroup Analysis and Moderating Effects

The following subgroup analyses were conducted on an exploratory basis and were not pre-specified in the study protocol. Given the modest sample size and increased risk of Type I error from multiple comparisons, these results should be interpreted with caution and treated as hypothesis-generating rather than confirmatory. Subgroup analyses examined whether intervention effects varied across participant characteristics, as shown in Table 4. sex stratification revealed comparable intervention efficacy for both males (Cohen's d = 1.52, 95% CI [0.94, 2.10]) and females (d = 1.44, 95% CI [0.96, 1.92]), with no significant sex × group × time interaction (F = 0.31, $p = 0.578$), indicating consistent benefits regardless of sex. Baseline anxiety severity substantially moderated intervention effects (F = 4.87, $p = 0.009$), with participants exhibiting severe symptoms (GAD-7 ≥ 15) demonstrating larger improvements (d = 1.89, 95% CI [1.21, 2.57]) compared to those with mild-to-moderate symptoms (GAD-7: 10–14; d = 1.28, 95% CI [0.79, 1.77]). Academic year analysis showed stronger effects among lower-grade students (freshmen-sophomores: d = 1.61, 95% CI [1.09, 2.13]) versus upper-grade students (juniors-seniors: d = 1.24, 95% CI [0.68, 1.80]), though the interaction approached but did not reach statistical significance (F = 2.94, $p = 0.089$). Prior informal music experience did not significantly moderate outcomes (F = 0.52, $p = 0.472$), with comparable effects for participants with (d = 1.39, 95% CI [0.71, 2.07]) and without (d = 1.49, 95% CI [1.05, 1.93]) previous exposure. As illustrated in Fig. 4A, forest plot visualization demonstrated that all subgroups benefited substantially from the intervention, with confidence intervals excluding zero across all stratifications. Dose-response analysis revealed significant positive correlations between attendance rates and anxiety reduction (r = 0.36, $p < 0.001$), with participants attending ≥90% of sessions (high attendance) achieving greater improvements (M = −5.2 ± 2.4) than those attending 75–89% (moderate; M = −3.8 ± 2.6) or <75% (low; M = −2.1 ± 2.8), as depicted in Fig. 4B. Linear regression confirmed that each 10% increase in attendance predicted an additional 0.57-point reduction in GAD-7 scores ($\beta = 0.36$, $p < 0.001$), indicating clear dose-dependent effects.

Table 4: Subgroup analysis of intervention effects on anxiety symptoms.

Subgroup	n	Baseline GAD-7 M ± SD	Post-Test GAD-7 M ± SD	Change M ± SD	Cohen's d [95% CI]	Interaction Test
Sex						F = 0.31, p = 0.578
Male	23	11.6 ± 3.4	7.1 ± 2.9	−4.5 ± 2.5	1.52 [0.94, 2.10]	
Female	32	11.9 ± 3.1	7.4 ± 2.7	−4.5 ± 2.8	1.44 [0.96, 1.92]	
Baseline Severity						F = 4.87, p = 0.009**
Severe (GAD-7 ≥ 15)	18	16.8 ± 1.6	9.2 ± 3.1	−7.6 ± 3.2	1.89 [1.21, 2.57]	
Mild-Moderate (10–14)	29	9.3 ± 1.8	6.1 ± 2.3	−3.2 ± 2.1	1.28 [0.79, 1.77]	
Academic Year						F = 2.94, p = 0.089
Lower (Year 1–2)	33	11.7 ± 3.3	6.9 ± 2.7	−4.8 ± 2.6	1.61 [1.09, 2.13]	
Upper (Year 3–4)	22	11.9 ± 3.1	7.9 ± 2.9	−4.0 ± 2.9	1.24 [0.68, 1.80]	
Prior Music Experience						F = 0.52, p = 0.472
Yes	12	11.4 ± 3.0	7.2 ± 2.6	−4.2 ± 2.7	1.39 [0.71, 2.07]	
No	43	11.9 ± 3.3	7.3 ± 2.9	−4.6 ± 2.8	1.49 [1.05, 1.93]	
Attendance Rate						r = 0.36, p < 0.001***
High (≥90%)	28	11.7 ± 3.2	6.5 ± 2.4	−5.2 ± 2.4	1.73 [1.21, 2.25]	
Moderate (75–89%)	15	11.8 ± 3.3	8.0 ± 2.8	−3.8 ± 2.6	1.17 [0.58, 1.76]	
Low (<75%)	4	12.1 ± 3.1	10.0 ± 3.2	−2.1 ± 2.8	0.67 [0.04, 1.30]	

Note: M = Mean; SD = Standard Deviation; GAD-7 = Generalized Anxiety Disorder-7; CI = Confidence Interval. Sex, academic year, and prior music experience subgroups include all enrolled intervention participants (n = 55); baseline severity and attendance subgroups include completers only (n = 47). Interaction tests examine whether intervention effects differ significantly across subgroups using three-way ANOVA (group × time × subgroup). **p < 0.01, ***p < 0.001. Negative change values indicate anxiety reduction (clinical improvement). Attendance rate was calculated as percentage of sessions attended out of 24 total sessions.

3.5 Intervention Adherence, Satisfaction, and Safety

Intervention adherence was high throughout the 12-week program, with participants in the intervention group demonstrating a mean attendance rate of 87.3 ± 11.2% (range: 58–98%) across 24 scheduled sessions. Among the 47 completers, 28 participants (59.6%) attended ≥90% of sessions, 15 participants (31.9%) attended 75–89%, and 4 participants (8.5%) attended <75%, as illustrated in Fig. 5A. The high overall adherence rate reflected strong program engagement and feasibility within the university setting. Intervention fidelity assessment confirmed excellent protocol compliance, with 94.2% of sessions delivered according to standardized procedures as verified through instructor checklists and periodic supervision observations. Participant satisfaction with the music education program was notably high, with an overall mean rating of 4.6 ± 0.5 on a 5-point Likert scale (1 = very dissatisfied to 5 = very satisfied). Dimensional analysis revealed consistently positive evaluations across multiple domains: course content (M = 4.7 ± 0.4), teaching methods (M = 4.5 ± 0.6), instructor quality (M = 4.8 ± 0.3), personal growth (M = 4.4 ± 0.6), and peer interaction (M = 4.6 ± 0.5), as depicted in Fig. 5B.

Qualitative feedback emphasized the program's stress-reduction benefits, supportive group atmosphere, and opportunities for creative expression. Regarding safety, no serious adverse events occurred during the intervention period. Three participants reported minor discomfort including temporary vocal strain (n = 2) and mild performance anxiety during group activities (n = 1), all of which resolved spontaneously without requiring intervention discontinuation. These minor events represented 6.4% of participants and were deemed unrelated to the core intervention components. The analysis of the complete data set from participants who completed all the tests (per protocol analysis: n = 47 in the intervention group and n = 44 in the control group) was the primary analysis and is presented in Tables 2–4. The intention-to-treat analysis included all participants (n = 110), with missing data values being replaced by multiple imputations using the chained equation method. As can be seen from the data presented above, the ITT and PP analysis estimates are highly consistent with each other, with the ITT analysis estimate of the primary outcome measure (GAD-7) being d = 1.18 (95% CI [0.78, 1.58]), which is very close to the estimate from the PP analysis:

d = 1.21 (95% CI [0.82, 1.60]). The same consistency between the ITT and PP analysis estimates was found across all the secondary outcomes, with the ITT analysis estimates being within 0.05–0.08 Cohen units of the PP analysis estimates. The estimates from the LME analysis also matched the RM ANOVA estimates across all the outcomes. Different strategies for dealing with missing data using the LOCF method also yielded similar estimates to the primary analysis, which confirms the reliability of the observed effect of the intervention.

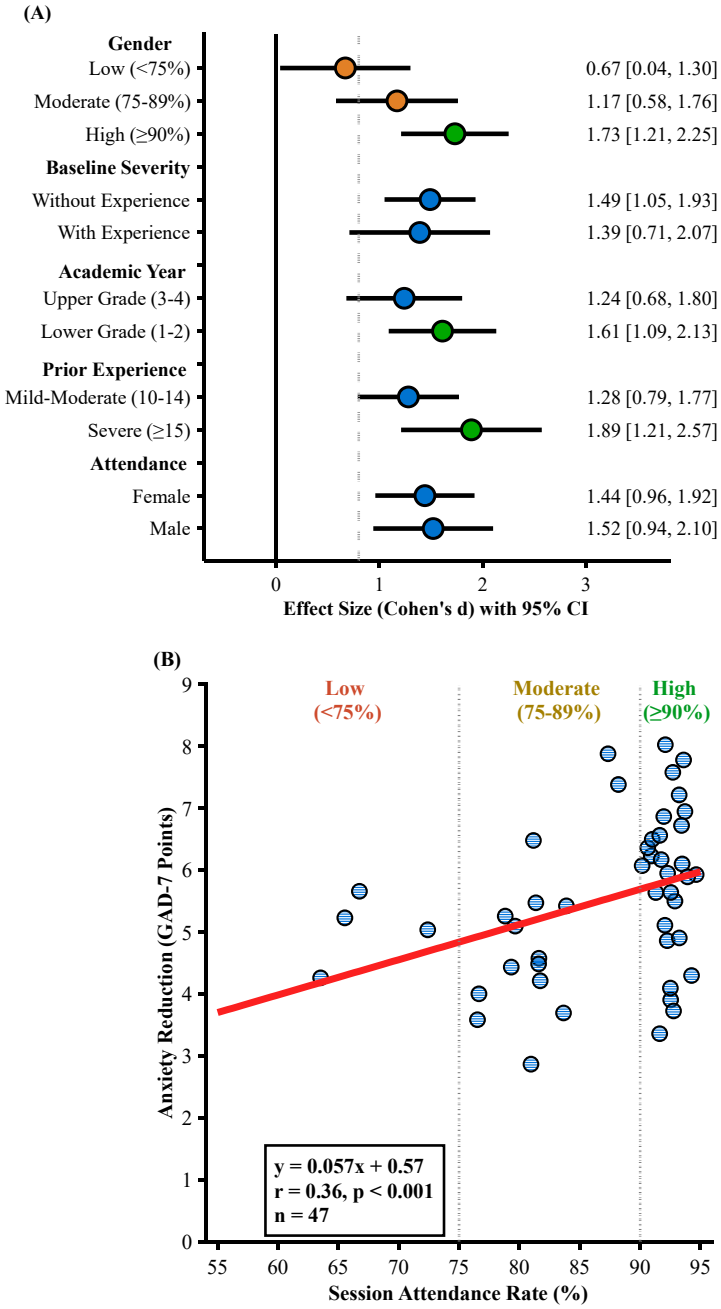

Figure 4: Subgroup analysis and dose-response relationship. (**A**) Forest plot of subgroup effect sizes. (**B**) Linear regression of attendance rate on anxiety reduction. Note: (**A**) Forest plot of Cohen's d (95% CI) across subgroups by sex, baseline severity, academic year, prior music experience, and attendance; all CIs exclude zero. (**B**) Linear regression of session attendance rate on anxiety reduction (GAD-7 points; $y = 0.057x + 0.57$, r = 0.36, $p < 0.001$, n = 47); shaded area = 95% CI; dotted lines demarcate low (<75%), moderate (75–89%), and high (≥90%) attendance.

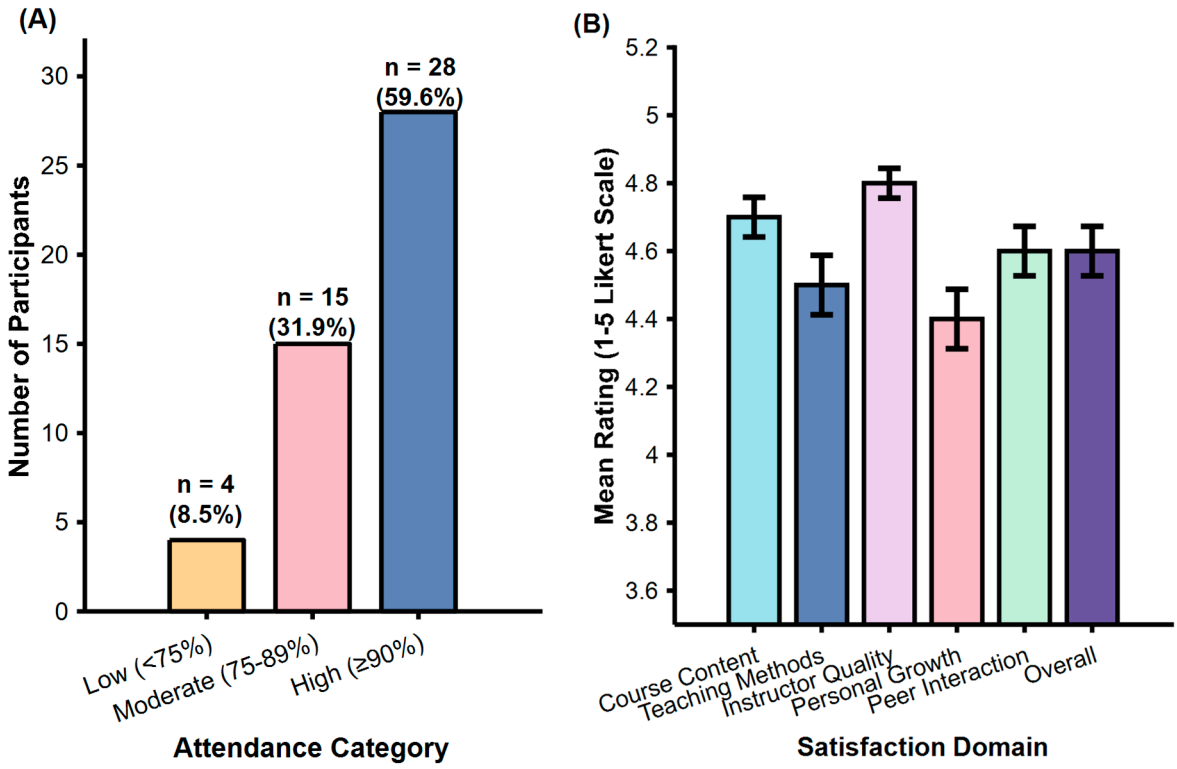

Figure 5: Intervention adherence and participant satisfaction. (**A**) Session attendance distribution across categories. (**B**) Mean satisfaction ratings across program domains. Note: (**A**) Distribution of participants (n = 47) across session attendance categories: low (<75%), moderate (75–89%), and high (≥90%). (**B**) Mean satisfaction ratings (1–5 Likert scale, error bars = SD) across five program domains and overall.

4 Discussion

4.1 Primary Anxiety Outcomes

The present quasi-experimental study was conducted with three pre-specified objectives and one hypothesis. Regarding Objective 1, the results confirmed that the 12-week music education intervention significantly reduced anxiety symptoms in the intervention group, with large effect sizes at both post-intervention (d = 1.47) and one-month follow-up (d = 1.32), supporting the primary hypothesis. Regarding Objective 2, secondary outcomes including depression (PHQ-9), psychological resilience (CD-RISC-10), quality of life (WHOQOL-BREF), and social support (SSRS) all showed significant improvements with medium-to-large effect sizes (Cohen's d = 0.43–0.68) in the intervention group. Regarding Objective 3, moderation analyses indicated that baseline anxiety severity and session attendance moderated intervention effects, while sex did not show a statistically significant moderation effect (p = 0.089). The pre-specified hypothesis that intervention group participants would report greater reductions in anxiety symptoms than the control group at post-intervention and follow-up was fully supported by the data. The intervention group demonstrated significant decreases in symptoms of anxiety from the baseline to the post-test measurement sessions (d = 1.47) and at the follow-up measurement sessions (d = 1.32), whereas the control group did not show significant changes in symptoms of anxiety. From the clinical perspective, 68.1% of the intervention group demonstrated significant relief in symptoms of anxiety, and 55.3% of the intervention group achieved subclinical levels of symptoms of anxiety, whereas only 12.0% and 18.0% of the control group demonstrated the same, respectively. The present study indicated that the structured music education program may be an

effective, feasible, and easily accessible solution in the management of symptoms of anxiety in non-music major university students. However, the present quasi-experimental study design must be interpreted with caution, and the findings must be replicated in randomized controlled trials.

4.2 Comparison with Existing Literature and Proposed Mechanisms

The degree of effect magnitude in this study can be favorably likened when placed alongside existing literature regarding interventions that rely upon music and address its role in the management of anxiety. Previous research regarding music therapy among medical students has found moderate effect sizes regarding the reduction of anxiety [5], while meta-analytic evidence synthesizing music interventions across diverse populations documented pooled effect sizes ranging from moderate to large [9,10], and a recent RCT demonstrated that online group music therapy significantly reduced stress and anxiety in undergraduate students relative to a no-intervention control [19]. More recently, a systematic review of randomized controlled trials further documented beneficial effects of music-based interventions on anxiety and depression across vulnerable populations [20], reinforcing the cross-population applicability of music as a therapeutic and educational tool. The effect sizes found in the current study exceed numerous effect sizes found in previous research, and such may be explained by a variety of reasons including, but not limited to, the comprehensive nature of the present intervention, its length allowing time for skill and psychological integration, and its focus on non-majors, potentially experiencing increased degrees of novelty and engagement [21]. The probable underlying mechanisms of such robust findings may include various pathways, such as those postulated by social cognitive theory and emotional intelligence theories. Music program experiences may raise self-efficacy beliefs with regard to controlling emotions based on experiences of personal expression, and group musical pursuits may help build social associations and increased perceived support networks as buffers against anxiety [22,23]. Participation in structured musical activities may also enhance self-efficacy and reduce performance-related anxiety, as musical engagement provides repeated opportunities for mastery experiences and behavioral confidence-building [24]. The neurophysiological phenomena of modulation of stress response systems and higher activation of reward systems provide biological insights into the psychologic benefits that can be obtained with musical activity [25–27], with dopaminergic reward pathway activation representing a key biological substrate for music-evoked emotional benefits [28].

4.3 Practical Implications

In terms of secondary outcomes, it was found that the music education intervention was associated with clinically significant improvements in all four domains. In terms of depressive symptoms, as measured by the PHQ-9, it was found that there were medium-to-large between-group effects at post-test (d = 0.68) and follow-up (d = 0.58), which are consistent with previous research demonstrating that anxiety and depression are commonly comorbid in university students and share underlying mechanisms [5,8]. Psychological resilience, as measured by the CD-RISC-10, was also found to have increased in the music education intervention group (d = 0.56 at T1, d = 0.43 at T2), suggesting that music education interventions can cultivate resilience as a coping resource for dealing with future psychological distress, a finding that is consistent with theories of resilience development through creative activities [29]. Finally, in terms of quality of life, as measured by the WHOQOL-BREF, it was found that there were medium effect sizes (d = 0.61 at T1, d = 0.44 at T2), suggesting that music education interventions are associated with improvements in quality of life that are not limited to symptoms of anxiety or depression. Finally, in terms of social support, as measured by the SSRS, it was found that there were small but significant improvements in the music education intervention group at post-test

(d = 0.39), although these were not maintained at follow-up (d = 0.24, $p = 0.142$), suggesting that social support benefits of music education interventions may dissipate without continued group musical engagement [30].

The finding that baseline severity of anxiety symptoms was a significant moderator also indicates that subjects with more severe symptoms may experience more absolute benefit from interventions in music education, although all subjects regardless of severity did experience significant change. This outcome was consistent with previous research that has shown interventions tend to be more effective in individuals with more severe symptoms [31]. The dose-response relationship seen through attendance analysis is significant, providing practical insight into the outcome-related benefits of increased levels of adherence, with r = 0.36, $p < 0.001$ [32]. The absence of significant moderation for sex or prior music experience suggests potential generalizability across diverse student subgroups, although it is important to note that final conclusions regarding generalizability are not possible in a single-site study of this nature [33]. Implementation-wise, with a high level of adherence at 87.3% and satisfaction at 4.6/5.0, it appears that interventions involving music education can be acceptable and feasible in academic environments, dispelling common concerns regarding adherence and participation in mental health-related interventions [34]. This feasibility aligns with broader evidence supporting whole-school approaches to mental health promotion as scalable and effective in educational settings [35]. The low incidence of adverse events (6.4%) and their transient course further confirm the safety of this method [36]. In comparison, meta-analytic evidence for mindfulness-based interventions in college student populations has reported effect sizes in the small-to-moderate range [37], suggesting that the current music education program may offer a comparably effective and potentially more engaging alternative for non-clinical university populations.

4.4 Limitations and Future Directions

Despite such encouraging results, however, several limitations need to be noted. The limitations of the quasi-experimental design without random allocation are that it does not rule out the possibility of confounding variables, which could contribute to differences between groups after the intervention, despite the equivalence of the groups at baseline. Generalization of the results of this study, which was conducted in a single university, might be limited by the possibility of cultural and institutional differences in the manifestation of mental health problems and in patterns of seeking help. Additionally, the method of recruiting participants, which relied on announcements in the university and word of mouth through departments, might have introduced self-selection bias into the study. This is because participants were willing to engage in a 12-week intervention program, which required commitment of two 90-min periods per week, and might differ systematically from the broader group of anxious students in the university in terms of motivational readiness, flexibility in terms of time, and pre-existing orientation towards music activities. This reliance on self-report measures raises potential issues concerning social desirability bias and subjective impressions, and, without objective measures of anxiety such as biological cues, mechanistic explanations are not feasible [38]. The one-month follow-up time is not sufficiently long to assess sustainability, and, lacking an active control, there may be issues with nonspecific factors such as attention, social interaction, and expectancy effects [39]. The standard protocol may not necessarily address individual variations regarding personal tastes in music, learning styles, and points of anxiety, pointing towards personal interventions [40]. Future research efforts should be placed on randomized controlled trial designs with active control groups, designed to distinguish discrete effects of music education from more general therapeutic processes, and multi-center designs to improve generalizability to various educational environments [41]. To better understand theories and optimize interventions, research into mediational processes via measurement of theorized mediators such as emotional regulation strategies, self-efficacy, and

social support quality would be highly informative [42]. The integration of objective measures of physiology, such as heart variability, cortical activity, and biomarkers of stress, would enhance the support for postulated neurobiological models and offer validating outcomes regarding claimed benefits reported by patients [43]. Such research directions would greatly enhance the body of evidence regarding the value and effectiveness of music education as part of comprehensive university approaches to mental health promotion.

5 Conclusion

This quasi-experimental study provides preliminary evidence that a structured music education program may reduce anxiety symptoms among non-music major university students, with clinically meaningful effect sizes (Cohen's d = 1.21–1.47) sustained at one-month follow-up. The program demonstrated clinical significance, with 68.1% of participants achieving significant anxiety reduction and 55.3% reaching subclinical levels, representing substantially greater improvement than observed in the control group. Additional benefits were observed across depression, psychological resilience, quality of life, and social support. The dose-response pattern (r = 0.36) and high adherence rate (87.3%) further support the feasibility and acceptability of such programs within university settings. These findings should be interpreted in light of the non-randomized design, single-site sample, and reliance on self-report measures; randomized controlled trials with active comparators and longer follow-up periods are needed to establish causal efficacy. Nonetheless, the results suggest that the integration of structured music programs into general education curricula warrants serious consideration by mental health professionals and academic administrators, particularly as a low-cost, non-stigmatizing complement to existing mental health services.

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Availability of Data and Materials: The datasets used and analysed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval: This study was approved by the Institutional Review Board of Zhejiang Shuren University (Approval Number: IRB-2024-043). All procedures were conducted in accordance with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants, who were fully informed of the study's purposes, procedures, risks, benefits, and confidentiality measures. Participation was voluntary, and participants could withdraw at any time without penalty. All data were anonymized and securely stored in compliance with applicable data protection regulations. The control group was provided access to the music education program after study completion as ethical compensation. Written informed consent was obtained from all participants prior to study enrollment. Participants were fully informed of the study's purposes, procedures, potential risks and benefits, and confidentiality measures, and were free to withdraw at any time without penalty.

Conflicts of Interest: The authors declare no conflicts of interest.

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