Science Innovation
2026, Vol. 14, No. 4, pp. 122–131
https://doi.org/10.11648/j.si.20261404.13

Research Article

Music Healing Empowering College Students' Mental Health: An Empirical Study

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Abstract

Against the backdrop of surging mild emotional distress among contemporary college students and prominent structural dilemmas in traditional university mental health services including severe counselor-staff shortages, help-seeking stigma and poor intervention sustainability, this study takes music healing as a low-threshold preventive psychological empowerment approach and constructs a multi-level "physiological-psychological-social" regulatory mechanism grounded in neurologic music therapy, interoception theory and interpersonal synchrony theory. An explanatory sequential mixed-methods design was adopted, combining an 8-week randomized controlled group intervention and post-intervention semi-structured interviews. A total of 89 valid undergraduates and postgraduates with mild to moderate depressive tendencies were divided into an intervention group and a waitlist control group, with multiple psychological scales, partial physiological indicators and self-developed behavioral transfer questionnaires deployed to collect data at pre-intervention, post-intervention and four-week follow-up stages. Quantitative statistical results revealed that the structured four-stage music healing program significantly reduced participants' depression, anxiety and stress levels, improved cognitive reappraisal ability, mindfulness awareness and social connectedness, and generated stable cross-scenario adaptive behavioral transfer effects that remained partially sustained one month after intervention. Qualitative thematic analysis further supplemented embodied, interpersonal and daily practical experience evidence to interpret the internal action paths of the theoretical model. This research innovatively shifts the research focus of music intervention from mere symptom relief to long-term psychological empowerment, systematically verifies the three parallel interactive regulatory pathways of music healing, and provides a complete operable group intervention protocol suitable for campus scenarios. The study also identifies limitations including single-school sample representativeness and insufficient synchronized physiological evidence, and proposes targeted directions for future neural mechanism exploration, culturally localized intervention development and university implementation science research. The findings offer solid theoretical support and practical guidelines for embedding standardized music healing modules into college mental health education and service systems.

Keywords

Music Healing, College Students' Mental Health, Emotion Regulation, Mechanism Model, Mixed-methods Research

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Received: 8 June 2026; **Accepted:** 14 July 2026; **Published:** 13 August 2026

1. Introduction

1.1. Problem Statement: The Structural Crisis of College Students' Mental Health

Current college students' mental health problems show a trend of high incidence, complexity, and younger age of onset. According to the 2023 “China College Student Mental Health Development Report”, the detection rate of anxiety symptoms among university students in China is 31.2%, and that of depressive symptoms is 26.8%, among which the proportions of severe and above cases account for 7.4% and 6.1%, respectively [1]. Meanwhile, a survey by the American College Health Association(ACHA) [2] also indicates that over 60% of college students reported experiencing "overwhelming anxiety" in the past year, and nearly 30% of students had their normal academic functioning affected due to emotional issues. These data collectively point to a serious reality: college students constitute a key and challenging population for mental health services.

More critically, the traditional mental health service model—centered on individual psychological counseling, group psychological coach, and psychiatric referral—faces three structural dilemmas in the university context.

First, huge supply-demand gap. The student-to-counselor ratio in university counseling centers in China averages about 1: 4000, far below the internationally accepted standard of 1: 1000-1500 [3]. Second, low willingness to seek help. Constrained by "stigma," "self-stigma," and catastrophic cognitions about psychological problems, a large number of students in need avoid professional help, enduring difficulties on their own or only engaging in informal peer disclosure [4]. Third, limited ecological validity. Traditional counseling is mostly conducted in fixed times and spaces with language as the primary medium, making it difficult to transfer to students' daily life scenarios (e.g., dormitories, study rooms, club activities), thus hindering the sustainability of intervention effects.

Therefore, exploring a psychological support pathway that is "low-threshold, highly accessible, embedded in daily life, and provides positive emotional experience" has become a key breakthrough point in the reform of college mental health education.

1.2. Music Healing: An Emerging Empowerment Pathway

Music Healing is a concept different from but deeply intersecting with clinical music therapy. The former focuses more on stimulating individuals' intrinsic self-repair and growth potential through unstructured musical activities such as listening, creating, and moving. It does not require leadership by a registered music therapist and can be guided by ordinary teachers, counselors, or peers [5]. The latter is a medical behavior requiring strict professional qualifications and treatment protocols. In the context of "sub-health" and "preventive intervention" among college students, music healing has greater potential for promotion due to its flexibility, accessibility, and low defensiveness.Maintaining a rhythmic musical experience over a long period of time can enhance the regulatory ability of the autonomic nervous system, helping individuals return to a stable state more quickly when facing external pressure. At the same time, the immune function will be strengthened, and physical and mental functions will be improved, gradually achieving a virtuous cycle where "physiological stability leads to emotional stability, and emotional stability in turn nourishes the physiological state" [6].

Modern neuroscience and psychological research have confirmed that music plays a significant role in regulating brain waves, neurotransmitter analysis, and the function of the autonomic nervous system, and has established a solid theoretical foundation for both physiological and psychological studies [7]. In the long-term immersion in music, individuals can gradually develop stable positive personality traits such as empathy, gratitude, bravery, tenacity and creativity. Promote the transformation of emotional adjustment from external methods and techniques to internalized personality qualities [8].

In recent years, interdisciplinary research in neuroscience and positive psychology has provided a solid empirical foundation for music healing. Functional magnetic resonance imaging (FMRI) and electroencephalography (EEG) studies have shown that music can rapidly activate reward pathways such as the nucleus accumbens and ventral tegmental area, releasing dopamine, while down regulating excessive activation of the amygdala and reducing cortisol levels . More importantly, musical rhythm can drive the activity of the interoception network (including the insula and anterior cingulate cortex), enhancing individuals' awareness and regulation of bodily signals—which are core neural bases for emotion regulation, impulse control, and self-awareness [9]. Furthermore, rhythmic synchronization, harmonic matching, and improvisational echoing in group musical activities have been shown to enhance inter-brain synchrony and oxytocin release, promoting empathy and prosocial behavior [10].

However, existing research mostly focuses on clinical samples (e.g., depression, autism spectrum disorder, post-traumatic stress disorder) or elderly populations. Systematic research on college students with "subthreshold" psychological distress is still relatively scarce. Although a few intervention studies have confirmed the short-term mood-improving effects of musical activities, many suffer from theoretical fragmentation (lack of an integrated mechanism model), methodological roughness (no control, small sample, short cycle), and insufficient ecological validity [11]. More importantly, few studies have focused on the higher-order goal of "empowerment"—that is, not merely symptom relief, but more crucially, helping students internalize a set of sustainable, autonomously applied psychological regulation strategies.

1.3. Research Purpose and Research Questions

Based on the above background, this study aims to systematically explore the value dimensions, mechanisms of action, and practical pathways for implementing music healing to empower college students' mental health, and to test its effectiveness through a mixed-methods study. The specific research questions are as follows:

Q1. Value Question: What unique empowering values can music healing provide for college students' mental health?

Q2. Mechanism Question: Through what psychological and physiological pathways are these values achieved? Is there a "physiological-psychological-social" multi-level regulatory model?

Q3. Practice Question: How should effective music healing interventions be designed and implemented in real university settings? What are their core elements and stage characteristics?

By answering these questions, this paper expects to provide a theoretical basis and operational paradigm for constructing an integrated system of "music healing for psychological education" in universities.

2. Research Methods

2.1. Research Design

This study adopted an "explanatory sequential mixed-methods design" [12]. The design consisted of two phases: Phase I was a quantitative study, using a randomized controlled trial to test the main effects and moderating effects of the music healing intervention on various indicators of college students' mental health; Phase II was a qualitative study, using semi-structured interviews to deeply explore participants' subjective experiences, mechanisms of change, and contextual factors, thereby supplementing and explaining the quantitative results. The integration point of the two phases was to use qualitative data to validate or revise the mechanism model established in the quantitative phase.

2.2. Research Subjects and Recruitment

Volunteers were recruited from a university (covering five major disciplines: humanities, science, engineering, business, and arts) through campus announcements, mental health course groups, and counselor referrals. Inclusion criteria were: (1) Full-time undergraduate or master's degree student; (2) In the past two weeks, a score between 5-14 on the Patient Health Questionnaire (PHQ-9) (i.e., mild to moderate depressive tendency, not yet severe or requiring immediate medical intervention); (3) No history of major mental illness (e.g., schizophrenia, bipolar I disorder), no organic brain injury or hearing impairment; (4) No systematic psychological counseling (≥4 sessions) or use of psychiatric medication in the past 3 months; (5) Informed consent and commitment to participate fully in the 8-week intervention.

After screening, 92 students met the criteria. Using a computer-generated random number table method, they were allocated in a 1: 1 ratio to the intervention group (n=46) and a waitlist control group (n=46). The number completing all 8 weeks of activities in the intervention group was 42 (dropout rate 8.7%). The control group had no structured activities during the waiting period, but 3 individuals withdrew from follow-up for personal reasons (final valid sample: intervention group n=42, control group n=43). The two groups showed no significant differences in demographic variables and main scale scores at baseline ($p > 0.05$). The overall sample age range was 18-26 years (M=20.7, SD=1.8), 65.9% female (n=56), 34.1% male (n=29); disciplinary distribution: humanities 27.1%, science/engineering 45.9%, business 17.6%, arts 9.4%.

2.3. Intervention Design

Based on core principles of neurologic music therapy, the interoception training model [13], and the rhythmic characteristics of college students' daily lives, the research team designed an 8-week group music healing intervention, held twice a week, each session lasting 45-50 minutes. Each session was led by a psychological counselor with a foundation in music therapy, assisted by a graduate student in music. Activities were conducted in a group activity room equipped with sound equipment, percussion instruments (hand drums, maracas, chime tree, ocean drum), and movable chairs.

Table 1. *The intervention stages.*

Phase	Objective	Activity Content	Theoretical Basis
Phase one (1-2 weeks) (wake up)	Establish a safe group atmosphere and train the recognition of musical emotional characteristics and the labeling of self-perception.	(1) Guided music listening: Select natural sounds (rain, stream), classical slow movements (e.g., Bach's "Air on the G String"), and low-frequency overtones (Xizang singing bowls), presenting 3-4 segments each time. (2) Emotion marking training: After closing their eyes and listening, participants name their	Improve the granularity of interoception to provide a "perception-labeling" basis for subsequent regulation (Liu Fang, 2020).

Phase	Objective	Activity Content	Theoretical Basis
		feelings with the words listed on the "Emotion Wheel" (such as "calm - sad - empty - tense - warm") and share them with their adjacent partners. (3) Breathing anchoring exercise: Select a fixed-length (30 seconds) piece of music and play it in a loop. Participants are required to match their inhalation and exhalation in accordance with the natural rise and fall of the musical phrases.	
Phase 2 (3-4 weeks) (synchronous)	The body's rhythm is driven by rhythmic auditory stimulation (RAS) to train the regulation of attention and the smooth transition of the autonomic nervous system.	(1) Metronome and music rhythm walking: Set a rhythm of 60-70 BPM (close to a calm heart rate), and participants walk with their heels and toes touching the ground in sequence, attempting to align their step frequency with the beat. (2) Double Breathing - Rhythm Mirroring: Two people form a pair. One person beats the breathing rhythm (the ratio of inhalation to exhalation duration) with their hand, and the other person follows with a sandhammer or tambourine. Then they switch positions. (3) Heart rate rhythm matching training: A wearable heart rate bracelet (provided by the research team) was used to display the heart rate in real time. Participants attempted to adjust their walking or breathing rhythms to align with the background music beats (personalized frequencies set based on the previous heart rate).	Rhythmic auditory stimulation can drive the motor cortex - basal ganglia - cerebellar circuit, while down-regulating the arousal level of the amygdala and improving the flexibility of the autonomic nervous system (Thaut & Hoemberg, 2014).
Phase 3 (5-6 weeks) (expression)	Provide non-verbal channels for emotional expression to enhance non-verbal responses and interpersonal security among groups.	(1) Vocal improvisation: By taking turns to create a "sound field" in forms such as single notes, glissando, and humming, others can freely join or remain silent, emphasizing the "no right or wrong" rule. (2) Percussion dialogue: Two people work in pairs. Without prior discussion on the rhythm pattern, one person plays a short phrase (2-3 seconds) first, and the other responds with the rhythm or timbre, forming a rotational "dialogue". （3）"Emotion Palette" ensemble: The group faces a large sheet of paper with an emotion color ring drawn on it together. Each color corresponds to a percussion instrument (for example, red = drum, blue = sound tree, yellow = hammer). The leader says an emotion word (such as "confused"), and the participants freely choose the corresponding instrument to play, forming a collective sound scene.	Improvisational music activities can bypass the language defense mechanism, activate the synergistic changes of the default mode network and the mentalization network, and promote the externalization and explicit attribution of emotions (Zhao Xiaohua & Wu Min, 2021).
Phase 4 (7 to 8 weeks) (integration)	Connect the musical experience with one's personal life story and formulate a sustainable self-maintenance plan.	(1) Music Lifeline Drawing: Each participant selects 5 to 7 pieces of music that are significant to them (from childhood to the present), marks the situation and feelings at that time on the timeline, and shares them within the group. (2) Future Self-narrative soundtrack: Imagine "your ideal mental state in half a year", choose or improvise a piece of music to represent this state, and describe it in 2-3 sentences. (3) Personal Music Healing Toolkit: Each	Integrating experiences into a coherent self-narrative can enhance psychological resilience, and music, as a powerful trigger for memory and emotion, can promote this integration process (Gao Tian, 2019).

Phase	Objective	Activity Content	Theoretical Basis
		participant summarizes their own "trigger - Music response" map (for example: when anxious → listen to Lofi hip hop and do 4-7-8 breathing; when lonely →play familiar choral songs and sing along softly).	

Control Group Handling

During this period, the control group did not engage in any structured music healing activities but could participate normally in daily campus recreational activities (e.g., listening to music on their own, attending parties, etc.). After all T2 data were collected, the control group received an abbreviated (4-week) music healing intervention as ethical compensation.

2.4. Measurement Tools

Quantitative data were collected at three time points: one week before intervention (T0), one week after intervention (T1), and the 4th week follow-up after intervention (T2). Main tools included:

Depression Anxiety Stress Scales-21 (DASS-21): 21 items, three subscales of 7 items each, 0-3 scoring. Cronbach's α in this study: 0.92 (depression), 0.89 (anxiety), 0.91 (stress).

Emotion Regulation Scale (ERS): 10 items, measuring tendency to use cognitive reappraisal (6 items) and expressive suppression (4 items). α=0.86.

Mindful Attention Awareness Scale (MAAS): Unidimensional, 15 items, measuring openness and acceptance of present-moment experience. α=0.90.

Social Connectedness Scale-Revised (SCS-R): 10 items, measuring sense of belonging and support with others and one's community. α=0.88.

Self-Report Questionnaire on Music Use and Transfer (self-developed): 8 items, measuring frequency, effectiveness, and transfer contexts of participants' use of music as a daily regulation tool after intervention. 1-5 scoring. Content Validity Index (CVI) was 0.84, reviewed by three music psychology experts.

Physiological Indicators (subsample): Resting heart rate variability (HRV: time-domain SDNN, frequency-domain HF) and salivary cortisol samples were collected from a randomly selected subsample of 20 from the intervention group at T0 and T1. Due to equipment malfunction, some data were missing; these are presented as auxiliary.

Qualitative interviews were conducted within one week after T2. Twelve participants were purposively selected from the intervention group based on gender, discipline, and baseline score level. Each underwent approximately 40 minutes of semi-structured interviews. The interview guide revolved around four core questions: "the most impressive musical activity," "moments of emotional or cognitive change," "how music affects daily behavior," and "difficulties or disappointments," using techniques of recall and specific incident anchoring (e.g., "Please describe a specific instance after leaving the activity when you actively used music to regulate your emotions").

2.5. Data Analysis Strategy

Quantitative data were analyzed using SPSS 27.0 and Mplus 8.3.

Independent samples t-tests and chi-square tests checked baseline equivalence between groups. A 2 (group) × 3 (time) repeated-measures ANOVA (RM-ANOVA) tested main and interaction effects for each dependent variable. Greenhouse-Geisser correction was applied if Mauchly's test of sphericity was significant. Simple effects analysis and post-hoc multiple comparisons (Bonferroni correction) were conducted for significant interaction terms. The PROCESS macro (Model 4) was used to test the mediating effect of social connectedness between the intervention and adaptive behavioral transfer. Effect sizes reported partial η^2 and Cohen's d. Significance level set at $\alpha=0.05$ (two-tailed).

Qualitative data were analyzed using thematic analysis [14]. Two independent psychology researchers coded the data, reached consensus through discussion, and used NVivo 12 for node management and model construction. The quantitative-qualitative integration focused on "validation and revision of the mechanism model," i.e., comparing qualitative themes against quantitative path coefficients to identify omitted or overemphasized variables.

3. Results

Findings are presented across four dimensions: emotion regulation efficacy, introspection and mindfulness levels, social connectedness, and adaptive behavioral transfer, integrating quantitative and qualitative findings.

3.1. Significant Improvement in Emotion Regulation Efficacy

RM-ANOVA showed a significant group × time interaction effect for DASS-21 total score ($F(1.78, 146.52) = 31.28$, $p < 0.001$, partial $\eta^2 = 0.28$). The intervention group's total score at T1 was 19.45 (SD=5.62), a 39.5% decrease from T0 (32.18, SD=6.93), while the control group only decreased from 31.94

(SD=7.11) at T0 to 28.67 (SD=8.03) at T1. Simple effects analysis indicated that the intervention group maintained significant improvement from T0-T1 and T1-T2 (24.15, SD=6.44) ($p < 0.001$), whereas the control group showed no significant change. On the subscales, the reduction in depression scores was most prominent in the intervention group ($F(2, 166)=24.07$, $p<0.001$), decreasing from 10.62 (SD=2.34) to 5.89 (SD=1.96), with a slight rebound to 6.73 (SD=2.11) at follow-up, still significantly lower than baseline.

At the level of emotion regulation strategies, cognitive reappraisal scores in the intervention group increased from T0 3.02 (SD=0.71) to T1 4.13 (SD=0.68) ($t(41)=9.24$, $p<0.001$, Cohen's $d=1.44$), while expressive suppression scores did not change significantly ($p=0.23$). The improvement in cognitive reappraisal was maintained at T2 (4.01, SD=0.72).

Qualitative interviews provided vivid process evidence. Many participants described a transition from "being overwhelmed by emotions" to "being able to coexist with emotions without being engulfed." One male engineering student noted: "Before exams, when I was anxious, I used to force myself not to think about it, but the more I suppressed it, the harder it got. Later I found that when I used white noise plus slow handclapping, I could feel anxiety like a 'soundtrack' beside me, not the main character." (P05, male, 22). Another female humanities student said: "Once when I was very sad, back in my dorm, instead of crying or finding someone to talk to as before, I used my phone to play a rhythm exercise from our class. I tapped along on my thigh for about five minutes, and the tears stopped. It wasn't about escaping the sadness; it felt like I could 'turn down the volume' of the sadness." (P09, female, 20). These descriptions highly align with the theoretical connotation of cognitive reappraisal—changing the interpretive framework of emotional events, rather than suppressing or avoiding them.

3.2. Deepening of Introspection and Mindfulness Levels

MAAS scores significantly increased in the intervention group from T0 3.34 (SD=0.66) to T1 4.08 (SD=0.59) ($F(1,83)=18.94$, $p<0.001$), while the control group changed only from 3.41 (SD=0.62) to 3.52 (SD=0.64). More importantly, the increase in MAAS was significantly negatively correlated with the decrease in DASS-21 ($r = -0.51$, $p < 0.01$), suggesting that mindfulness may be a mediating variable in music healing's alleviation of emotional distress.

Qualitative analysis further extracted two sub-themes: "sense of body anchoring" and "enhanced ability to name emotions." Regarding body anchoring, one participant described the experience of the rhythmic walking exercise: "I never knew my body was so tense before; I always thought it was just my mind being chaotic. But when I focused on the feeling of my feet hitting the ground, matching the drumbeat, I realized my shoulders had been hunched. The moment I noticed, I could intentionally relax them." (P02, female, 21). Another participant emphasized the clarity brought by "labeling emotions": "Before, I only knew I was in a bad mood, but I couldn't tell if it was annoyance, emptiness, or fear. The emotion wheel in class was very useful. Now I have an 'emotion palette' in my mind, and I can quickly distinguish that dull feeling as actually 'helplessness' plus a little 'fatigue'." (P08, male, 23).

This result supports the interoception theory perspective: music provides non-threatening, rhythmically structured interoceptive cues, making it easier for individuals to transform vague bodily signals into meaningful emotional labels, thereby providing raw material for cognitive reappraisal.

3.3. Reconstruction and Generalization of Social Connectedness

SCS-R scores in the intervention group increased from T0 2.78 (SD=0.71) to T1 3.83 (SD=0.68) ($F(1,83)=22.16$, $p<0.001$, partial $\eta^2=0.21$). Notably, this increase in connectedness was not limited to within-group members but generalized to daily social environments—at T2 follow-up, the intervention group reported a 34% increase in "closeness with classmates/friends" compared to baseline, while the control group reported only a 5% increase.

Mediation analysis further revealed: the "frequency of nonverbal attunement" in group activities (recorded by assistants each session) significantly predicted changes in SCS-R ($\beta=0.43$, $p<0.01$), and changes in SCS-R significantly predicted "self-rated availability of social support" at T2 ($\beta = 0.56$, $p < 0.001$). That is, music healing indirectly enhanced broader social belonging by enhancing immediate interpersonal synchrony experiences.

In qualitative materials, "rhythm dialogue" and "collective improvisation" were repeatedly mentioned as key events. One initially very introverted student said: "During the percussion dialogue, I played a very soft rhythm, and then that boy across from me, who usually seemed very cool, didn't judge. He responded to me very gently with almost the same rhythm. I almost cried at that moment because I felt 'held'." (P11, female, 19). Another participant mentioned cross-context transfer: "Now in the cafeteria or classroom, I no longer feel like an island. Because I've experienced that feeling of 'being understood without speaking' in the music group, which makes me feel more secure in daily interpersonal interactions." (P04, female, 20). This finding echoes the "synchrony-trust" model in interpersonal neuroscience: sharing a temporal structure can promote oxytocin release and desynchronization of the default mode network, reducing psychological defenses.

3.4. Adaptive Behavioral Transfer and Consolidation of Self-Management Skills

An important indicator of music healing empowerment is the "spillover effect" of intervention—i.e., the transfer of skills and habits acquired in activities to real-life scenarios.

The self-developed music use questionnaire showed that at T2, the intervention group reported an average frequency of "actively using music as an emotion regulation tool" of 4.12 (SD=0.79, 1-5 scale), compared to 1.68 (SD=0.83) in the control group (t (83)=13.52, p<0.001). The most common transferred behaviors included: (1) using specific playlists to aid study focus (71.4%); (2) engaging in guided music breathing before sleep or during anxiety (59.5%); (3) using rhythmic tapping to replace self-harm or destructive behaviors (16.7%, for 4 participants with mild self-harm ideation); (4) sharing music with friends and establishing "music mutual aid agreements" (31.0%).

Qualitative interviews revealed two key conditions for behavioral transfer: "low-effort triggering" and "positive emotional anchoring." One participant illustrated: "I knew listening to music could relax me before, but I never tried specific methods. The course gave us a 'three-minute emergency kit' at the end—a fixed playlist + breathing ratio (inhale 4 beats, exhale 6 beats). Now whenever I get agitated, I mechanically open that playlist. As soon as the first song's intro starts, my body automatically starts adjusting my breathing, more effective than any willpower." (P01, male, 22). Another female student described the formation of a "micro-habit": "I simplified the hand drum rhythm from class to tapping my fingers on the desk. I do it discreetly while waiting to enter the exam hall. People around me think I'm just jiggling my leg, but I'm actually 'resetting' myself." (P07, female, 20).

These results strongly support the core hypothesis of this study: the ultimate value of music healing lies not only in alleviating immediate emotional symptoms but also in helping college students internalize a set of pleasant, low-cognitive-load self-regulation tools, thereby enhancing long-term psychological resilience.

4. Discussion

4.1. Core Contributions of This Research

The theoretical and practical contributions of this study are mainly reflected in the following three aspects.

4.1.1. Proposing a Three-Dimensional Value Framework of "Prevention-Integration-Sustainability"

Existing literature mostly evaluates music intervention effects from the perspective of symptom relief [15]. In contrast, this study operationalized "empowerment" as a core concept, emphasizing that musical activities not only improve emotional states but, more importantly, enhance individuals' conscious regulatory capacity over their own psychological processes (mindfulness), social belonging, and behavioral transfer ability. This framework highly aligns with the concepts of "resilience" in positive psychology and "self-determination theory" (autonomy, competence, relatedness), offering an alternative paradigm to the traditional "problem-intervention" model for university psychological education.

4.1.2. Constructing and Partially Validating a "Physiological-Psychological-Social" Three-Stage Regulatory Mechanism Model

This study integrated neurologic music therapy [13, 15], interoception theory [12], and the interpersonal synchrony framework [13], proposing that music healing works through three parallel and interacting pathways: (1) Physiological pathway (rhythm driving-autonomic regulation- interoception enhancement); (2) Psychological pathway (emotion labeling-cognitive reappraisal-mindfulness enhancement); (3) Social pathway (non-verbal synchrony- empathy enhancement-belonging reconstruction). Quantitative analyses confirmed the mediating effects of cognitive reappraisal, mindfulness, and social connectedness, while qualitative materials provided specific mechanistic evidence such as "body anchoring" and "rhythm dialogue." This model transcends single-dimension explanations and provides a testable theoretical framework for subsequent mechanistic research.

4.1.3. Validating the Effectiveness and Feasibility of the 8-Week Four-Stage Structured Intervention Protocol

The results show that this protocol has a low dropout rate (8.7%) and high subjective satisfaction (anonymous post-intervention average 4.6/5) in real university settings. Particularly noteworthy is that intervention effects were partially maintained at follow-up (T2), and behavioral transfer was significant. This suggests that the protocol not only has short-term effects but also has the potential to be transformed into daily self-care skills. This provides a directly referenceable operational template for university mental health curriculum development, counselor workshops, and student club activities.

4.2. Limitations of This Study

Despite the above findings, this study has several notable limitations.

4.2.1. Limited Representativeness and External Validity of the Sample

All participants came from a single comprehensive university, with a high proportion of females (65.9%). Evidence suggests that gender differences affect neural responses to musical emotion processing, and females may benefit more from group musical activities. Furthermore, this study did not include students with formal music training backgrounds (arts students only accounted for 9.4%), and the level of musical training may significantly moderate healing effects [8]. Therefore, generalization of conclusions to other types of universities (e.g., science-engineering institutions, vocational colleges)

and different demographic characteristics should be cautious.

4.2.2. Lack of Active Placebo Control and Double-Blind Design

This study used a waitlist control group, which, while controlling for time and testing effects, cannot rule out the contribution of non-specific factors (e.g., group attention, novelty effects, social desirability) to the results. An ideal design would include an active control, such as a "handicraft group" or a "reading discussion group." Additionally, due to the nature of the intervention, neither participants nor research assistants could be fully blinded, potentially introducing expectancy bias.

4.2.3. Insufficient Direct Evidence for Physiological Mechanisms

Although the study attempted to collect HRV and salivary cortisol, equipment malfunction and variable sampling windows resulted in a small effective sample size (n=12), precluding robust statistical inference. Therefore, the claimed "physiological pathway" in this study relies mainly on literature inference and qualitative reports, lacking direct support from synchronized physiological measurement data.

4.2.4. Relatively Short Follow-up Period (only 4 Weeks), Unable to Assess Long-Term Maintenance Effects

Although qualitative reports of behavioral transfer were positive, self-report questionnaires may overestimate actual usage frequency. Future long-term follow-ups (e.g., 6 months, 12 months) are necessary. Furthermore, this study did not measure potential adverse effects (e.g., music triggering traumatic memories or emotional flooding in a few individuals). Although no obvious adverse events were observed during the intervention, systematic assessment remains an ethical requirement.

4.2.5. Insufficient Consideration of Cultural Specificity

The music materials used in this study were primarily Western classical, new age, and neutral natural sounds. Although attempts were made to include fragments of Chinese traditional instruments (guqin, xiao), there was no systematic comparison of intervention effects across different cultural modes (pentatonic scale vs. major/minor system). Chinese college students' musical preferences and emotion regulation habits may differ from Western samples; directly transplanting intervention materials may lose ecological validity.

4.3. Future Research Directions

Based on the above limitations and the current frontier dynamics in the interdisciplinary field of music healing and college student mental health, future research can be expanded in the following four directions.

4.3.1. Multimodal Physiological Measurement and Neural Mechanism Research

Future research should integrate portable functional near-infrared spectroscopy (FNIRS), electrocardiography (ECG), galvanic skin response (GSR), and other devices to simultaneously collect multi-brain, multi-physiological data in real group music scenarios. Specifically, hyperscanning techniques can be used to examine the causal relationship between dynamic changes in inter-brain synchrony and social connectedness during dyadic or group improvisational musical activities [15]. Meanwhile, endocrine indicators (oxytocin, cortisol, testosterone) should be included to test the impact of music healing on the "stress-empathy" dual pathway. Longitudinal physiological data collection (weekly) could also reveal cumulative dose-response relationships of intervention effects.

4.3.2. Individual Differences and Precision Matching Research

Future studies should systematically examine the moderating effects of baseline individual difference variables on music healing outcomes, including but not limited to: musical training background (professional/amateur/none), music preference type (rock/classical/electronic/folk), personality traits (openness, neuroticism), interoceptive sensibility (MAIA scores), and attachment style. Using latent class analysis or decision tree methods, a "music healing matching algorithm" could be developed to recommend optimal intervention types and dosages (e.g., low-intensity daily self-directed listening vs. high-intensity group improvisation) for college students with different characteristics. This would move music healing from a one-size-fits-all approach to precision mental health practice.

4.3.3. Culturally Adapted Interventions and Indigenous Resource Development

In traditional Chinese culture, the idea that "music is the movement of the heart" and "five tones heal illnesses" has a long history. Future research could systematically compare the similarities and differences in healing effects between Chinese and Western musical elements and develop indigenous music healing protocols based on the pentatonic scale (gong-shang-jue-zhi-yu), guqin pieces, opera arias, and traditional percussion. Furthermore, attention should be paid to whether highly synchronous activities like "chorus" and "unison playing" in collectivist cultural contexts have stronger social bonding effects compared to improvisational solos in individualist Western cultures. Qualitative research and cross-cultural comparative designs would be necessary methods.

4.3.4. Implementation Science Pathways and Cost-Effectiveness Analysis

Scaling up the validated 8-week four-stage protocol to real

university systems will inevitably face implementation barriers related to resources, training, and sustainability. Future research should introduce implementation science frameworks (e.g., CFIR, RE-AIM) to systematically analyze factors influencing the "landing" of music healing programs in universities, including: training thresholds for counselors/psychology teachers, required hardware and space, student attendance incentives, and models for coordination with traditional psychological counseling services. Concurrently, cost-effectiveness analysis (CEA) and cost-utility analysis (CUA) should be conducted to quantify the incremental cost-effectiveness ratio (cost per unit reduction in DASS-21) of music healing compared to alternative interventions such as individual counseling or online CBT programs. These studies will provide data support for university management decisions, promoting music healing as a formal mental health service option rather than remaining only at the level of research projects.

Additionally, future research should attend to potential adverse effects and develop response guidelines, as well as develop smartphone-based "ecological momentary assessment+music intervention" systems to achieve low-intensity, high-timeliness daily support.

5. Conclusion

Focusing on the core proposition of "music healing empowering college students' mental health," through theoretical construction and mixed-methods empirical testing, this study draws the following main conclusions:

Music healing provides three core values for college students' mental health: preventive (reducing risk of transition from mild emotional distress to severe disorder), integrative (simultaneously acting on physiological arousal, cognitive appraisal, and social belonging), and sustainable (promoting skill internalization and behavioral transfer). These values make music healing a powerful supplement to traditional psychological counseling, especially suitable for large-scale campus environments with limited resources and low help-seeking willingness.

The empowering mechanism of music healing can be summarized as a "physiological-psychological-social" three-stage regulatory model: at the physiological level, rhythm driving and interoceptive training downregulate stress responses and enhance body awareness; at the psychological level, emotion labeling and cognitive reappraisal reconstruct the interpretive framework of stressful events; at the social level, non-verbal synchrony and group improvisation repair interpersonal belonging and trust. These three form a positive cycle, collectively enhancing psychological resilience.

The 8-week four-stage structured intervention protocol (Arousal→Synchronization→Expression→Integration) has significant effectiveness and feasibility in real university settings. Results from the randomized controlled trial showed that the intervention group was significantly superior to the control group on measures of depression-anxiety-stress, cognitive reappraisal, mindfulness, and social connectedness, with effects partially maintained at the 4-week follow-up. Behavioral transfer was common, with participants autonomously applying music regulation strategies in academic, sleep, and interpersonal contexts.

Current limitations include sample diversity, placebo control, physiological evidence, and follow-up duration. Future research should strengthen multi-modal physiological measurement, precision matching for individual differences, culturally adapted interventions, and implementation science.

In summary, music healing, as a low-threshold, highly accessible, positively experienced psychological empowerment pathway, has full potential to be integrated into college mental health service systems. It is recommended that university mental health education centers incorporate music healing modules into freshman orientation courses, departmental group counseling, and dormitory culture construction, and train counselors in basic music healing facilitation skills. Through interdisciplinary collaboration (psychology, musicology, neuroscience, educational technology), music healing can become an important practical paradigm for psychological education in universities in the new era.

Abbreviations

ACHA	American College Health Association
FMRI	Functional magnetic resonance imaging
EEG	electroencephalography
CEA	Cost-Effectiveness Analysis
CUA	Cost-Utility Analysis
DASS-21	Depression Anxiety Stress Scales-21
ERS	Emotion Regulation Scale
MAAS	Mindful Attention Awareness Scale
SCS-R	Social Connectedness Scale-Revised
CVI	Content Validity Index

Author Contributions

Zhang Xinghui: Conceptualization, Data curation, Methodology, Resources

Conflicts of Interest

The authors declare no conflicts of interest.

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