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Effects of Mindfulness-based Music on Sleep of Chinese College Students: The Mediating Role of Resilience and Anxiety

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Article

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Abstract

In an era where college students face mounting academic pressures and sleep disturbances, mindfulness-based music shows as the key to unlocking better sleep and mental well-being. This study investigates the effects of mindfulness-based music on the sleep quality of Chinese college students, with a focus on the mediating roles of psychological resilience and anxiety. A cross-sectional survey was conducted among 704 undergraduate students in Fuzhou, Fujian Province, China, to explore the relationships between mindfulness-based music engagement, resilience, anxiety, and sleep disturbances. Findings reveal a significant positive correlation between mindfulness-based music engagement and resilience, suggesting that such music may enhance resilience, which in turn could improve sleep. Mediation analysis identified two pathways: mindfulness-based music indirectly reduced sleep disturbances through increased resilience and through reduced anxiety. These results underscore the potential of mindfulness-based music to improve sleep by fostering resilience and mitigating anxiety, offering valuable insights for addressing sleep issues in college students.

1. Introduction

Mindfulness-based music has a developmental history that can be traced back to ancient Eastern civilizations. As early as the spiritual practices of Buddhism and Hinduism [1][2][3], music was utilized to facilitate meditation [4][5][6][7]. Mindfulness-based music has gradually given rise to a more diverse array of musical styles, such as natural soundscapes [8], white noise [9][10], and sound healing with singing bowls [11][12]. In recent years, with the increasing prominence of mental health issues and the accelerating pace of life, meditative music has garnered widespread attention due to its unique relaxation and therapeutic effects [13]. It has become particularly popular among university students [14].

Mindfulness-based music has been shown to effectively alleviate stress, improve mood, enhance concentration, and positively impact sleep quality [15][16]. For Chinese university students facing academic pressure, employment anxiety, and interpersonal challenges, meditative music serves not only as a tool for relaxation but also as a potential means to improve sleep, enhance psychological resilience, and reduce anxiety [17]. Research indicates that mindfulness-based music offers a wide range of benefits for the human body. Mindfulness-based music can regulate the autonomic nervous system, reduce heart rate and blood pressure, and alleviate muscle tension, thereby promoting physical relaxation and recovery [18][19][20][21]. Additionally, meditative music has been proven to enhance immune system function [22] and lower cortisol levels (the stress hormone), thereby helping the body better cope with stress and illness. Mindfulness-based music effectively alleviates anxiety and depressive symptoms while enhancing positive emotional experiences [23][24]. Furthermore, it can improve cognitive functions, such as attention and memory [25]. Specifically, students who listen to meditative music before exams experience reduced academic anxiety and improved academic performance [26]. Mindfulness-based music has been shown to enhance empathy and the quality of

interpersonal relationships, as it helps individuals better regulate their emotions, leading to greater patience and understanding in social interactions [27].

The issue of poor sleep quality among university students has become increasingly prominent [28][29]. Sleep disturbances not only affect individuals' physical and mental health but also have profound negative impacts on academic performance, social functioning, and overall quality of life. Psychological stress is considered one of the primary causes of sleep problems among university students [30], with factors such as academic workload [31], employment anxiety [32], and interpersonal pressures [33] potentially triggering or exacerbating sleep disorders. In recent years, some studies have begun to explore the role of meditative music in improving sleep. Meditative music has been shown to significantly enhance sleep quality, reduce the frequency of nighttime awakenings, and prolong deep sleep duration [34][35][7]. However, research on the effects of meditative music on the sleep quality of university students remains limited, and the specific mechanisms underlying the relationship between meditative music and sleep quality are still unclear.

Although substantial evidence suggests that psychological resilience [36] and anxiety [37] are critical factors influencing sleep quality, and meditative music has been proven to improve mental health by enhancing social support and alleviating depressive symptoms, no studies have yet examined the mediating roles of social support and depressive symptoms in the relationship between meditative music and sleep quality. Therefore, this study aims to address this research gap by investigating the mediating effects of psychological resilience and anxiety, thereby providing a deeper understanding of the mechanisms through which meditative music influences the sleep quality of Chinese university students. The findings are expected to offer scientific evidence and practical guidance for improving sleep-related issues among university students.

This study aims to fill these gaps by investigating the mechanisms through which meditative music influences the sleep quality of Chinese university students. Based on previous research demonstrating significant associations between meditative music, psychological resilience, anxiety, and sleep disturbances, this study hypothesizes that meditative music indirectly reduces the risk of sleep disturbances through two independent sequential mediation models involving psychological resilience and anxiety. Specifically, we hypothesize that higher engagement with meditative music is associated with increased levels of psychological resilience and reduced symptoms of anxiety, thereby lowering the risk of sleep disturbances. Accordingly, we propose the following hypotheses:

H1: Mindfulness-based music has a specific indirect effect on sleep disturbances through resilience.

H2: Mindfulness-based music has a specific indirect effect on sleep disturbances through anxiety.

H3: Mindfulness-based music has a sequential multiple mediation effect on sleep disturbances through both psychological resilience and anxiety.

2. Methodology

2.1Participants

The data were collected from a cross-sectional survey conducted in Fuzhou, Fujian Province, China, between December 2024 and January 2025. The target population consisted of undergraduate students enrolled in local universities. The sample size was calculated using the standard formula for cross-sectional studies: $n = z^2 P \cdot \frac{1-P}{E^2}$, where *P* (the prevalence of sleep disturbances) was estimated at 40% based on previous research [38], *z* was set at 1.96 for a 95% confidence interval, and the margin of error *E* was set at 5%. To account for a potential refusal or dropout rate of 20%, the final sample size was increased to 704 participants. To ensure a representative sample of the local university student population, a stratified random sampling method was employed for participant recruitment.

The inclusion criteria were as follows: (1) aged between 18 and 25 years, (2) currently enrolled as a full-time university student, (3) no history of severe mental illness, (4) no long-term use of sleep-inducing medications, (5) possessing normal cognitive and literacy abilities to complete the questionnaire, and (6) willingness to participate in the study and provide informed consent. The exclusion criteria were: (1) individuals with severe hearing impairments or insensitivity to music, and (2) those experiencing major life events (e.g., serious illness) during the study period that could potentially affect sleep quality. Ultimately, a total of 704 university students were successfully recruited, meeting the required sample size for the study.

2.2 Procedure

This study was approved by the Ethics Review Committee of Fujian Health College (Ethics Review Letter RT2024-38). Data collection was carried out by a research team consisting of 10 undergraduate students from Fujian Health College. Prior to the formal survey, the research team members underwent standardized and comprehensive training, which included techniques for questionnaire interviews, standardized procedures for data collection, and ethical considerations. The training combined lectures and role-playing exercises to ensure that each member could proficiently master the survey methods.

The research team approached potential participants both online and offline within the campus, providing detailed explanations of the study's objectives, procedures, and the rights and responsibilities of participants to each interested individual. After participants fully understood the study and provided written informed consent, eligible individuals were invited to complete a series of questionnaires. Given that the majority of participants were young adults, the research team placed particular emphasis on friendly communication and the convenience of questionnaire completion to enhance participant cooperation. Throughout the data collection process, the research team regularly checked the completeness of the questionnaires and conducted preliminary reviews of the data after the survey to ensure accuracy, completeness, and consistency.

2.3 Measures

2.3.1 Brief Resilience Scale (BRS)

The Brief Resilience Scale (BRS) was developed by Smith et al. [39] designed to measure an individual's capacity to bounce back from stress and adversity. BRS provides a quick yet effective measure of resilience, the BRS consists of six items that participants respond to on a 5-point Likert scale, ranging from strongly disagree to strongly agree.

BRS has demonstrated robust measurement properties and reliability across diverse populations, including a noteworthy application within a cohort of healthy workers. The Dutch Language Version of the Brief Resilience Scale (BRS-DLV), as examined in a comprehensive study, exhibited commendable psychometric properties, affirming its utility across different cultural contexts. Notably, the BRS-DLV was shown to possess good model fit, with exploratory and confirmatory factor analyses revealing satisfactory internal consistency (Cronbach's alpha = 0.72), underscoring its reliability for scientific investigations [40]. The scale's construct validity was corroborated through significant associations with several work-related and psychological constructs, such as work engagement, psychological complaints, and need for recovery. These relationships underline the scale's capability to meaningfully predict and assess an individual's resilience and coping mechanisms in the face of stress and adversity [40].

2.3.2 Anxiety Symptoms Questionnaire (ASQ)

The Anxiety Symptoms Questionnaire (ASQ) is a brief self-report questionnaire designed to measure the frequency and intensity of anxiety symptoms over the past week [41]. It contains 17 items that assess a range of symptoms central to anxiety, including nervousness, worrying, irritability, trouble relaxing, insomnia, lack of energy, difficulty concentrating, somatic symptoms, and impairment in functioning due to anxiety. Each item is rated on a 0–10 Likert-type scale, with specific anchors to provide a clear interpretation of the scores: 0 (never), 1–3 (occasionally), 4–6 (often), 7–9 (usually), and 10 (all the time). We adopted a five-point scoring system based on these anchors to simplify the scoring process while maintaining the richness of the original scale.

Unlike some other measures that focus primarily on physical symptoms (e.g., Beck Anxiety Inventory) or are clinician-administered and time-consuming (e.g., Hamilton Anxiety Scale), the ASQ measures a broad range of anxiety symptoms and is self-rated, making it more efficient and accessible. The ASQ has demonstrated strong internal consistency and test–retest reliability in both clinical and college student samples. It also shows high concurrent validity with existing measures of anxiety and good discriminant validity between anxiety and depression. Additionally, ASQ supports a dimensional approach to understanding anxiety, which aligns with current research and clinical practice that emphasizes the importance of assessing the severity and frequency of symptoms over time. The scale revealed satisfactory internal consistency (Cronbach's alpha = 0.96).

2.3.3 General Sleep Disturbance Scale (GSDS-IT)

The General Sleep Disturbance Scale (GSDS-IT) is a self-assessment questionnaire designed to measure sleep disturbances over the past week. It consists of 21 items divided into six domains: difficulty getting to sleep, waking up during sleep, quality of sleep, quantity of sleep, daytime sleepiness, and the use of

substances to help induce sleep. Each item is rated on an eight-point scale ranging from 0 (no days) to 7 (every day), with higher scores indicating more frequent sleep disturbances [42].

The GSDS-IT provides a comprehensive assessment of sleep disturbances across multiple domains, including difficulty getting to sleep, waking up during sleep, sleep quality, sleep quantity, daytime sleepiness, and the use of substances to induce sleep. Besides, the GSDS-IT is highly time-efficient, as it can be completed in less than 5 minutes, making it practical for use in both clinical and research settings. The scale has demonstrated strong psychometric properties, with good internal consistency (Cronbach's α of 0.94), ensuring that it produces consistent and reliable results [43]. The scale includes a validated cut-off score (38.5) for distinguishing between good and bad sleep, allowing for meaningful comparisons with the general population [44]. These features make the GSDS-IT an ideal tool for assessing sleep disturbances in individuals with spinal cord injury (SCI), a population known to experience higher rates of sleep disorders [42].

2.4 Data Analysis

The data analysis for this study was conducted using a series of statistical techniques to examine the relationships between mindfulness-based music engagement, psychological resilience, anxiety, and sleep disturbances among Chinese college students. The analysis was performed using SPSS 25.0 and PROCESS macro for mediation analysis [45].

Descriptive statistics were calculated to summarize the demographic characteristics of the participants and the main research variables. Frequencies, means, and standard deviations were reported for variables such as gender, physical illness, mindfulness-based music engagement frequency, duration of meditation music experience, and the main research variables (resilience, anxiety, and sleep disturbances).

Pearson correlation coefficients were computed to examine the bivariate relationships between mindfulness-based music engagement, resilience, anxiety, and sleep disturbances. This analysis provided initial insights into the strength and direction of the associations between these variables.

To test the hypothesized mediation models, a serial multiple mediation analysis was conducted using the PROCESS macro (Model 6) in SPSS. This approach allowed for the examination of the indirect effects of mindfulness-based music engagement on sleep disturbances through resilience and anxiety, both independently and sequentially. The analysis estimated the direct and indirect effects, along with their corresponding 95% confidence intervals (CIs), using 5,000 bootstrap samples. The significance of the mediation effects was determined by whether the confidence intervals included zero.

3. Results

3.1 Descriptive statistics

Table 1 lists the demographic characteristics of the participants and the descriptive statistics of the main research variables. In terms of gender distribution, females accounted for 53.98% (n = 380) and males accounted for 46.02% (n = 324). The vast majority of participants reported physical illness (99.14%, n = 698).

In terms of meditation music participation, most participants participated once a month (57.1%, n = 402), followed by 2–3 times (20.17%, n = 142), and 8.52% (n = 60) participated more than 10 times. In terms of the duration of meditation music experience, most participants experienced it for 3 months (63.07%, n = 444), and 7.67% (n = 54) of the participants experienced it for 36 months. In terms of the duration of each meditation music session, more than half of the participants chose 10 minutes (52.98%, n = 373), 25% of the participants chose 11–20 minutes (n = 176), and only 3.98% of the participants chose a duration of more than 60 minutes each time (n = 28). Regarding the measurement results of the main research variables, the average score of resilience was 3.01 (SD = 0.87), the average score of anxiety was 0.94 (SD = 0.90), and the average score of sleep disorders was 2.04 (SD = 1.13).

Table 1
Descriptive data

Variable		Mean (SD)/N(%)
Demographical characteristics		
Sex	Female	380(53.98)
	Male	324(46.02)
Physical illness	Yes	698(99.14)
	No	6(0.86)
Mindfulness-based music frequency (month)	1	402(57.1)
	2–3	142(20.17)
	3–5	68(9.66)
	5–10	32(4.55)
	>10	60(8.52)
Mindfulness-based music experience(month)	3	444(63.07)
	6	99(14.06)
	12	72(10.23)
	24	35(4.97)
	36	54(7.67)
Mindfulness-based music duration (minutes)	10	373(52.98)
	11–20	176(25)
	21–30	103(14.63)
	31–60	24(3.41)
	>60	28(3.98)
Resilience	M (SD)	3.01(0.87)
Anxiety	M (SD)	0.94(0.90)
Sleep	M (SD)	2.04(1.13)

3.2 Correlations on the key variables

Table 2 shows the results of the correlation analysis between the main research variables. Meditation music and resilience are significantly positively correlated ($r = 0.06$, $p < 0.001$), indicating that the higher the level of meditation music participation, the higher the individual's resilience level. The correlation

between meditation music and anxiety (r = 0.15) did not reach statistical significance. Meditation music and sleep disorders are significantly positively correlated (r = 0.14, p < 0.001), indicating that there is a certain association between meditation music participation and sleep problems.

Resilience is significantly positively correlated with anxiety (r = 0.22, p < 0.001), and resilience is also significantly positively correlated with sleep disorders (r = 0.20, p < 0.001). The strongest correlation occurs between anxiety and sleep disorders (r = 0.62, p < 0.001), indicating that the higher the level of anxiety, the higher the degree of sleep disorders, and there is a strong positive correlation between the two.

Table 2
Correlation on the key variables

Variables	Mindfulness-based music	Resilience	Anxiety	Sleep
Mindfulness-based music	1			
Resilience	0.06***	1		
Anxiety	0.15	0.22***	1	
Sleep	0.14***	0.20***	0.62***	1

3.3 Serial-mediation model analysis

The results of the sequential mediation model analysis in Table 3 and Fig. 1 reveal a complex network of relationships between meditation music participation, resilience, anxiety, and sleep disorders. The overall effect of meditation music participation on sleep disorders showed a significant positive relationship (B = 0.0654, SE = 0.0017, 95% CI [0.636, 0.0671]), which is consistent with the results of the initial correlation analysis. By further decomposing this total effect, we found that it contained three unique indirect paths, each showing a different mechanism of action.

Through the mediation path of resilience (B = 0.0043, SE = 0.0002, 95% CI [0.0041, 0.0047]), it was revealed that meditation music participation may affect sleep quality by enhancing individual resilience (B = 0.05). It is worth noting that resilience showed a strong positive effect on sleep disorders (B = 0.85, p < 0.001), which is different from traditional cognition, suggesting that in this study group, high resilience may be associated with certain behaviors or cognitive patterns that are not conducive to sleep. This result may reflect the influence of specific cultural or environmental factors and needs to be further explored in the research discussion.

Meditation music constituted a major part of the total effect through the mediation path of anxiety (B = 0.0610, SE = 0.0017, 95% CI [0.0593, 0.0627]). Meditation music participation was positively associated with anxiety (B = 0.14), and anxiety was significantly positively associated with sleep disturbance (B = 0.39). This path raises an important question: Is it possible that meditation music participation may increase anxiety levels in some cases? This may be related to the type of meditation music experience, motivation for participation, or individual differences of participants.

The most revealing finding was the serial mediation path (B=-0.0016, SE = 0.0001, 95% CI [0.0017, -0.0014]), which had an effect direction opposite to the other paths. This path suggests that meditation music participation may improve resilience (B = 0.05), thereby reducing anxiety levels (B=-0.07, $p < 0.05$), and ultimately alleviate sleep disorders. Although this negative indirect effect is numerically small, it reveals a potential protective mechanism, that is, meditation music may improve sleep quality by enhancing resilience and then reducing anxiety.

Table 3
Total, direct, and indirect effects of music engagement on sleep disturbance.

Path	B	SE	LLCI	ULCI
Total effect	0.0654	0.0017	0.636	0.0671
Music engagement→Resilience→Sleep disturbance	0.0043	0.0002	0.0041	0.0047
Music engagement→Anxiety→Sleep disturbance	0.0610	0.0017	0.0593	0.0627
Music engagement→Resilience→Anxiety→Sleep disturbance	-0.0016	0.0001	0.0017	-0.0014

4. Discussion

4.1 Summary of the findings

As a practice originating from ancient Eastern civilization, meditation music has gradually attracted attention worldwide in recent years, especially among college students. Studies have shown that meditation music can effectively relieve stress, improve mood, enhance concentration, and have a positive impact on sleep quality. However, although the potential of meditation music in improving mental health and sleep has been widely recognized, research on its specific impact mechanism on the sleep quality of Chinese college students is still limited.

This study aims to explore the impact of meditation music on the sleep quality of Chinese college students and examine the mediating role of psychological resilience and anxiety in this relationship. Through a cross-sectional survey of Chinese college students, the study found that the participation of meditation music was significantly positively correlated with psychological resilience, indicating that meditation music may improve sleep quality by enhancing individual psychological resilience. However, the correlation between meditation music and anxiety did not reach statistical significance, which may reflect the complex role of meditation music in different individuals.

The study also found that there was a significant positive correlation between psychological resilience and anxiety and sleep disorders, among which anxiety had the strongest correlation with sleep disorders. This shows that the higher the anxiety level, the higher the degree of sleep disorders. Through the analysis of the sequential mediation model, the study found that the effect of meditation music on sleep disorders was mainly achieved through two independent mediation paths: one was through the separate

mediation of psychological resilience, and the other was through the separate mediation of anxiety. In addition, the study also revealed a sequential mediation path, that is, meditation music can enhance psychological resilience, thereby reducing anxiety levels and ultimately alleviating sleep disorders.

Although the direct effect of meditation music on sleep disorders was positive, the sequential mediation path revealed the potential mechanism by which meditation music may improve sleep quality by enhancing psychological resilience and reducing anxiety. This finding provides new insights into the role of meditation music in improving the sleep quality of college students and emphasizes the importance of psychological resilience and anxiety in this process.

4.2 Correlations on the key variables

The statistically significant positive correlation between mindfulness-based music engagement and resilience, although modest in magnitude, supports theoretical frameworks suggesting that mindfulness practices may enhance psychological resilience (Nila et al., 2016). This finding aligns with previous research demonstrating that mindfulness activities, including music-based interventions, can strengthen adaptive coping mechanisms and psychological flexibility that characterize resilience [46].

The non-significant correlation between mindfulness-based music engagement and anxiety warrants careful interpretation. While contradicting literature suggesting anxiety-reducing effects of mindfulness interventions [47], this finding may reflect the cross-sectional nature of our data, potentially capturing individuals with higher baseline anxiety who gravitate toward mindfulness practices as a self-management strategy. The significant positive correlation between mindfulness-based music engagement and sleep disturbance similarly presents an apparent contradiction to established therapeutic applications of music for sleep improvement. However, this association likely reflects complex bidirectional relationships rather than causality, with sleep-troubled individuals possibly seeking relief through mindfulness music.

The strongest correlation observed between anxiety and sleep disturbance provides robust evidence for the well-established relationship between these constructs, consistent with extensive literature documenting anxiety as a significant predictor of sleep problems [48]. The significant positive correlation between resilience and anxiety presents an intriguing finding that challenges conventional understanding of resilience as protective against negative affective states. This unexpected relationship may reflect culture-specific manifestations of resilience in Chinese academic contexts, where high resilience might coincide with performance pressure and perfectionistic tendencies that simultaneously elevate anxiety levels [49]. These correlation patterns collectively establish the statistical foundation for our subsequent mediation analyses while highlighting the complex, sometimes counterintuitive relationships among mindfulness practices, psychological resources, and sleep outcomes in this population.

4.3 Serial-mediation model

The complex findings from our serial mediation analysis reveal important insights into the mechanisms connecting mindfulness-based music engagement and sleep disturbance among Chinese college

students. The positive direct effect and primary indirect pathways suggest that, contrary to some established literature, mindfulness music engagement may be associated with increased sleep disturbance in this population. This apparent contradiction might be explained through the lens of reverse causality, where students experiencing greater sleep difficulties may be more likely to seek out mindfulness-based music as a coping strategy, creating a positive correlation in cross-sectional data that masks potential long-term benefits [50][51]. Additionally, the cultural context of Chinese higher education, characterized by high academic pressure and competitive environments, may create conditions where even potentially beneficial practices like mindfulness music become entangled with stress-inducing factors [15].

Particularly noteworthy is the competing mediational pathways identified in our analysis. While the primary indirect effects through resilience alone and anxiety alone were positive, the small but significant negative serial mediation effect reveals a potential beneficial mechanism that is overshadowed by stronger opposing pathways. This pattern aligns with Zou et al.'s [52] concept of "inconsistent mediation" and suggests that mindfulness-based music may simultaneously trigger both beneficial and detrimental processes affecting sleep. The resilience-anxiety sequence provides theoretical support for mindfulness-based interventions while highlighting the complexity of their implementation. As Chen et al. [15] observed in their work with Chinese students, the effectiveness of mindfulness interventions often depends on sufficient practice duration and appropriate guidance to navigate the initial period where awareness of negative states may temporarily increase before regulation skills develop. This dynamic may explain why cross-sectional data captures predominantly positive associations between mindfulness music and sleep disturbances, even while containing evidence of potential beneficial mechanisms that might emerge more strongly in longitudinal designs.

5. Conclusion

This study investigated the effects of mindfulness-based music on sleep quality among Chinese college students, with a focus on the mediating roles of psychological resilience and anxiety. The findings revealed that engagement with mindfulness-based music was significantly associated with enhanced psychological resilience, which in turn influenced sleep quality through both direct and indirect pathways. While the direct association between mindfulness-based music and sleep disturbances appeared counterintuitively positive in cross-sectional analysis, the sequential mediation model highlighted a protective mechanism: mindfulness-based music may improve sleep quality by strengthening resilience and subsequently reducing anxiety. These results align with theoretical frameworks suggesting that mindfulness practices foster adaptive coping strategies and emotional regulation, which are critical for mitigating sleep-related issues in high-pressure academic environments.

This study has several limitations. First, its cross-sectional design precludes causal inferences about the relationships between mindfulness-based music engagement, resilience, anxiety, and sleep disturbances. Second, the sample was drawn exclusively from one province in China, limiting the generalizability of findings to broader populations or diverse cultural contexts. Third, reliance on self-

reported measures for key variables (e.g., sleep quality, anxiety) may introduce recall or social desirability biases. Fourth, unmeasured confounders, such as specific music characteristics (e.g., tempo, genre) and environmental factors during listening, were not controlled, potentially influencing outcomes.

Future studies should adopt longitudinal or experimental designs to establish causality and explore the long-term effects of mindfulness-based music interventions. Incorporating objective sleep assessments and diversifying samples across regions and cultures would enhance the validity and applicability of findings. Additionally, investigating the role of specific music characteristics (e.g., tempo, instrumentation) and individualized preferences could refine interventions for optimal efficacy.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. All procedures performed in this study involving human participants were conducted ethically and was approved by the Ethics Review Committee of Fujian Health College (Ethics Review Letter RT2024-38). All participants provided informed consent.

Consent for publication

Informed consent was obtained from all individual participants included in the study.

Availability of data and materials

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Competing interests

The authors have no competing interests

Authors' contributions

TY and RY conceived of the presented idea. TY developed the theory and performed the computations. RY verified the analytical methods.

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Figures

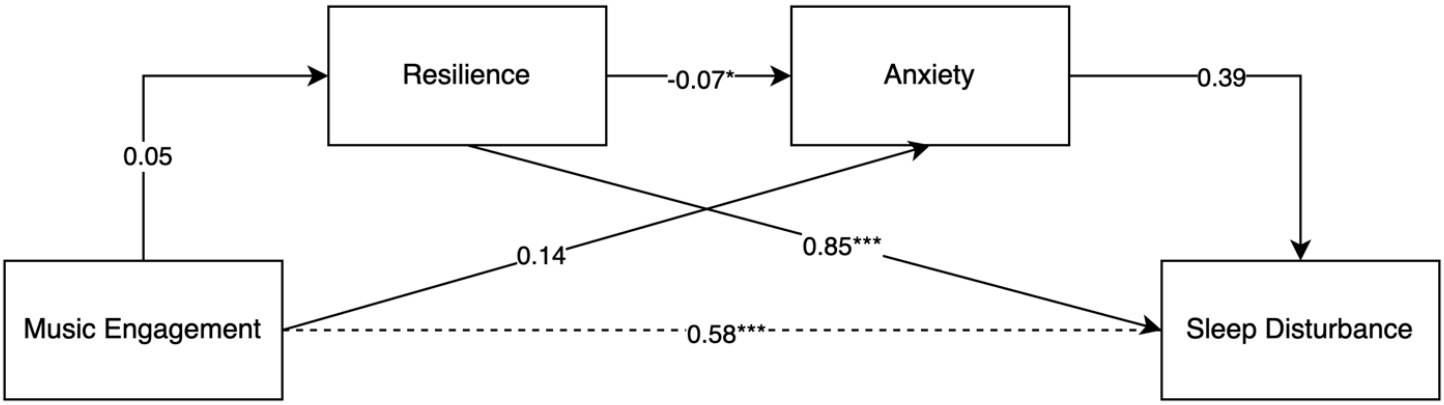

Figure 1

Serial mediation model for the relationship of music engagement and sleep disturbance with social support and depressive symptoms.