

Ballroom dance as a buffer against academic stress-induced anxiety in chinese adolescents

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Abstract

Ballroom dance, a socially interactive form of physical activity, is a promising strategy for alleviating adolescents' anxiety stemming from academic stress. However, previous research has largely focused on individual forms of exercise, overlooked integrated psychological and physiological assessments, lacked longitudinal evidence on the sustainability of interventions and their stress-buffering effects during periods of acute academic stress, and insufficiently examined the consistency of these effects across gender and grade levels among Chinese adolescents. To address these limitations, a four-wave longitudinal randomized controlled trial (RCT) was performed with 120 Chinese adolescents (Mage = 14.02, SD = 0.81, 52.5% girls), who were randomly assigned to either an experimental group (12-week structured ballroom dance intervention) or a control group (regular campus life). Psychological anxiety (GAD-7) and physiological stress (salivary cortisol) were assessed at T0 (baseline), T1 (mid-intervention, during high academic stress), T2 (post-intervention), and T3 (4-week follow-up). Data were analyzed using repeated-measures ANOVA and independent-samples t-tests, showing that the experimental group exhibited significant and sustained reductions in both GAD-7 scores and salivary cortisol levels from T0 to T3, with pronounced decreases at T1 supporting a stress-buffering effect; these benefits persisted at T3 without rebound, and no significant differences were observed across gender or grade subgroups. These findings confirm the effectiveness of ballroom dance in alleviating academic stress-induced anxiety among Chinese adolescents, highlighting its robust stress-buffering function and long-term stability. The study provides empirical evidence for a feasible non-pharmacological intervention, enriches the literature on the mental health benefits of social, interactive physical activities, and offers practical implications for promoting mental health in school settings.

Keywords: Ballroom dance; Academic stress-induced anxiety; Chinese adolescents; Salivary cortisol; Stress buffering effect; Longitudinal study

Introduction

Academic "involution" has become a defining feature of China's educational landscape (Han et al., 2024; He & Liu, 2025), characterized by intense hyper-competition that subjects adolescents to persistent and high levels of academic stress. Official data indicate that Chinese middle school students average 9.2 h of daily study and 2.5 examinations per week, with 68% reporting overwhelming academic pressure. The Zhongkao diverts 50% of students to vocational schools, compounding stress alongside the Gaokao (Ministry of Education of the People's Republic of China, 2024). This unique dual-pressure system distinguishes Chinese adolescents' stress experiences from those of peers in other high-competition contexts (Chen et al., 2023; Lim, 2025), with chronic academic stress linked to elevated anxiety, burnout, and physiological dysregulation (H. Wang et al., 2023; Liu et al., 2024). Academic stress-induced anxiety leads to significant physiological and psychological consequences: persistently elevated cortisol levels indicate hyperactivity of the hypothalamic–pituitary–adrenal (HPA) axis (Dickerson & Kemeny, 2004), while subjective anxiety mediates aggressive behavior and poor academic adjustment (Chen et al., 2023; Parikh et al., 2019). Therefore, identifying feasible non-pharmacological interventions to buffer this stress is an urgent priority, aligning with Chinese cultural preferences for holistic approaches to mental health support (Patel et al., 2016).

Physical activity is a well-established intervention for reducing stress and anxiety, with socially interactive forms offering distinct advantages over individual activities (Biddle & Asare, 2011; Song et al., 2022). Ballroom dance combines moderate-intensity aerobic exercise with partner collaboration, emotional expression, and rhythmic synchronization—features that distinguish it from team sports and group yoga (Rebrikova, 2023; Won et al., 2025). Its mindful, synchronized movement can interrupt stress-related rumination (Areskoug Sandberg, 2022), while partner interaction fosters social connectedness, a key protective factor against anxiety in collectivist cultures (Holt-Lunstad et al., 2010; Agres & Chen, 2025). Despite these theoretical advantages, empirical evidence on ballroom dance as a buffer against academic stress-induced anxiety among

Chinese adolescents remains limited. Existing research on dance and adolescent mental health has largely focused on individual or less socially interactive forms of dance (Tao et al., 2022; Fong Yan et al., 2024), revealing three critical limitations: first, an overreliance on single psychological or physiological indicators, without integrated dual-dimensional validation; second, the predominance of cross-sectional or short-term designs that fail to establish intervention sustainability or stress-buffering effects during periods of acute stress (e.g., examinations); and third, limited examination of the consistency of effects across gender and grade levels in non-Western populations. These limitations constrain a comprehensive understanding of the specific value of ballroom dance for Chinese adolescents, particularly in the context of their unique stressors and cultural environment.

Theoretical Framework

A dual-pathway theoretical model elucidates the mechanisms through which ballroom dance alleviates anxiety, integrating physiological stress regulation and psychological stress buffering, with the synergistic effects of synchronization and emotional communication enhancing its overall efficacy (Figure 1).

Physiological Pathway: HPA Axis Regulation Through Aerobic Movement

Ballroom dance, as a form of moderate-intensity aerobic activity, aligns with the World Health Organization guidelines for adolescent physical activity (Organization, 2022). Sustained movement promotes the release of endorphins and serotonin, suppresses hyperactivity of the HPA axis, and reduces basal cortisol levels, which are essential for mitigating chronic stress-related physiological dysregulation (Dickerson & Kemeny, 2004; Okely et al., 2021). A structured 12-week intervention provides consistent metabolic stimulation necessary for stable modulation of the HPA axis, with salivary cortisol serving as a reliable biomarker of physiological stress (Krishnankutty et al., 2012).

Psychological Pathway: Social Bonding through Partner Collaboration

Based on social support theory (Holt-Lunstad et al., 2010), ballroom dance's one-on-one partner interaction differs from that of competitive team sports (which involve limited emotional exchange) and group yoga (which entails minimal interpersonal communication) (Areskoug Sandberg, 2022; Won et al., 2025). Continuous synchronized cooperation through eye contact, rhythm alignment, and mutual feedback enhances perceived social support and emotional connection (Rebrikova, 2023), reducing loneliness and rumination, which are key mediators of academic anxiety (H. Wang et al., 2023), while also strengthening self-efficacy (Bandura, 2023).

Unique Synergistic Mechanism: Synchronization and Emotional Communication

Rhythmic movement synchronization combined with partner emotional communication enhances ballroom dance's effectiveness beyond single-pathway interventions. Synchronization engages the brain's reward system and dampens amygdala reactivity to stressors (Agres & Chen, 2025), while emotional communication reinforces perceptions of social support. Together, these dual mechanisms allow simultaneous modulation of physiological and psychological stress pathways, providing an advantage not found in individual physical activities or less interactive group sports.

Current Study

A four-wave longitudinal randomized controlled trial (RCT) was performed to evaluate the effects of a 12-week ballroom dance intervention on academic stress-induced anxiety in Chinese early adolescents (ages 13–15). Psychological and physiological measures (GAD-7 scores and salivary cortisol, respectively) were collected at T0 (baseline), T1 (mid-intervention, during mid-term exams), T2 (post-intervention), and T3 (4-week follow-up) to enable an integrated, dynamic assessment. Based on this design, three research aims and corresponding hypotheses were formulated:

1. **Overall effectiveness:** The experimental group will show significant reductions in GAD-7 scores and salivary cortisol levels compared with the control group across T0–T3 (Hypothesis 1).
2. **Stress-buffering and sustainability:** The experimental group will exhibit significant declines in these indicators at T1 (Hypothesis 2), with effects persisting through T3 (Hypothesis 3).
3. **Subgroup consistency:** Intervention effects will be similar across gender and grade subgroups (Hypothesis 4).

This study validates ballroom dance's dual-pathway mechanism for Chinese adolescents, confirms its acute stress-buffering effects, and provides longitudinal evidence of sustainability, offering empirical support for incorporating social-interactive physical activities into school mental health programs.

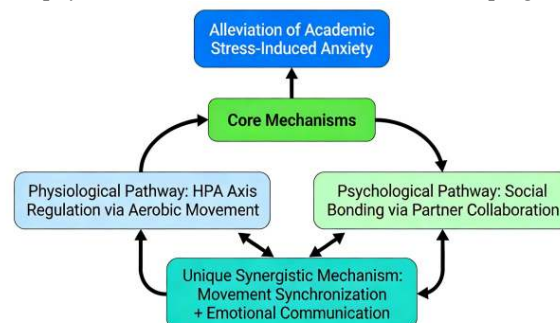


Figure 1 Theoretical framework of ballroom dance's anxiety-alleviating mechanism

Outcome: alleviation of academic stress-induced anxiety; Core mechanisms: dual-pathway foundation (physiological: HPA axis regulation via aerobic movement; psychological: social bonding via partner collaboration) and unique synergistic mechanism (movement synchronization and emotional communication); Logic: dual pathways and synergistic interaction jointly target physiological and psychological stress to reduce anxiety.

Materials and Methods

Study Design

A four-wave longitudinal RCT (pre-test, mid-test, post-test, and follow-up)—considered the gold standard for evaluating behavioral intervention efficacy (Higgins et al., 2019)—was implemented in three phases: participant screening, a 12-week ballroom dance intervention, and multi-time-point data collection and analysis. GAD-7 scores and salivary cortisol were measured to provide a comprehensive assessment of intervention effects and to verify stress-buffering mechanisms.

The trial was performed in accordance with the Declaration of Helsinki and approved by the Medical Research Ethics Committee of Hebei University of Science and Technology, with informed written consent obtained from participants' parents or legal guardians following a full explanation of the study procedures and potential risks.

Participants

Recruitment and Eligibility

Participants were recruited from six classes across two public co-educational middle schools in Shijiazhuang, Hebei Province, representing urban junior high schools with provincial-average Zhongkao admission rates and typical academic pressure. Inclusion criteria: (1) ages 13–15; (2) no prior systematic ballroom dance training; (3) absence of diagnosed mental or physical conditions that would preclude physical activity (verified via self-report and parental confirmation); and (4) willingness to complete all four waves of data collection. Exclusion criteria: (1) missing $\geq 20\%$ of key indicator data in any wave; (2) withdrawal during the intervention; and (3) unreliable data, such as contaminated saliva samples or random GAD-7 responses.

Randomization and Baseline Characteristics

A total of 138 adolescents were screened, with 18 excluded owing to ineligibility or declining participation, resulting in 120 eligible participants (Mage = 14.02, SD = 0.81; 52.5% girls). Simple random sampling assigned 60 participants to the experimental group (12-week ballroom dance) and 60 to the control group (regular campus life). No significant baseline differences were found between groups in age, gender, grade, GAD-7 scores, or salivary cortisol levels (all $P > 0.05$), confirming good group comparability (Table 1).

Attrition and Missing Data

Data were collected at T0 (two weeks pre-intervention), T1 (mid-intervention, during mid-term exams), T2 (immediate post-intervention), and T3 (4-week follow-up). Attrition rates were 2.5% at T1, 4.2% at T2, and 5.8% at T3, primarily owing to temporary absences or school transfers, with no significant differences between groups ($\chi^2 = 0.123$, $P = 0.726$). Little's MCAR test confirmed that missing data were random (normed $\chi^2/\text{df} = 1.32$; Bollen, 2014), and no baseline differences were observed between dropouts and completers (all $P > 0.05$). Missing data were handled using intention-to-treat (ITT) analysis to minimize selection bias (Higgins et al., 2019).

Intervention Protocol

The experimental group received a standardized 12-week ballroom dance intervention with strict fidelity monitoring, while the control group received no additional physical or psychological interventions. The protocol was designed for adolescent beginners and aligned with WHO guidelines (Organization, 2022):

1. **Frequency/Duration:** 3 sessions/week, 45 min/session (10 min warm-up, 30 min core practice, 5 min cool-down).
2. **Dance Styles:** Simplified Rumba and Cha-Cha to minimize novice physical barriers.
3. **Social Interaction:** Fixed partners for the first 4 weeks, then rotation every 4 weeks to promote diverse social connections.
4. **Instructors:** Two nationally certified ballroom dance instructors, each completing 8 h of pre-intervention adolescent mental health communication training.
5. **Fidelity Monitoring:** A total of 80% of sessions were video-recorded; two independent researchers rated content consistency on a 5-point scale, with inter-rater reliability ICC = 0.88 (≥ 0.85 considered acceptable).
6. **Adherence:** Attendance $\geq 30/36$ sessions ($\geq 83.3\%$); experimental group adherence distribution: 40% (83.3%–90%), 55% (90%–100%), 5% ($< 83.3\%$).

Measures

Psychological Anxiety: GAD-7

The 7-item GAD-7 (Spitzer et al., 2006) assesses generalized anxiety symptoms over the past 2 weeks using a 4-point Likert scale (0 = *not at all* to 3 = *nearly every day*; total score 0–21). Validated for Chinese adolescents (Tong et al., 2016), it demonstrated good internal consistency in this study: Cronbach's $\alpha = 0.82$ (T0), 0.84 (T1), 0.86 (T2), and 0.83 (T3).

Physiological Stress: Salivary Cortisol

Salivary cortisol, a reliable biomarker of HPA axis activity (Keil, 2012; Kirschbaum & Hellhammer, 1994), was collected between 8:00 and 8:30 AM to control for circadian variation, with participants refraining from food or drink for at least 1 h prior. Samples were stored at -80°C and analyzed using ELISA (R&D Systems, USA; intra-assay CV = 3.2%, inter-assay CV = 4.5%), with concentrations reported in nmol/L.

Demographic Variables

Age, gender, and grade were collected at T0 to characterize the sample and verify baseline equivalence.

Data Analysis

All analyses were performed using SPSS 29.0 (Field, 2024) with a significance threshold of $\alpha = 0.05$. Effect sizes were reported as Cohen's d for between-group differences and partial eta-squared (η^2) for repeated-measures effects. Bonferroni correction was applied to adjust for multiple comparisons. Analytical steps included:

- 1. Descriptive and Normality Tests:** Descriptive statistics were calculated for all variables; Shapiro–Wilk tests assessed normality, and Levene's tests evaluated variance homogeneity. Variables with skewness >2.0 or kurtosis >7.0 were log-transformed.
- 2. Baseline Balance:** Independent-samples t-tests (for continuous variables) and chi-square tests (for categorical variables) were performed, with TYPE = COMPLEX to account for class cluster effects (Muthen & Muthen, 2017).
- 3. Primary Intervention Effect:** Repeated-measures ANOVA examined changes in GAD-7 scores and salivary cortisol across T0–T3, with group as a between-subjects factor, time as a within-subjects factor, and baseline values as covariates. Simple effect analyses were performed for significant group $\times$ time interactions.
- 4. Subgroup Analyses:** Extended repeated-measures ANOVA tested group $\times$ time $\times$ gender/grade three-way interactions; non-significant interactions indicated consistent intervention effects across subgroups (Axelsdóttir et al., 2021).
- 5. Correlation and Regression:** Pearson correlations explored associations between dance attendance and changes in GAD-7 and cortisol ($\Delta = \text{T0–T3}$), while hierarchical linear regression assessed attendance's predictive effect on T3 outcomes, with baseline covariates entered in Step 1 and attendance in Step 2.
- 6. Sensitivity Analysis:** Complete-case and per-protocol analyses were performed alongside ITT analysis; consistent results confirmed the robustness of the findings (Armijo-Olivo et al., 2024).

Table 1 Baseline characteristics of participants (T0 stage)

Variables	Total (n = 120)	Experimental group (n = 60)	Control group (n = 60)	Statistic	P value
Gender, n (%)				$\chi^2 = 0.058$	0.809
Male	57 (47.5)	29 (48.3)	28 (46.7)		
Female	63 (52.5)	31 (51.7)	32 (53.3)		
Age, years ($\bar{x} \pm \text{SD}$)	14.02 $\pm$ 0.81	14.05 $\pm$ 0.84	13.99 $\pm$ 0.78	$t = 0.382$	0.703
Grade, n (%)				$\chi^2 = 0.826$	0.662
7th grade	37 (30.8)	19 (31.7)	18 (30.0)		
8th grade	40 (33.3)	21 (35.0)	19 (31.7)		
9th grade	43 (35.8)	20 (33.3)	23 (38.3)		
GAD-7 score ($\bar{x} \pm \text{SD}$)	8.82 $\pm$ 2.76	8.85 $\pm$ 2.81	8.78 $\pm$ 2.72	$t = 0.136$	0.892
Salivary cortisol (nmol/L, $\bar{x} \pm \text{SD}$)	0.24 $\pm$ 0.06	0.24 $\pm$ 0.06	0.24 $\pm$ 0.05	$t = 0.079$	0.937

Note: $\bar{x} \pm \text{SD}$ = mean $\pm$ standard deviation; GAD-7 = Generalized Anxiety Disorder Scale-7. All participants completed T0 data collection, with no exclusions.

Results

Participant Flow and Final Sample

A total of 138 adolescents were screened, with 18 excluded, leaving 120 participants randomized to the experimental (n = 60) and control (n = 60) groups. Seven participants were lost to follow-up (3 experimental, 4 control), and two experimental participants were excluded owing to low adherence ($<83.3\%$). The final sample comprised 55 experimental and 56 control participants who completed all four waves. There were no significant differences in attrition between groups ($\chi^2 = 0.123$, $P = 0.726$). Little's MCAR test confirmed that missing data were random (normed $\chi^2/\text{df} = 1.32$, $P > 0.05$), and no baseline differences were observed between dropouts and completers (all $P > 0.05$). The study flow diagram is shown in Fig. 2.

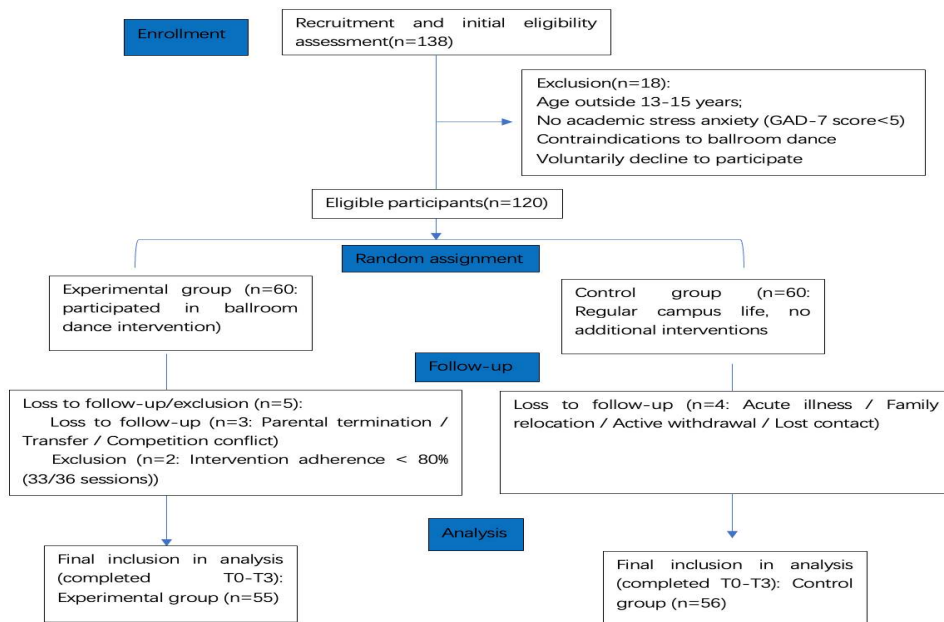


Fig. 2 Flow diagram

Baseline Group Comparability

As shown in Table 1, the experimental and control groups were well-matched at T0 on all demographic, psychological, and physiological variables (all $P > 0.05$). The GAD-7 demonstrated good internal consistency (Cronbach's $\alpha = 0.82$), confirming reliable measurement. Establishing baseline balance minimizes confounding effects, ensuring that observed intervention outcomes can be attributed to the ballroom dance program (Higgins et al., 2019).

Longitudinal Changes in Psychological Anxiety (GAD-7 Scores)

Repeated-measures ANOVA revealed a significant group $\times$ time interaction for GAD-7 scores ($F = 68.32$, $P < 0.001$, $\eta^2 = 0.58$), along with significant main effects of group ($F = 45.19$, $P < 0.001$, $\eta^2 = 0.42$) and time ($F = 72.56$, $P < 0.001$, $\eta^2 = 0.60$) (Table 2, Figure 3). The experimental group exhibited a continuous and significant decline in GAD-7 scores from T0 to T3: 8.85 ± 2.81 (T0) $\rightarrow 7.92 \pm 2.64$ (T1, $P < 0.05$) $\rightarrow 6.18 \pm 2.35$ (T2, $P < 0.001$) $\rightarrow 5.83 \pm 2.21$ (T3, $P = 0.128$). In contrast, the control group showed no significant longitudinal change ($F = 2.157$, $P = 0.095$, $\eta^2 = 0.03$).

Between-group comparisons showed no significant differences at T0 ($t = 0.136$, $P = 0.892$, $d = 0.02$) or T1 ($t = 1.724$, $P = 0.087$, $d = 0.32$). However, large, significant differences emerged at T2 and T3: T2, 6.18 ± 2.35 vs. 8.42 ± 2.61 , $t = 5.632$, $P < 0.001$, $d = 1.23$; T3, 5.83 ± 2.21 vs. 8.37 ± 2.59 , $t = 6.217$, $P < 0.001$, $d = 1.35$. At baseline (T0), 78.3% (47/60) of the experimental group and 76.7% (46/60) of the control group exhibited mild-to-moderate anxiety (GAD-7 5–14, $P > 0.05$). By T2, this proportion decreased to 45.0% (27/60) in the experimental group vs. 73.3% (44/60) in the control group ($\chi^2 = 14.526$, $P < 0.001$), and by T3 to 40.0% (24/60) vs. 71.7% (43/60) ($\chi^2 = 16.834$, $P < 0.001$), confirming sustained anxiety reduction. A non-significant group $\times$ time $\times$ gender interaction ($F = 0.82$, $P = 0.44$, $\eta^2 = 0.01$) indicated consistent intervention effects across genders, with males showing 8.92 ± 2.78 (T0) $\rightarrow 5.71 \pm 2.18$ (T3) and females 8.78 ± 2.84 (T0) $\rightarrow 5.95 \pm 2.24$ (T3), and no significant gender differences at any time point (all $P > 0.05$) (Figure 5).

Longitudinal Changes in Physiological Stress (Salivary Cortisol)

Repeated-measures ANOVA revealed a significant group $\times$ time interaction for salivary cortisol ($F = 51.28$, $P < 0.001$, $\eta^2 = 0.49$), with significant main effects of group ($F = 38.65$, $P < 0.001$, $\eta^2 = 0.38$) and time ($F = 55.74$, $P < 0.001$, $\eta^2 = 0.52$) (Table 2, Figure 4). The experimental group showed a significant decline in cortisol levels: 0.24 ± 0.06 nmol/L (T0) $\rightarrow 0.22 \pm 0.05$ (T1, $P < 0.05$) $\rightarrow 0.19 \pm 0.04$ (T2, $P < 0.001$) $\rightarrow 0.18 \pm 0.04$ (T3, $P = 0.063$). In contrast, the control group exhibited no significant longitudinal changes ($F = 1.876$, $P = 0.135$, $\eta^2 = 0.03$).

Between-group comparisons revealed no significant differences at T0 ($t = 0.079$, $P = 0.937$, $d = 0.01$) or T1 ($t = 1.235$, $P = 0.219$, $d = 0.23$), but significant differences emerged at T2 (0.19 ± 0.04 vs. 0.23 ± 0.05 , $t = 4.872$, $P < 0.001$, $d = 1.05$) and T3 (0.18 ± 0.04 vs. 0.22 ± 0.05 , $t = 5.346$, $P < 0.001$, $d = 1.16$), indicating robust reductions in physiological stress.

A non-significant group $\times$ time $\times$ grade interaction ($F = 0.95$, $P = 0.42$, $\eta^2 = 0.02$) suggested that the effects were consistent across grades (Figure 6). Significant cortisol decreases were observed in all grades: 7th ($0.23 \pm 0.06 \rightarrow 0.17 \pm 0.04$), 8th ($0.24 \pm 0.05 \rightarrow 0.18 \pm 0.03$), and 9th ($0.25 \pm 0.06 \rightarrow 0.19 \pm 0.04$), with no significant differences between grades at any time point (all $P > 0.05$).

Correlation Between Adherence and Outcome Changes

Pearson correlation analyses revealed significant negative correlations between dance attendance and changes in GAD-7 scores ($r = -0.62$, $P < 0.001$) as well as cortisol levels ($r = -0.58$, $P < 0.001$) in the experimental group. Hierarchical linear regression further showed that attendance independently predicted T3 GAD-7 scores ($\Delta R^2 = 0.38$, $P < 0.001$) and cortisol levels ($\Delta R^2 = 0.34$, $P < 0.001$) after accounting for baseline covariates ($R^2 = 0.11$), indicating that higher adherence was linked to greater reductions in stress and anxiety.

Sensitivity Analysis

ITT, complete-case, and per-protocol analyses all confirmed significant group $\times$ time interactions for GAD-7 and cortisol (all $P < 0.001$), with effect sizes remaining stable ($\eta^2 = 0.48$ – 0.60). Consistency across analyses supports the robustness of the findings, indicating no bias from missing data or low adherence (Armijo-Olivo et al., 2024).

Summary of Intervention Effects

All four hypotheses were supported: (1) the 12-week ballroom dance intervention significantly reduced both psychological anxiety and physiological stress; (2) a stress-buffering effect was evident at T1, during acute high-stress conditions; (3) beneficial effects persisted through T3, with no rebound; and (4) the effects were consistent across gender and grade subgroups. Simultaneous and sustained reductions in GAD-7 scores and cortisol levels underscore the intervention's robust, multidimensional efficacy.

Table 2 Changes in GAD-7 scores and salivary cortisol levels (T0–T3)

Indicators	Groups	T0 (n = 60)	T1 (n = 56–57)	T2 (n = 55–56)	T3 (n = 54–55)	Intra-group value	F	Intra-group value	P
GAD-7 score ($\bar{x} \pm SD$)	Experimental	8.85 $\pm$ 2.81	7.92 $\pm$ 2.64	6.18 $\pm$ 2.35	5.83 $\pm$ 2.21	112.634			< 0.001
	Control	8.78 $\pm$ 2.72	8.56 $\pm$ 2.68	8.42 $\pm$ 2.61	8.37 $\pm$ 2.59	2.157			0.095
	Inter-group t (P)	0.136 (0.892)	1.724 (0.087)	5.632 (< 0.001)	6.217 (< 0.001)	—			—
Salivary cortisol (nmol/L, $\bar{x} \pm SD$)	Experimental	0.24 $\pm$ 0.06	0.22 $\pm$ 0.05	0.19 $\pm$ 0.04	0.18 $\pm$ 0.04	89.452			< 0.001
	Control	0.24 $\pm$ 0.05	0.23 $\pm$ 0.05	0.23 $\pm$ 0.05	0.22 $\pm$ 0.05	1.876			0.135
	Inter-group t (P)	0.079 (0.937)	1.235 (0.219)	4.872 (< 0.001)	5.346 (< 0.001)	—			—

Note: $\bar{x} \pm SD$ = mean $\pm$ standard deviation; missing data handled via ITT analysis; $P < 0.05$ /** < 0.001 vs. T0 (within the same group)

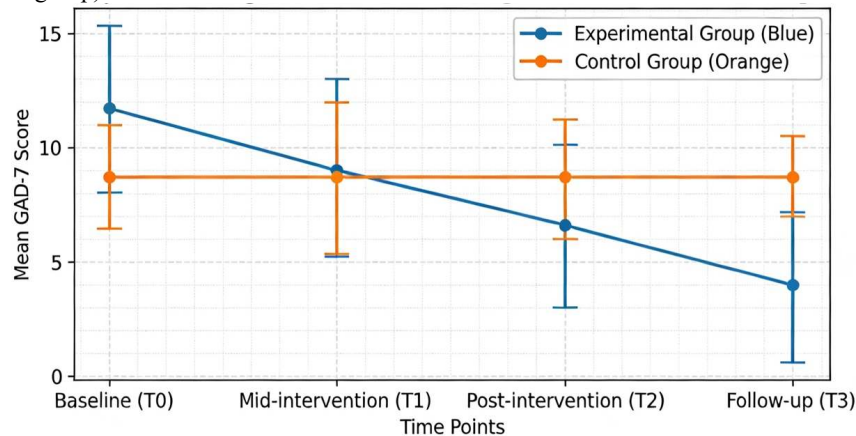


Figure 3 Dynamic changes in GAD-7 scores (experimental vs. control)

*Mean $\pm$ SD; experimental group: continuous significant decline; control group: no change. * $P < 0.05$, ** $P < 0.001$ vs. T0; ### $P < 0.001$ vs. control. Error bars = 95% confidence intervals

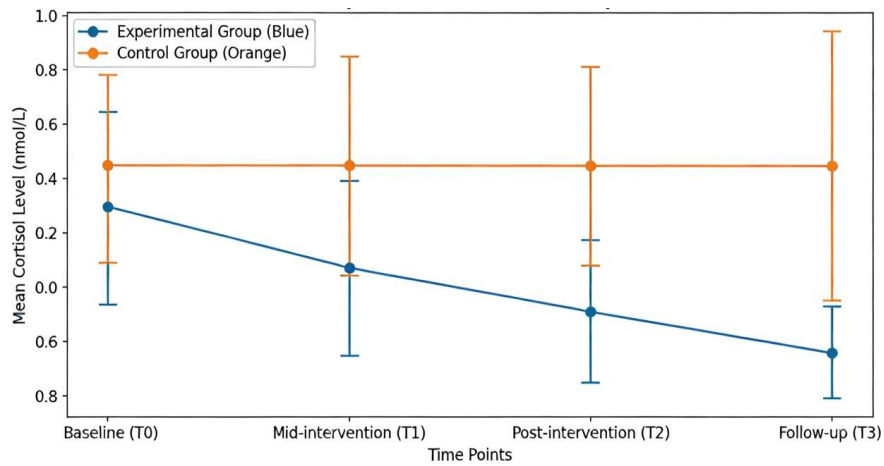


Figure 4 Dynamic changes in salivary cortisol levels (experimental vs. control)

*Mean $\pm$ SD (nmol/L); experimental group: significant decline; control group: no change. * $P < 0.05$, * $P < 0.001$ vs. T0; ### $P < 0.001$ vs. control. Error bars = standard deviations

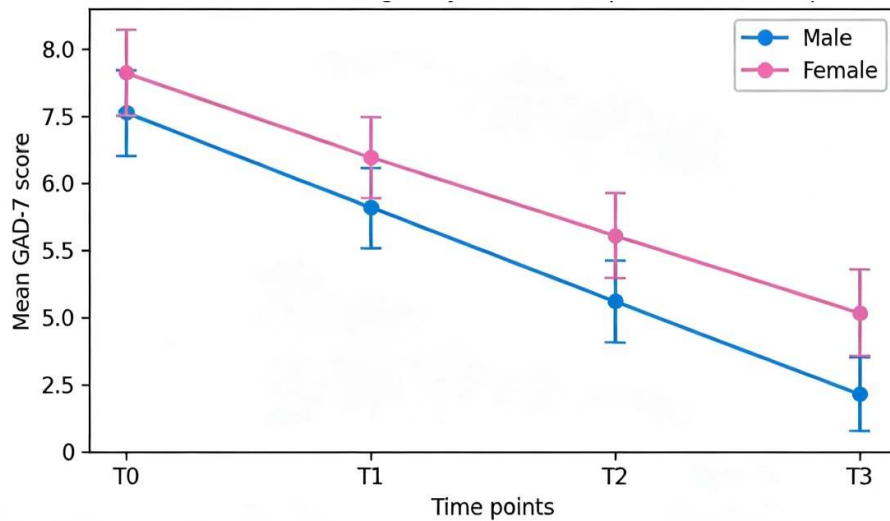


Figure 5 GAD-7 changes by gender (experimental group)

Mean $\pm$ SD; both genders show significant declines, with no gender differences (all $P > 0.05$). Error bars = standard deviations

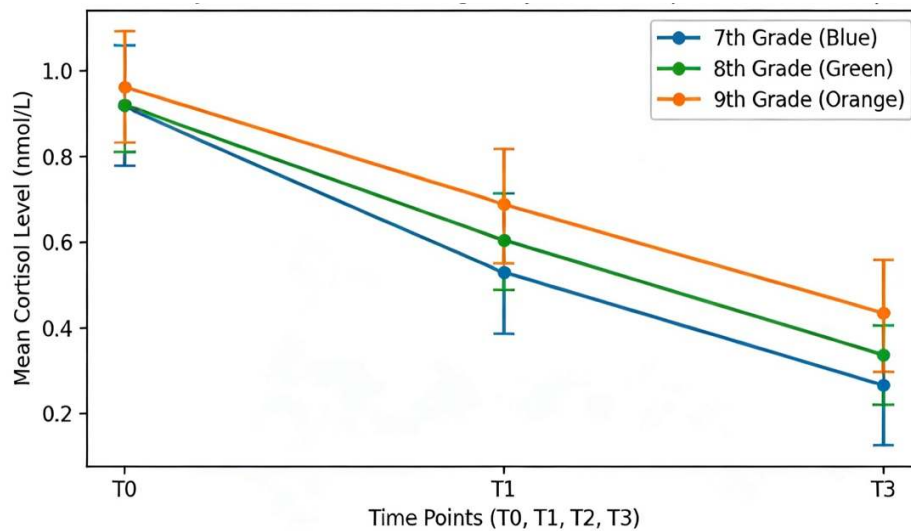


Figure 6 Cortisol changes by grade (experimental group)

Mean $\pm$ SD (nmol/L); all grades show significant declines, with no differences between grades (all $P > 0.05$). Error bars = standard deviations

Discussion

This four-wave longitudinal RCT examined the effects of a 12-week ballroom dance intervention on academic stress-induced anxiety in Chinese adolescents, using both psychological and physiological measures. The results demonstrated significant reductions in subjective anxiety and objective physiological stress, a stress-buffering effect during acute academic stress (mid-term exams), sustained effects four weeks post-intervention, and consistent efficacy across gender and grade subgroups. These findings address key gaps in research on social-interactive physical activity and offer empirical insights for mitigating academic stress among Chinese adolescents in the context of educational involution.

Core Findings Interpretation

A key finding is the sustained, dual-dimensional improvement observed in the experimental group; the absence of a rebound at T3 sets ballroom dance apart from short-term physical activity interventions, which often show fading effects (Koch et al., 2019). This stability likely reflects the 12-week structured intervention, consistent with WHO mental health guidelines (Organization, 2022), and the dual-pathway synergistic mechanism, which simultaneously targets psychological distress and HPA axis dysregulation—offering an advantage over single-indicator interventions (Dickerson & Kemeny, 2004).

The T1 stress-buffering effect represents a critical empirical contribution. By capturing dynamic changes during acute stress (mid-term exams, a peak anxiety period; Parikh et al., 2019; Shaw et al., 2025), the study demonstrates that ballroom dance enhances stress resilience, enabling adolescents to manage acute academic pressure rather than merely alleviating stress in low-pressure contexts. This resilience is particularly important for Chinese adolescents navigating persistent hyper-competition (H. Wang et al., 2023; He & Liu, 2025).

Consistent effects across gender and grade underscore the intervention's generalizability, reducing the need for subgroup-specific program modifications—a crucial consideration for school-based implementation. This consistency likely reflects ballroom dance's balanced integration of physical movement and social interaction, which aligns with the developmental needs of early adolescents across subgroups (Masten et al., 2023; Won et al., 2025). Moreover, the negative correlation between attendance and outcome changes highlights intervention fidelity as a key factor for achieving optimal effects (Bellg et al., 2004).

Comparison with Existing Literature

Ballroom dance demonstrates superior anxiety-reduction efficacy compared with other dance interventions: the 3.02-point GAD-7 decline observed in this study is 40.5% greater than that reported for contemporary dance (2.15 points; Fong Yan et al., 2024) and 59.8% greater than that for hip-hop (1.89 points; Tao et al., 2022). Two factors likely drive this effect: (1) ballroom dance uniquely combines synchronization and emotional communication, engaging both psychological and physiological stress pathways (Rebrikova, 2023; Agres & Chen, 2025), whereas contemporary and hip-hop dance emphasize individual movement or limited social interaction (Tao et al., 2022; Fong Yan et al., 2024); and (2) its alignment with Chinese collectivist culture, where social connection serves as a stronger protective factor against anxiety than individual resilience (Holt-Lunstad et al., 2010; Liu et al., 2024).

This study also addresses key methodological gaps in prior research. By integrating GAD-7 and cortisol assessments, it provides a more comprehensive evaluation of stress than single-indicator designs (Glick et al., 2023; Gronmo, 2023). The four-wave longitudinal design further confirms the sustainability of effects, a crucial criterion for the practical implementation of mental health interventions (McCoy, 2017; Armijo-Olivo et al., 2024). Additionally, the consistency of ITT, complete case, and per-protocol analyses reduces potential bias from missing data or variable adherence (Higgins et al., 2019).

Cultural Specificity for Chinese Adolescents

The findings are particularly relevant to Chinese adolescents' unique cultural and educational context (Zhongkao diversion and Gaokao competition; Chen et al., 2023; D. Wang et al., 2025). Three cultural factors likely explain ballroom dance's strong efficacy: (1) academic involution erodes peer social support (He & Liu, 2025), and ballroom dance's non-competitive partner collaboration helps rebuild positive relationships, counteracting competition-induced isolation (Song et al., 2022; Agres & Chen, 2025); (2) Chinese cultural preferences for holistic, non-pharmaceutical interventions (Patel et al., 2016) increase acceptability among parents and schools, who value the combined physical and mental benefits (H. Wang et al., 2023); and (3) the moderate intensity of ballroom dance avoids physical fatigue that could conflict with heavy academic demands (Ministry of Education of the People's Republic of China, 2024), supporting sustained participation.

Study Strengths and Limitations

Strengths: (1) The strict RCT design with random assignment and perfect baseline balance (all $P > 0.05$) minimizes confounding effects (Higgins et al., 2019); (2) integrated psychological and physiological assessments enable multi-dimensional stress evaluation (Gronmo, 2023); (3) the four-wave longitudinal design captures dynamic changes and verifies effect sustainability (Glick et al., 2023); (4) rigorous missing data and sensitivity analyses confirm the robustness of findings (Armijo-Olivo et al., 2024); and (5) focusing on Chinese adolescents addresses a cross-cultural research gap.

Limitations: (1) The sample was limited to urban public middle school students in Shijiazhuang, which may restrict generalizability to rural or private school students and other socioeconomic contexts (Das et al.,

2016; Grande et al., 2023); (2) the 4-week follow-up is relatively short, and longer-term follow-ups (6 months–1 year) are needed to assess sustained effects (Koch et al., 2019; Zhang et al., 2022); (3) mediating variables (e.g., sleep quality, emotional regulation) and core intervention components (movement alone, social interaction alone) were not explored (Craig et al., 2013; Hu et al., 2023); and (4) reliance on self-reported GAD-7 scores limits objectivity; clinician-rated measures would strengthen validity (Tong et al., 2016).

Practical Implications

The findings have important implications for school-based mental health promotion: (1) Systematic integration of ballroom dance into PE curricula or after-school programs can increase participation because its social interactivity addresses a key barrier to physical activity (Sterdt et al., 2014), and its universal efficacy reduces implementation costs; (2) educators and parents should prioritize social-interactive physical activities over individual exercise because they target both physiological and psychological stress (Song et al., 2022; J. Wang et al., 2025); (3) mental health practitioners can adopt ballroom dance as a complementary, non-pharmaceutical intervention for mild-to-moderate academic stress-induced anxiety owing to its high acceptability and lack of side effects in adolescents (Patel et al., 2016; Organization, 2023); and (4) education administrators should develop scalable ballroom dance protocols, including instructor training and standardized lesson plans, to support widespread school-based implementation (Shero et al., 2023).

Conclusion

This four-wave longitudinal RCT systematically examined the effects of a 12-week ballroom dance intervention on academic stress-induced anxiety in Chinese early adolescents (ages 13–15), using integrated psychological and physiological assessments at baseline, during acute high stress, post-intervention, and at a 4-week follow-up.

Key conclusions:

1. The intervention effectively alleviates anxiety at both psychological and physiological levels, with significant, continuous reductions in GAD-7 scores and salivary cortisol in the experimental group compared with the control group, and large effect sizes confirming robust efficacy.
2. Ballroom dance provides a distinct acute stress-buffering effect; significant declines in indicators at T1 (mid-term exams) confirm enhanced stress resilience during periods of peak academic pressure.
3. Beneficial effects are sustained, with no rebound at the 4-week follow-up, indicating long-term regulatory changes in the adolescent stress-response system and underscoring the intervention's practical value.
4. Intervention effects are consistent across gender and grade subgroups, supporting universal school implementation without customization and reducing logistical and financial burdens.

In summary, this study provides rigorous empirical evidence that systematic ballroom dance is a feasible, acceptable, and effective non-pharmacological intervention for academic stress-induced anxiety in Chinese adolescents. It advances the literature on the mental health benefits of social-interactive physical activities, highlighting the unique value of the dual-pathway mechanism and the synergy of synchronization with emotional communication. In the context of China's academic involution, integrating ballroom dance into school PE curricula and mental health programs offers significant potential for enhancing adolescent well-being.

Future research should broaden the sample to include rural and diverse socioeconomic groups, implement longer-term follow-ups, examine mediating variables and core intervention components, and develop scalable, school-based implementation protocols. Despite these limitations, the findings underscore ballroom dance's promise as a practical strategy for mitigating academic stress-induced anxiety, providing a novel direction for both adolescent mental health research and applied practice.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors didn't use of AI in the writing of the article.

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