

Research article

Effects of A Smartphone-Delivered Mindfulness Program on Pre-Competition Anxiety and Self-Efficacy in Competitive Sprinters

Bo Wang¹✉, Zhuzhu Wang² and Xiaoming Guan³

¹ School of Physical Education and Health, Wen Hua College, China; ² Gongren Village Street, Qingshan District, Wuhan, Hubei, China; ³ Department of Cardiology, First Affiliated Hospital of Liaoning Medical University, China

Abstract

This study tested a self-report psychological intervention in an 8-week app-based mental training program (MindSprint) using a two-arm, parallel randomized controlled trial involving 70 track athletes allocated to an intervention group ($n = 35$) or waitlist control ($n = 35$) and assessed at baseline (T0), week 4 (T1), week 8 (T2), and week 12 follow-up (T3). Five participants withdrew from the intervention group (14.3%) and three from the control group (8.6%); intention-to-treat analyses were conducted. Engagement was high (46.4 ± 7.3 of 56 sessions; 5.8 ± 1.3 sessions/week; 515.2 ± 120.4 min total practice; adherence 82.9%). Mixed-model ANOVAs showed significant group $\times$ time effects for cognitive state worry ($F(3, 204) = 18.33, p < .001, \eta^2 = .212$) and somatic arousal ($F(3, 204) = 22.71, p < .001, \eta^2 = .250$). From T0 to T2, the intervention group decreased cognitive scores from 24.8 ± 4.1 to 16.5 ± 3.5 and somatic scores from 23.5 ± 4.5 to 15.1 ± 3.9 , with effects maintained at T3 (17.1 ± 3.6 ; 15.8 ± 4.0); controls remained essentially unchanged across timepoints. Perceived capability improved in the intervention group (105.2 ± 12.8 to 128.4 ± 10.5 at T2; $F(3, 204) = 15.96, p < .001, \eta^2 = .190$) and was sustained at follow-up (126.9 ± 11.1), while controls stayed stable (approximately 104 - 106). Dispositional mindfulness increased (118.6 ± 14.2 to 145.2 ± 11.8 ; $F(3, 204) = 25.11, p < .001, \eta^2 = .269$), and improvements in these skills correlated with reductions in cognitive ($r = -.65$) and somatic ($r = -.61$) indices and gains in perceived capability ($r = .59$) (all $p < .001$). Because objective sprint performance and physiological anxiety markers were not measured, the findings should be interpreted as evidence for changes in self-reported psychological outcomes.

Key words: Randomized controlled trial, CSAI-2R, FFMQ, digital intervention adherence, mediation analysis.

Introduction

Competitive sprinting represents a domain of human performance where success is determined by fractions of a second. Athletes in disciplines such as the 100, 200, and 400 meters operate at the peak of their physiological capacity, an environment where psychological factors can be the ultimate arbiter of victory and defeat. Among the most pervasive of these factors is pre-competition anxiety, a complex emotional state characterized by feelings of apprehension and tension associated with an upcoming competition (Cheng et al., 2009). This anxiety manifests in two primary forms: cognitive anxiety, which involves negative thoughts, worries, and doubts about performance, and somatic anxiety, which encompasses the physiological arousal and symptoms like increased heart rate, muscle tension, and butterflies in the stomach (Morris et al., 1981;

Steptoe and Kearsley, 1990). Research has consistently demonstrated a negative correlation between high levels of cognitive anxiety and athletic performance, as it can disrupt concentration and decision-making (Craft et al., 2003; Eysenck et al., 2007). Similarly, while a certain level of somatic arousal is necessary for peak performance, excessive physiological symptoms can lead to neuromuscular tightness and inefficient movement patterns, thereby impairing a sprinter's explosive power and coordination (Bandura, 1977).

In parallel with the need to manage anxiety, the cultivation of self-efficacy is paramount for athletic success. Defined by Bandura as an individual's belief in their capabilities to execute the courses of action required to produce given attainments, self-efficacy is a cornerstone of motivation and perseverance in sports (Carson and Collins, 2016). For a sprinter, this translates to a firm belief in their ability to execute a perfect start, maintain form under pressure, and push through the physiological and psychological pain of the final meters. High self-efficacy influences an athlete's choice of activities, effort expenditure, and persistence in the face of adversity (Moritz et al., 2000). It is a dynamic construct, susceptible to influence from past performances, vicarious experiences, verbal persuasion, and physiological states. Consequently, the debilitating effects of pre-competition anxiety can directly erode an athlete's self-efficacy, creating a vicious cycle of doubt and underperformance. Therefore, interventions that can simultaneously mitigate anxiety and bolster self-efficacy are of immense value in sports psychology.

Traditionally, athletes have utilized psychological skills training (PST), incorporating techniques like goal-setting, imagery, and self-talk to manage their mental state (Birrer and Morgan, 2010). More recently, mindfulness-based interventions (MBIs) have gained significant traction within sports psychology as a powerful approach to enhancing mental well-being and performance (Gardner and Moore, 2017; Noetel et al., 2019). Mindfulness is defined as the practice of paying attention to the present moment, on purpose, and non-judgmentally (Kabat-Zinn, 2003). Rather than attempting to eliminate or control anxious thoughts, mindfulness teaches athletes to observe them as transient mental events without becoming entangled in their content. This decentering perspective can reduce the impact of cognitive anxiety and help regulate somatic arousal by fostering a greater awareness of bodily sensations (Shapiro et al., 2006). Studies have shown that MBIs can lead to significant reductions in anxiety symptoms and improvements in overall psychological well-

being among athletes (Bühlmayer et al., 2017; Wang et al., 2023).

The proliferation of smartphone technology has created a paradigm shift in the delivery of mental health interventions. Smartphone applications offer an unprecedented opportunity to provide accessible, convenient, and scalable psychological support to athletes who often face significant time constraints and logistical challenges in accessing traditional face-to-face services (Wu et al., 2021; Linardon et al., 2024). These platforms can deliver guided mindfulness exercises, psychoeducational content, and progress tracking, allowing athletes to integrate mental training seamlessly into their daily routines (Gao et al., 2024). Commercially available apps like Headspace and Calm have been used in athletic contexts, demonstrating the potential of this delivery model (Huberty et al., 2021; Ren et al., 2022). This technological advancement makes it possible to provide consistent, evidence-based support that was previously difficult to implement on a large scale.

Despite the theoretical promise, the empirical evidence for smartphone-delivered mindfulness programs in athletic populations remains nascent and has yielded mixed results. While some meta-analyses and studies report favorable effects on anxiety (Blanck et al., 2018; Wang et al., 2023) other rigorous randomized controlled trials (RCTs) conducted with college athletes have found no significant reduction in anxiety levels compared to control conditions (Röthlin et al., 2020; Gao et al., 2024; Lee et al., 2024). These inconsistencies highlight a critical research gap and suggest that the design, content, and implementation of such digital interventions may be crucial determinants of their efficacy. Furthermore, there is a distinct lack of research focusing specifically on elite sprinters, a population with unique psychological demands. Moreover, few studies have simultaneously investigated the impact of a smartphone MBI on both pre-competition anxiety and sport-specific self-efficacy, leaving the interconnectedness of these constructs within the context of a digital intervention largely unexplored.

Therefore, the purpose of this study was to design and evaluate a bespoke, 8-week smartphone-delivered mindfulness program, named "MindSprint," for pre-competition anxiety and self-efficacy in competitive sprinters. We conducted a randomized controlled trial to test the following hypotheses: (H1) Sprinters in the MindSprint intervention group would demonstrate significantly greater reductions in both cognitive and somatic pre-competition anxiety from baseline to post-intervention compared with a waitlist control group. (H2) The MindSprint intervention group would show a significantly greater increase in sport-specific self-efficacy from baseline to post-intervention compared with the control group. (H3) As a planned mechanistic analysis, we further hypothesized that changes in dispositional mindfulness would mediate the intervention effect on cognitive anxiety, the anxiety component most directly aligned with worry, rumination, and decentering; associations with somatic anxiety and self-efficacy were examined as complementary exploratory relationships.

Methods

Participants and recruitment

A total of 70 competitive sprinters (38 male, 32 female)

were recruited from Wen Hua College and affiliated athletic clubs. Inclusion criteria required participants to be between 18 and 28 years of age ($M = 22.4$, $SD = 2.8$), actively competing in 100 m, 200 m, or 400 m events for at least three years, and owning an iOS or Android smartphone. Participants were excluded if they had an existing formal meditation practice (more than once per week) or were currently receiving psychological treatment for anxiety. The study received ethical approval from the University Institutional Review Board (IRB), and all participants provided digital informed consent prior to their enrollment, in accordance with established ethical guidelines (World Medical Association, 2013; Skelton et al., 2020).

Study design

This study employed a two-arm, parallel-group randomized controlled trial (RCT) design. Participants were randomly allocated, using a computer-generated sequence, to either the smartphone-delivered mindfulness intervention (IG; $n = 35$) or a waitlist control group (CG; $n = 35$). A researcher not involved in data collection managed the allocation concealment. Assessments were conducted at four time points: baseline (T0), mid-intervention (T1; 4 weeks), immediately post-intervention (T2; 8 weeks), and at a 4-week follow-up (T3; 12 weeks). To capture pre-competition psychological states while reflecting the realities of track-and-field scheduling, electronic assessments were targeted for the 24 hours before the nearest scheduled competition within each nominal assessment window. When a race did not fall exactly at week 4, week 8, or week 12, the nearest scheduled race within the relevant window was used. Competition level was recorded descriptively (club, collegiate/regional, or championship-level), but event importance was not entered as a statistical covariate.

Intervention: The "MindSprint" application

The intervention group received access to "MindSprint," a custom-developed smartphone application designed specifically for this study. The 8-week program consisted of daily audio-guided mindfulness exercises, each lasting approximately 10 - 15 minutes (Huberty et al., 2019). The content was structured progressively. Weeks 1 - 2 focused on foundational mindfulness skills, including focused attention on the breath and body scan meditations (Kabat-Zinn, 2003). Weeks 3 - 4 introduced mindfulness of thoughts and emotions, teaching athletes to observe their mental content non-judgmentally. Weeks 5 - 6 centered on acceptance and self-compassion in relation to performance setbacks. Weeks 7 - 8 integrated sport-specific content, including mindful visualization of a race and mindfulness during movement exercises. A supplementary weekly outline describes the session themes, typical audio duration, notification schedule, adherence definition, and app navigation structure.

Core weekly modules were released sequentially to

preserve the intended progression, whereas short practice components (e.g., breathing space and body scan exercises) remained available for optional review after first release. The app sent one daily push-notification reminder and displayed a personal dashboard with completed sessions and total practice time (Yardley et al., 2016;

Volgemute et al., 2025). Adherence was defined descriptively as the proportion of the 56 recommended daily sessions completed across the intervention period. No separate formal usability trial was conducted before the efficacy study; app feasibility was monitored through backend completion logs, attrition, and participant use patterns.

Control group

The waitlist control group received no mindfulness intervention during the 12-week study period and continued with regular training and competition schedules. At baseline, waitlist participants were told that they would receive access to MindSprint after completing the T3 follow-up assessment. They received the same electronic assessment reminders as the intervention group but did not receive app content, mindfulness prompts, or practice feedback during the trial.

Measures

Pre-Competition Anxiety: The Competitive State Anxiety Inventory-2 Revised (CSAI-2R) was used to measure pre-competition anxiety (Cox et al., 2003; Andrade Fernández et al., 2007). This validated instrument consists of three 9-item subscales assessing cognitive state anxiety, somatic state anxiety, and state self-confidence. Participants rated items on a 4-point Likert scale, with subscale scores ranging from 9 to 36. Higher scores indicate greater levels of the respective construct. The CSAI-2R has demonstrated strong psychometric properties in athletic populations.

Self-Efficacy: Sport-specific self-efficacy was measured using the Athlete Self-Efficacy Scale (ASES) (Jackson et al., 2011). This 15-item scale assesses an athlete's belief in their ability to perform well under pressure, focus effectively, and overcome challenges in their sport. Items are rated on a 10-point Likert scale. The ASES has shown good validity and high internal consistency (Cronbach's $\alpha = .88$) in previous research with adult athletes (Stephen et al., 2022; Evans et al., 2024).

Mindfulness: Dispositional mindfulness was assessed using the 39-item Five Facet Mindfulness Questionnaire (FFMQ), which measures five facets of mindfulness: Observing, Describing, Acting with Awareness, Non-judging of inner experience, and Non-reactivity to inner experience. It is a widely used and validated measure of mindfulness skills.

Engagement: Adherence and engagement with the MindSprint app were measured objectively via the application's backend server. Data collected included the number of mindfulness sessions completed, the total duration of practice in minutes, and the frequency of app opens (Perski et al., 2017; Miller et al., 2019).

Statistical analysis

Analyses were conducted with IBM SPSS Statistics, version 29.0 (IBM Corp., Armonk, NY, USA). Two-sided tests used an alpha level of .05. Baseline group comparisons used independent-samples *t* tests for continuous variables and chi-square tests for categorical variables. Primary and secondary outcomes were analyzed with 2×4 mixed-model repeated-measures ANOVAs, with group (intervention vs. control) as the between-participant factor and time (T0, T1, T2, and T3) as the repeated factor. Mauchly's test

was used to assess sphericity; Greenhouse-Geisser corrections were applied when the assumption was violated. Significant interactions were followed by Bonferroni-adjusted simple-effects comparisons.

The intention-to-treat dataset retained all 70 randomized participants. For the eight participants who withdrew after randomization, missing post-randomization questionnaire scores were imputed by the last-observation-carried-forward method before repeated-measures analysis. Effect sizes for ANOVA were reported as partial eta squared (η^2). Between-group Cohen's *d* values were calculated from pooled standard deviations at each time point, with positive values denoting lower anxiety in the intervention group and negative values denoting higher self-efficacy or mindfulness in the intervention group. Confidence intervals for indirect effects were estimated with 5,000 bias-corrected bootstrap samples.

The mediation model was specified a priori for the cognitive-anxiety change score because cognitive worry was the outcome most directly linked to mindfulness-based decentering. The model used the full randomized sample, intervention assignment as the independent variable, change in FFMQ score from T0 to T2 as the mediator, and change in cognitive anxiety from T0 to T2 as the dependent variable. Baseline values were represented through change-score construction and were not entered as separate covariates. Correlations between engagement, mindfulness, somatic anxiety, and self-efficacy were treated as exploratory association analyses.

Results

Participant Flow and Baseline Characteristics

Of the 98 sprinters assessed for eligibility, 70 met the inclusion criteria and were randomized into the intervention group (IG; $n = 35$) or the waitlist control group (CG; $n = 35$). Over the course of the 12-week study, five participants (14.3%) from the IG and three (8.6%) from the CG withdrew, citing time constraints or injury. As described in the Statistical Analysis subsection, the intention-to-treat analysis retained the full randomized sample of 70 participants. The flow of participants through each stage of the trial is detailed in the CONSORT diagram (Figure 1). Baseline demographic and athletic characteristics are presented in Table 1. No statistically significant differences were found between the two groups at baseline on demographic, athletic, or primary outcome variables, indicating successful randomization.

Intervention Adherence and Engagement

Engagement data, collected automatically from the MindSprint application, are summarized in Table 2. Participants in the intervention group completed an average of 5.8 sessions per week ($SD = 1.3$) out of the 7 recommended sessions, representing an adherence rate of 82.9%. The average duration of a completed session was 11.2 minutes ($SD = 2.1$). Over the 8-week intervention, the mean total practice time was 515.2 minutes ($SD = 120.4$). This level of engagement is considered robust for a mobile health intervention (Giovanazzi et al., 2022).

Primary outcomes: Pre-competition anxiety

The mean scores and standard deviations for cognitive and

somatic anxiety at each time point are presented in Table 3.

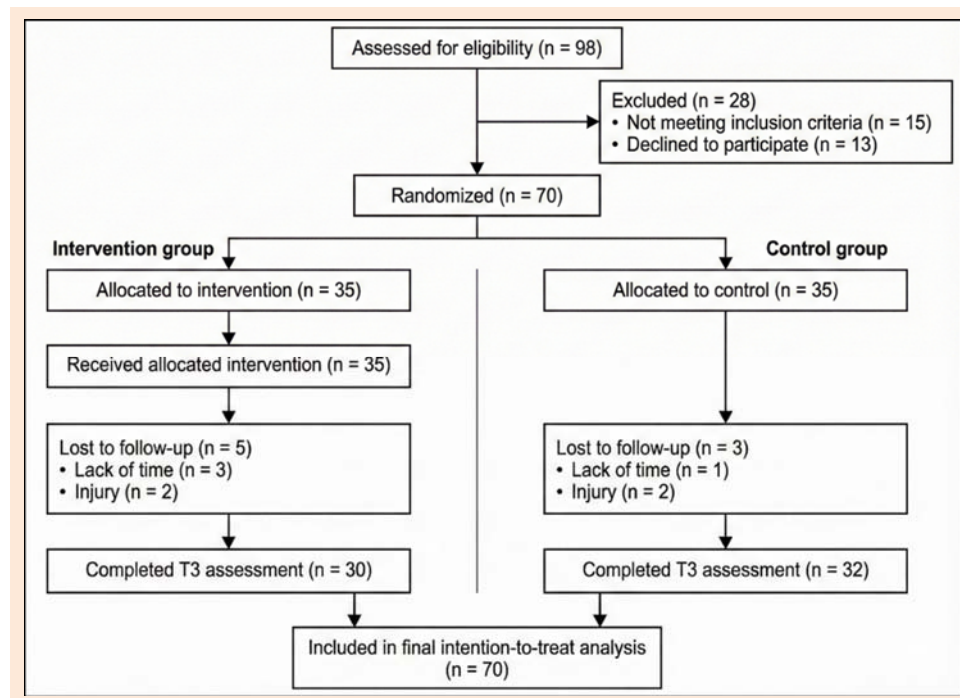


Figure 1. CONSORT flow diagram of participant recruitment and retention. The final intention-to-treat analysis included all randomized participants (intervention group $n=35$; control group $n=35$), including eight participants who withdrew after randomization.

Table 1. Baseline demographic and outcome characteristics of participants. Data are means (SD).

Characteristic	Intervention (n = 35)	Control (n = 35)	Statistic	p-value
Age (years),	22.1 (2.6)	22.7 (3.0)	$t(68) = -0.89$	.376
Gender, n (%)	Male	18 (51.4)	-	-
	Female	17 (48.6)	-	-
Years competing,	6.8 (2.1)	7.1 (2.5)	$t(68) = -0.54$	.588
Primary event, n (%)	100m	11 (31.4)	$\chi^2(2) = 0.45$	.798
	200m	15 (42.9)		
	400m	9 (25.7)		
Cognitive anxiety (CSAI-2R)	24.8 (4.1)	25.1 (3.9)	$t(68) = -0.32$	.748
Somatic anxiety (CSAI-2R)	23.5 (4.5)	23.9 (4.2)	$t(68) = -0.39$	.697
Self-efficacy (ASES)	105.2 (12.8)	104.6 (13.5)	$t(68) = 0.19$	.848
Mindfulness (FFMQ)	118.6 (14.2)	119.3 (15.1)	$t(68) = -0.20$	.840

CSAI-2R = Competitive State Anxiety Inventory-2 Revised; ASES = Athlete Self-Efficacy Scale; FFMQ = Five Facet Mindfulness Questionnaire. M = Mean; SD = Standard Deviation.

Table 2. MindSprint application engagement metrics for the intervention Group (n=35).

Engagement Metric	Mean	SD	Range
Total Sessions Completed (out of 56)	46.4	7.3	28 - 56
Average Sessions per Week	5.8	1.3	3.5 - 7.0
Total Practice Time (minutes)	515.2	120.4	290 - 645
Average Session Duration (minutes)	11.2	2.1	8.5 - 13.1

SD = Standard Deviation.

Table 3. Means and standard deviations for CSAI-2R subscales by group and time.

Outcome	Group	T0 (baseline)	T1 (week 4)	T2 (week 8)	T3 (week 12)
Cognitive anxiety	Intervention	24.8 (4.1)	20.1 (3.8)	16.5 (3.5)	17.1 (3.6)
	Control	25.1 (3.9)	24.9 (4.0)	25.3 (4.2)	24.8 (4.1)
Somatic anxiety	Intervention	23.5 (4.5)	19.2 (4.1)	15.1 (3.9)	15.8 (4.0)
	Control	23.9 (4.2)	23.6 (4.4)	24.1 (4.1)	23.5 (4.3)

T0 = baseline; T1 = week 4; T2 = week 8 post-intervention; T3 = week 12 follow-up. CSAI-2R subscale scores range from 9 to 36, with higher scores indicating greater cognitive or somatic anxiety. Values are presented as mean (standard deviation).

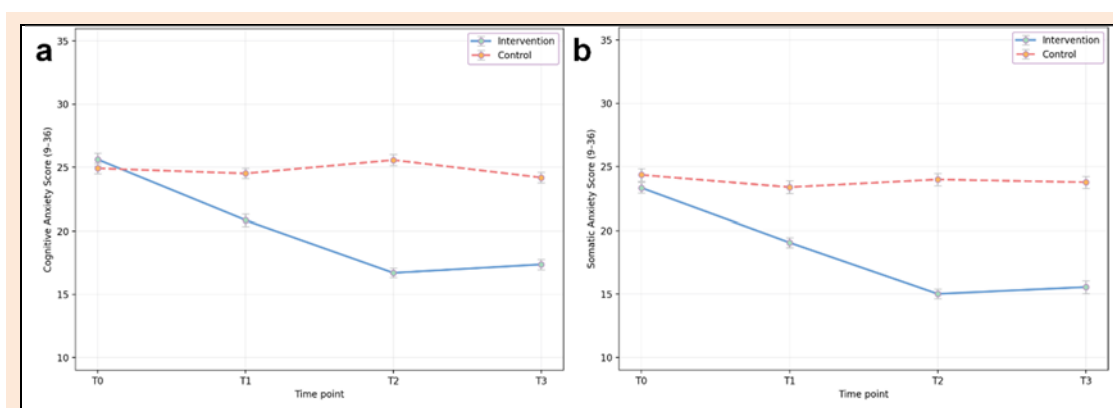


Figure 2. Changes in pre-competition anxiety over time. Panel a shows cognitive anxiety and panel b shows somatic anxiety measured with the CSAI-2R (score range 9–36) at T0, T1, T2, and T3. Points are group means for the intention-to-treat sample (intervention $n = 35$; control $n = 35$); error bars represent standard errors.

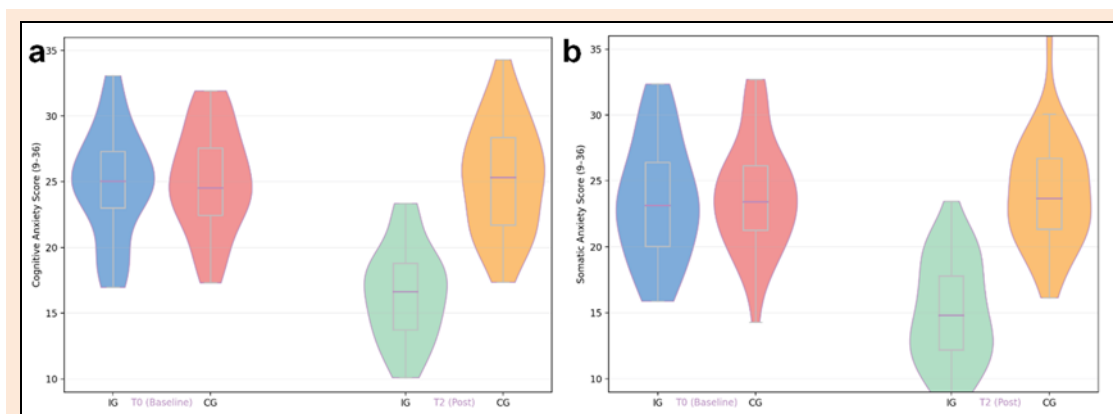


Figure 3. Distribution of anxiety scores at baseline and post-intervention. Violin and embedded box plots show CSAI-2R cognitive anxiety (panel a) and somatic anxiety (panel b) for the intervention and control groups at T0 and T2; the y-axis is the subscale score (range 9–36).

For cognitive anxiety, the 2x4 mixed-model ANOVA revealed a significant group-by-time interaction effect, $F(3, 204) = 18.33$, $p < .001$, $\eta^2 = .212$, indicating that the changes in cognitive anxiety over time differed significantly between the two groups. Simple effects analysis showed a significant decrease in cognitive anxiety for the intervention group from T0 to T2 ($p < .001$), which was maintained at T3 ($p < .001$). No significant changes were observed in the control group across any time points ($p > .05$). Between-group comparisons confirmed that the intervention group had significantly lower cognitive anxiety than the control group at T1, T2, and T3 (all $p < .001$).

Similarly, for somatic anxiety, a significant group-by-time interaction was found, $F(3, 204) = 22.71$, $p < .001$, $\eta^2 = .250$. The intervention group experienced a significant reduction in somatic anxiety from T0 to T2 ($p < .001$), an effect that was sustained at the T3 follow-up ($p < .001$). The control group's scores remained stable over time ($p > .05$). The intervention group reported significantly lower somatic anxiety than the control group at T1, T2, and T3 (all $p < .001$). These longitudinal changes are visualized in Figure 2, and the distributional shifts from baseline to post-

intervention is illustrated in Figure 3.

Secondary outcome: Self-Efficacy

Mean scores for the Athlete Self-Efficacy Scale (ASES) are presented in Table 4. The mixed-model ANOVA revealed a significant group-by-time interaction effect for self-efficacy, $F(3, 204) = 15.96$, $p < .001$, $\eta^2 = .190$. Simple effects analysis indicated a significant increase in self-efficacy for the intervention group from T0 to T2 ($p < .001$), which was sustained at T3 ($p < .001$). The control group showed no significant change in self-efficacy. Between-group analyses showed the intervention group had significantly higher self-efficacy scores than the control group at T1, T2, and T3 (all $p < .001$). The group differences at each time point are displayed in Figure 4. An exploratory bivariate correlation in the intervention group showed that total mindfulness practice time was positively associated with the change in self-efficacy from T0 to T2 ($r = .58$, $p = .002$; Figure 5). This association was not adjusted for baseline ASES scores and is therefore interpreted as descriptive evidence of an engagement-response pattern rather than as an independent causal estimate.

Table 4. Means and standard deviations for ASES scores by group and time.

Outcome	Group	T0 (baseline)	T1 (week 4)	T2 (week 8)	T3 (week 12)
Self-efficacy	Intervention	105.2 (12.8)	115.8 (11.9)	128.4 (10.5)	126.9 (11.1)
	Control	104.6 (13.5)	105.1 (13.2)	104.2 (13.8)	105.5 (13.0)

ASES = Athlete Self-Efficacy Scale; T0 = baseline; T1 = week 4; T2 = week 8 post-intervention; T3 = week 12 follow-up. Higher scores indicate greater self-efficacy. Values are presented as mean (standard deviation).

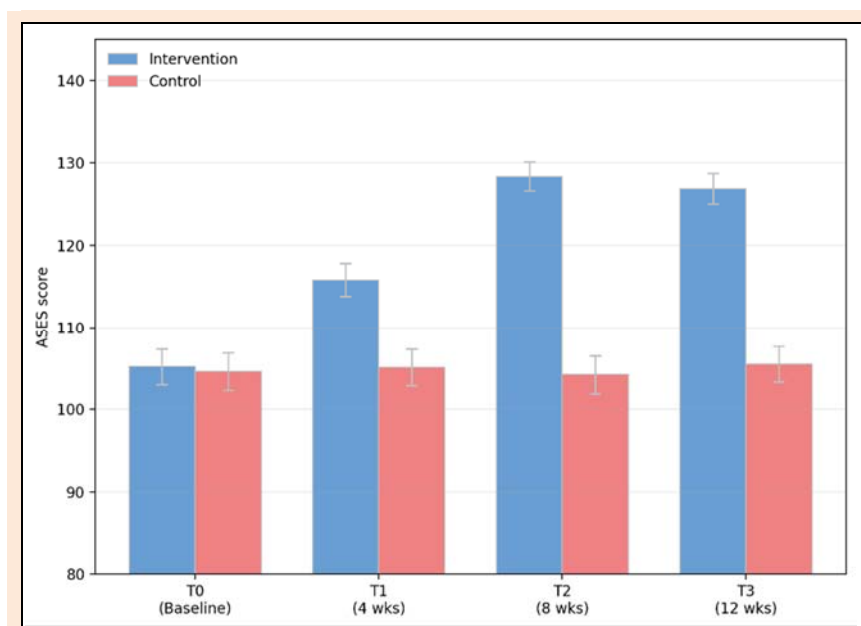


Figure 4. Comparison of mean self-efficacy scores over time. Bars show mean ASES scores for the intervention and control groups at T0, T1, T2, and T3; error bars represent standard errors (intervention $n = 35$; control $n = 35$ in the intention-to-treat sample).

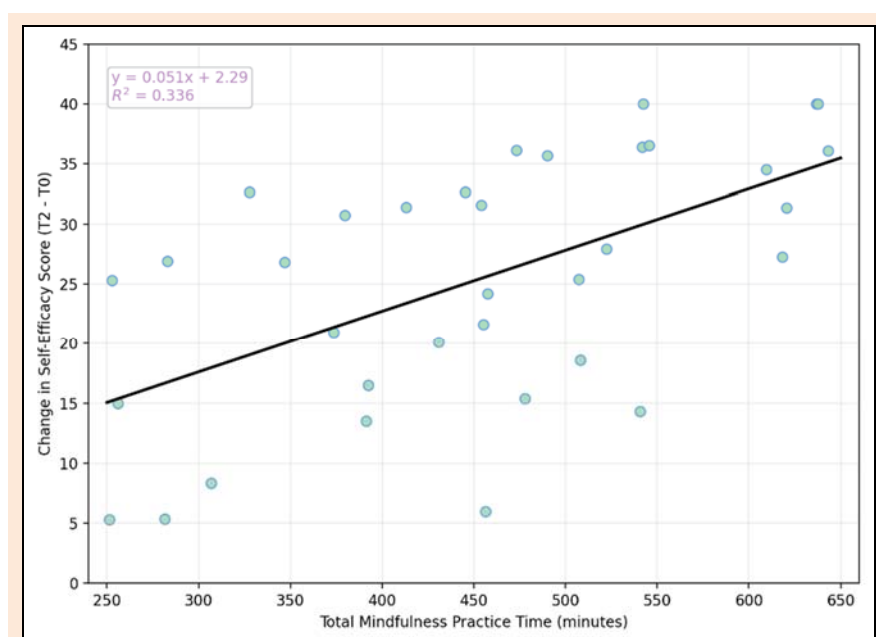


Figure 5. Correlation between mindfulness practice time and change in self-efficacy. Points represent intervention-group participants ($n = 35$); the x-axis is total MindSprint practice time in minutes and the y-axis is the unadjusted ASES change score from T0 to T2. The fitted line shows the exploratory bivariate association.

Mechanism of change: Mindfulness skills

As shown in Table 5, the intervention produced a significant increase in dispositional mindfulness. The ANOVA for the FFMQ total score yielded a significant group-by-time interaction, $F(3, 204) = 25.11$, $p < .001$, $\eta^2 = .269$. The intervention group's FFMQ scores increased significantly from T0 to T2 ($p < .001$) and were maintained at T3.

Analyses of the FFMQ subscales revealed significant interactions for Acting with Awareness, Non-judging, and Non-reactivity (all $p < .001$), but not for Observing or Describing. Figure 6 provides a visual characterization of the change profile across the five mindfulness facets for the intervention group.

Table 5. Means and standard deviations for FFMQ total scores by group and time.

Outcome	Group	T0 (baseline)	T1 (week 4)	T2 (week 8)	T3 (week 12)
Mindfulness	Intervention	118.6 (14.2)	130.5 (13.1)	145.2 (11.8)	143.8 (12.5)
	Control	119.3 (15.1)	119.9 (14.9)	118.8 (15.3)	119.5 (15.0)

FFMQ = Five Facet Mindfulness Questionnaire; T0 = baseline; T1 = week 4; T2 = week 8 post-intervention; T3 = week 12 follow-up. Higher scores indicate greater dispositional mindfulness. Values are presented as mean (standard deviation).

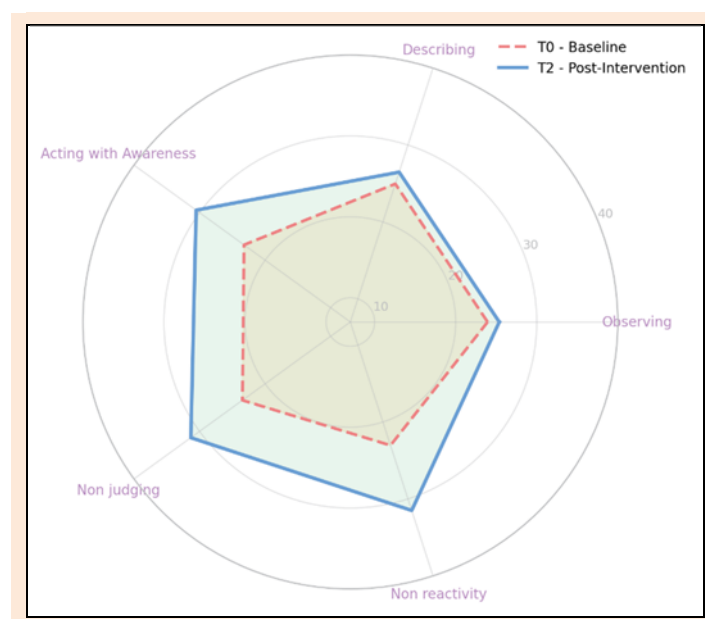


Figure 6. Profile of change in mindfulness facets for the intervention group. Radar axes show the five FFMQ facets; higher values indicate greater mindfulness skills. Dashed red values represent T0 baseline scores and solid blue values represent T2 post-intervention scores for intervention-group participants.

Correlational and Mediation Analyses

The correlation matrix (Table 6) summarizes change-score associations. For outcomes measured in the full sample, changes in mindfulness (Δ FFMQ) were strongly and negatively correlated with changes in cognitive anxiety ($r = -.65$, $p < .001$) and somatic anxiety ($r = -.61$, $p < .001$), and positively correlated with changes in self-efficacy ($r = .59$, $p < .001$). Engagement correlations used only intervention-group participants because app-use data were available only for those assigned to MindSprint ($n = 35$). Table 7

summarizes between-group effect sizes at each time point. The planned mediation analysis (Table 8) supported the hypothesized cognitive-anxiety pathway, indicating that the increase in mindfulness skills mediated the relationship between intervention assignment and reduction in cognitive anxiety (indirect effect = -3.87 , 95% CI $[-5.62, -2.19]$). Somatic anxiety and self-efficacy were not modeled as mediation outcomes in this trial because the planned mechanistic test focused on cognitive worry, the construct most directly linked to mindfulness-based decentering.

Table 6. Change-score correlation matrix for key variables at T2.

Variable	1	2	3	4	5
1. Δ cognitive anxiety (T2 - T0)	--				
2. Δ somatic anxiety (T2 - T0)	.78**	--			
3. Δ self-efficacy (T2 - T0)	-.71**	-.66**	--		
4. Δ mindfulness (FFMQ) (T2 - T0)	-.65**	-.61**	.59**	--	
5. Intervention engagement (minutes; IG only)	-.52**	-.48**	.58**	.67**	--

Variables 1-4 are change scores from baseline to post-intervention (T2 - T0) and are based on the full intention-to-treat sample ($N=70$). Variable 5 uses intervention-group app-use data only ($n = 35$); correlations involving engagement should therefore be interpreted within the intervention group. ** $p < .01$.

Table 7. Between-group effect sizes (Cohen's d) for primary and secondary outcomes.

Outcome	T1 (4 wks)	T2 (8 wks)	T3 (12 wks)
Cognitive Anxiety	1.21	2.24	1.95
Somatic Anxiety	1.02	2.22	1.83
Self-Efficacy	-0.82	-1.89	-1.67
Mindfulness (FFMQ)	-0.76	-1.91	-1.74

T1 = week 4; T2 = week 8 post-intervention; T3 = week 12 follow-up. Positive Cohen's d values indicate a favorable outcome for the intervention group on anxiety outcomes (lower scores), whereas negative values indicate a favorable outcome for the intervention group on self-efficacy and mindfulness outcomes (higher scores).

Table 8. Planned mediation analysis of mindfulness change on the intervention-cognitive anxiety pathway.

Path	Coefficient	SE	t	p-value	95% CI
Total Effect (c)	-8.41	1.05	-8.01	< .001	[-10.49, -6.33]
Path a (IV $\rightarrow$ Mediator)	26.40	2.89	9.13	< .001	[20.67, 32.13]
Path b (Mediator $\rightarrow$ DV)	-0.15	0.04	-3.56	< .001	[-0.23, -0.06]
Direct Effect (c')	-4.54	1.12	-4.05	< .001	[-6.76, -2.32]
Indirect Effect (ab)	-3.87	0.88			[-5.62, -2.19]

IV = intervention assignment; mediator = Δ FFMQ score from T0 to T2; DV = Δ cognitive anxiety score from T0 to T2. The indirect effect was estimated with 5,000 bias-corrected bootstrap samples; a 95% CI that does not contain zero indicates significant mediation. Baseline values were represented through change scores rather than entered as separate covariates.

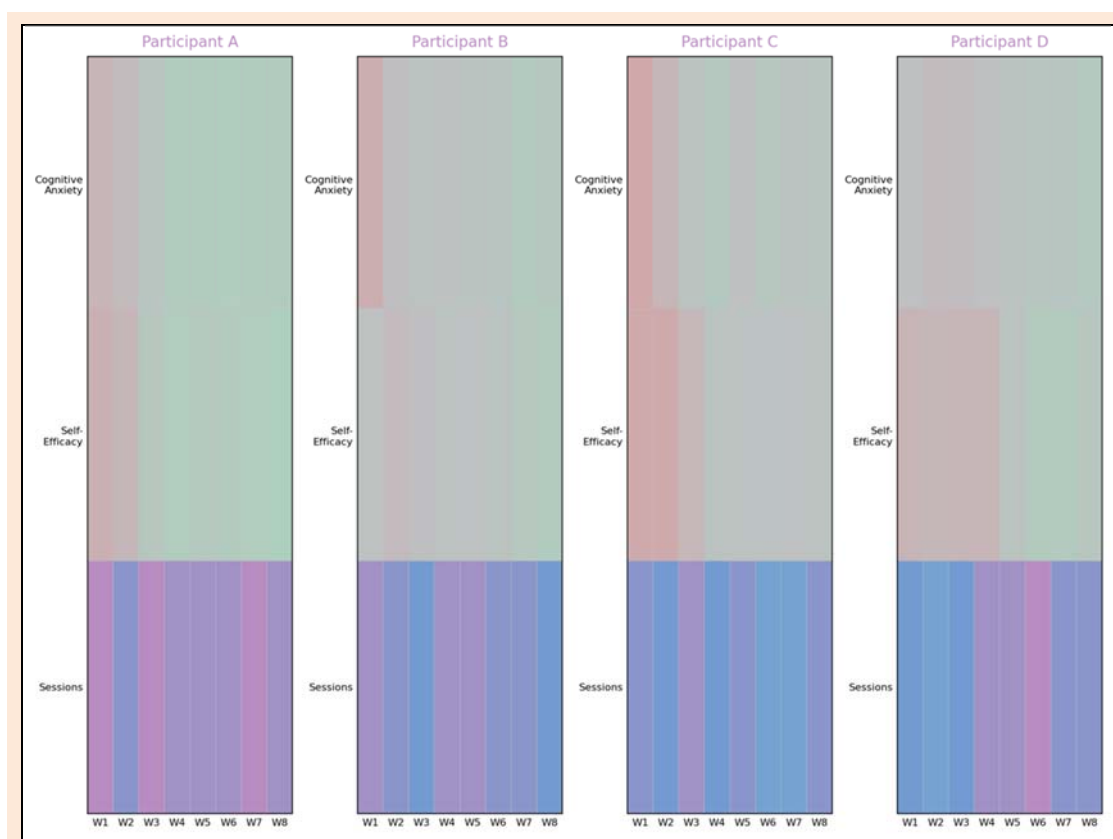


Figure 7. Weekly psychological profile heatmaps for four intervention participants. Participants A-D were selected to illustrate rapid improvement with consistent use, gradual improvement, fluctuating response, and lower/variable engagement. Rows show cognitive anxiety, self-efficacy, and completed sessions across intervention weeks 1 - 8. Color intensity represents within-participant weekly values for each row, allowing visual comparison of changes over time rather than between-participant ranking.



Figure 8. Component analysis of mindfulness exercise completion. The tree map shows the percentage share of all completed MindSprint practice sessions logged by intervention-group participants ($n = 35$; denominator = 1,624 completed sessions). Larger rectangles indicate modules completed more frequently.

Individual and Material Characterization

To provide a more granular characterization of the intervention's impact, Figure 7 presents weekly psychological profile heatmaps for four intervention-group participants selected to illustrate distinct adherence-response patterns (rapid improvement with consistent use, gradual improvement, fluctuating response, and lower/variable engagement). These maps visualize the week-by-week interplay between anxiety levels, self-efficacy, and app engagement,

highlighting the heterogeneity of individual responses rather than identifying statistically representative cases. Figure 8 offers a component analysis of the intervention material itself, illustrating the distribution of completed MindSprint practice components among intervention-group users. The "Daily Mindful Moment" and the "Pre-Sleep Body Scan" accounted for the largest shares of completed sessions, suggesting athletes favored shorter, easily integrated practices.

Discussion

The primary aim of this study was to evaluate a custom-designed, smartphone-delivered mindfulness program, "MindSprint," for reducing self-reported pre-competition anxiety and enhancing self-reported sport-specific self-efficacy in competitive sprinters. The findings of this randomized controlled trial support the study hypotheses. Participants in the 8-week MindSprint program demonstrated significant reductions in both cognitive and somatic anxiety, alongside increases in sport-specific self-efficacy, when compared with a waitlist control group. These changes were maintained at the 4-week follow-up, suggesting that the intervention may help athletes develop durable psychological skills.

The marked reduction in pre-competition anxiety aligns with a substantial body of literature demonstrating the anxiolytic effects of mindfulness-based interventions in athletic populations (Mehrsafar et al., 2019). The large effect sizes observed for both cognitive anxiety ($d = 2.24$) and somatic anxiety ($d = 2.22$) at post-intervention are particularly noteworthy and compare favorably to, or exceed, the moderate-to-large effects reported in meta-analyses of traditional face-to-face mindfulness programs (Bühlmayer et al., 2017). Our positive results stand in contrast to some previous studies of smartphone-delivered mindfulness for athletes that found null effects (Gao et al., 2024). Several factors may explain this discrepancy. First, the "MindSprint" application was not a generic, one-size-fits-all program; its content, language, and examples were specifically tailored to the experiences of competitive athletes, which may have enhanced engagement and relevance. Second, the 8-week duration provided sufficient "dosage" for skills to be learned and consolidated, which may not be the case in shorter interventions. Third, the high adherence rate (82.9% of recommended sessions) suggests the program was successfully integrated into the athletes' routines, a common barrier in digital health studies (Kelders et al., 2012).

A key finding of this study is the improvement in athlete self-efficacy. This supports the theoretical proposition that mindfulness can bolster self-efficacy by altering an athlete's relationship with internal experiences. By learning to observe self-critical thoughts and feelings of doubt non-judgmentally, athletes may be less likely to identify with them, thereby preserving their belief in their capabilities (Gardner and Moore, 2004). The mindfulness practice of returning attention to the body and breath may also reduce distracting cognitive anxiety, allowing athletes to focus on the task at hand and draw confidence from physical readiness. The positive association between total practice time and gains in self-efficacy (Figure 5) is consistent with an engagement-response pattern, although this unadjusted association cannot establish that engagement independently caused the observed change. This finding extends the literature by suggesting that a mobile-delivered MBI may support psychological strengths such as self-efficacy as well as anxiety management.

Our investigation into the mechanisms of change provides further insight into how the intervention may have achieved its effects. As hypothesized, the MindSprint program was accompanied by increases in dispositional

mindfulness, particularly in the facets of Acting with Awareness, Non-judging, and Non-reactivity (Figure 6). The planned mediation analysis (Table 8) provided statistical support for the cognitive-anxiety pathway, showing that increases in mindfulness skills accounted for part of the relationship between intervention assignment and reductions in cognitive anxiety. This pattern is consistent with the view that athletes learned to notice pre-race thoughts, respond less judgmentally, and reduce escalating worry.

The use of a smartphone-based delivery model is a central feature of this study. The high engagement rates and low attrition (14.3% in the IG) relative to typical digital interventions, which can see dropout rates exceeding 50% (Eysenbach, 2005; Geraghty et al., 2013) underscore the feasibility of this approach for dedicated athletic populations. The convenience of the app allowed sprinters to practice mindfulness at times that suited their demanding training schedules, such as during travel to competitions or before sleep. The objective engagement data collected from the app (Table 2, Figure 8) is a significant methodological strength, providing a more accurate measure of adherence than self-report diaries (Lee et al., 2017). The component analysis (Figure 8) offers practical insights for future app development, indicating a preference for shorter, highly practical exercises that can be easily integrated into a daily routine. This suggests that micro-interventions may be a particularly effective strategy for athletes.

Despite the strengths of this research, including its randomized design, use of validated measures, longitudinal follow-up, and focus on an understudied population, several limitations must be acknowledged. First, the sample size was based on the available eligible sprinter cohort rather than a documented *a priori* power calculation, and prospective trial registration was not documented in the study materials. Second, the use of a waitlist control group means

we cannot rule out placebo effects, expectancy effects, or the non-specific benefits of receiving attention as part of a study; moreover, waitlist participants knew they would receive app access after follow-up, which may have influenced expectations or motivation. Third, pre-competition assessments were anchored to scheduled races, but competition timing and event importance could not be fully standardized across athletes, and event level was not modeled as a covariate. Fourth, outcome measures were based exclusively on self-report questionnaires. Future studies would be strengthened by including objective performance data (e.g., reaction times or race times), physiological markers of anxiety such as heart rate variability or salivary cortisol, and active-control conditions. Finally, engagement-response analyses were exploratory and did not adjust for baseline self-efficacy; these associations should be interpreted as descriptive rather than causal.

The practical implications of these findings are relevant for athletes, coaches, and sport psychologists. This study suggests that a sport-specific smartphone application can be a feasible and accessible tool for supporting psychological preparation in competitive athletes. Such apps may serve as a standalone resource or as a supplement to traditional sport psychology support. Coaches can encourage athletes to use such tools as part of a regular mental-skills

routine, and sport psychologists may use mobile applications to support remote monitoring and practice continuity.

Conclusion

In conclusion, this randomized controlled trial showed that an 8-week, smartphone-delivered mindfulness program, MindSprint, was associated with reductions in self-reported pre-competition cognitive and somatic anxiety and increases in sport-specific self-efficacy among competitive sprinters. The outcomes were sustained at a 4-week follow-up, and the cognitive-anxiety pathway was partly mediated by changes in mindfulness skills. These findings support continued investigation of tailored digital mindfulness interventions in sport, with future trials incorporating active controls, objective performance and physiological outcomes, prospective registration, and stronger baseline-adjusted analyses.

Acknowledgements

This study was supported by the 2025 Key Project of Educational Science Planning of Hubei Province: Research on the Mechanism and Path of "Sports-Health Integration" Collaborative Education in Universities Empowered by Smart Sports (2025GA119). The datasets generated during the current study are not publicly available but are available from the corresponding author upon reasonable request. The authors declare that they have no conflict of interest. All experimental procedures were conducted in compliance with the relevant legal and ethical standards of the country where the study was carried out. The authors declare that no Generative AI or AI-assisted technologies were used in the writing of this manuscript.

References

- Andrade Fernández, E.M., Lois Río, G. and Arce Fernández, C. (2007) Psychometric properties of the Spanish version of the Revised Competitive State Anxiety Inventory-2 with athletes. *Psicothema* **19**, 150-155.
- Bandura, A. (1977) Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review* **84**, 191-215. <https://doi.org/10.1037/0033-295x.84.2.191>
- Birrer, D. and Morgan, G. (2010) Psychological skills training as a way to enhance an athlete's performance in high-intensity sports. *Scandinavian Journal of Medicine & Science in Sports* **20** Suppl 2, 78-87. <https://doi.org/10.1111/j.1600-0838.2010.01188.x>
- Blanck, P., Perleth, S., Heidenreich, T., Kröger, P., Ditzgen, B., Bents, H. (2018) Effects of mindfulness exercises as stand-alone intervention on symptoms of anxiety and depression: Systematic review and meta-analysis. *Behaviour Research and Therapy* **102**, 25-35. <https://doi.org/10.1016/j.brat.2017.12.002>
- Bühlmayer, L., Birrer, D., Röthlin, P., Faude, O. and Donath, L. (2017) Effects of Mindfulness Practice on Performance-Relevant Parameters and Performance Outcomes in Sports: A Meta-Analytical Review. *Sports Medicine (Auckland, N.Z.)* **47**, 2309-2321. <https://doi.org/10.1007/s40279-017-0752-9>
- Carson, H.J. and Collins, D. (2016) The fourth dimension: A motoric perspective on the anxiety-performance relationship. *International Review of Sport and Exercise Psychology* **9**, 1-21. <https://doi.org/10.1080/1750984x.2015.1072231>
- Cheng, W.N., Hardy, L. and Markland, D.A. (2009) Toward a three-dimensional conceptualization of performance anxiety: Rationale and initial measurement development. *Psychology of Sport and Exercise* **10**, 271-278. <https://doi.org/10.1016/j.psychsport.2008.08.001>
- Cox, R.H., Martens, M.P. and Russell, W.D. (2003) Measuring Anxiety in Athletics: The Revised Competitive State Anxiety Inventory-2. *Journal of Sport and Exercise Psychology* **25**, 519-533. <https://doi.org/10.1123/jsep.25.4.519>
- Craft, L.L., Magyar, T.M., Becker, B.J. and Feltz, D.L. (2003) The Relationship between the Competitive State Anxiety Inventory-2 and Sport Performance: A Meta-Analysis. *Journal of Sport and Exercise Psychology* **25**, 44-65. <https://doi.org/10.1123/jsep.25.1.44>
- Evans, A.L., Coffee, P. and Barker, J.B. (2024) The effects of social identity and social identity content on cohesion, efficacy, and performance across a competitive rugby league season. *International Journal of Sport and Exercise Psychology* **22**, 1724-1742. <https://doi.org/10.1080/1612197x.2023.2229349>
- Eysenbach, G. (2005) The Law of Attrition. *Journal of Medical Internet Research* **7**, e402. <https://doi.org/10.2196/jmir.7.1.e11>
- Eysenck, M.W., Derakshan, N., Santos, R. and Calvo, M.G. (2007) Anxiety and cognitive performance: Attentional control theory. *Emotion* **7**, 336-353. <https://doi.org/10.1037/1528-3542.7.2.336>
- Gao, Y., Shi, L., Fu, N., Yang, N., Weeks-Gariepy, T. and Mao, Y. (2024) Mobile-Delivered Mindfulness Intervention on Anxiety Level Among College Athletes: Randomized Controlled Trial. *Journal of Medical Internet Research* **26**, e40406. <https://doi.org/10.2196/40406>
- Gardner, F.L. and Moore, Z.E. (2004) A mindfulness-acceptance-commitment-based approach to athletic performance enhancement: Theoretical considerations. *Behavior Therapy* **35**, 707-723. [https://doi.org/10.1016/s0005-7894\(04\)80016-9](https://doi.org/10.1016/s0005-7894(04)80016-9)
- Gardner, F.L. and Moore, Z.E. (2017) Mindfulness-based and acceptance-based interventions in sport and performance contexts. *Current Opinion in Psychology* **16**, 180-184. <https://doi.org/10.1016/j.copsyc.2017.06.001>
- Geraghty, A.W.A., Torres, L.D., Leykin, Y., Pérez-Stable, E.J. and Muñoz, R.F. (2013) Understanding attrition from international internet health interventions: a step towards global eHealth. *Health Promotion International* **28**, 442-452. <https://doi.org/10.1093/heapro/das029>
- Giovanazzi, A., Jones, K., Carr, R.M., Fairhurst, C.M., Backhouse, M.R. and Adamson, J.A. (2022) Current practice in the measurement and interpretation of intervention adherence in randomised controlled trials: A systematic review. *Contemporary Clinical Trials* **118**, 106788. <https://doi.org/10.1016/j.cct.2022.106788>
- Huberty, J., Green, J., Glissmann, C., Larkey, L., Puzia, M. and Lee, C. (2019) Efficacy of the Mindfulness Meditation Mobile App "Calm" to Reduce Stress Among College Students: Randomized Controlled Trial. *JMIR mHealth and uHealth* **7**, e14273. <https://doi.org/10.2196/14273>
- Huberty, J., Puzia, M.E., Green, J., Vlisides-Henry, R.D., Larkey, L., Irwin, M.R. (2021) A mindfulness meditation mobile app improves depression and anxiety in adults with sleep disturbance: Analysis from a randomized controlled trial. *General Hospital Psychiatry* **73**, 30-37. <https://doi.org/10.1016/j.genhosppsych.2021.09.004>
- Jackson, B., Gucciardi, D.F. and Dimmock, J.A. (2011) Tripartite efficacy profiles: a cluster analytic investigation of athletes' perceptions of their relationship with their coach. *Journal of Sport & Exercise Psychology* **33**, 394-415. <https://doi.org/10.1123/jsep.33.3.394>
- Kabat-Zinn, J. (2003) Mindfulness-Based Interventions in Context: Past, Present, and Future. *Clinical Psychology: Science and Practice* **10**, 144-156. <https://doi.org/10.1093/clipsy.bpg016>
- Kelders, S.M., Kok, R.N., Ossebaard, H.C. and Van Gemert-Pijnen, J.E. (2012) Persuasive System Design Does Matter: A Systematic Review of Adherence to Web-Based Interventions. *Journal of Medical Internet Research* **14**, e152. <https://doi.org/10.2196/jmir.2104>
- Lee, H., Ahn, H., Nguyen, T.G., Choi, S.-W. and Kim, D.J. (2017) Comparing the Self-Report and Measured Smartphone Usage of College Students: A Pilot Study. *Psychiatry Investigation* **14**, 198-204. <https://doi.org/10.4306/pi.2017.14.2.198>
- Lee, Y.H., Chiu, W., Hwang, J. and Noh, S. (2024) Mobile-based mindfulness meditation intervention's impact on mental health among young male judo athletes in South Korea: a quasi-experimental study. *Scientific Reports* **14**, 12691. <https://doi.org/10.1038/s41598-024-63637-0>
- Linardon, J., Messer, M., Goldberg, S.B. and Fuller-Tyszkiewicz, M. (2024) The efficacy of mindfulness apps on symptoms of depression and anxiety: An updated meta-analysis of randomized controlled trials. *Clinical Psychology Review* **107**, 102370. <https://doi.org/10.1016/j.cpr.2023.102370>
- Mehrsafar, A.H., Strahler, J., Gazerani, P., Khabiri, M., Sánchez, J.C.J., Moosakhani, A. (2019) The effects of mindfulness training on competition-induced anxiety and salivary stress markers in elite Wushu athletes: A pilot study. *Physiology & Behavior* **210**, 112655. <https://doi.org/10.1016/j.physbeh.2019.112655>

- Miller, S., Ainsworth, B., Yardley, L., Milton, A., Weal, M., Smith, P. (2019) A Framework for Analyzing and Measuring Usage and Engagement Data (AMUsED) in Digital Interventions: Viewpoint. *Journal of Medical Internet Research* **21**, e10966. <https://doi.org/10.2196/10966>
- Moritz, S.E., Feltz, D.L., Fahrbach, K.R. and Mack, D.E. (2000) The relation of self-efficacy measures to sport performance: a meta-analytic review. *Research Quarterly for Exercise and Sport* **71**, 280-294. <https://doi.org/10.1080/02701367.2000.10608908>
- Morris, L.W., Davis, M.A. and Hutchings, C.H. (1981) Cognitive and emotional components of anxiety: literature review and a revised worry-emotionality scale. *Journal of Educational Psychology* **73**, 541-555. <https://doi.org/10.1037/0022-0663.73.4.541>
- Noetel, M., Ciarrochi, J., Van Zanden, B. and Lonsdale, C. (2019) Mindfulness and acceptance approaches to sporting performance enhancement: a systematic review. *International Review of Sport and Exercise Psychology* **12**, 139-175. <https://doi.org/10.1080/1750984x.2017.1387803>
- Perski, O., Blandford, A., West, R. and Michie, S. (2017) Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. *Translational Behavioral Medicine* **7**, 254-267. <https://doi.org/10.1007/s13142-016-0453-1>
- Ren, P., Song, T., Chi, L., Wang, X. and Miao, X. (2022) The Adverse Effect of Anxiety on Dynamic Anticipation Performance. *Frontiers in Psychology* **13**, 823989. <https://doi.org/10.3389/fpsyg.2022.823989>
- Röthlin, P., Horvath, S., Trösch, S., Holtforth, M. grosse and Birrer, D. (2020) Differential and shared effects of psychological skills training and mindfulness training on performance-relevant psychological factors in sport: a randomized controlled trial. *BMC Psychology* **8**, 80. <https://doi.org/10.1186/s40359-020-00449-7>
- Shapiro, S.L., Carlson, L.E., Astin, J.A. and Freedman, B. (2006) Mechanisms of mindfulness. *Journal of Clinical Psychology* **62**, 373-386. <https://doi.org/10.1002/jclp.20237>
- Skelton, E., Drey, N., Rutherford, M., Ayers, S. and Malamateniou, C. (2020) Electronic consenting for conducting research remotely: A review of current practice and key recommendations for using e-consenting. *International Journal of Medical Informatics* **143**, 104271. <https://doi.org/10.1016/j.ijmedinf.2020.104271>
- Stephen, S.A., Habeeb, C.M. and Arthur, C.A. (2022) Congruence of efficacy beliefs on the coach-athlete relationship and athlete anxiety: Athlete self-efficacy and coach estimation of athlete self-efficacy. *Psychology of Sport and Exercise* **58**, 102062. <https://doi.org/10.1016/j.psychsport.2021.102062>
- Stephens, A. and Kearsley, N. (1990) Cognitive and somatic anxiety. *Behaviour Research and Therapy* **28**, 75-81. [https://doi.org/10.1016/0005-7967\(90\)90057-p](https://doi.org/10.1016/0005-7967(90)90057-p)
- Volgemute, K., Vazne, Z. and Malinauskas, R. (2025) The benefits of guided imagery on athletic performance: a mixed-methods approach. *Frontiers in Psychology* **16**, 1500194. <https://doi.org/10.3389/fpsyg.2025.1500194>
- Wang, Y., Lei, S.-M. and Fan, J. (2023) Effects of Mindfulness-Based Interventions on Promoting Athletic Performance and Related Factors among Athletes: A Systematic Review and Meta-Analysis of Randomized Controlled Trial. *International Journal of Environmental Research and Public Health* **20**, 2038. <https://doi.org/10.3390/ijerph20032038>
- World Medical Association (2013) World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* **310**, 2191-2194. <https://doi.org/10.1001/jama.2013.281053>
- Wu, A., Scult, M.A., Barnes, E.D., Betancourt, J.A., Falk, A. and Gunning, F.M. (2021) Smartphone apps for depression and anxiety: a systematic review and meta-analysis of techniques to increase engagement. *npj Digital Medicine* **4**, 20. <https://doi.org/10.1038/s41746-021-00386-8>
- Yardley, L., Spring, B.J., Riper, H., Morrison, L.G., Crane, D.H., Curtis, K. (2016) Understanding and Promoting Effective Engagement With Digital Behavior Change Interventions. *American Journal of Preventive Medicine* **51**, 833-842. <https://doi.org/10.1016/j.amepre.2016.06.015>

Key points

- An eight-week smartphone-delivered mindfulness program (MindSprint) was evaluated in a randomized controlled trial involving 70 competitive sprinters.
- MindSprint reduced self-reported cognitive and somatic pre-competition anxiety compared with a waitlist control group.
- Sport-specific self-efficacy improved, and the anxiety and self-efficacy benefits were maintained four weeks after the intervention ended.
- Dispositional mindfulness increased; greater mindfulness gains were associated with lower anxiety and higher self-efficacy.
- App adherence averaged 82.9%. The findings concern self-reported psychological outcomes; objective sprint performance and physiological anxiety markers were not assessed.

AUTHOR BIOGRAPHY



Bo WANG

Employment

School of Physical Education and Health, Wen Hua College, China

Degree

MSc Title: Associate Professor

Research interests

Sports management; mental health education; physical education; sports psychology.

E-mail:

Wangbo1611589087@163.com



Zhuzhu WANG

Employment

Gongren Village Street, Qingshan District, Wuhan, Hubei, China

Degree

BS

Research interests

Youth sports and health education.

E-mail: 25179855@qq.com



Xiaoming GUAN

Employment

Department of Cardiology, First Affiliated Hospital of Liaoning Medical University, China

Degree

BS Title: Senior Nurse

Research interests

Cardiac health care and psychological education.

E-mail: Guanxiaoming@whc.edu.cn

✉ Bo Wang

School of Physical Education and Health, Wen Hua College, 430071, China