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Effects of mindfulness-based interventions on sport performance and psychological outcomes in athletes: A systematic review and meta-analysis of randomised controlled trials

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Abstract

Objective: To give a comprehensive review on the effectiveness of mindfulness-based intervention in sports performance in athletes.

Methodology: Six online databases including Web of Science, EBSCOhost(Elton B. Stephens Company), Cochrane library, Embase, Scopus, Pubmed were searched to identify randomized controlled trials (RCTs) exploring the effects of mindfulness training on athletes' sports performance. Meta-analyses, subgroup analyses, and publication bias analyses were done using the RevMan version 5.4 software package.

Results: Of the 1853 articles identified, 21 RCTs were included, which included 920 athletes, 467 athletes in the experimental group and 453 athletes in the control group, including 496 males and 324 females. Overall, mindfulness training enhanced athletes' mindfulness level ($d = 0.77$, $p < 0.05$), mindfulness flow experience ($d = 0.87$, $p < 0.05$) and athletic performance ($d = 0.94$, $p < 0.05$), and reduced athletes' competitive anxiety ($d = -1.13$, $p < 0.05$), but had no significant effect on stress ($p > 0.05$), emotional regulation ($p > 0.05$) and mental toughness ($p > 0.05$). Exploratory subgroup analyses found no statistically significant differences in the effects on sport performance according to intervention type ($p = 0.98$), sport type ($p = 0.37$), competitive level ($p = 0.08$), or session duration ($p = 0.11$).

Conclusion: Mindfulness training appears to have a positive effect on improving athletic performance and mindfulness. Future research should focus on combining mindfulness interventions with specific sports to develop high-quality interventions for specific sports, while carefully considering the unique requirements of each sport's environment.

Key words: Mindfulness training, Athlete performance, Athlete, Meta-analysis

Introduction

Within competitive sports, optimal athletic performance is fundamental to achieving success and goal orientation, as athletes continually engage in the pursuit of personally significant objectives, endeavor to meet elevated expectations, and strive toward a sense of accomplishment. Nevertheless, when the pursuit of high achievement is jeopardized, athletes frequently experience heightened stress and emotional dysregulation, which can result in impaired performance or even competitive failure. (Jekauc et al., 2021). For example, athletes may experience complex dysfunctional emotional states such as game anxiety, anger, and impulsiveness during competition(Fritsch et al., 2022). Such emotional responses may induce considerable distraction, altered attentional focus, and various physiological reactions, which can manifest as muscle tension and difficulties in executing complete technical movements(Widmeyer, 2016).

Applied research in sport psychology has increasingly shifted its attention toward

mindfulness-based mental training, emphasising its potential to improve athletes' psychological well-being, regulate emotional responses, and optimise performance outcomes by fostering greater present-moment awareness and attentional control(Birrer et al., 2012; Bühlmayer et al., 2017; Josefsson et al., 2017; Moore, 2009; Myall et al., 2022; Noetel et al., n.d., 2019; Rogowska & Tataruch, 2024; Sparks et al., 2021).Mindfulness, rooted in Eastern Zen philosophy, is commonly defined as the practice of present-moment awareness characterized by a nonjudgmental and nonreactive stance, a quality that supports optimal functioning and performance under pressure(Moore, 2016).

In sport, mindfulness training promotes present-moment awareness because it allows athletes to be free of their thoughts and emotions, allowing them to observe these experiences from a distance without directly engaging with them(Su et al., 2024). What's more, non-judgmental thinking allows athletes to reduce emotional overreactions and maintaining stable attention or decisions during unexpected situations without the need for self-blame(Birrer et al., 2012). Regular training of mindfulness has been shown to help athletes better reduce competitive anxiety and stress during competition(Josefsson et al., 2019), Athletes who practice mindfulness may reduce rumination and enhance their emotion-regulation abilities, thereby improving sport-related coping skills and ultimately enhancing athletic performance(Josefsson et al., 2017). In addition, evidence suggests that trait mindfulness improves athletic performance by attenuating reinvestment during sport execution, indicating that the non-judgmental component of mindfulness plays a key role in reducing reinvestment(Sparks et al., 2021). Furthermore, perceived stress levels are significantly positively correlated with competitive anxiety(Tang et al., 2023). and mindfulness training has become an important tool for achieving optimal athletic performance by alleviating perceived stress, reducing competitive anxiety, and improving athletic performance (Minkler et al., 2024).

The body of research on mindfulness training to enhance athletic performance has expanded in recent years, however, much of it remains conceptual or confined to single-sample intervention studies. Only one meta-analysis has investigated the effects of mindfulness training on the psychological well-being of elite athletes(Myall et al., 2022). Subgroup analyses focusing on different athletic populations indicate that mindfulness yields greater benefits for older and retired athletes than for adolescent or para-athletes(Myall et al., 2022). Other studies have shown that mindfulness interventions significantly enhance athletes' performance, whereas their effects on mental health outcomes are not consistently significant(Wang et al., 2023). Additional research has explored the combined effects of yoga and mindfulness on athletes' psychological well-being and performance, with findings similarly demonstrating significant improvements in mindfulness, flow, and performance(Kanaujia et al., 2023). Moreover, several studies have reported the impact of mindfulness training on physiological outcomes (salivary cortisol levels, immune function, resting heart rate, and maximal oxygen uptake) and psychological outcomes (flow, goal-directed energy, anxiety/apprehension, and anxiety) in athletes, and results suggest that while mindfulness exerts limited influence on physiological indices, it has more pronounced effects on athletic performance and psychological measures(Bühlmayer et al., 2017). But there is a dearth of data on the efficacy of various mindfulness-based interventions and intervention times on athletes' performance. Therefore, the purpose of this review is to give a comprehensive overview of the effects of mindfulness training on athletes' sport performance and related psychological indicators,

focusing on the application of different mindfulness training methods and intervention times on athletes' sport performance at different levels of athletes and in different sports. The findings could provide recommendation for athletes, coaches, sports psychologists, and athletic programs about the significance of incorporating mindfulness practices into training programs, ultimately leading to optimized performance and improved emotional resilience in athletes.

Materials & Methods

Protocol and registration

The system evaluation scheme was officially enrolled with the International Prospective Register of Systematic Reviews (PROSPERO) on March 6, 2025, with registration number PROSPERO (CRD420251004127).

Literature search strategy

This systematic review was designed and conducted in line with established methodological recommendations outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019), and the reporting process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021).A comprehensive literature search was carried out in August 2025 across multiple electronic databases, including Web of Science, EBSCOhost (Elton B. Stephens Company), the Cochrane Library, Embase, Scopus, and PubMed. To enhance the completeness of the search, additional studies were identified through manual screening of reference lists from relevant articles. The search strategy was developed by integrating both controlled vocabulary terms and free-text keywords. Controlled terms (e.g., MeSH) included concepts related to “mindfulness” and “athletic performance,” while free-text terms were used to capture variations such as “athlete,” “sports,” “performance,” and related expressions. These terms were combined using Boolean operators to optimize retrieval sensitivity.

Eligibility criteria

The eligibility criteria for study selection were established based on the Population, Intervention, Comparison, Outcomes, and Study design (PICOS) framework (Page et al., 2021).Studies were considered eligible if they met the following conditions: (1) participants were athletes, including team or individual competitors across different performance levels (e.g., junior, collegiate, or elite); (2) the intervention involved mindfulness-based approaches, such as mindfulness training or meditation practices; (3) the comparator included either a no-intervention control group or alternative psychological interventions; (4) at least one relevant outcome was reported, including mindfulness level, competitive anxiety, flow state, athletic performance, emotional regulation, mental toughness, or stress; and (5) the study employed a randomized controlled trial (RCT) design. Studies were excluded if they met any of the following criteria: (1) non-randomized study designs; (2) participants were not athletes; (3) interventions did not involve mindfulness-based components; (4) publication types such as conference abstracts, dissertations, reviews, or meta-analyses, as well as duplicate records or

studies without accessible full texts; (5) lack of relevance to the research topic; (6) outcomes not aligned with the variables of interest; or (7) insufficient or unavailable data for analysis.

Selection procedure

All retrieved records were imported into EndNote 20 for reference management, and duplicate entries were removed through a combination of automated detection and manual checking. The screening process was conducted by two reviewers (CZ and TH), who evaluated titles and abstracts to identify potentially relevant studies, followed by full-text assessment of eligible articles. In cases where discrepancies arose during the selection process, they were addressed through discussion, and a third reviewer (NH) was consulted when necessary to reach a final decision. A total of 21 studies were ultimately included in the review. Relevant data were then extracted from the included studies, including information on authorship and publication year, study design, participant characteristics (e.g., age, gender, and sample size), details of the intervention and comparison conditions, as well as the reported outcome measures.

Study risk of bias and certainty assessment

Risk of bias in the included studies was evaluated in accordance with the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019). The assessment covered key methodological domains, including sequence generation, allocation concealment, blinding procedures, completeness of outcome data, selective reporting, and other potential sources of bias. Particular attention was given to the adequacy of the randomization process, the implementation of allocation concealment, and the extent to which blinding was maintained for both participants and outcome assessment. In addition, issues related to incomplete data and selective reporting were examined. Each domain was judged as presenting a low, high, or unclear risk of bias, depending on whether the relevant methodological criteria were met, not met, or insufficiently reported.

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework was used to define the certainty of the evidence for each individual outcome. Outcomes may be downgraded from ‘high’ to ‘moderate’, ‘low’ or ‘very low’ certainty of evidence due to risk of bias, publication bias, inconsistency, imprecision or indirectness.48 Two authors (XW and TH) independently assessed the evidence; in unclear cases, a decision was made by consensus.

Data analysis

Statistical analyses were performed using Review Manager (RevMan, version 5.4). For continuous outcomes, effect sizes were calculated as either weighted mean differences (WMD) or standardized mean differences (SMD), depending on the consistency of measurement tools across studies. Specifically, WMD was applied when the same instruments were used, whereas SMD was selected when different scales were employed. Due to variability in measurement approaches among the included studies, SMD was ultimately adopted as the primary effect size indicator. Between-study heterogeneity was evaluated using the I^2 statistic in conjunction with the corresponding p-value. A fixed-effects model was applied when heterogeneity was considered low ($p \geq 0.10$ and $I^2 \leq 50\%$), while a random-effects model was used in the presence of substantial heterogeneity ($p < 0.10$ and $I^2 > 50\%$).

Results

Search results

The initial search identified 1,853 records. After removing duplicates, 777 articles were screened for eligibility, of which 64 underwent full-text review. Ultimately, 21 studies were incorporated into the qualitative synthesis and meta-analysis. The PRISMA flow diagram is shown in Fig 1.

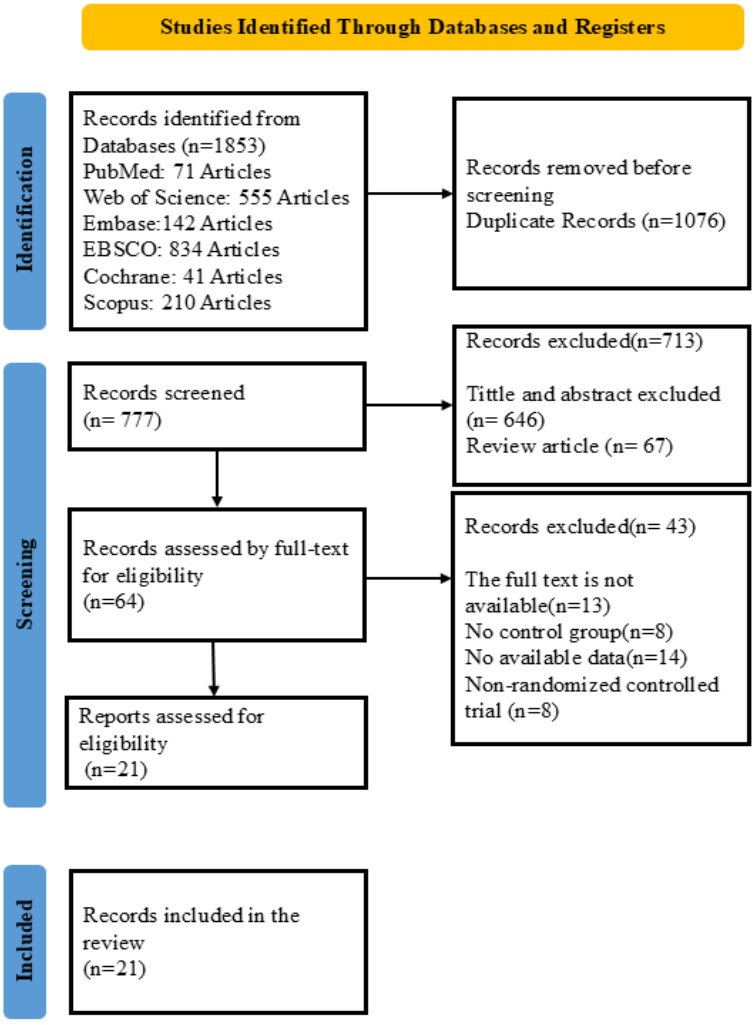

Fig 1 Flowchart of study inclusion/exclusion process

Study Characteristics

The retrieved records were evaluated in accordance with predefined inclusion and exclusion criteria, resulting in 21 eligible randomized controlled trials. 17 of these studies were published in 2016 or later. The total sample comprised 920 participants: 467 participants in the experimental group and 453 in the control (intervention) group, including 496 males and 324 females. Mean ages ranged from 16 to 67 years; however, two studies (Ojaghi et al., 2013;

Frode Moen et al., 2015) did not report gender, and two studies (Frode Moen et al., 2015; Dana et al., 2022) did not report age. Intervention modalities included the Mindfulness-Acceptance-Commitment (MAC) method, mindfulness-based stress reduction (MBSR), and hybrid approaches combining MAC and MBSR. Control groups typically received no intervention or relaxation training. Outcome measures included mindfulness, anxiety, flow, athletic performance, emotion regulation, stress, and mental toughness. According to Cohen's (1962) benchmarks—small ($d \approx 0.2$), medium ($d \approx 0.5$), and large ($d \geq 0.8$)—effect sizes were interpreted using $p < .05$ as the threshold for statistical significance (Cohen, 1962). As show in Table 1.

Table 1. Characteristics of the literature included in the study

Author and year	Country	Target sample	N		Sex		Age (M±SD)	Intervention		Outcome index
			E	C	Male	Female		E	C	
Josefsson et al. (2019)	Sweden	Elite Mixed Athletes	36	32	35	33	E:20.9±4.24 C:21.0±4.16	MAC 50 min/session 1session/week 7weeks	PST	① Mindfulness (AMQ) ② Sport performance ③ Emotion regulation(DERS)
Dehghani et al. (2018)	Iran	College women's basketball players	14	15	0	29	E:23.44±0.49 C:23.34±0.34	MAC 1.5h/session 8sessions	NT	① Anxiety (SCAT) ② Sport performance
Zadeh et al. (2019)	Iran	Elite soccer players	22	22	44	0	E:23.77±1.95 C:24.86±4.68	MAC 45 min/time 1sessions/week 7weeks	NT	① Mindfulness (MSPQ) ②Team performance
Norouzi et al. (2020)	Iran	Football players	20	20	40	0	34.05±1.72	MBSR 90 min/time 16sessions/week 8weeks	NT	① Stress (PSS) ② Anxiety(BAI)
Scott-Hamilton et al. (2016)	Australia	Cyclist	27	20	42	5	E:38.96±12.40 C:40.65±10.88	MiCBT 65 min/time 7sessions/week	NT	① Mindfulness (FFMQ) ②Flow (DFS-2)

								8weeks		③Anxiety (SAS-2)
Ojaghi et al. (2013)	Iran	Elite table tennis players	20	20	Unreported		E:25.95± 6.02 C:24.45± 7.7	Mindfulness	NT	① Mindfulness (MAAS) ② Sport performance
Aherne et al. (2011)	Australia	Elite athletes	6	7	9	4	21.00±1.68	Mindfulness and CD 60 min/time 2days/week 6weeks	NT	① Mindfulness (CAMS-R) ②Flow (FSS-2)
Ajilchi et al. (2019)	*Iran*	Basketball players	15	15	30	0	E:23.53± 1.06 C:23.40± 1.06	MSPE 90min/time 1session/week 6weeks	NT	① Mindfulness (MSPQ) ② Mental toughness (MTQ) ③ Emotion intelligence (SEIS)
Ajilchi et al. (2022)	*Iran*	Female Athletes	21	21	0	42	E:21.62± 1.56 C:21.47± 1.72	MAC 45 min/time 1session/week 8weeks	NT	① Mindfulness (MIS) ② Mental toughness (SMTQ)
Wang et al. (2021)	China	Female college students	33	34	0	67	E:19.30± 0.77 C:19.76± 0.82	MAIC 90 min/time 1session/week	NT	① Mindfulness (FFMQ)

								8weeks		② Mental toughness (PTS)
Su etal. (2024)	China	Martial arts and Bowling	20	20	23	17	E:15.65± 1.39 C:15.85± 1.23	MAIC 60 min/time 1session/week 8weeks	NT	① Mindfulness (AMQ) ② Sport performance
Sánchez-Sánchez et al. (2023)	Costa Rica	Athletes	21	20	27	14	E:21.74± 4.93 C:23.92± 6.31	Meditation 90 min/time 1session/week 10weeks	NT	Anxiety (CSAI-2R)
Mousavi et al. (2023)	Iran	Wrestler	15	15	30	0	26.73± 0.80	MBSR 120 min/time 2sessions/week 8weeks	NT	Stress
Mohebi et al. (2022)	Iran	Female athletes	20	20	0	40	E:22.00± 2.30 C:21.45± 2.52	MAC 60 min/time 1session/week 7weeks	NT	Mindfulness (MIS)
Frode Moen et al. (2015)	Norway	Junior cross-country skiers, shooters, track and field athletes	23	27	Unreported		Unreported	Meditation Body scanning 3 weeks/period 4periods	NT	① Mindfulness (MAAS) ② Stress (PSS-14) ③ Sport performance

Carraça et al. (2018)	Portugal	Footballer	28	29	57	0	E:25.68± 3.42 C:25.90± 3.18	MBSoccerP 90-120 min/time 1session/week 8weeks	NT	① Flow (DFS-2) ② Mindfulness (FFMQ)
Doron et al. (2020)	France	Elite badminton players	18	11	15	14	E:16.22± 0.94 C:16.64± 1.29	Meditation Body Scan 20-45 min/time 1session/week 8weeks	NT	① Mindfulness ② Sport Performance
Dana et al. (2022)	Iran	Shooter	15	15	30	0	Unreported	Meditation Body Scan 60 min/time 1session/week 6weeks		① Anxiety ② Sport performance
Zhang et al. (2016)	China	College dart throwers	22	21	16	27	19.23±1.27	MAC 80-90 min/session 1session/week 8weeks	SPL	① Mindfulness (FFMQ) ② Flow (SDFS) ③ Dart throwing performance
John et al. (2011)	Saudi Arabia	Elite Shooters	48	48	96	0	E:29.4± 4.08 C:30.2± 4.68	MMT 20 min/day 6days/week 4weeks	NT	Shooting performance
Sparks & Ring (2022)	England	Rowing athletes	23	21	12	32	E:36.35± 20.4 C:55.29± 12.37	Rowing-specific mindfulness Intervention	NT	Sport performance

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Risk of Bias in Studies

Risk of bias was assessed using the Cochrane Risk of Bias 2 tool for randomised trials. Eight of the 21 included studies (38.1%) were judged to be at low risk of bias in the randomisation process, 12 studies (57.1%) raised some concerns, and one study (4.8%) was judged to be at high risk. All studies raised some concerns regarding deviations from the intended interventions, principally because of insufficient information concerning intervention-related deviations and the analytical approaches used to estimate the effect of assignment to the intervention. All studies were judged to be at low risk for missing outcome data. Bias in outcome measurement was the principal source of high risk, with 19 studies (90.5%) judged to be at high risk and only two studies (9.5%) at low risk. This judgement mainly reflected the frequent use of participant-reported psychological outcomes in trials in which participants were aware of their intervention allocation, creating the possibility that knowledge of the intervention could influence outcome assessment. All studies raised some concerns regarding selection of the reported result, primarily because study protocols, registrations, or prespecified statistical analysis plans were unavailable or provided insufficient information to exclude selective reporting.

Overall, 19 studies (90.5%) were classified as having a high risk of bias, whereas John et al. (2011) and Sparks and Ring (2022) were judged to raise some concerns. No study was classified as having an overall low risk of bias. The predominance of high overall judgements was largely driven by the outcome-measurement domain.as show in Fig 2.



Note: D1, randomisation process; D2, deviations from intended interventions; D3, missing outcome data; D4, measurement of the outcome; D5, selection of the reported result. (Cochrane RoB 2 (22 August 2019))

Fig 2. Risk assessment for inclusion in the literature

Results of individual studies and meta-analysis

Mindfulness

Fourteen studies examining mindfulness training among 597 athletes from various sports were included. The findings indicated a high level of heterogeneity across the research investigations ($P < 0.001$, $I^2 = 74\%$), a random-effects model was employed. As shown in Fig 3, mindfulness levels were significantly higher in the experimental group relative to the control group (SMD = 0.77; 95% CI: 0.43 to 1.12; $P < 0.001$). This SMD of 0.77 represents a moderate to large effect size based on conventional benchmarks (e.g., Cohen's $d \geq 0.8$ for large), These findings suggest that mindfulness training may enhanced mindfulness among athletes.

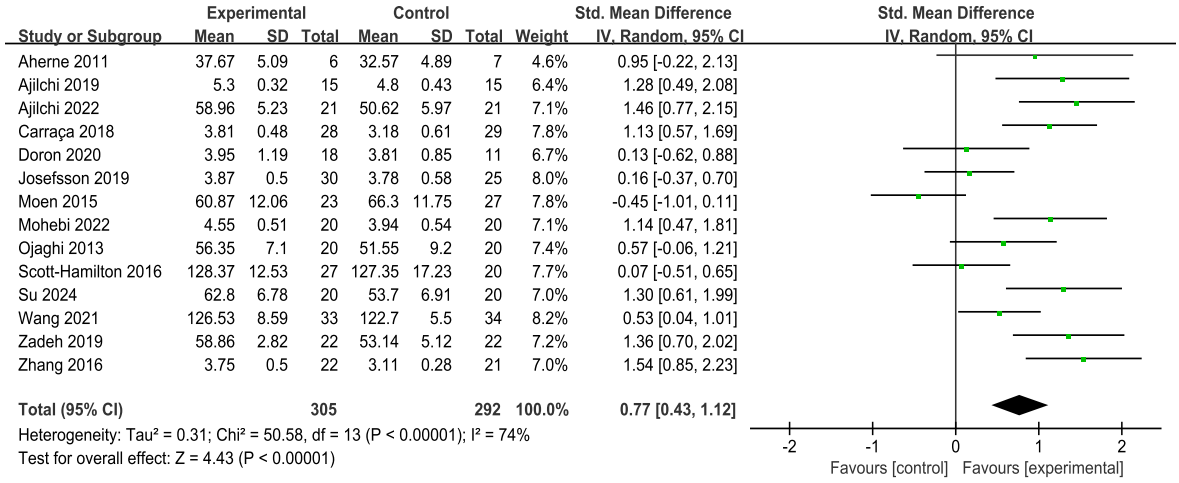

Fig 3. Forest diagram of the effect of mindfulness training on the level of mindfulness of athletes.

Anxiety

Five studies assessing the impact of mindfulness interventions on anxiety levels in 185 athletes across various sports were included. Due to significant heterogeneity ($P < 0.001$, $I^2 = 86\%$), a random-effects model was used. As shown in Fig 4, the experimental group demonstrated significantly lower anxiety compared to the control group (SMD = –1.13; 95% CI: –1.99 to –0.27; $P = 0.01$). An SMD of –1.13 indicates a moderate to large effect size, with the negative sign reflecting a decrease in anxiety levels in the experimental group. These results suggest that individuals' psychological anxiety was alleviated by the end of the intervention.

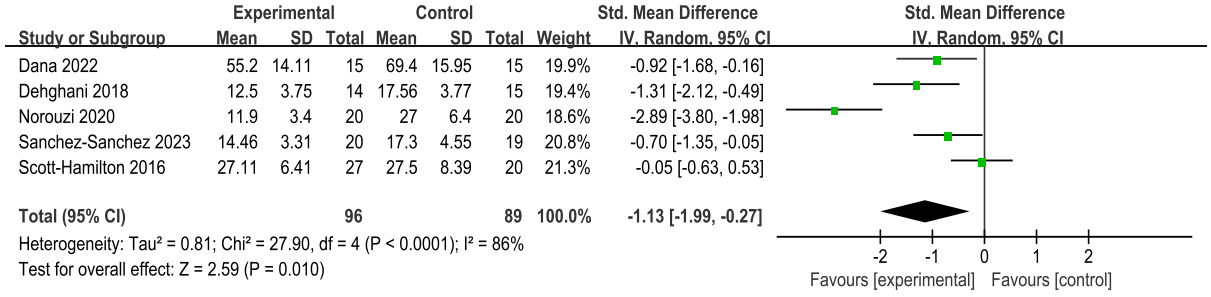

Fig 4. Forest diagram of the effect of mindfulness training on the anxiety of athletes

Flow state

Four studies examined the impact of mindfulness training on the flow state in 160 athletes

across various sports. Due to moderate heterogeneity (P = 0.03, I^2 = 67%), a random-effects model was used (Fig 5). The analysis showed that the experimental group experienced significantly higher flow state compared to the control group (SMD = 0.87; 95% CI: 0.25 to 1.48; P = 0.006). An SMD of 0.87 indicates a moderate to large effect size. These findings suggest that mindfulness training may enhanced flow state among athletes.

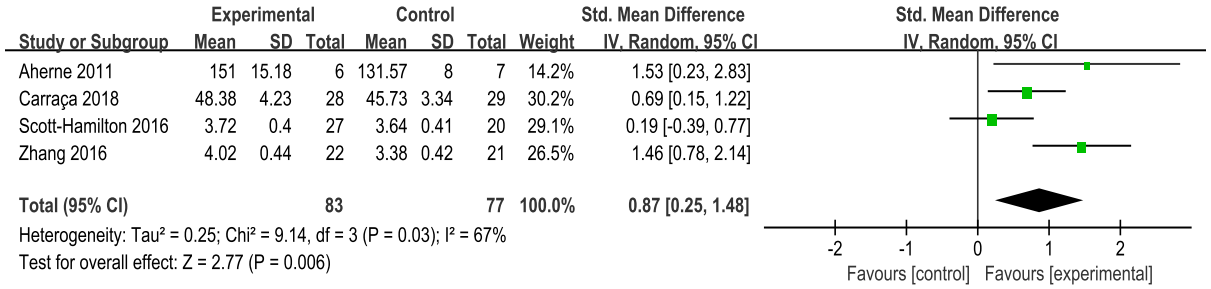

Fig 5. Forest diagram of the effect of mindfulness training on the level of flow of athletes.

Sport performance

Eleven studies assessed the impact of mindfulness training on athletic performance in 494 athletes across various sports. Due to substantial heterogeneity (P < 0.001, I^2 = 75%), a random-effects model was applied (Fig 6). The analysis demonstrated that the experimental group exhibited significantly better sports performance compared to the control group (SMD = 0.94; 95% CI: 0.56 to 1.32; P < 0.001). An SMD of 0.94 indicates a moderate to large effect size, suggesting that mindfulness training may improve athletic performance.

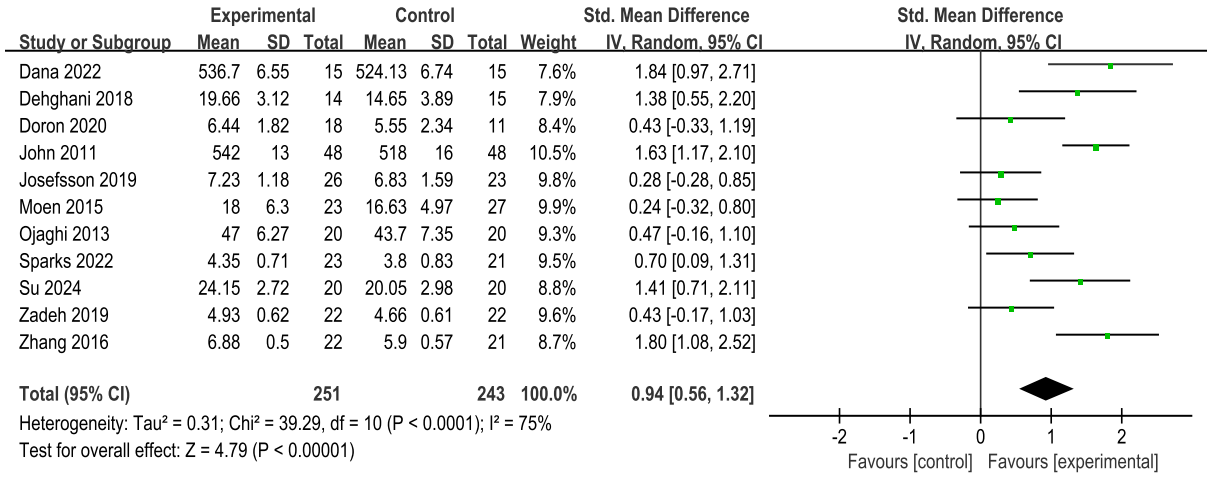

Fig 6. Forest diagram of the effect of mindfulness training on the sport performance of athletes.

Stress

Three studies evaluated the impact of mindfulness intervention on stress levels in 120 athletes from various sports. Due to high heterogeneity (P = 0.0001, I^2 = 89%), a random-effects model was used (Fig 7). The analysis revealed markedly reduced stress in the experimental group compared to the control group (SMD = –1.11; 95% CI: –2.32 to 0.10; P = 0.07), indicating a moderate to large effect size and suggesting meaningful stress reduction following mindfulness training.

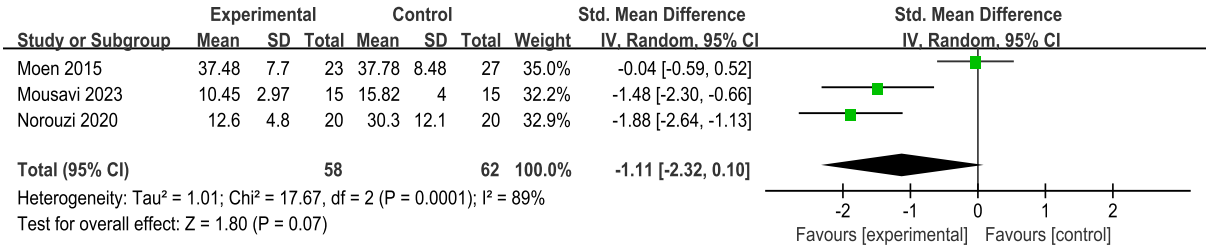

Fig 7. Forest diagram of the effect of mindfulness training on the stress of athletes.

Emotion regulation

Two studies assessed the effect of mindfulness training on emotion regulation in 85 athletes across various sports. Due to very high heterogeneity ($P < 0.001$, $I^2 = 89\%$), a random-effects model was employed (Fig 8). The analysis indicated no significant effect between the experimental and control groups in emotion regulation (SMD = 1.05; 95% CI: –0.51 to 2.62; P = 0.19). This indicates that previous research evidence on mindfulness training interventions for emotion regulation is insufficient.

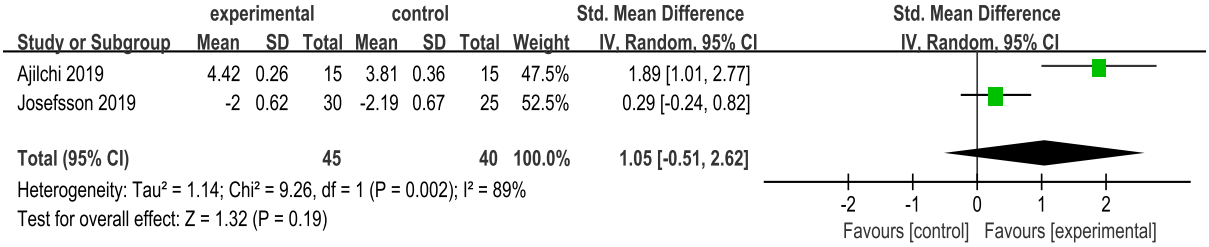

Fig 8. Forest diagram of the effect of mindfulness training on the emotion regulation of athletes.

Mental toughness

Three studies evaluated the effect of mindfulness training on mental toughness in 139 athletes across various sports. Due to high heterogeneity ($P = 0.0001$, $I^2 = 89\%$), a random-effects model was applied (Fig 9). The analysis showed that the experimental group scored higher on mental toughness than the control group (SMD = 1.18; 95% CI: 0.00 to 2.35; P = 0.05). However, due to the wide 95% confidence interval and the P-value being near the significance level (P = 0.05), the results exhibit some uncertainty, suggesting that mindfulness training has a potential positive impact on improving mental toughness. However, the precision of the evidence needs further improvement due to sample size limitations.

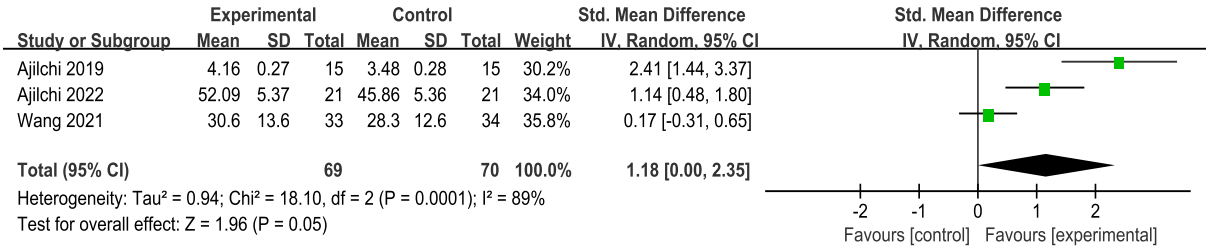

Fig 9. Forest diagram of the effect of mindfulness training on the mental toughness of athletes.

Publication Bias

Publication bias was assessed using Duval and Tweedie's trim-and-fill method to generate funnel plots for each outcome. Funnel plot asymmetry was visually examined, and the trim-and-fill procedure was used to estimate potentially missing studies and calculate adjusted pooled effect sizes. Egger's regression test, Begg and Mazumdar's rank-correlation test, and Rosenthal's fail-safe N were additionally used to explore potential publication bias. Because several outcomes included fewer than 10 studies, these analyses were considered exploratory and interpreted cautiously. (Figs 10). For mindfulness ($k = 14$), the trim-and-fill procedure imputed no additional studies, and neither Egger's test ($Z = 1.26$, $p = 0.207$) nor Begg's test ($T = 0.27$, $p = 0.171$) indicated significant funnel-plot asymmetry. The fail-safe N was 366. Similarly, no studies were imputed for sport performance ($k = 11$), with non-significant Egger ($Z = 1.05$, $p = 0.294$) and Begg tests ($T = 0.38$, $p = 0.102$); the fail-safe N was 357. For outcomes containing fewer than 10 studies, the analyses were considered exploratory. No studies were imputed for anxiety, flow state, stress, or mental toughness. Egger's test indicated potential asymmetry for anxiety ($Z = -4.44$, $p < 0.001$), stress ($Z = -2.24$, $p = 0.025$), and mental toughness ($Z = 4.32$, $p < 0.001$), whereas Begg's test was significant only for anxiety ($T = -1.00$, $p = 0.014$). For emotion regulation, the trim-and-fill procedure imputed one study on the left side of the funnel plot, reducing the pooled effect from $g = 1.05$ (95% CI -0.51 to 2.62) to $g = 0.29$ (95% CI -1.27 to 1.85). However, this analysis included only two studies. Given the small number of studies and substantial between-study heterogeneity, these findings should be interpreted as possible small-study effects rather than definitive evidence of publication bias.

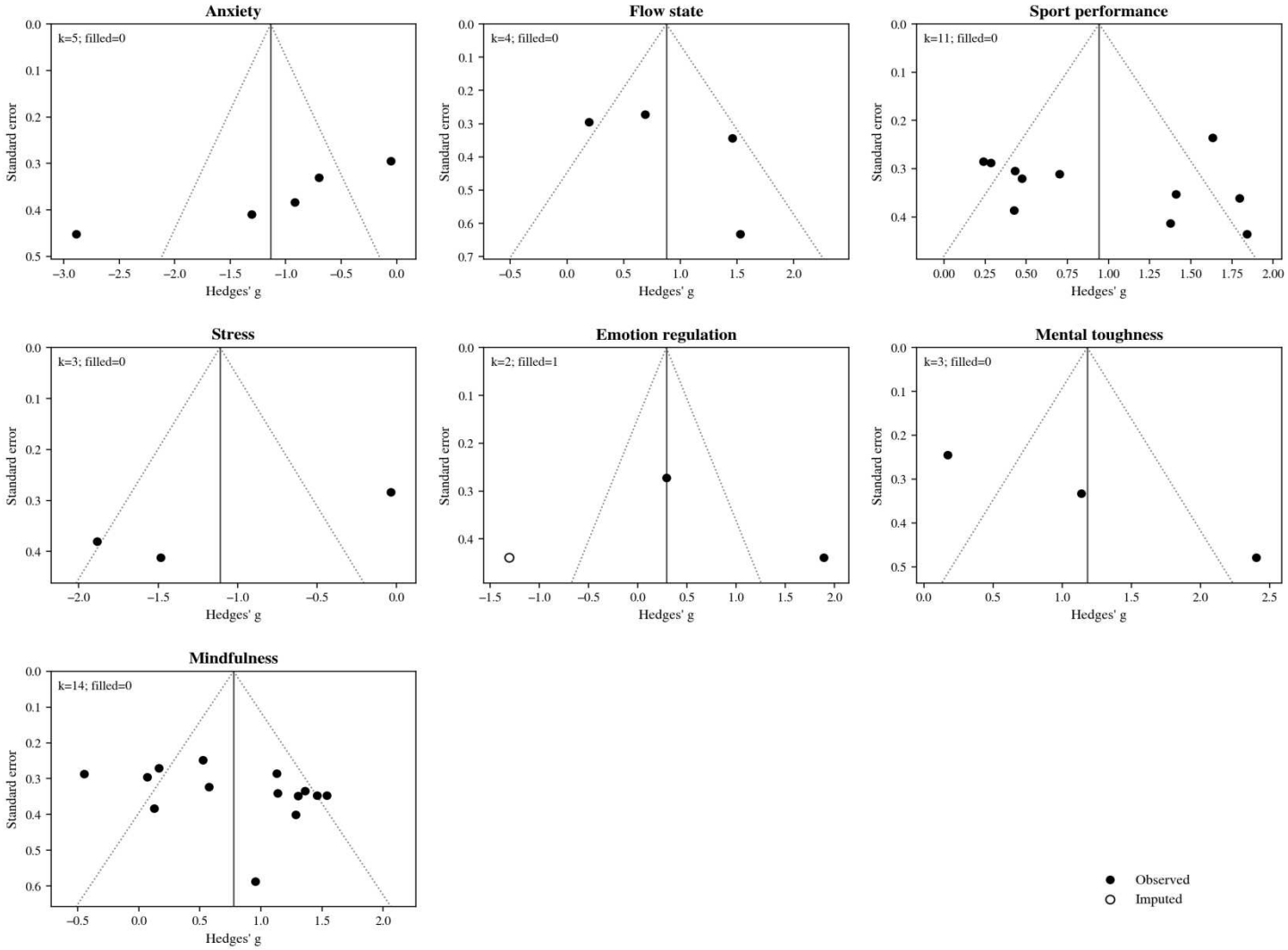

Fig 10. Duval and Tweedie's trim-and-fill funnel plots for each outcome.

Subgroup analysis

A preliminary subgroup analysis was performed using the available data on athletic performance data. Mindfulness training was found to positively impact athletes' performance. However, given variations in intervention methods, duration, sport type, and athlete skill levels, a subgroup investigation was performed. This analysis examined how different mindfulness-based intervention (MBI) methods, types of sports, athlete levels, and intervention durations might moderate the effects on athletic performance.

MBI

Two main subgroups were analyzed based on different mindfulness training methods: Mindfulness-Acceptance-Commitment (MAC) and a mixed approach (MIX) combining MAC and Mindfulness-Based Stress Reduction (MBSR). A total of 11 studies involving 494 athletes were included—four studies (165 athletes) in the MAC subgroup and seven studies (329 athletes) in the MIX subgroup (Fig 11). Both methods significantly improved athletic performance: MAC yielded an SMD of 0.94 (95% CI: 0.22 to 1.66; P = 0.01), while MIX produced an SMD of 0.95 (95% CI: 0.46 to 1.44; P = 0.0001). However, The test for subgroup differences showed no statistically significant differences between mindfulness acceptance commitment interventionsand other mindfulness-based interventions ($X^2 = 0$, df = 1, P = 0.98).

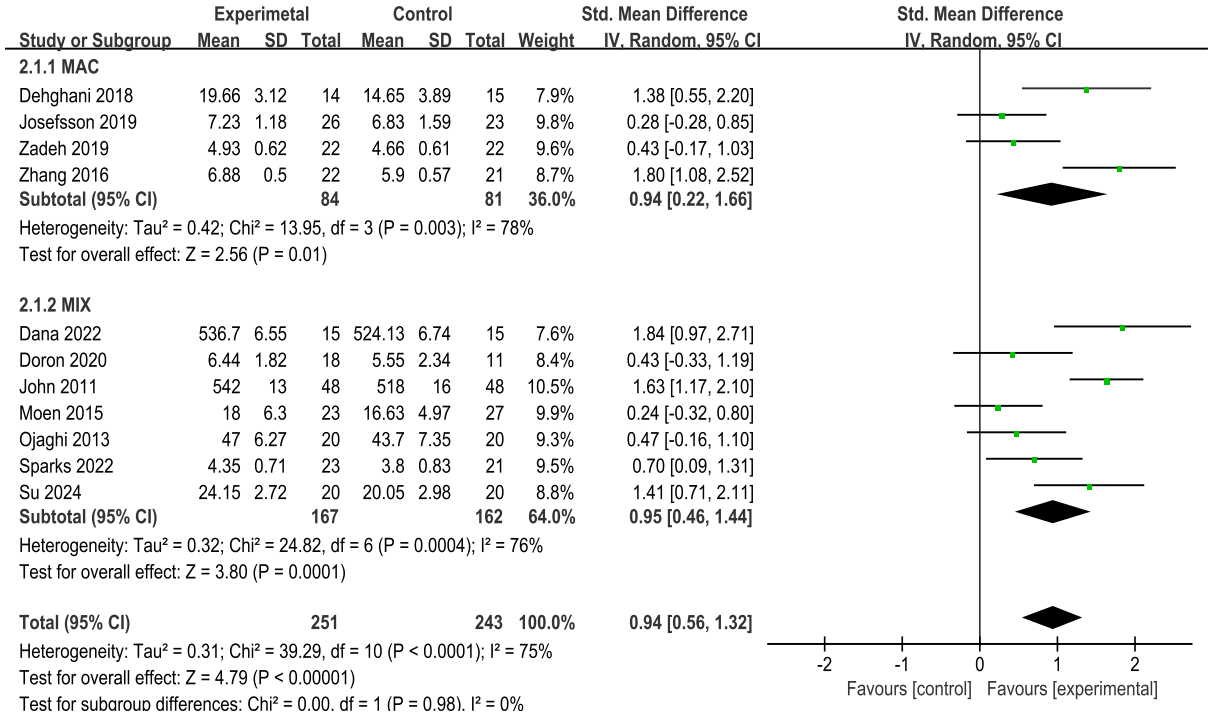

Fig 11. Forest plot illustrating the effects of subgroups of different mindfulness on athletes' performance

Team and Individual Sports

In examining the influence of mindfulness training across different sport contexts, studies were classified into two subgroups; team sports and individual sports. Ten studies involving a total of 445 athletes met the inclusion criteria, in which three studies (117 athletes) focused on team sports, and seven studies (328 athletes) on individual sports. The subgroup analysis

indicated that mindfulness training produced a meaningful positive effect in both contexts. (Fig 12). Athletes participating in team sports experienced improved performance (SMD = 0.77, 95% CI: 0.27 to 1.27, P = 0.002), while those in individual sports saw even greater benefits (SMD = 1.10, 95% CI: 057 to 1.63, P < 0.001). However, The test for subgroup differences showed no statistically significant differences between team- and individual-sport athletes (X^2 = 0.80, df = 1, P = 0.37).

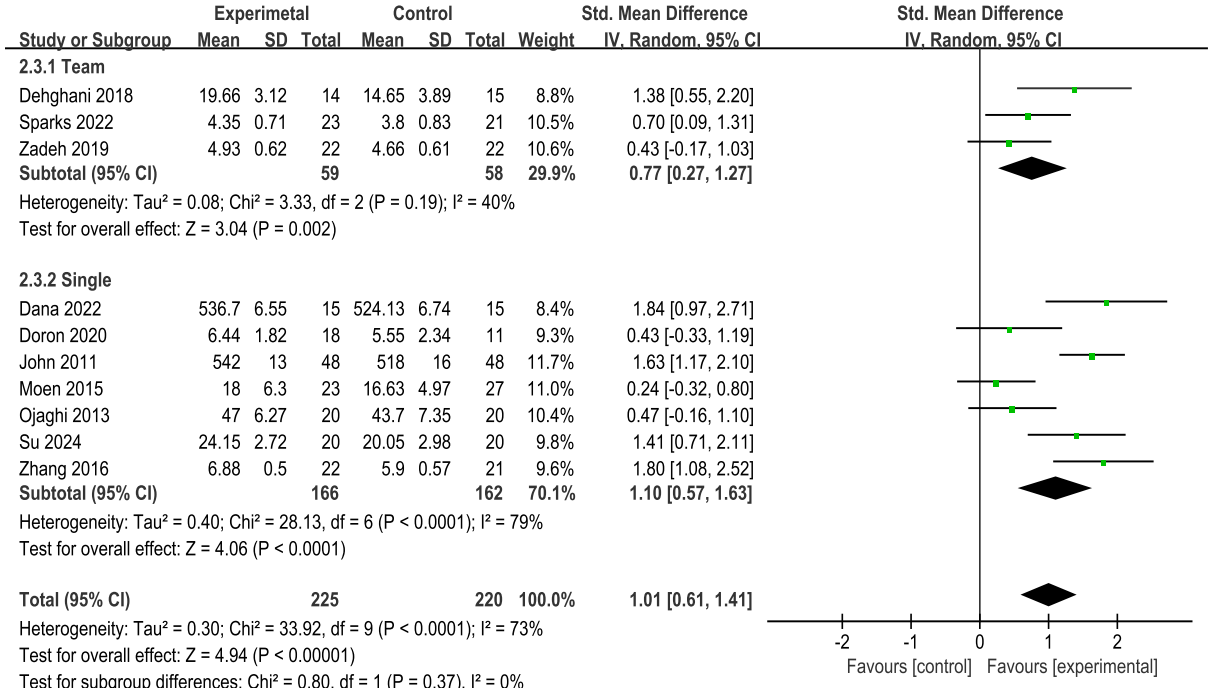

Fig 12. Forest plot illustrating the effects of subgroups of mindfulness training on performance in individual and team sports

Sports Participation Level

In examining the effects of mindfulness training across athlete levels, studies were categorized into three subgroups including college, elite, and youth athletes. Eleven studies consisted of a total of 515 athletes were analyzed; two studies (72 athletes) involved college athletes, seven studies (353 athletes) involved elite athletes, and two studies (90 athletes) involved youth athletes (Fig 13). Mindfulness training produced a statistically significant in athletic performance among college athletes (SMD = 1.61; 95% CI: 1.07 to 2.16; P < 0.001) and elite athletes (SMD = 0.78; 95% CI: 0.30 to 1.26; P = 0.002). However, there was no statistically significant effect observed in youth athletes (P > 0.05). In addition The test for subgroup differences showed no statistically significant differences between College-, Junior- and Elite-sport athletes (X^2 = 5.08, df = 2, P = 0.08).

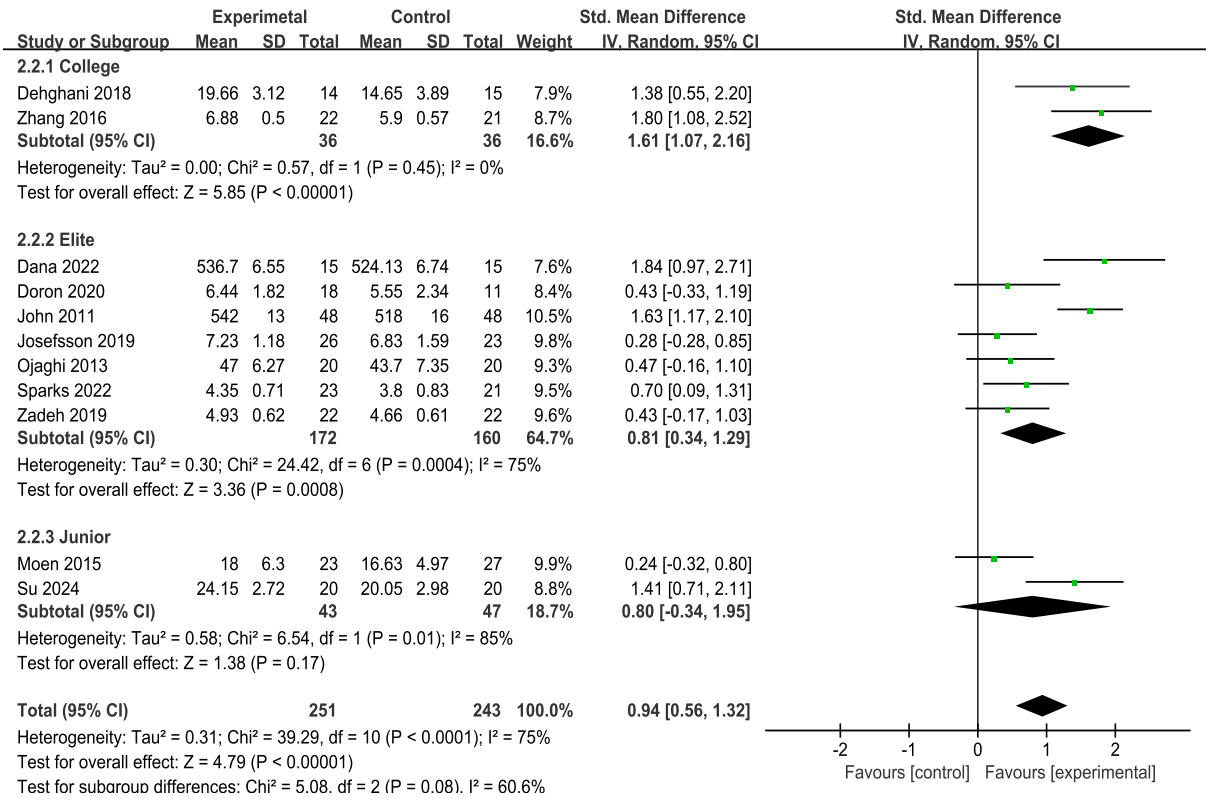

Fig 13. Forest plot illustrating the effects of subgroups of mindfulness training on performance at different sports participation levels

Time duration of mindfulness intervention

Ten studies involving 434 athletes investigated the impact of mindfulness training on athletic performance (Fig 14). These interventions were categorized by session duration; ≤ 45 minutes, 45–90 minutes, and ≥ 90 minutes. Statistical analysis revealed that only sessions lasting between 45 and 90 minutes had a significant positive effect on athletic performance (SMD = 1.37; 95% CI: 1.01 to 1.73; $P < 0.001$). Sessions of 45 minutes or less, as well as those lasting 90 minutes or more, did not demonstrate significant improvements (both $P > 0.05$). In addition No significant subgroup differences were identified according to session duration ($X^2 = 4.50$, df = 2, $P = 0.11$).

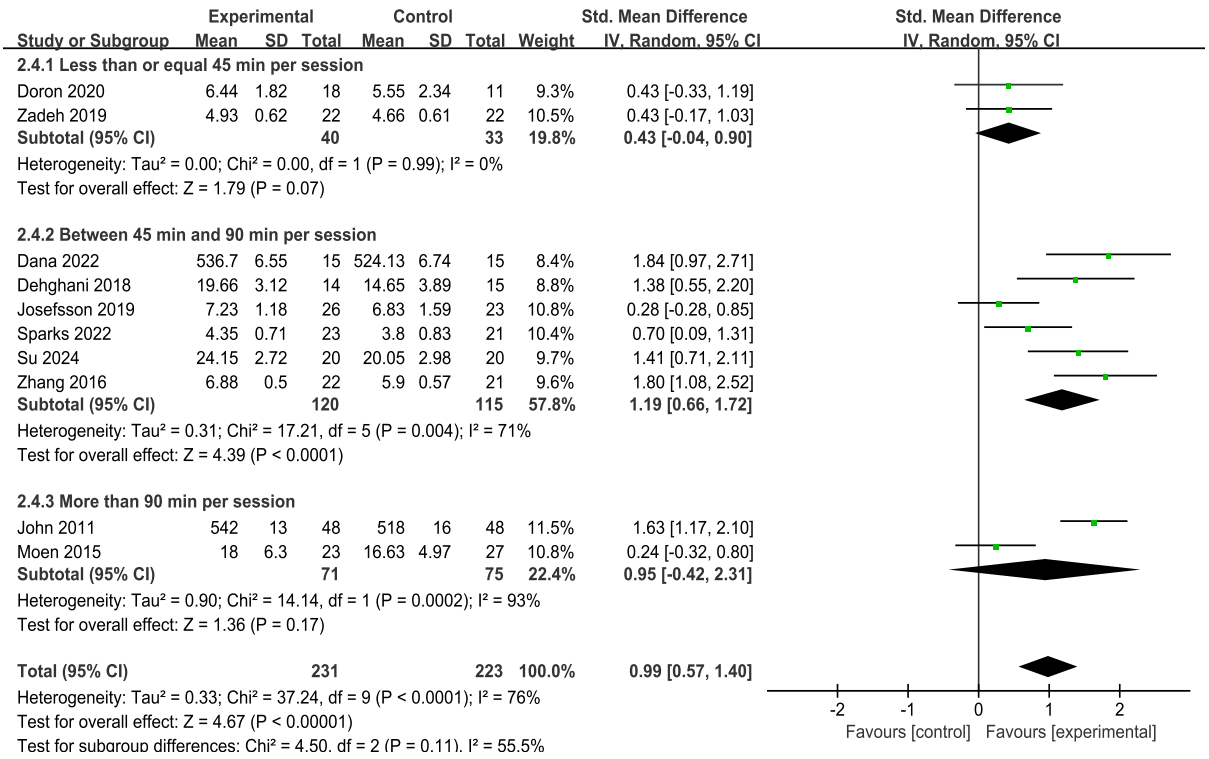

Fig 14. Forest plot illustrating the effects of different time duration of mindfulness intervention on athletes' performance

Certainty Assessment

Certainty of the evidence was assessed for each outcome using the GRADE rating tool (see Table 2.). Explanations for each rating judgement are provided in footnotes. Across outcomes, certainty of evidence was predominantly rated as Very Low. Evidence was largely downgraded for Risk of Bias, Inconsistency (heterogeneity in effects) and Indirectness (lack of stand-alone interventions and samples defined by sub-clinical symptoms). While publication bias was not examined statistically due to the small number of included studies, it was not strongly suspected as we found both negative and positive trial publications and employed a comprehensive search strategy.

Table 2. Summary of findings and GRADE certainty of evidence for mindfulness-based interventions in athletes

Outcome	Meta-analysis results				GRADE certainty assessment						Plain-language interpretation
	Studies	Participants (MBI/control)	SMD (95% CI)	I^2	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Certainty	
Mindfulness	14	597 (305/292)	0.77 (0.43 to 1.12)	74%	Serious[a]	Serious[b]	Not serious	Not serious	Not suspected[g]	**LOW** ⊕⊕◯◯	MBI may improves mindfulness.
Anxiety	5	185 (96/89)	-1.13 (-1.99 to -0.27)	86%	Serious[a]	Serious[b]	Not serious	Serious[c]	Undetected[h]	**VERY LOW** ⊕◯◯◯	MBI may reduce anxiety, but the estimate is very uncertain.
Flow state	4	160 (83/77)	0.87 (0.25 to 1.48)	68%	Serious[a]	Serious[b]	Not serious	Serious[c]	Undetected[h]	**VERY LOW** ⊕◯◯◯	MBI may improve flow, but the estimate is very uncertain.
Sport performance	11	494 (251/243)	0.94 (0.56 to 1.32)	75%	Serious[a]	Serious[b]	Not serious	Not serious	Not suspected[g]	**LOW** ⊕⊕◯◯	MBI may improves sport performance; outcome measures varied.
Stress	3	120 (58/62)	-1.11 (-2.32 to 0.10)	89%	Serious[a]	Very serious[c]	Not serious	Very serious[f]	Undetected[h]	**VERY LOW** ⊕◯◯◯	The effect on stress is very uncertain; the CI includes no effect.
Emotion regulation	2	85 (45/40)	1.05 (−0.51 to 2.62)	89%	Serious[a]	Very serious[c]	Serious[d]	Very serious[f]	Undetected[h]	**VERY LOW** ⊕◯◯◯	The effect on emotion regulation is very uncertain.
Mental toughness	3	139 (69/70)	1.18 (0.00 to 2.36)	89%	Serious[a]	Very serious[c]	Not serious	Very serious[f]	Undetected[h]	**VERY LOW** ⊕◯◯◯	The effect on mental toughness is very uncertain.

Note:

a Downgraded one level for serious risk of bias. Outcome-specific RoB 2 judgments were predominantly high risk, mainly because self-reported outcomes were measured in unblinded behavioural trials. The 21-study overview used the higher judgment when outcomes differed, but the GRADE decision was made separately for each outcome.

b Downgraded one level for serious inconsistency because heterogeneity was substantial (I^2 68%–86%) and remained clinically unexplained.

c Downgraded two levels for very serious inconsistency because I^2 was 89% and effect magnitudes varied across a small number of studies.

d Downgraded one level for serious indirectness because DERS and SEIS measure related but non-equivalent constructs, although score directions were harmonised before pooling.

e Downgraded one level for serious imprecision because few participants and studies contributed and the confidence interval remained wide.

f Downgraded two levels for very serious imprecision because only two or three small studies contributed and the confidence interval included no effect together with potentially large effects.

g Publication bias was not suspected from visual inspection of the funnel plot for outcomes with at least 10 studies; no regression-based asymmetry test was supplied.

h Publication bias was not assessed for outcomes with fewer than 10 studies because funnel-plot asymmetry methods have low power; no additional downgrade was applied solely for this reason.

Abbreviations: CI, confidence interval; DERS, Difficulties in Emotion Regulation Scale; GRADE, Grading of Recommendations Assessment, Development and Evaluation; MBI, mindfulness-based intervention; SEIS, Schutte Emotional Intelligence Scale; SMD, standardised mean difference.

Discussion

Summary of findings

This systematic review and meta-analysis synthesised evidence on the effects of mindfulness-based interventions (MBIs) on psychological and sport-performance outcomes in athletes. The pooled estimates suggested that MBIs may improve mindfulness, flow state, and sport performance and may reduce anxiety, primarily competition-related anxiety. However, the certainty of these findings was limited by substantial between-study heterogeneity, small sample sizes, and concerns regarding risk of bias. No clear evidence of an effect was found for stress, emotion regulation, or mental toughness because their confidence intervals included the null effect and the corresponding estimates were highly heterogeneous and imprecise.

Exploratory subgroup analyses did not identify statistically significant differences in the effects on sport performance according to intervention type ($P = 0.98$), sport type ($P = 0.37$), competitive level ($P = 0.08$), or session duration ($P = 0.11$). Although statistically significant pooled effects were observed within some subgroups, these within-subgroup findings do not demonstrate that one intervention format, athlete group, sport type, or session duration was more effective than another. The subgroup findings should therefore be interpreted as hypothesis-generating rather than confirmatory.

Interpretation and comparison with previous research

The observed improvements in mindfulness and flow state are broadly consistent with previous reviews suggesting that mindfulness-based programmes may enhance present-moment attention, non-judgemental awareness, and engagement with sport-related tasks (Bühlmayer et al., 2017; Kanaujia et al., 2023). These psychological processes may help athletes maintain task-focused attention and respond more adaptively to distracting thoughts and emotions. Nevertheless, the present meta-analysis did not directly examine mediating mechanisms; therefore, attentional control, acceptance, and emotion regulation should be regarded as plausible explanations rather than established causal pathways.

Mindfulness-based interventions were also associated with lower anxiety scores. This finding is generally consistent with the results reported by Myall et al. (2022), although the high heterogeneity indicates that the magnitude of the effect varied considerably across studies. Differences in athlete populations, anxiety measures, intervention formats, control conditions, and study quality may have contributed to this variability. In contrast, the pooled effect on stress was not statistically significant and its confidence interval included no effect. Therefore, the present findings do not establish that MBIs reduce stress in athletes, even though previous reviews have reported beneficial effects. The discrepancy may reflect the small number of contributing studies, differences in stress measures, or variation in intervention delivery.

The pooled estimate for sport performance favoured MBIs, but this result should be interpreted cautiously. Sport performance was assessed using a combination of objective indicators and self-rated performance measures. Self-reported performance outcomes in unblinded behavioural interventions may be particularly susceptible to expectancy and

response biases. In addition, substantial heterogeneity suggests that the magnitude of the effect may differ across sports, performance measures, intervention settings, and participant characteristics. Because the evidence base also includes non-randomized controlled studies, the main interpretation should be informed by sensitivity analyses restricted to randomized trials and by analyses distinguishing objective from self-reported performance outcomes.

Evidence for emotion regulation and mental toughness remained very uncertain. Only two studies contributed to the emotion-regulation analysis, and the pooled estimate had a wide confidence interval and substantial heterogeneity. Moreover, the DERS and SEIS assess related but non-equivalent constructs, even after their scoring directions were harmonised. Similarly, the mental-toughness analysis included only three small studies and produced a borderline estimate with a confidence interval extending to the null effect. These findings should not be interpreted as evidence that MBIs are ineffective; rather, the available evidence is insufficient to determine whether meaningful effects exist.

The subgroup analyses provided no statistical evidence that intervention type, sport type, competitive level, or session duration modified the effect on sport performance. In particular, the significant pooled estimates observed for MAC, college athletes, individual-sport athletes, and sessions lasting 45–90 minutes do not demonstrate superiority because the corresponding tests for subgroup differences were not statistically significant. The finding for competitive level approached, but did not reach, conventional statistical significance ($P = 0.08$) and may justify further investigation in adequately powered studies. At present, however, no specific mindfulness format, athlete group, sport category, or session duration can be recommended as more effective than the alternatives.

Limitations

This review examined multiple psychological and performance-related outcomes and considered potential sources of heterogeneity through subgroup analyses. However, several limitations should be acknowledged. First, most of the included studies had small samples, and relatively few studies contributed to the analyses of anxiety, flow state, stress, emotion regulation, and mental toughness. Consequently, several pooled estimates were imprecise and publication bias could not be assessed reliably for outcomes containing fewer than 10 studies. Second, substantial heterogeneity was present across most outcomes. The included studies differed in athlete age, competitive level, sport type, cultural context, intervention content, session duration, intervention frequency, control condition, follow-up time, and outcome measurement. The exploratory subgroup analyses did not explain this heterogeneity, and their limited statistical power means that potentially important effect modifiers cannot be excluded. Third, several psychological outcomes and some sport-performance outcomes were based on self-report measures. Because blinding participants to mindfulness training is generally not possible, knowledge of intervention allocation may have influenced participants'responses. The combination of objective and subjective sport-performance measures may also have reduced the comparability of the effect estimates. Future meta-analyses should distinguish objective performance outcomes, coach-rated outcomes, and athlete-reported performance wherever sufficient data are available. Fourth, the evidence base included both randomized and non-randomized controlled intervention studies. Non-randomized studies may be affected by confounding and selection bias, and their inclusion may influence pooled estimates. Accordingly, randomized trials should form the primary analysis, with non-randomized studies

included in design-stratified or sensitivity analyses. Cluster-randomized studies should also be analysed using methods that account for clustering. Finally, the subgroup analyses were based on study-level characteristics and small numbers of studies. They should therefore be regarded as exploratory and cannot establish an optimal intervention format or dose. The current evidence does not support prescribing a specific session duration or frequency. Future studies should be prospectively registered, adequately powered, and designed to compare intervention formats and doses directly. They should also report intervention fidelity, instructor qualifications, participant adherence, adverse events, and longer-term follow-up and should prioritise objective and sport-specific performance measures.

From a practical perspective, MBIs may be considered a potentially useful adjunct to athletes' psychological preparation. However, programmes should be adapted to the sporting context, delivered by appropriately trained practitioners, and evaluated continuously rather than applied according to a single presumed optimal format. Given the low to very low certainty of the current evidence, implementation decisions should remain cautious and responsive to individual athlete needs.

Conclusion

This systematic review and meta-analysis suggests that mindfulness-based interventions may improve mindfulness, flow state, and sport performance and may reduce anxiety among athletes. However, no clear evidence was found for beneficial effects on stress, emotion regulation, or mental toughness, for which the available evidence was limited and highly uncertain. Exploratory subgroup analyses did not identify statistically significant differences according to intervention type, sport type, competitive level, or session duration. Therefore, the current findings do not support the superiority of any specific mindfulness approach, athlete population, sport category, or intervention duration. The findings should be interpreted cautiously because of substantial between-study heterogeneity, small sample sizes, reliance on self-reported outcomes, risk-of-bias concerns, and the inclusion of both randomized and non-randomized controlled studies. Overall, the certainty of evidence ranged from low to very low. Future research should employ adequately powered and prospectively registered randomized controlled trials, use validated and objective sport-performance measures, report intervention fidelity and participant adherence, and include longer-term follow-up. Direct comparisons of intervention formats and doses are also needed before specific recommendations regarding the optimal type, frequency, or duration of mindfulness training can be made.

Data Availability

All data extracted and analysed during this systematic review and meta-analysis are included in the article and its supplementary information files.

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