On the Within-Person Associations Between Mindfulness, Stress, Mood, and Self-Reported Performance: A Daily Diary among Elite Chinese Athletes

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Abstract

Evidence for the protective role of dispositional mindfulness for athletic performance, stress, and mood among elite athletes has been demonstrated through correlational and interventional studies. The effects of state mindfulness on athletic functioning in day-to-day training contexts remains unclear. We examined the effects of state mindfulness on mood, biological markers of stress, and self-rated athletic performance in elite athletes during daily training. We used a diary study design to collect data on state mindfulness, mood, self-rated athletic performance, and salivary cortisol directly following training sessions of 78 elite athletes. For each athlete, a total of 27 data points were obtained across 9 weeks with data collected on a separate day, 3 days per week. Data were analyzed with multilevel structural equation modelling. At both the between-person and within-person levels, state mindfulness was significantly and negatively related to total mood disturbance and maladaptive dimensions of mood, including anger, confusion, depression, fatigue, and tension. Conversely, state mindfulness was positively related to vigor and self-rated athletic performance. Relations between state mindfulness and biological markers of stress were non-significant. Overall, findings of the current study provide preliminary empirical evidence supporting the utility of mindfulness interventions for improving state mindfulness of elite athletes. Such interventions may increase the positive mood of athletes and their performance during training.

Keywords: daily training; diary method; mood disturbance; mindfulness; sport performance; stress biological marker.

Introduction

During daily training, athletes can experience chronic stress, negative affect, and depleted mood, as they strive to improve their athletic performance (Rice et al., 2016). In addition to the use of traditional psychological skills to promote athletic performance (Lange-Smith et al., 2023) and psychotherapies to improve mental health outcomes (Stillman et al., 2019), mindfulness intervention is widely considered an effective approach for improving athletic performance and mental wellbeing (Bühlmayer et al., 2017; Myall et al., 2023). In the context of sports, mindfulness can buffer maladaptive outcomes including stress, negative affect, and maladaptive forms of mood (e.g., depression) among athletes (e.g., Gross et al., 2018). However, a key limitation of previous work in this field is that it has relied predominantly on evidence from cross-sectional snapshots (e.g., Shannon et al., 2020) and longitudinal research designs (e.g., Zhang et al., 2023) with widely spaced assessments that offer limited resolution on within-person effects. Even interventional designs (e.g., Quaglia et al., 2016) typically take only a few, infrequent measures to capture changes in dispositional mindfulness and adaptive/maladaptive outcomes (e.g., baseline and post-study follow-up measurements). Dispositional mindfulness reflects an individual's innate capacity to attend to or be aware of present-moment experiences with an attitude of acceptance (Brown & Ryan, 2003). State mindfulness, on the other hand, is the purposeful direction of attention to present-moment experiences to intentionally cultivate and maintain a mindful state that emphasizes nonelaborative awareness and acceptance of a situation (Bishop et al. 2014). The cultivation of greater state mindfulness over time during mindfulness meditation contributes to increases in dispositional mindfulness (Kiken et al., 2015).

Although the research on dispositional mindfulness provides insights on the understanding of nomological network of mindfulness and individual differences (Karl & Fischer, 2022), some researchers view mindfulness as much closer to a state than a trait, given the state-like, context-dependent, and variable nature of mindfulness (Bishop et al., 2014; Tanay & Bernstein, 2013). For example, Bravo et al. (2018) found that both dispositional mindfulness and state mindfulness facets increased with the frequency of meditation practice, yet the associations between them were relatively weak. Further, the effects of an individual's state mindfulness on adaptive and maladaptive outcomes do not depend on their dispositional mindfulness (Bravo et al., 2018; Kiken et al., 2015). As a result, findings based on dispositional mindfulness offer limited ecological validity and cannot be directly generalized to athletes' day-to-day training regimes (Reifsteck et al., 2021). Despite an emerging body of evidence distinguishing state mindfulness from dispositional mindfulness, our understanding of the state/dispositional mindfulness distinction both within and beyond sports contexts remains limited. Further research on state mindfulness is required to assess the mechanism of mindful experiences rather than mindfulness as a dispositional tendency. To address this gap, we adopted a daily diary design to examine the within-person associations between state mindfulness, biological markers of stress, mood, and self-rated athletic performance in a sample of elite Chinese athletes during daily training.

Mindfulness has been found to play an important role in alleviating the influence of stress among both elite (Myall et al., 2023) and non-elite (e.g., student) athletes (Petterson & Olson, 2017). Dispositional mindfulness is negatively associated with self-reported stress in elite and elite junior athletes (Gustafsson et al., 2015; O'Connor et al., 2022). In terms objective indicators of stress, salivary cortisol is widely used as a non-invasive biomarker of stress in sport and other contexts (Lindsay & Costello, 2017). Mindfulness interventions have been shown to reduce biological markers of stress (e.g., salivary cortisol) in elite military units (Meland et al., 2015), elite shooters (John et al., 2011), and elite Wushu athletes (Mehrsafar et al., 2019). Despite this accumulating body of evidence supporting the utility of mindfulness for reducing athlete stress, inconsistencies remain in the literature. For example, Moen and colleagues (2015) found no significant effects of a 12-week mindfulness intervention on perceived stress in elite junior athletes. Similarly, Roeser and colleagues (2013) found that a mindfulness intervention significantly reduced perceived occupational stress, yet it did not produce changes in physiological measures of stress in a sample of teachers. Thus, despite mindfulness interventions showing promise for reducing stress in sports, further examination of the effects of state mindfulness on biological indicators of athlete stress is warranted, particularly in daily training contexts, which allow researchers to examine how state mindfulness differentiates stress within individual athlete's training regimes, as well as between athletes.

Mindfulness can also enhance affect and mood of athletes (Lever et al., 2021; Myall et al., 2023; White et al., 2021). Experience sampling studies have demonstrated day-to-day associations between state mindfulness and improved mood in non-sporting contexts. For example, Iida and Shapiro (2019) conducted a 24-day daily diary study of cohabiting heterosexual couples and found that on days when participants reported higher levels of non-judgmental mindfulness, they experienced lower levels of negative mood. Interventional studies have demonstrated that mindfulness training can produce increases in positive mood, while also reducing maladaptive aspects of mood including negative affect, anxiety, depression, fatigue, and confusion (e.g., Caldwell et al., 2010; Vieten & Astin, 2008; Carlson & Garland, 2005). However, the literature does not unanimously support adaptive effects of mindfulness interventions for mood. For example, Mohammed and colleagues (2018) found no significant effect of a mindfulness intervention on the mood of injured athletes who were absent from training for more than three months. Although there has been some investigation of the effects of mindfulness interventions on mood in competitive settings, research on the relation between state mindfulness and fluctuations in mood over athletes' day-to-day training schedules is lacking. Given that mood and affect vary across days, it is important to examine the effects of state mindfulness on mood and affect at daily level for a more granular perspective than has previously been uncovered.

In addition to supporting the psychological wellbeing of athletes, there is emerging evidence indicating that mindfulness can facilitate athletic performance (Bühlmayer et al., 2017). Several studies have demonstrated small-to-medium positive associations between dispositional mindfulness and athletic performance (Gooding & Gardner, 2009; Gustafsson et al., 2015). Improvements following mindfulness training have been observed in objective indicators of performance such as free throw shooting in basketball players (Tebourski et al., 2022), shooting performance of shooters (John et al., 2011), and dart throwing performance of beginners (Zhang et al., 2016), as well as self-rated (Josefsson et al., 2019) and coach-rated performance (Gross et al., 2018). However, in another study, the effects of a 12-week mindfulness intervention on athletic performance of elite junior athletes was statistically inconsequential (Moen et al., 2015). Most research on mindfulness in sport has focused on dispositional mindfulness in competitive settings, with data being collected pre- and post-intervention (e.g., Glass et al., 2019; Gross et al., 2018; Mardon et al., 2016). However, tests of the effects of state mindfulness are needed, given that dispositional mindfulness measures are likely to overlook state-like elements of mindfulness. Based on the current literature, it is unclear whether the benefits of state mindfulness translate to the maintenance of performance across training situations. Given that training contexts provide athletes with opportunities to explore mindfulness strategies in ways that are best aligned with competition settings, it is important to examine associations between state mindfulness and athletic performance during training.

The Current Study

Given that factors such as state mindfulness, mood, and performance are likely to differ for individual athletes across training sessions, it is crucial to consider within-athlete variations alongside between-athlete differences. Somewhat surprisingly, few studies with elite athletes (e.g., Hancox et al., 2017; Röthlin et al., 2023; Rumbold et al., 2020) have adopted daily diary designs to provide sufficient granularity on within-person processes and outcomes with ecological validity. Addressing this gap will be key for developing effective mindfulness-based interventions that can be integrated into daily training regimes of elite athletes and could potentially provide an evidentiary basis for the integration of mindfulness practice as a part of elite athletes' training routines, rather than a one-off, short-term intervention program.

In the current study we used an intensive longitudinal assessment approach to examine the effects of state mindfulness on mood, biological markers of stress, and self-rated athletic performance in a diverse sample of elite Chinese athletes across 27 training sessions over 9 weeks. We hypothesized that state mindfulness is significantly and negatively related to maladaptive aspects of mood (e.g., depression) and biological indicators of stress at both the between-person level (i.e., variance due to individual differences) and the within-person level (i.e., day-to-day intra-individual variability). We also hypothesized that state mindfulness is significantly and positively related to positive aspects of mood (e.g., vigor) and self-rated athletic performance at both the between-person and within-person levels.

Methods

Transparency and Openness

We report how we determined our sample size, measures, procedures, and other methods in the study. The data sets generated during the current study are publicly available on the open science framework (OSF): https://osf.io/5a7vj/. The study was not preregistered.

Study Design

The day-reconstruction method (Kahneman et al., 2004) was used to avoid disrupting the training of elite athletes as it is less burdensome on athletes than experience sampling and can reduce memory biases of global recall (Diener & Tay, 2014). We obtained athlete's self-reported state mindfulness, mood, and athletic performance, and collected saliva samples directly after their afternoon training sessions (e.g., between 16:00-18:00). Building on theoretical considerations (Birrer et al., 2012; Lindsay & Creswell, 2019) and existing empirical evidence on the effects of dispositional mindfulness on athletic performance, as well as adaptive and maladaptive outcomes (e.g., Röthlin et al., 2016; Zhang et al., 2021, 2023), multilevel structural equation modelling (Preacher et al., 2016) was used to investigate the between-person and within-person effects from state mindfulness to biological stress, mood, and athletic performance.

Participants

According to the Participant Classification Framework (McKay et al., 2022), participants in the current study are highly-trained national-level athletes. Our sample can be classified as elite athletes given that they reached the performance standard required to compete nationally and completed structured and periodized training (i.e., at least five days per week) for more than three years within a given sport (Swann et al., 2015). We focused on elite athletes rather than athletes at any performance level because research demonstrates that elite athletes are vulnerable to a range of mental health problems (Rice et al., 2016) due to overtraining, injury, burnout, deteriorated performance, and other factors in high-performance environments (Hughes et al., 2012).

In total, 78 elite Chinese athletes (49 males and 29 females) in a provincial sport training center in South China participated in this study. Monte Carlo simulations of multilevel data with medium sized intraclass correlation coefficients indicate a sample of 70 participants providing 25 observations would produce 80% power to detect small ($\beta > .12$) within-person effects (Arend & Schäfer, 2019). Thus, the present sample size is adequate given we were predominantly interested in daily mean levels and included 27 observations at the within-person level (Nezlek, 2020). The athletes represented 11 different individual ($n = 69$; 88.5%) and team sports ($n = 9$; 11.5%), including synchronized swimming ($n = 3$), trampoline ($n = 8$), weight lifting ($n = 6$), table tennis ($n = 7$), free combat ($n = 4$), water polo ($n = 6$), gymnastics ($n = 17$), athletics ($n = 9$), diving ($n = 5$), martial arts ($n = 5$), and swimming ($n = 8$). To increase the generalizability of study findings, both junior and adult elite athletes were invited to participate in the current study. Participants comprised both elite ($n = 51$) and junior elite athletes ($n = 27$) aged between 13 and 26 years ($M = 18.67$; $SD = 2.88$). All participants were competing at the national level competition and 17 participants (19.2%) also competed at the international level. Years of sports training for participants of the current study ranged from 3 to 19 years ($M = 10.25$; $SD = 3.83$). Approximately half of the participants reported having previous meditation experience ($n = 40$; 51.3%).

Procedure

We reached an agreement with the elite sports training center to collect data from the center-based elite athletes. Part of the agreement required that athlete support personnel (e.g., physicians, physiotherapists, sport psychology practitioners) manage the data collection process with athletes in their direct supervision with our support. For junior elite athletes younger than 18 years old, we obtained approvals from their coaches, who served as a proxy of parents. At baseline assessment, consenting athletes reported their demographic information and their dispositional mindfulness. For the diary data, athletes completed surveys each day, three times per week, for nine weeks, with a total of 27 time points obtained from each participant. The training center recommended this data collection schedule to minimize participant burden and maximize potential data quality because the center-based elite athletes normally train five to six days per week. Athletes completed daily diaries either on Monday, Wednesday, and Friday, or on Tuesday, Thursday, and Saturday, depending the training schedules of their team. Our research team distributed and collected the questionnaires at the end of their afternoon training. Salivary samples were also collected from athletes immediately after training and then stored in a research grade freezer upon collection. The Research Ethics Committee (REC) of Hong Kong Baptist University approved this study protocol prior to initiation and execution.

Measures

Dispositional Mindfulness. We measured participants' dispositional mindfulness using the 16-item Athlete Mindfulness Questionnaire (AMQ; Zhang et al., 2017). The AMQ consists of three dimensions: present-moment attention (e.g., "I can maintain my attention on my training"), awareness (e.g., "During training or competition, I can be immediately aware of my emotional changes"), and acceptance (e.g., "During training and competition, it doesn't matter if the situation is good or bad, I can accept myself for who I am"). Items were rated on a five-point rating scale, ranging from 1 (never true) to 5 (always true). In the current study, the composite reliabilities of the three subscales are all acceptable: present-moment attention (ω = .746), present-moment attention (ω = .805), and present-moment attention (ω = .805).

State Mindfulness. We adapted the Chinese version of the 5-item Mindful Attention Awareness Scale (MAAS) – State (Brown & Ryan, 2003), which has been validated in a Chinese sample (Black et al., 2012), for use in the sporting context (see the online supplementary file Table *S1*). We specifically adapted items to target training experiences of that day; for example, we rephrased the statement "I find it difficult to stay focused on what's happening in the present" to "I find it difficult to stay focused on today's training sessions". Athletes rated each statement using a 7-point Likert rating scale from 0 (not at all) to 6 (very much). We reversed scored items then calculated an average of the 5 items, such that higher scores indicated higher state mindfulness. We pilot tested the scale with junior elite athletes to ensure they understood the items. In the current study, we examined psychometric properties of the adapted sport-specific 5-item MAAS-state using multilevel confirmatory factor analysis (MCFA; Muthén, 1994). A single factor solution provided satisfactory model-data fit (CFI = .932, RMSEA = .057, SRMR within = .030, and SRMR between = .007).

Mood. We utilized the 23-item Chinese version of the Brunel Mood Scale (BRUMS; Terry et al., 2003) to measure athletes' mood after their daily training sessions. Across four samples of adolescent athletes, adolescent students, adult athletes, and adult students, the Chinese version BRUMS showed adequate validities and composite reliabilities with both the negative dimensions of mood on anger (.82-.89), confusion (.71-.79), depression (.77-.85), fatigue (.83-.85), and tension (.83-.88), as well as the positive dimension of mood, vigor (.81-.86) (Zhang et al., 2014). In line with previous research (e.g., Burgum & Smith, 2021), a total mood disturbance score was also calculated by summing the five negative mood states. Athletes rated short terms that reflect various mood types (e.g., angry, nervous, and unhappy) with a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely) using the response timeframe of "What are your feelings during training today?". The inclusion of total mood disturbance is necessary as its calculation can reflect an overall mood status rather than only relying on the pre-determined mood dimensions as positive or negative (Han, 2020).

Self-rated athletic performance. Consistent with previous research (e.g., Josefsson et al., 2019), we asked participants to assess their overall sport performance of the training that day using a 10-point Likert rating scale from 1 (extremely bad) to 10 (extremely good).

Stress. We assessed human cortisol and human secretory immunoglobulin A (sIgA) via saliva samples with the enzyme-linked immunosorbent assay (ELISA) kit (Crowther, 2009). The ELISA kit includes a set of calibration standards to measure the concentration of sIgA and cortisol in the sample. The analyses of the biological stress levels of cortisol and sIgA were provided by the manufacturer of the ELISA kit, Guangzhou Haisi Medical Technology Co., Ltd.

Data Analyses

We calculated descriptive statistics including means, standard deviations, and bivariate correlations among study variables using IBM SPSS 20. Composite reliabilities of the MAAS-State and mood subscales of BRUMS were calculated following the recommendation of Lai (2021) using the lavaan package in R. Given the nested structure of the data, with multiple daily assessments nested within each participant, we calculated the intraclass correlation coefficient (ICC) for each variable. When ICC values exceed 0.5, analysts are advised to utilize statistical models that account for nonindependence in the data (Barcikowski, 1981; Bryk & Raudenbush, 1992). We used multilevel structural equation modelling with a robust maximum likelihood estimator (Hox et al., 2010) in Mplus 8.6 (Muthén & Muthén, 1998-2017) to estimate the effects of state mindfulness on outcome variables (Mehta & Neale, 2005). Missing data were handled by the full information maximum-likelihood estimation (Enders, 2010) within Mplus 8.6.

We constructed five models to examine the effects of mindfulness on total mood disturbance (Model 1), different dimensions of mood (Model 2), self-rated athletic performance (Model 3), sIgA (Model 4), and cortisol (Model 5). Athletes' gender, age, years of training, type of sport (individual vs. team sports), dispositional mindfulness, and meditation experience were included as covariates to control for their potential influence on key study outcome variables at the between-person level. A depiction of the multilevel model for the effects from mindfulness to total mood disturbance is provided as an example (*Figure 1*). To account for potentially inflated type 1 error rates due to multiple comparisons, we adjusted the alpha values for statistical significance from $p < 0.05$ to $p < 0.01$. Model fit was evaluated using the comparative fit index (CFI) and Tucker-Lewis Index (TLI), root-mean-square error of approximation (RMSEA), and standardized root-mean-square residual (SRMR). Adequate fit was indicated with CFI and TLI ≥ .95, RMSEA ≤ .08, and SRMR ≤ .08 (Yuan & Bentler, 2007).

Results

Descriptive Statistics

We present descriptive statistics, internal consistency estimates, ICCs, and bivariate correlations at the within-person and between-person levels in *Table 1*. Internal consistency estimates of the state mindfulness and subscales of mood using composite reliability are all acceptable ($\omega > .70$). For detailed coefficients with confidence intervals, see the online supplementary file *Table S2*. At the within-person level, on days where athletes reported higher state mindfulness during training relative to their average, they tended to experience reduced negative mood ($r = -.464$, $p < .001$) and lower levels of biological stress ($r^{cortisol} = -.057$, $p = .009$). Additionally, athletes rated their perceived performance as better during training on days where they reported higher levels of state mindfulness relative to their average ($r = .067$, $p = .009$). Regarding between-person level effects, athletes who reported higher levels of state mindfulness experienced lower mean levels of biological stress ($r^{cortisol} = -.837$, $p < .001$; $r^{sIgA} = -.833$, $p < .001$) and rated their athletic performance higher ($r = .863$, $p < .001$). Overall, ICC values supported a multilevel approach to testing the research questions.

Multilevel Structural Equation Modelling

Model fit indices indicate adequate fits for all tested models (see the online supplementary file *Table S3*). We present a summary of between-person and within-person effects of mindfulness on total mood disturbance, subdimensions of mood (i.e., anger, confusion, depression, fatigue, tension, and vigor), self-rated athletic performance, sIgA, and cortisol in *Table 2*. Given the associations between control covariates and key outcome variables are tangential to our hypotheses, we provide them in the online supplementary file *Table S4*.

Effect of mindfulness on mood. State mindfulness was significantly and negatively related to total mood disturbance at both the within-person (β = -.454, p < .001) and between-person (β = -.610, p < .001) levels. Regarding the association between mindfulness and individual dimensions of mood, at the within-person level, mindfulness was negatively related to anger (β = -.278, p < .001), confusion (β = -.433, p < .001), depression (β = -.375, p < .001), fatigue (β = -.296, p < .001), tension (β = -.306, p < .001), and positively related to vigor (β = .205, p < .001). Similarly, at the between-person level, mindfulness was negatively related to anger (β = -.503, p < .001), confusion (β = -.702, p < .001), depression (β = -.561, p < .001), fatigue (β = -.327, p = .023), tension (β = -.523, p < .001), and positively related to vigor (β = .195, p = .053).

Effect of mindfulness on athletic performance. Mindfulness was positively related to self-rated athletic performance during training at the within-person (β = .426, p < .001) and between-person levels (β = .415, p < .001).

Effect of mindfulness on stress. Using p <.01 as the adjusted cutoff of significance, the effects of mindfulness on sIgA at the within-person level (β = .043, p = .023) and between-person level (β = -.096, p = .758) were non-significant. The effects from mindfulness on cortisol at the within-person level (β = -.028, p = .205) and between-person level (β = -.113, p = .836) were also non-significant. It seems that daily state mindfulness was not related to stress indicated by biological markers.

Discussion

The current study examined the effects of state mindfulness on mood, self-rated athletic performance, and biological indicators of stress during daily training in a sample of Chinese elite athletes. Study findings support a negative relationship between state mindfulness and total mood disturbance, as well as maladaptive sub-dimensions of mood such as anger, confusion, depression, fatigue, and tension. Conversely, mindfulness was positively associated with vigor and self-rated athletic performance. Despite associations with reduced maladaptive mood and increased performance, state mindfulness was not related to biological indicators of stress. Overall, our study findings provide preliminary empirical support for interventions targeting the improvement of state mindfulness to increase the mood of athletes and perceived performance during training.

Our results demonstrate that higher levels of state mindfulness in athletes are associated with reduced negative mood during training. These findings are in line with previous studies. For example, increased dispositional mindfulness was significantly related to improved mood among college students (Caldwell et al., 2010) and women in cohabiting heterosexual couples (Iida & Shapiro, 2019). In the context of sport, mindfulness training can be used to promote mood in junior tennis players (Lever et al., 2021). Developing mindfulness outside of competitive settings is an important consideration for athletes' long-term wellbeing, as it has the potential to help prevent mood disturbance and mental health issues (Myall et al., 2023). Indeed, many mindfulness-based interventions target emotional regulation, experiential acceptance, and decentering as working mechanisms that relate mindfulness to adaptive mood-related outcomes such as positive affect, subjective well-being, and flourishing (Nien et al., 2023; Zhang et al., 2021). Future research could also consider examining the working mechanisms from state mindfulness to mood in daily training contexts and use more ecological momentary designs such as experience sampling methodology to help shed light on nuanced temporal associations.

When applying mindfulness to sports contexts, the main role is for performance enhancement among athletes (Birrer et al., 2012; Bühlmayer et al., 2017). Findings of this study provided preliminary empirical support that state mindfulness is related to self-rated athletic performance in daily training, which complements and extends previous work on the association between mindfulness and performance. Elite athletes with high levels of dispositional mindfulness report lower levels of performance worries (Röthlin et al., 2016) and dispositional mindfulness is positively related to self-rated (Gustafsson et al., 2015) and objective (Gooding & Gardner, 2009) indicators of athletic performance. Furthermore, mindfulness-based intervention studies have demonstrated that mindfulness training is effective for improving athletic performance among elite shooters (John et al., 2011), basketball players (Tebourski et al., 2022), dart throw beginners (Zhang et al., 2016), and student athletes (Glass et al., 2019; Gross et al., 2018).

In the current study, we did not measure objective athletic performance, but instead focus on athlete's perceptions of their performance. While it is important to produce actual athletic performance during training, it is equally important to improve an individual's perception of their performance. According to Bandura (1977), it is key for athletes to establish self-efficacy. Athletes with high levels of perceived success in previous performances typically exhibit higher levels of performance in the future (George, 1994). During practice, when athletes have a relatively consequence-free environment to try new things or perfect specific techniques, the establishment of self-efficacy is likely to foster future success. Our results indicate significant and positive associations between state mindfulness and self-rated athletic performance, implying that state mindfulness may play a critical role in this process. Our research provides preliminary empirical support for future intervention studies looking to apply brief mindfulness exercises in the context of athletes' daily training to promote both perceived and potentially also objectively measured athletic performance (Shaabani et al., 2020).

This study showed that the effects from state mindfulness to sIgA and cortisol were non-significant at both the between-person and within-person levels. Findings of this study are inconsistent with previous research showing that mindfulness interventions reduced levels of salivary cortisol in Wushu athletes (Mehrsafar et al., 2019), elite shooters (John et al., 2011), and individuals from a military helicopter unit (Meland et al., 2015). One potential explanation for this inconsistency may be that the measure of state mindfulness used in this study (MAAS-State; Brown & Ryan, 2003) does not measure specific facets of mindfulness, such as non-reactivity and non-judgment. Meland and colleagues (2015) measured mindfulness using the Five Facets Mindfulness Questionnaire (Baer et al., 2008) and showed that the facets of non-judgement of inner experiences and non-reactivity to inner experiences were highly relevant when athletes modulate their stress responses. Another potential explanation is that biological stress indices in the aforementioned studies were collected cross-sectionally at a single time point. In comparison, repeatedly collecting salivary samples in over period of time via diary methods typically provide more accurate results (Ohly et al., 2010). Indeed, Mehrsafar and colleges (2019) collected diary samples and found that daily salivary alpha-amylase (sAA) of Wushu athletes was unaffected by a mindfulness intervention, corroborating the findings of the present study, which also used a diary study approach. In previous studies, biological data was collected either pre-competition (John et al., 2011) or during competition-related national selection periods (Mehrsafar et al., 2019). In this study, biological data was collected immediately after the daily training, which is typically "lower stakes" than competition and therefore may induce less of a stress response than competitive settings. Finally, we found relatively low ICCs for both sIgA and cortisol indicating high within-person variability of these biological measures. This indicates that people's biological stress markers varied substantially from training session to training session. Conversely, we observed a high ICC in our measure of state mindfulness (MAAS; Brown & Ryan, 2003), which may be because this instrument uses negatively worded items that capture low mindfulness/mindlessness (Sauer et al., 2011). Accordingly, the non-significant effects from state mindfulness to sIgA and cortisol might be due to the inconsistencies between high ICC of state mindfulness and low ICC of the stress biological markers.

Regarding the use of cortisol as a reliable biological measure of stress, Rist and Pearce (2019) emphasized that researchers should be conscious of not overgeneralizing the findings of cortisol levels to the psychological profile of stress. Overemphasizing the role of cortisol levels can lead to biased interpretations of the stress levels of athletes. Subjective measures reflect acute and chronic training loads with superior sensitivity and consistency to objective measures (such as cortisol), and it is recommended objective measures (e.g., physiological and biochemical makers) are accompanied by subjective measures of athlete stress and well-being (Saw et al., 2016). Subjective and biological markers of stress are different yet related concepts. Psychologically, subjective stress can be viewed as a filter of biological indices and reflects the extent to which various biological stress makers have been activated by subjective experiences (Pace-Schott et al., 2019). Previous research demonstrated significant negative relations between mindfulness and perceived stress among elite athletes (e.g., Gustafsson et al., 2015; O'Connor et al., 2022). We found similar negative relations between state mindfulness and negative mood, which can be indicative of stress (Stone et al., 1993). Future research should consider assessing athletes' stress levels using both the stress-related biological markers and the self-reported perceived stress.

Strengths, Limitations, and Future Directions

The present study has several strengths. First, we focused on an important but neglected area by examining relations between state mindfulness and athletes' stress, mood, and athletic performance in training. Second, we measured stress repeatedly using the biological markers from the elite athletes' saliva samples collected directly after training. Third, we collected data from a sample of athletes from 11 different individual and team sports, making the findings of this study generalizable across athletes from different sporting backgrounds.

However, the current study is not without its limitations. First, we did not include any objective measures of athletic performance during training. Performance is evaluated differently across sports. Given we sampled athletes from 11 different sports it was difficult to develop a standardized measure of objective athletic performance. Second, the design of the current study was correlational in nature, and as such, we cannot determine whether state mindfulness played a causal role in producing the observed results. Nonetheless, this work paves the way for future studies looking to adopt an experimental approach with brief mindfulness training before or during training sessions. Third, as discussed, we chose to use the 5-item MAAS-State to measure state mindfulness, but acknowledge that this scale was not developed for the sport context and may therefore overlook some aspects of mindfulness. We chose to use this scale, which has been validated in a Chinese sample (Black et al., 2012), to reduce participant burden, an important consideration in diary studies (Janssens et al., 2018). On a related note, the negatively wording of the MAAS (Brown & Ryan, 2003) arguably captures mindlessness but does not necessarily mean the participants were mindful (Sauer et al., 2011). Future research should therefore consider using scales that were specifically developed to measure state mindfulness in sport contexts, such as the State Mindfulness Scale (Tanay & Bernstein, 2013) and State Mindfulness Scale for Physical Activity (Ullrich-French et al., 2022). Fourth, we measured biological stress markers directly after each athlete's afternoon training session because we were interested in associations between state mindfulness in training contexts. Given athletes from different sports had different training schedules, the time of day that samples were collected were relative to training schedules and were not necessarily consistent across sports. Biological indicators of stress such as salivary cortisol and sIgA can be influenced by athletes' daily rhythms and may have influenced results (Pritchard et al., 2017). Relatedly, athletes might feel less stressed during training compared to competition or pre-competition settings. Collecting data during competition typically produces larger effects related to biological markers of stress (e.g., Dehghan et al., 2019; Sinnott-O'Connor et al., 2018). Moreover, given that in our study there are female elite athletes aged 13 and above and data collection lasts for one month, menstruation may have affected the measured biological markers (Klusmann et al., 2022). We did not control for these effects directly but operate under the assumption that fluctuations caused by menstruation are relatively random would thus be captured by random-effects component of our models. Further, controlling for differences in participants' biological sex partials out differences due to having a period versus not having a period. Nonetheless, we suggest an interesting avenue for future investigation would be to consider the effects of menstruation and other potential biological differences related to sex on the effects of mindfulness, biological stress markers, and performance.

Conclusion

Using a diverse sample of elite athletes from a variety of disciplines, the current study provided preliminary empirical support for associations between state mindfulness, mood, and self-rated athletic performance both within- and between- athletes engaging in training. Findings of the current study are encouraging for the development brief mindfulness training programs for integration into the daily training schedules of elite athletes. Enhancing day-to-day state mindfulness in athletes has the potential to improve both mental wellbeing and athletic performance.

References

Arend, M. G., & Schäfer, T. (2019). Statistical power in two-level models: A tutorial based on Monte Carlo simulation. *Psychological methods*, *24*(1), 1-19. http://dx.doi.org/10.1037/met0000195

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., ... & Williams, J. M. G. (2008). Construct validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment*, *15*(3), 329-342. https://doi.org/10.1177/1073191107313003

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Barcikowski, R. S. (1981). Statistical power with group mean as the unit of analysis. *Journal of Educational Statistics*, *6*(3), 267-285. https://doi.org/10.3102/10769986006003267

Birrer, D., Röthlin, P., & Morgan, G. (2012). Mindfulness to enhance athletic performance: Theoretical considerations and possible impact mechanisms. *Mindfulness*, *3*(3), 235-246. https://doi.org/10.1007/s12671-012-0109-2

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*(3), 230-241. https://doi.org/10.1093/clipsy.bph077

Black, D. S., Sussman, S., Johnson, C. A., & Milam, J. (2012). Psychometric assessment of the mindful attention awareness scale (MAAS) among Chinese adolescents. *Assessment*, *19*(1), 42-52. https://doi.org/10.1177/1073191111415365

Bravo, A. J., Pearson, M. R., Wilson, A. D., & Witkiewitz, K. (2018). When traits match states: Examining the associations between self-report trait and state mindfulness following a state mindfulness induction. *Mindfulness*, *9*, 199-211. https://doi.org/10.1007/s12671-017-0763-5

Brown, K.W. & Ryan, R.M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822-848. https://doi.org/10.1037/0022-3514.84.4.822

Bryk, A. S., & Raudenbush, S.W. (1992). *Hierarchical linear models*. Newbury Park, CA: Sage.

Bühlmayer, L., Birrer, D., Röthlin, P., Faude, O., & Donath, L. (2017). Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: A meta-analytical review. *Sports Medicine*, *47*(11), 2309-2321. https://doi.org/10.1007/s40279-017-0752-9

Burgum, P., & Smith, D. T. (2021). Reduced mood variability is associated with enhanced performance during ultrarunnning. *Plos One, 16(9)*: e0256888. https://doi.org/10.1371/journal.pone.0256888

Caldwell, K., Harrison, M., Adams, M., Quin, R. H., & Greeson, J. (2010). Developing mindfulness in college students through movement-based courses: effects on self-regulatory self-efficacy, mood, stress, and sleep quality. *Journal of American College Health*, *58*(5), 433-442. https://doi.org/10.1080/07448480903540481

Carlson, L. E., & Garland, S. N. (2005). Impact of mindfulness-based stress reduction (MBSR) on sleep, mood, stress and fatigue symptoms in cancer outpatients. *International Journal of Behavioral Medicine*, *12*(4), 278-285. https://doi.org/10.1207/s15327558ijbm1204_9

Crowther, J. R. (2009). *The ELISA guidebook* (Vol. 566). New York: Humana press. https://doi.org/10.1007/978-1-60327-254-4

Dehghan, F., Khodaei, F., Afshar, L., Shojaei, F. K., Poorhakimi, E., Soori, R., ... & Azarbayjani, M. A. (2019). Effect of competition on stress salivary biomarkers in elite and amateur female adolescent inline skaters. *Science & Sports*, *34*(1), e37-e44. https://doi.org/10.1016/j.scispo.2018.04.011

Diener, E., & Tay, L. (2014). Review of the day reconstruction method (DRM). *Social Indicators Research*, *116*, 255-267. https://doi.org/10.1007/s11205-013-0279-x

Enders, C. K. (2010). *Applied missing data analysis.* New York: Guilford Press.

George, T. R. (1994). Self-confidence and baseball performance: A causal examination of self-efficacy theory. *Journal of Sport and Exercise Psychology*, *16*(4), 381-399. https://doi.org/10.1123/jsep.16.4.381

Glass, C. R., Spears, C. A., Perskaudas, R., & Kaufman, K. A. (2019). Mindful sport performance enhancement: Randomized controlled trial of a mental training program with collegiate athletes. *Journal of Clinical Sport Psychology*, *13*(4), 609-628. https://doi.org/10.1123/jcsp.2017-0044

Gooding, A., & Gardner, F. L. (2009). An investigation of the relationship between mindfulness, preshot routine, and basketball free throw percentage. *Journal of Clinical Sport Psychology*, *3*(4), 303-319. https://doi.org/10.1123/jcsp.3.4.303

Gross, M., Moore, Z. E., Gardner, F. L., Wolanin, A. T., Pess, R., & Marks, D. R. (2018). An empirical examination comparing the mindfulness-acceptance-commitment approach and psychological skills training for the mental health and sport performance of female student athletes. *International Journal of Sport and Exercise Psychology*, *16*(4), 431-451. https://doi.org/10.1080/1612197X.2016.1250802

Gustafsson, H., Skoog, T., Davis, P., Kenttä, G., & Haberl, P. (2015). Mindfulness and its relationship with perceived stress, affect, and burnout in elite junior athletes. *Journal of Clinical Sport Psychology*, *9*(3), 263-281. https://doi.org/10.1123/jcsp.2014-0051

Han, C. S. Y. (2020). *Psychometric properties, mood profile clusters, and predictive effectiveness of the Brunel Mood Scale in a Singaporean context.* Unpublished doctoral dissertation. University of Southern Queensland. https://doi.org/10.26192/045d-9236

Hancox, J. E., Quested, E., Ntoumanis, N., & Duda, J. L. (2017). Teacher-created social environment, basic psychological needs, and dancers' affective states during class: A diary study. *Personality and Individual Differences*, *115*, 137-143.

https://doi.org/10.1016/j.paid.2016.03.033

Hox, J. J., Maas, C. J., & Brinkhuis, M. J. (2010). The effect of estimation method and sample size in multilevel structural equation modeling. *Statistica Neerlandica*, *64*(2), 157-170. https://doi.org/10.1111/j.1467-9574.2009.00445.x

Iida, M., & Shapiro, A. (2019). Mindfulness and daily negative mood variation in romantic relationships. *Mindfulness*, *10*(5), 933-942. https://doi.org/10.1007/s12671-018-1056-3

Janssens, K. A., Bos, E. H., Rosmalen, J. G., Wichers, M. C., & Riese, H. (2018). A qualitative approach to guide choices for designing a diary study. *BMC Medical Research Methodology*, *18*(1), 1-12. https://doi.org/10.1186/s12874-018-0579-6

John, S., Verma, S. K., & Khanna, G. L. (2011). The effect of mindfulness meditation on HPA-Axis in pre-competition stress in sports performance of elite shooters. *National Journal of Integrated Research in Medicine*, *2*(3), 15-21.

Josefsson, T., Ivarsson, A., Gustafsson, H., Stenling, A., Lindwall, M., Tornberg, R., & Böröy, J. (2019). Effects of mindfulness-acceptance-commitment (MAC) on sport-specific dispositional mindfulness, emotion regulation, and self-rated athletic performance in a multiple-sport population: an RCT study. *Mindfulness*, *10*(8), 1518-1529. https://doi.org/10.1007/s12671-019-01098-7

Kahneman, D., Krueger, A. B., Schkade, D. A., Schwarz, N., & Stone, A. A. (2004). A survey method for characterizing daily life experience: The day reconstruction method. *Science*, *306*(5702), 1776-1780. https://doi.org/10.1126/science.1103572

Karl, J. A., & Fischer, R. (2022). The state of dispositional mindfulness research. *Mindfulness*, *13*(6), 1357-1372. https://doi.org/10.1007/s12671-022-01853-3

Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S., & Gaylord, S. A. (2015). From a state to a trait: Trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personality and Individual Differences*, *81*, 41-46.

https://doi.org/10.1016/j.paid.2014.12.044

Klusmann, H., Schulze, L., Engel, S., Bücklein, E., Daehn, D., Lozza-Fiacco, S., ... & Schumacher, S. (2022). HPA axis activity across the menstrual cycle-a systematic review and meta-analysis of longitudinal studies. *Frontiers in Neuroendocrinology*, *66*, 100998. https://doi.org/10.1016/j.yfrne.2022.100998

Lai, M. H. C. (2021). Composite reliability of multilevel data: It's about observed scores and construct meanings. *Psychological Methods, 26*(1), 90-102. https://doi.org/10.1037/met0000287

Lange-Smith, S., Cabot, J., Coffee, P., Gunnell, K., & Tod, D. (2023). The efficacy of psychological skills training for enhancing performance in sport: a review of reviews. *International Journal of Sport and Exercise Psychology*, 1-18. https://doi.org/10.1080/1612197X.2023.2168725

Lever, J. R., Murphy, A. P., Duffield, R., & Fullagar, H. H. (2021). A combined sleep hygiene and mindfulness intervention to improve sleep and well-being during high-performance youth tennis tournaments. *International Journal of Sports Physiology and Performance*, *16*(2), 250-258. https://doi.org/10.1123/ijspp.2019-1008

Lindsay, A., & Costello, J. T. (2017). Realising the potential of urine and saliva as diagnostic tools in sport and exercise medicine. *Sports Medicine*, *47*, 11-31. https://doi.org/10.1007/s40279-016-0558-1

Lindsay, E. K., & Creswell, J. D. (2019). Mindfulness, acceptance, and emotion regulation: Perspectives from Monitor and Acceptance Theory (MAT). *Current Opinion in Psychology*, *28*, 120-125. https://doi.org/10.1016/j.copsyc.2018.12.004

McKay, A. K., Stellingwerff, T., Smith, E. S., Martin, D. T., Mujika, I., Goosey-Tolfrey, V. L., ... & Burke, L. M. (2021). Defining training and performance caliber: a participant classification framework. *International Journal of Sports Physiology and Performance*, *17*(2), 317-331. https://doi.org/10.1123/ijspp.2021-0451

Mardon, N., Richards, H., & Martindale, A. (2016). The effect of mindfulness training on attention and performance in national-level swimmers: An exploratory investigation. *The Sport Psychologist*, *30*(2), 131-140. https://doi.org/10.1123/tsp.2014-0085

Mehrsafar, A. H., Strahler, J., Gazerani, P., Khabiri, M., Sánchez, J. C. J., Moosakhani, A., & Zadeh, A. M. (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

Mehta, P. D., & Neale, M. C. (2005). People are variables too: Multilevel structural equations modeling. *Psychological Methods, 10*(3), 259-284. https://doi.org/10.1037/1082-989X.10.3.259

Meland, A., Ishimatsu, K., Pensgaard, A. M., Wagstaff, A., Fonne, V., Garde, A. H., & Harris, A. (2015). Impact of mindfulness training on physiological measures of stress and objective measures of attention control in a military helicopter unit. *The International Journal of Aviation Psychology*, *25*(3-4), 191-208. https://doi.org/10.1080/10508414.2015.1162639

Moen, F., Abrahamsen, F., & Furrer, P. (2015). The effects from mindfulness training on Norwegian junior elite athletes in sport. *International Journal of Applied Sports Sciences*, *27*(2), 98-113. https://doi.org/10.24985/ijass.2015.27.2.98

Mohammed, W. A., Pappous, A., & Sharma, D. (2018). Effect of mindfulness based stress reduction (MBSR) in increasing pain tolerance and improving the mental health of injured athletes. *Frontiers in Psychology, 9*, 722. https://doi.org/10.3389/fpsyg.2018.00722

Muthén, B. O. (1994). Multilevel covariance structure analysis. *Sociological Methods & Research*, *22*(3), 376-398. https://doi.org/10.1177/0049124194022003

Muthén, L. K., & Muthén, B. O. (1998-2017). *Mplus user's guide* (Eighth). Muthén & Muthén. https://www.statmodel.com/HTML_UG/introV8.htm

Myall, K., Montero-Marin, J., Gorczynski, P., Kajee, N., Sheriff, R. S., Bernard, R., ... & Kuyken, W. (2023). Effect of mindfulness-based programmes on elite athlete mental health: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 57(2), 99-108.

http://dx.doi.org/10.1136/bjsports-2022-105596

Nezlek, J. (2020). Diary studies in social and personality psychology: An introduction with some recommendations and suggestions. *Social Psychological Bulletin*, *15*(2), 1-19. https://doi.org/10.32872/spb.2679

Nien, J. T., Gill, D. L., Ting-Yin, C., Liu, C. S., Geng, X., Hung, T. M., & Chang, Y. K. (2023). Effect of brief mindfulness and relaxation inductions on anxiety, affect and brain activation in athletes. *Psychology of Sport and Exercise*, 67, 102422. https://doi.org/10.1016/j.psychsport.2023.102422

O'Connor, E. J., Crozier, A. J., Murphy, A., & Immink, M. A. (2022). Dispositional mindfulness may have protected athletes from psychological distress during COVID-19 in Australia. *Perceptual and Motor Skills, 129*(3), 670-695. https://doi.org/10.1177/00315125221087523

Ohly, S., Sonnentag, S., Niessen, C., & Zapf, D. (2010). Diary studies in organizational research. *Journal of Personnel Psychology,* 9(2), 79-93. https://doi.org/10.1027/1866-5888/a000009

Pace-Schott, E. F., Amole, M. C., Aue, T., Balconi, M., Bylsma, L. M., Critchley, H., ... & VanElzakker, M. B. (2019). Physiological feelings. *Neuroscience & Biobehavioral Reviews*, *103*, 267-304. https://doi.org/10.1016/j.neubiorev.2019.05.002

Petterson, H., & Olson, B. L. (2017). Effects of mindfulness-based interventions in high school and college athletes for reducing stress and injury, and improving quality of life. *Journal of Sport Rehabilitation*, *26*(6), 578-587. https://doi.org/10.1123/jsr.2016-0047

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2016). Multilevel structural equation models for assessing moderation within and across levels of analysis. *Psychological Methods, 21*(2), 189-205. https://doi.org/10.1037/met0000052

Pritchard, B. T., Stanton, W., Lord, R., Petocz, P., & Pepping, G. J. (2017). Factors affecting measurement of salivary cortisol and secretory immunoglobulin A in field studies of athletes. *Frontiers in Endocrinology*, *8*, 168. https://doi.org/10.3389/fendo.2017.00168

Quaglia, J. T., Braun, S. E., Freeman, S. P., McDaniel, M. A., & Brown, K. W. (2016). Meta-analytic evidence for effects of mindfulness training on dimensions of self-reported dispositional mindfulness. *Psychological Assessment, 28*(7), 803-818. https://doi.org/10.1037/pas0000268

Rice, S. M., Purcell, R., De Silva, S., Mawren, D., McGorry, P. D., & Parker, A. G. (2016). The mental health of elite athletes: A narrative systematic review. *Sports Medicine*, *46*, 1333-1353. https://doi.org/10.1007/s40279-016-0492-2

Rist, B., & Pearce, A. J. (2019). Tiered levels of resting cortisol in an athletic population. A potential role for interpretation in biopsychosocial assessment?. *Journal of Functional Morphology and Kinesiology*, *4*(1), 8. https://doi.org/10.3390/jfmk4010008

Roeser, R. W., Schonert-Reichl, K. A., Jha, A., Cullen, M., Wallace, L., Wilensky, R., ... & Harrison, J. (2013). Mindfulness training and reductions in teacher stress and burnout: Results from two randomized, waitlist-control field trials. *Journal of educational psychology*, *105*(3), 787-804. https://doi.org/10.1037/a0032093

Röthlin, P., Horvath, S., & Birrer, D. (2016). Mindfulness promotes the ability to deliver performance in highly demanding situations. *Mindfulness*, *7*(3), 727-733. https://doi.org/10.1007/s12671-016-0512-1

Röthlin, P., Horvath, S., Messerli, T., Krieger, T., Berger, T., & Birrer, D. (2023). Associations of self-compassion with shame, guilt, and training motivation after sport-specific daily stress–a smartphone study. *International Journal of Sport and Exercise Psychology*, *21*(1), 90-101. https://doi.org/10.1080/1612197X.2021.2025134

Rumbold, J., Fletcher, D., & Daniels, K. (2020). An experience sampling study of organizational stress processes and future playing time in professional sport. *Journal of Sports Sciences*, *38*(5), 559-567. https://doi.org/10.1080/02640414.2020.1717302

Sauer, S., Walach, H., Offenbächer, M., Lynch, S., & Kohls, N. (2011). Measuring mindfulness: a

Rasch analysis of the Freiburg mindfulness inventory. *Religions*, *2*(4), 693-706. https://doi.org/10.3390/rel2040693

Saw, A. E., Main, L. C., & Gastin, P. B. (2016). Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: a systematic review. *British Journal of Sports Medicine*, *50*(5), 281-291. http://dx.doi.org/10.1136/bjsports-2015-094758

Shaabani, F., Naderi, A., Borella, E., & Calmeiro, L. (2020). Does a brief mindfulness intervention counteract the detrimental effects of ego depletion in basketball free throw under pressure? *Sport, Exercise, and Performance Psychology, 9*(2), 197-215. https://doi.org/10.1037/spy0000201

Shannon, S., Hanna, D., Leavey, G., Haughey, T., Neill, D., & Breslin, G. (2020). The association between mindfulness and mental health outcomes in athletes: testing the mediating role of autonomy satisfaction as a core psychological need. *International Journal of Sport and Exercise Psychology*, 1-16. https://doi.org/10.1080/1612197X.2020.1717578

Sinnott-O'Connor, C., Comyns, T. M., Nevill, A. M., & Warrington, G. D. (2018). Salivary biomarkers and training load during training and competition in Paralympic swimmers. *International Journal of Sports Physiology and Performance*, *13*(7), 839-843. https://doi.org/10.1123/ijspp.2017-0683

Stillman, M. A., Glick, I. D., McDuff, D., Reardon, C. L., Hitchcock, M. E., Fitch, V. M., & Hainline, B. (2019). Psychotherapy for mental health symptoms and disorders in elite athletes: a narrative review. *British Journal of Sports Medicine*, *53*(12), 767-771. http://dx.doi.org/10.1136/bjsports-2019-100654

Stone, A. A., Neale, J. M., & Shiftman, S. (1993). Daily assessments of stress and coping and their association with mood. *Annals of Behavioral Medicine*, *15*(1), 8-16. https://doi.org/10.1093/abm/15.1.8

Swann, C., Moran, A., & Piggott, D. (2015). Defining elite athletes: Issues in the study of expert performance in sport psychology. *Psychology of Sport and Exercise*, *16*, 3-14. http://dx.doi.org/10.1016/j.psychsport.2014.07.004

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment, 25*(4), 1286-1299. https://doi.org/10.1037/a0034044

Tebourski, K., Bernier, M., Ben Salha, M., Souissi, N., & Fournier, J. F. (2022). Effects of mindfulness for performance programme on actual performance in ecological sport context: Two studies in Basketball and Table Tennis. *International Journal of Environmental Research and Public Health*, *19*(19), 12950. https://doi.org/10.3390/ijerph191912950

Terry, P. C., Lane, A. M., & Fogarty, G. J. (2003). Construct validity of the Profile of Mood States-Adolescents for use with adults. *Psychology of Sport & Exercise, 4*, 125-139. https://doi.org/10.1016/S1469-0292(01)00035-8

Ullrich-French, S., Cox, A. E., & Huong, C. (2022). The State Mindfulness Scale for Physical Activity 2: Expanding the assessment of monitoring and acceptance. *Measurement in Physical Education and Exercise Science*, *26*(2), 116-129. https://doi.org/10.1080/1091367X.2021.1952207

Vieten, C., & Astin, J. (2008). Effects of a mindfulness-based intervention during pregnancy on prenatal stress and mood: results of a pilot study. *Archives of women's mental health*, *11*(1), 67-74. https://doi.org/10.1007/s00737-008-0214-3

White, R. G., Bethell, A., Charnock, L., Leckey, S., & Penpraze, V. (2021). Mindfulness-and acceptance-based interventions for performance and mental health outcomes in sport. In R. G., White, A., Bethell, L., Charnock, S., Leckey, & V., Penpraze (eds.) *Acceptance and commitment approaches for athletes' wellbeing and performance* (pp. 37-65). Palgrave Macmillan, Cham.

Yuan, K. H., & Bentler, P. M. (2007). Multilevel covariance structure analysis by fitting multiple single-level models. *Sociological methodology*, *37*(1), 53-82. https://doi.org/10.1111/j.1467-9531.2007.00182

Zhang, C.-Q., Chung, P. K., & Si, G. (2017). Assessing acceptance in mindfulness with direct-worded items: The development and initial validation of the athlete mindfulness questionnaire. *Journal of Sport and Health Science*, *6*(3), 311-320. https://doi.org/10.1016/j.jshs.2015.09.010

Zhang, C.-Q., Li, X., Chung, P. K., Huang, Z., Bu, D., Wang, D., ... & Si, G. (2021). The effects of mindfulness on athlete burnout, subjective well-being, and flourishing among elite athletes: A test of multiple mediators. *Mindfulness*, *12*(8), 1899-1908. https://doi.org/10.1007/s12671-021-01644-2

Zhang, C. Q., Li, X., Si, G., Chung, P. K., Huang, Z., & Gucciardi, D. F. (2023). Examining the roles of experiential avoidance and cognitive fusion on the effects from mindfulness to athlete burnout: A longitudinal study. *Psychology of Sport and Exercise*, *64*, 102341. https://doi.org/10.1016/j.psychsport.2022.102341

Zhang, C.-Q., Si, G., Chung, P. K., Du, M., & Terry, P. C. (2014). Psychometric properties of the Brunel Mood Scale in Chinese adolescents and adults. *Journal of Sports Sciences*, *32*(15), 1465-1476. https://doi.org/10.1080/02640414.2014.898184

Zhang, C.-Q., Si, G., Duan, Y., Lyu, Y., Keatley, D. A., & Chan, D. K. (2016). The effects of mindfulness training on beginners' skill acquisition in dart throwing: A randomized controlled trial. *Psychology of Sport and Exercise*, *22*, 279-285. https://doi.org/10.1016/j.psychsport.2015.09.005

Zhang, C.-Q., Zhang, R., Riddell, H., Dr, Shufang, Z., Pan, J., Wang, D., & Gucciardi, D. (2023, November 6). The Effects of Mindfulness on Daily Stress, Mood, and Self-Rated Athletic Performance among Elite Athletes: A Diary Study. Retrieved from osf.io/5a7vj

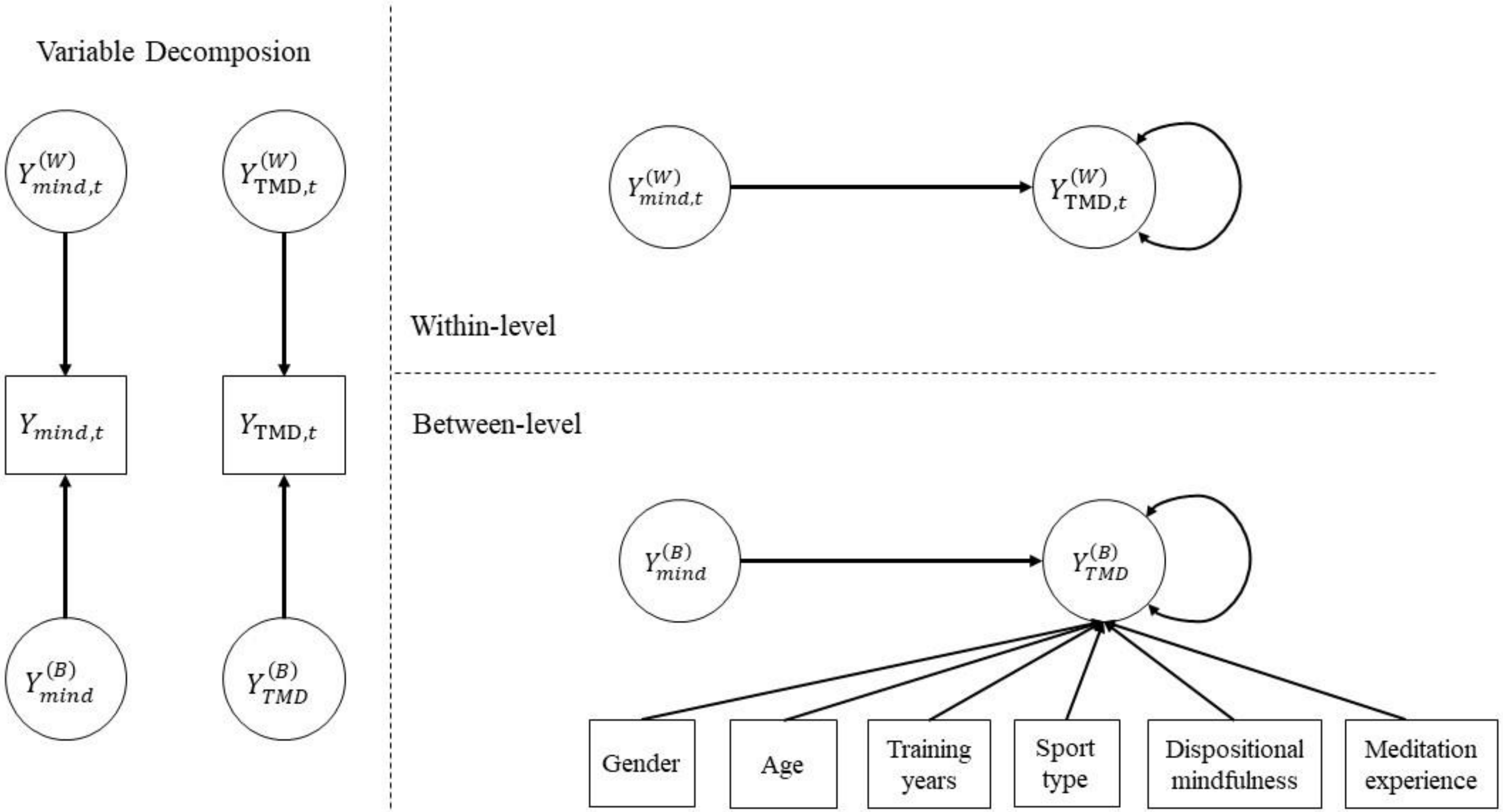

Figure 1. The multilevel structural equation model of the effects from mindfulness (*mind*) to total mood disturbance (*TMD*)

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Table 1.
Means, standard deviations (*SD*s), internal consistency reliabilities, ICCs, and correlations among key study variables among Chinese elite athletes (n = 78)

Variable	*Mean* ± *SD*	Reliability	ICC	Correlations				
				Mindfulness	TMD	Athletic performance	Cortisol	sIgA
Mindfulness (n = 2036) [a]	5.01±1.13	.911	.840	-	-.268	.863***	-.837***	-.833***
TMD (n = 2032)	.99±.53	.902 [b]	.547 [c]	-.464***	-	.086	-.151	-.191**
Athletic performance (n = 2036)	6.19±1.85	-	.989	.067**	-.056**	-	-.997***	-.988***
Cortisol (n = 2016)	919.33±243.94	-	.110	-.057**	.015	.002	-	.993***
sIgA (n = 2016)	19.31±5.28 [d]	-	.148	.030	-.031	.000	.212***	-

Note. TMD = total mood disturbance; ICC = intraclass correlation coefficient; sIgA = human secretory immunoglobulin A. Internal consistency reliability was the mean of scale reliabilities across 27 daily assessments. Within-person correlations are at the lower triangle and the between-person correlations are at the upper triangle.

**p < .01; ***p < .001.

[a] n is the total number of valid observation points;

[b] the internal consistency reliability of mood subscales: anger α = .888, confusion α = .854, depression α = .884, fatigue α = .867, tension α = .881, and vigor α = .903.

[c] for different dimensions of mood: anger ICC = .441, confusion ICC = .493, depression ICC = .408, fatigue ICC = .527, tension ICC = .507, and vigor ICC = .606.

[d] the units of Cortisol and ssIgA are nmol/L

Table 2.

Findings of the between-person and within-person effects of mindfulness on total mood disturbance, subdimensions of mood, self-rated athletic performance, sIgA, and cortisol among Chinese elite athletes (*n* = 78)

Model	Dependent Variable	Within-person effects			Between-person effects		
		Estimate	*SE*	95% *CI*	Estimate	*SE*	95% *CI*
Model 1							
	Total mood disturbance	-.454***	.039	[-.530, -.378]	-.610***	.101	[-.809, -.411]
Model 2							
	Anger	-.278***	.062	[-.399, -.157]	-.503***	.108	[-.715, -.291]
	Confusion	-.433***	.048	[-.527, -.339]	-.702***	.096	[-.891, -.514]
	Depression	-.375***	.035	[-.444, -.306]	-.561***	.118	[-.792, -.330]
	Fatigue	-.296***	.032	[-.358, -.233]	-.327*	.144	[-.608, -.045]
	Tension	-.306***	.041	[-.386, -.226]	-.523**	.123	[-.764, -.281]
	Vigor	.205***	.046	[.114, .296]	.195	.103	[-.007, .397]
Model 3							
	Athletic performance	.426***	.052	[.325, .527]	.415***	.101	[.217, .614]
Model 4							
	sIgA	.043*	.019	[.006, .081]	-.096	.312	[-.707, .515]
Model 5							
	Cortisol	-.028	.022	[-.072, .015]	-.113	.258	[-.619, .393]

Note. sIgA = human secretory immunoglobulin A. *SE* = standardized error; *CI* = confidence interval; Total mood disturbance = total scores of five negative dimensions of mood minus vigor. For all models, the independent variable was mindfulness with age, gender, years of training, and regions controlled. *Estimate* = standardized regression coefficients.

*p < .05; **p < .01; ***p < .001.

Online Supplementary File

Table S1.

The 5-item Mindful Attention Awareness Scale (MAAS) – State for Sports

Instruction: On the scale of 0 to 6, please indicate the degree to which you had each of these experiences **during your training today**. Please answer in terms of your actual experience and not what you think it should be.

Items	
1	I find it difficult to stay focused on today's training sessions. 我发现自己很难保持专注在今天的训练上。
2	I did not concentrate on training. 我训练不专心。
3	I was preoccupied with the future or the past. 我沉浸在将来或过去的事上。
4	I was training automatically, without being aware of what I was doing. 我刚才自动化地训练，没有意识到当时正在做什么。
5	I was rushing through training without being really attentive to it. 我仓促地完成训练，没有真正留心于训练。

Note.

Items are rated on a 7-point Likert rating scale from 0 (*not at all*) to 6 (*very much*).

Table *S2*.
Composite reliabilities of the Brunel Mood Scale (BRUMS) and Mindful Attention Awareness Scale (MAAS) – State at the within-person and between-person levels.

Scales and subscales	Composite Reliability			Within-person Level			Between-person level		
	Omega	95%*CI*		Omega	95%*CI*		Omega	95%*CI*	
		LL	*UL*		*LL*	*UL*		*LL*	*UL*
BRUMS									
Anger	.900	.882	.913	.836	.823	.847	.939	.910	.954
Confusion	.859	.832	.879	.760	.742	.777	.932	.899	.950
Depression	.882	.864	.897	.852	.841	.862	.878	.817	.911
Fatigue	.898	.877	.914	.835	.823	.846	.925	.890	.944
Tension	.893	.872	.909	.808	.794	.821	.944	.917	.958
Vigor	.911	.889	.926	.789	.773	.805	.968	.953	.976
MAAS-state	.913	.894	.927	.873	.864	.882	.918	.881	.939

Note. CI = confidence intervals; LL = lower limit; UL = upper limit.

Table S3.
Model fit indices on models of mindfulness on total mood disturbance, subdimensions of mood, self-rated athletic performance, sIgA, and cortisol among Chinese elite athletes (n = 78)

Model	χ^2	*df*	*p*	CFI	TLI	RMSEA	SRMR	
							Within-person	Between-person
Model 1: Total mood disturbance	16.109	6	.013	.974	.930	.029	.000	.087
Model 2: Dimensions of mood	16.112	6	.013	.996	.946	.029	.000	.077
Model 3: Athletic performance	16.108	6	.013	.973	.927	.029	.000	.082
Model 4: sIgA	18.335	6	.005	.891	.710	.032	.001	.088
Model 5: Cortisol	14.478	6	.025	.941	.844	.026	.000	.102

Note. sIgA = human secretory immunoglobulin A. χ^2 = chi-square; *df* = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

Table S4.
Effects from demographic variables and dispositional mindfulness to outcome variables at the between-person level (*n* = 78)

Model	Dependent variable	Gender	Age	Years of training	Sport type	Dispositional mindfulness	Meditation experience
Model 1							
	Total mood disturbance	-.089	-.213*	.217*	-.346***	-.212*	.068
Model 2							
	Anger	.143	-.346**	-.006	-.193*	-.139	.244*
	Confusion	-.001	-.040	.034	-.192	-.077	.044
	Depression	.082	-.439***	.155	-.232*	-.110	.174
	Fatigue	.037	-.035	.082	-.341*	-.163	-.033
	Tension	-.056	-.322**	.276*	-.314*	-.160	.056
	Vigor	.462***	-.074	-.346**	.195	.223	.075
Model 3							
	Athletic performance	.172	-.009	-.308**	.077	.444***	.165
Model 4							
	sIgA	-.087	.907	-.806	.466	.357	-.215
Model 5							
	Cortisol	-.266	.384	-.635	.663***	.499**	-.373

Note. *: p<0.05; **: p<0.01; ***: p<0.001