The Association between Trait Mindfulness and Mental Fatigue-Related Neurocognitive Function and Endurance Performance in Athletes

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Aim

The present study aims to examine whether trait mindfulness in athletes is associated with impairments in neurocognitive function and endurance performance resulting from mental fatigue. It was hypothesized that following the mental fatigue manipulation, athletes with higher trait mindfulness would exhibit fewer impairments in neurocognitive function and endurance performance, report lower mental fatigue, higher task motivation and fewer mood disturbances. Furthermore, it was hypothesized that athletes with higher trait mindfulness would exhibit superior neurocognitive function and endurance performance across both experimental sessions.

Methods

Design and Sample

The participants visited the lab on two counterbalanced order occasions to complete either an incongruent version Stroop task (mental fatigue condition, MF) or a congruent version Stroop task (control condition, CON) for 30 minutes to induce the mental fatigue state. Ninety athletes aged 18 to 25 years were recruited and categorized into higher trait mindfulness (HM, n = 27), intermediate trait mindfulness (IM, n = 35), and lower trait mindfulness (LM, n = 28).

Procedure

Participants completed the two sessions using a counterbalanced design, in which the Stroop task was administered for MF and a CON. Following Stroop task, behavioral and neuroelectric outcomes of neurocognitive function were measured using Flanker task with electroencephalography recording. Endurance performance outcomes were measured using the graded exercise test. Task motivation and mood states were assessed as secondary outcome.

Statistical Analysis Plan

The Statistical Package for the Social Sciences for mac version 26 (SPSS Inc., Chicago, IL, USA) was used to conduct all statistical analyses. All data are presented as means with standard errors of the mean ($M \pm SEM$). No missing data were identified. Initial data screening identified eight univariate outliers exceeding ± 3.29 standard deviations from the mean. These outliers were adjusted by assigning a value one unit above or below the next most extreme value in the distribution. Data distribution was ascertained using Kolmogorov-Smirnov's test, and Greenhouse-Geisser correction was applied when the assumption of sphericity was violated. To test for group differences in baseline characteristics, a one-way analysis of variance (ANOVA) was utilized for continuous variables, whereas a chi-square test was used for categorical variables.

For the manipulation check, a mixed-design 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) × 3 (Assessment Time: T0 vs. T1 vs. T2) ANOVA was used to examine changes in subjective mental fatigue (i.e., VAS-MF) among the three mindfulness levels following the experimental manipulation and Flanker task. Additionally, another mixed-design 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) × 5 (Block: B1, B2, B3, B4, B5) ANOVA was conducted to compare changes in objective mental fatigue (i.e., SCWT accuracy) across Stroop blocks among the three mindfulness levels.

For the neurocognitive function, multiple mixed-design 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) × 2 (Congruency: congruent vs. incongruent) ANOVAs were conducted separately to examine the difference in behavioral outcomes (i.e., reaction time and accuracy) and neuroelectric outcomes (i.e., the averaged mean amplitudes for N2 and P3) in Flanker task among the three mindfulness levels following the experimental manipulation.

For the endurance performance, separate mixed-design 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) ANOVAs were conducted to examine the difference in TTE and VO_2peak in GXT. Given that person-situation fit may influence the effects of mental fatigue, sport discipline was included as a covariate in the endurance performance analyses, dummy coded into six categories to contro NCT05466136 l for its potential impact. Finally, a mixed-design 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) ANOVA was conducted to examine the difference in task motivation (i.e., VAS-M) during Flanker task and GXT among the three mindfulness levels.

For the mood state, a mixed 3 (Mindfulness Level: HM vs. IM vs. LM) × 2 (Manipulation: MF vs. CON) × 2 (Assessment Time: T0 vs. T1) ANOVAs were conducted to examine the changes in BRUMS subscales among the three mindfulness levels following the experimental manipulation. All statistical analyses were conducted with $\alpha = 0.05$. The Bonferroni correction for multiple comparisons was applied when main effects and interactions were significant, and partial eta-squared (η^2_p) was reported as an estimate of effect size in all ANOVA analyses.

Abbreviations: HM = higher trait mindfulness; IM = intermediate trait mindfulness; LM = lower trait mindfulness; MF = mental fatigue session; CON = control session; T0 = baseline; T1 = after manipulation; T2 = after Flanker task; VAS-MF = visual analogue scale for subjective mental fatigue; B1-B5 = block 1 to block 5; SCWT = Stroop Color and Word Test; VAS-M = visual analogue scale for motivation; GXT = graded exercise test; TTE = time to exhaustion.