RESEARCH ARTICLE
OPEN ACCESS

REVISTA RIICS
Investigación e innovación en ciencias de la salud

Are Mindfulness and Sleep Predictors of Cognitive Fatigue in Student Athletes?

¿Son la atención plena y el sueño predictores de la fatiga cognitiva en los estudiantes deportistas?

Mehmet Ali Uzgu[1], **Emre Ozan Tingaz**[2]

[1] *Institute of Health Sciences; Gazi University; Ankara; Turkey.*

[2] *Faculty of Sport Sciences; Gazi University; Ankara; Turkey.*

Correspondence
Emre Ozan Tingaz.
Email: emreozan@gazi.edu.tr

Cite like this
Uzgu MA, Tingaz EO. Are Mindfulness and Sleep Predictors of Cognitive Fatigue in Student Athletes. Revista de Investigación e Innovación en Ciencias de la Salud. 2025;7(1):1-13. e-v7n1a313. https://doi.org/10.46634/riics.313

Received: 04/15/2024
Revised: 05/02/2024
Accepted: 06/03/2024

Editor:
Fraidy-Alonso Alzate-Pamplona, MSc.

Declaration of interests
The authors have declared that there is no conflict of interest.

Data availability
All relevant data is in the article. For futher information, contact the corresponding author.

Abstract

Introduction. Cognitive fatigue is crucial for student-athletes who have the task of both fulfilling their academic tasks and ensuring their athletic performance. Therefore, it is essential to explore the predictors of cognitive fatigue in student-athletes.

Objective. This study aimed to examine mindfulness and sleep behavior as predictors of cognitive fatigue in student athletes.

Method. A total of 144 student-athletes (40.3% male, 59.7% female, M age = 20.7, SD = 3.13) with a mean sports experience of 9.03 years (SD = 3.75) were included in the study. The Mindfulness for Sport Inventory (MIS), the Athlete Sleep Behavior Questionnaire (ASBQ), and the cognitive fatigue part of the Scale of Physical and Cognitive Fatigue Perceived (SPCFP) were used as data collection tools.

Results. Cognitive fatigue was negatively associated with mindfulness while positively associated with poor sleep behavior. In addition, mindfulness and sleep were significant predictors of cognitive fatigue.

Conclusion. Mindfulness and sleep should be taken into consideration to reduce cognitive fatigue in student-athletes.

Keywords
Cognition; mental fatigue; sleep; sport; poor sleep behavior.

Resumen

Introducción. La fatiga cognitiva es crucial para los estudiantes deportistas que deben cumplir con sus tareas académicas y asegurar su rendimiento deportivo. Por lo tanto, es esencial explorar los predictores de la fatiga cognitiva en los estudiantes deportistas.

Financing
None. The author received no specific funding for this work.

Statement of Responsibility
The content of this article is the sole responsibility of the authors and does not reflect the official position of their institution, funder, or the *Revista de Investigación e Innovación en Ciencias de la Salud*.

Contribution of the authors
Mehmet Ali Uzgu: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, resources, software, validation, visualization, writing – original draft, writing – review & editing.
Emre Ozan Tingaz: Funding acquisition, project administration, supervision.

Objetivo. Este estudio tenía como objetivo examinar la atención plena y el comportamiento del sueño como predictores de la fatiga cognitiva en estudiantes deportistas.

Método. Un total de 144 estudiantes depotistas (40,3% hombres, 59,7% mujeres, M edad = 20,7, SD = 3,13) con una experiencia deportiva media de 9,03 años (SD = 3,75) se incluyeron en el estudio. Se utilizaron como herramientas de recolección de datos el Inventario de Mindfulness para el Deporte (MIS), el Cuestionario de Conducta del Sueño del Atleta (ASBQ) y la parte de Fatiga Cognitiva de la Escala de Fatiga Física y Cognitiva Percibida (SPCFP).

Resultados. La fatiga cognitiva se asoció negativamente con la atención plena, mientras que se asoció positivamente con un comportamiento de sueño deficiente. Además, la atención plena y el sueño fueron predictores significativos de la fatiga cognitiva.

Conclusión. La atención plena y el sueño deben tenerse en cuenta para reducir la fatiga cognitiva en los estudiantes deportistas.

Palabras clave
Cognición; fatiga mental; sueño; deporte; mal comportamiento durante el sueño.

Introduction

Cognitive fatigue, characterized by a decline in cognitive performance, is a state of mental fatigue and reluctance resulting from prolonged cognitive activities [1-4]. It negatively impacts cognitive functions and diminishes physical performance [4-8]. In a systematic review study conducted by Sun et al. [9], which explored the effects of mental fatigue on skill performance among athletes, the authors concluded that mental fatigue detrimentally affects various sports skills, including high-level athletes' technical and decision-making abilities. Furthermore, another study examined the impact of cognitive fatigue on passing decision-making in professional soccer players, concluding that mental fatigue influences the passing decisions of soccer players during matches [10]. Cognitive fatigue is particularly significant for student-athletes who juggle academic responsibilities with their sporting careers.

Mindfulness and sleep are two critical factors influencing cognitive performance. Mindfulness, characterized by focusing on the present moment and non-judgmental awareness, diminishes mind wandering and cognitive stress while enhancing mental flexibility and psychological well-being [11-15]. Amishi et al. [16] investigated the effects of mindfulness training on working memory capacity and affective experience, concluding that adequate mindfulness training can mitigate functional impairments associated with high-stress contexts. Another study on athletes as a quasi-experimental intervention found that mindfulness practices improve attention levels [17]. Considering these mechanisms of action, we expect that mindfulness has a predictive effect on cognitive fatigue. Similarly, sleep is essential for restoring and rejuvenating cognitive functions. Sleep is of fundamental importance for the mental and physical health of individuals. Numerous studies have demonstrated that poor sleep habits diminish cognitive performance by affecting attention, concentration, memory, and mental flexibility [18,19]. In their study on athletes, Vitale et al. [20] reported that sleep deprivation impairs cognitive functions such as judgment and decision-making. Given these effects, we propose that sleep behavior has a predictive impact on cognitive fatigue.

Our research aimed to examine the predictive role of mindfulness and sleep behavior on cognitive fatigue in student athletes. We also revealed the relationships between cognitive fatigue, mindfulness, and sleep behavior. The current study is important in helping to determine the extent to which mindfulness and sleep regulations effectively improve athletes' performance and reduce cognitive fatigue. In addition, this study could contribute to research in the field of sport psychology and cognitive psychology to develop new strategies for understanding and managing the effects of cognitive fatigue within sports.

Methods

Participants

This cross-sectional study was conducted at the Faculty of Sport Sciences at Gazi University and Selcuk University. To ensure a diverse representation within the sample group, participants were selected using a sampling method supplemented with snowball sampling. The student-athletes reached out through convenience sampling and were asked to share the link to the scale with their student-athlete friends. The inclusion criteria included in the study were as follows: being an active athlete, not currently taking psychiatric medication, not participating in psychotherapy, and not having significant sleep disorders.

The G*Power 3.1 program was used to determine the sample size [21]. Based on findings in the literature, effect size criteria for use in the power analysis were determined. Howell et al. [22] reported a positive correlation between sleep quality and mindfulness ($r = .41$, $p = 0.001$). Byun et al. [23] showed a negative correlation between sleep quality and cognitive problems ($r = -.37$, $p = 0.001$). Zhang et al. [24] also reported a negative correlation between mindfulness and perceived fatigue ($r = - .49$, $p = 0.01$). Relationship coefficients of .10 indicate a small effect size, .30 a moderate effect size, and .50 a large effect size [25]. Accordingly, considering that the values of .41, -.37, and -.49 fall within the moderate effect size range, a sample size capable of providing a moderate effect size for positive correlations (.30) and negative correlations (-.30) was considered. With an effect size of .30, a margin of error of .05, and 95% power, the number of participants for the correlation test was calculated to be 138, and the number of participants for the regression test was 56. To account for a potential 10% missing or invalid response rate, the target sample size was calculated using Patel and Rowe's formula [26]. With this calculation, it was revealed that a minimum of 154 data should be reached.

In total, 202 university student-athletes who were competing in different branches of Turkey in 2024 were identified. Fifty-eight individuals were excluded from the study because they did not meet the study criteria and/or provided missing scales. Thus, a final sample of 144 student-athletes (40.3% male, 59.7% female, M age = 20.7, SD = 3.13) with a mean sports experience of 9.03 years (SD = 3.75) was included in the analysis.

Measurements

All participants responded to the demographics, mindfulness inventory for sport, cognitive fatigue part of the Scale of Physical and Cognitive Fatigue Perceived, and the Athlete Sleep Behavior Questionnaire**.** The measurements were collected manually and through Google Forms. There was no time interval between measurements. Before their involvement, all participants provided informed consent. The participants were assured of the confidentiality of their responses and their right to withdraw from the study at any time without consequence. Ethical approval for this research was obtained from the Ethics Committee of Gazi University (Approval No: E-77082166-604.01.02-824995).

Demographics

The participants were asked to complete a personal information form. This form included questions about age, gender, athlete license status, years of involvement in sports, sports discipline, university, department, and class, any diagnosed sleep-related disorders, information about psychotherapeutic support, and psychiatric medication usage. During the data collection phase, we took special care to distribute the scales to participants in different orders, aiming to mitigate the primacy-recency effect. Control questions were added between the scales (e.g., "We are currently in 2019").

The Mindfulness Inventory for Sport (MIS)

The Athlete Mindfulness Scale, originally developed by Thienot et al. [27] and subsequently adapted into Turkish by Tingaz [28], comprises 15 items distributed across three subdimensions: mindfulness, nonjudgment, and refocusing. The respondents rated each item on a 6-point Likert scale ranging from 1 (almost never) to 6 (almost always). Tingaz [28] reported internal consistency coefficients using Cronbach's alpha, indicating a high level of reliability for the overall inventory ($\alpha = 0.82$). The subdimensions also demonstrated satisfactory internal consistency, with values for awareness ($\alpha = 0.81$), nonjudgment ($\alpha = 0.70$), and refocusing ($\alpha = 0.77$). To assess the scale's stability over time, Tingaz [28] reported a robust test-retest correlation coefficient of $r = 0.89$ for the overall inventory. The subdimensions also exhibited respectable test-retest correlations, with values for awareness ($r = 0.72$), nonjudgment ($r=0.77$), and refocusing ($r = 0.96$). As a result, the scale was found to be reliable and valid. The higher the scores obtained from the scale are, the greater the mindfulness level; the lower the scores are, the lower the level of mindfulness [28]. The Cronbach's alpha reliability coefficient for the recent study was 0.88.

The Scale of Physical and Cognitive Fatigue Perceived (SPCFP)

The Scale of Physical and Cognitive Fatigue Perceived (SPCFP), developed by Tekkurşun Demir et al. [29], aimed to determine the perceived physical and cognitive fatigue of athletes. The scale consists of a total of 19 items and two dimensions: perceived physical fatigue and perceived cognitive fatigue. Participants score between 19 and 95 points. They expressed their experiences using a five-point Likert scale (1: strongly disagree, 5: strongly agree). The Cronbach's alpha coefficients were .77 for perceived physical fatigue, .82 for perceived cognitive fatigue, and .80 for the total SPCFP. Since the cognitive fatigue of the participants was examined in our study, items belonging to the "perceived cognitive fatigue" subdimension of the SPCFP (items 9 to 19) were used. In our study, the Cronbach's alpha coefficient was found to be .91.

The Athlete Sleep Behavior Questionnaire (ASBQ)

The Athlete Sleep Behavior Questionnaire (ASBQ) developed by Driller et al. [30] to determine the sleep behaviors of athletes was adapted into Turkish by Darendeli et al. [31]. The 17-item scale consists of 4 subdimensions: sport-related factors, sleep quality factors, habitual sleep efficiency factors, and sleep disturbance factors. Participants expressed their experiences using a five-point Likert scale (1: never, 5: always). Darendeli et al. [31] reported that the reliability of the scale was acceptable (ICC = 0.85, r = 74, CV = 5.6). The total Cronbach's alpha reliability coefficient of the scale was .62, that of sport-related factors was .89, that of sleep quality factors was .78, that of habitual sleep efficiency factors was .87, and that of sleep disturbance factors was .67. For the 17-item ASBQ-TR, it has been suggested that a total score ≤ 34 indicates 'good sleep behavior' and ≥ 40 indicates 'poor sleep behavior' [31]. The Cronbach's alpha reliability coefficient in our study was 0.75.

Data Analysis

We used the Jamovi (version 2.3.28) program for the data analysis. 58 of the 202 student-athletes were excluded from the study due to missing, invalid, or noncriteria data, and the analysis was performed with the remaining 144 athletes. First, the scales with invalid or missing responses were excluded from the analysis. Subsequently, the kurtosis and skewness values of all scale items were assessed to ensure the normal distribution of the data, with values falling within the range of ±2.00 for all items, as recommended by George and Mallery [32]. Following this, the Shapiro-Wilk test was conducted to verify the assumptions for multiple regression analysis, yielding a p-value of 0.098, which indicated a normal distribution. Additionally, the Durbin-Watson test was performed to examine autocorrelation, resulting in a DW statistic of 2.03 with a p-value of 0.924, a value that suggested no significant autocorrelation. Collinearity diagnostics were conducted, revealing a variance inflation factor (VIF) of 1, which indicated no issues with multicollinearity. Consequently, the data met the assumptions for regression analysis. Pearson correlation analysis was utilized to examine the relationships between cognitive fatigue, mindfulness, sleep, and their subdimensions. Subsequently, multiple regression analysis was employed to ascertain the predictive value of these variables.

Linguistic revisions were conducted in collaboration with an artificial intelligence (AI) language model. The manuscript underwent automated linguistic analysis and revisions using the AI tool to ensure linguistic appropriateness. This process involved examining various linguistic aspects, including grammar and syntax, with the assistance of ChatGPT 3.5. The revisions were integrated into the manuscript to enhance its clarity and coherence.

Results

Relationships among Cognitive Fatigue, Mindfulness, and Sleep Behavior

Using the Pearson correlation, we examined the relationships between cognitive fatigue, mindfulness, and sleep behavior among student-athletes. Table 1 presents the correlations between cognitive fatigue, mindfulness, sleep behavior, and their subdimensions.

Cognitive fatigue was negatively correlated with mindfulness ($r = -0.384$; $p < .001$). Regarding the subdimensions of mindfulness, cognitive fatigue was negatively correlated with both nonjudgment ($r = -0.325$; $p < .001$) and refocusing ($r = -0.178$; $p < .05$). However, there was no significant correlation between cognitive fatigue and awareness ($r = -0.108$; $p > .05$).

Cognitive fatigue was positively correlated with poor sleep behavior ($r = 0.340$; $p < .001$). For the subdimensions of sleep behavior, cognitive fatigue was positively correlated with sport-related factors ($r = 0.239$; $p < .05$), sleep quality ($r = 0.271$; $p < .001$), and sleep efficiency ($r = 0.313$; $p < .001$). Interestingly, no significant correlation was found between cognitive fatigue and sleep disturbance ($r = 0.148$; $p > .05$).

Predictors of Cognitive Fatigue: Regression Analysis

Multiple regression analysis was conducted to explore whether mindfulness and sleep behavior predict cognitive fatigue among university student-athletes. The results, presented in Table 2 and Table 3, revealed significant predictors of cognitive fatigue.

Table 1. Correlation Matrix.

		1	2	3	4	5	6	7	8	9
1. Cognitive Fatigue	r	-								
	df	-								
	p	-								
2. MIS Total	r	-0.384***	-							
	df	142	-							
	p	.000	-							
3. Awareness	r	-0.108	0.661***	-						
	df	142	142	-						
	p	0.199	.000	-						
4. Non-Judgment	r	-0.325***	0.261**	-0.436***	-					
	df	142	142	142	-					
	p	.000	0.002	.000	-					
5. Refocusing	r	-0.178*	0.772***	0.674***	-0.288***	-				
	df	142	142	142	142	-				
	p	0.033	.000	.000	.000	-				
6. ASBQ Total	r	0.340***	-0.009	0.153	-0.312***	0.197*	-			
	df	142	142	142	142	142	-			
	p	.000	0.916	0.068	.000	0.018	-			
7. Sport Related	r	0.239**	0.100	0.182*	-0.271**	0.307***	0.760***	-		
	df	142	142	142	142	142	142	-		
	p	0.004	0.233	0.029	0.001	.000	.000	-		
8. Sleep Quality	r	0.271***	0.011	0.189*	-0.330***	0.217**	0.811***	0.501***	-	
	df	142	142	142	142	142	142	142	-	
	p	.000	0.897	0.023	.000	0.009	.000	.000	-	
9. Efficiency	r	0.313***	0.006	0.155	-0.198*	0.089	0.780***	0.386***	0.568***	-
	df	142	142	142	142	142	142	142	142	-
	p	.000	0.946	0.063	0.017	0.289	.000	.000	.000	-
10. Disturbance	r	0.148	-0.213*	-0.161	-0.049	-0.153	0.492***	0.105	0.194*	0.338***
	df	142	142	142	142	142	142	142	142	142
	p	0.077	0.010	0.054	0.561	0.067	.000	0.209	0.020	.000

Note. * $p < .05$, ** $p < .01$, *** $p < .001$, N = 144, MIS: Mindfulness for Sport Inventory, ASBQ: Athlete Sleep Behavior Questionnaire. For the ASBQ and its subdimensions, higher scores indicate poorer sleep behavior.

Model 1 showed moderate fit with an R^2 of 0.116, indicating that 11.6% of the variance in cognitive fatigue was explained by sleep behavior alone. Model 2, which included both sleep behavior and mindfulness, demonstrated improved model fit, with an R^2 of 0.261. This suggests that 26.1% of the variance in cognitive fatigue was explained by the combined influence of sleep behavior and mindfulness (Table 2). The ΔR^2 of 0.145 and the significant F-statistic ($F = 27.7$, $p < .001$) demonstrate that the addition of mindfulness to the model significantly increased its explanatory power compared to the model with sleep behavior alone (Table 2).

Table 2. Model Fit Measures for Multiple Regression.

Model Fit Measures – Cognitive Fatigue						
Model	**R**	**R^2**				
ASBQ (1)	0.340	0.116				
MIS (2)	0.511	0.261				
Model Comparisons						
Comparison						
Model	**Model**	**ΔR^2**	**F**	**df1**	**df2**	**p**
1	2	0.145	27.7	1	141	<.001

Note. ASBQ: Athlete Sleep Behavior Questionnaire, MIS: The Mindfulness Inventory for Sports.

The standardized estimate of 0.337 (95% CI: 0.194, 0.480) indicates that poorer sleep behavior positively predicts cognitive fatigue among student-athletes (Table 3). Conversely, the standardized estimate of -0.381 (95% CI: -0.524, -0.238) suggests that higher levels of mindfulness negatively predict cognitive fatigue. In other words, student-athletes with greater mindfulness tend to experience lower levels of cognitive fatigue (Table 3).

Table 3. Multiple Regression Results.

Model Coefficients – Cognitive Fatigue									
			95% Confidence Interval					**95% Confidence Interval**	
Predictor	**Estimate**	**SE**	**Lower**	**Upper**	**t**	**p**	**Stand. Estimate**	**Lower**	**Upper**
Intercept	3.163	0.530	2.117	4.210	5.97	<.001			
ASBQ	0.565	0.121	0.325	0.805	4.65	<.001	0.337	0.194	0.480
MIS	-0.563	0.107	-0.775	-0.351	-5.26	<.001	-0.381	-0.524	-0.238

Note. MIS: The Mindfulness Inventory for Sports, ASBQ: Athlete Sleep Behavior Questionnaire.

Discussion

We investigated the correlation between cognitive fatigue, mindfulness, and sleep behavior, as well as the predictive effects of mindfulness and sleep patterns on cognitive fatigue. Our findings revealed a negative correlation between cognitive fatigue and mindfulness, indicating that higher levels of mindfulness were associated with lower levels of cognitive fatigue. Specifically, cognitive fatigue showed negative correlations with both nonjudgment and refocusing, two subdimensions of mindfulness. These results are consistent with previous studies [33,34], which also reported a negative correlation between mindfulness and cognitive fatigue. In a study by Zhu et al. [35], the acute effects of mindfulness-based intervention (MBI) on mental fatigue were examined in athletes, with results indicating a reduction in mental fatigue levels following MBI. Similarly, Zadkhosh et al. [36] investigated the impact of Mindfulness-Based Cognitive Therapy on cognitive skills in athletes, observing an improvement in cognitive skills. These findings align with the theoretical foundations of mindfulness. The attentional control theory of Derakshan and Eysenck [37] provides a theoretical framework for understanding the mechanisms through which mindfulness may mitigate cognitive fatigue. According to this theory, cognitive fatigue arises from the depletion of cognitive control resources required for tasks involving sustained attention. By enhancing attentional control and cognitive flexibility, mindfulness may replenish cognitive resources and prevent their depletion, thereby reducing cognitive fatigue. Additionally, the self-awareness, self-regulation, and transcendence (S-ART) model proposed by Vago and Silbersweig [38] suggests that mindfulness practices cultivate self-awareness and self-regulation, thereby modulating cognitive processes related to fatigue. By increasing awareness of cognitive states and emotions, individuals can better regulate their cognitive resources and prevent cognitive fatigue.

Cognitive fatigue was positively correlated with poor sleep behavior, suggesting that higher levels of cognitive fatigue were related to worse sleep behavior. For the subdimensions of sleep behavior, cognitive fatigue was positively correlated with sport-related factors, sleep quality, and sleep efficiency, indicating that higher levels of cognitive fatigue were related to poorer sleep quality and efficiency. This was not surprising, as there are many findings that indicate poor sleep behavior is related to cognitive functions [23,39-45].

Surprisingly, our study did not find a significant correlation between cognitive fatigue and sleep disturbance, contrary to findings in other populations [46,47]. This discrepancy may be attributed to the unique stressors and demands inherent in the student-athlete population, which may modulate the relationship between sleep disturbance and cognitive fatigue. Additionally, the absence of a direct correlation underscores the multifactorial nature of cognitive fatigue, implicating the presence of mediating variables or moderating factors that warrant further exploration.

The initial model, focusing solely on sleep behavior, elucidated a noteworthy but partial understanding of cognitive fatigue, explaining 11.6% of its variance. This underscores the substantial influence of sleep on cognitive functioning among student-athletes. Consistent with previous research [48,49], poorer sleep behavior was found to reduce cognitive performance. This underscores the critical importance of sleep in mitigating cognitive fatigue and optimizing psychological performance, which expands upon this model by incorporating mindfulness yielded compelling results. The augmented model, encompassing both sleep behavior and mindfulness, exhibited a substantial enhancement in explanatory power, explaining 26.1% of the variance in cognitive fatigue. This highlights the complementary nature of mindfulness in conjunction with sleep behavior in influencing cognitive well-being among student-athletes.

The substantial increase in R^2 and the significant F-statistic corroborate the pivotal role of mindfulness in bolstering the predictive accuracy of the model. The observed difference in R-squared of 0.145 underscores the unique contribution of mindfulness above and beyond sleep behavior alone, signifying its potential as a targeted intervention avenue. Notably, the standardized estimates provided further granularity to the predictive relationships within the model. Consistent with theoretical expectations [50], higher levels of mindfulness were associated with diminished cognitive fatigue, as evidenced by the negative standardized estimate. This underscores the complementary relationship between mindfulness and sleep behavior in shaping cognitive fatigue among university student-athletes. Conversely, the positive standardized estimate for sleep behavior reaffirms its detrimental impact on cognitive fatigue, emphasizing the need for comprehensive sleep interventions tailored to the unique demands of student-athletes.

In sum, the findings underscore the interdependent roles of mindfulness and sleep behavior in shaping cognitive fatigue among university student-athletes. Interventions targeting both domains hold promise in optimizing cognitive well-being, thereby fostering holistic approaches to student-athlete welfare.

Limitations

Our research has several limitations. Our study has a cross-sectional design. This design limits the possibility of capturing changes over time and shows that correlational relationships are correlational rather than causal. Furthermore, the fact that the study was conducted only in public universities limits the generalisability of the results and suggests that there may be different results among students in private universities or in different geographical regions. The fact that sleep and cognitive fatigue were assessed indirectly through the scales used to measure sleep and cognitive fatigue may also not have provided a complete picture of participants' actual sleep habits and cognitive status. These limitations should be considered in future research to ensure that more comprehensive methods are adopted and that the results are evaluated in a wider context.

Conclusions

As a result of this study, mindfulness and sleep should be considered to reduce cognitive fatigue in student-athletes.

References

1. Hockey R. The psychology of fatigue: Work, effort and control. New York: Cambridge University Press; 2013. 290 p.
2. Marcora SM, Staiano W, Manning V. Mental fatigue impairs physical performance in humans. J Appl Physiol (1985) [Internet]. 2009;106(3):857-64. doi: https://doi.org/10.1152/japplphysiol.91324.2008
3. Boksem MA, Meijman TF, Lorist MM. Effects of mental fatigue on attention: an ERP study. Brain Res Cogn Brain Res [Internet]. 2005;25(1):107-16. doi: https://doi.org/10.1016/j.cogbrainres.2005.04.011
4. Yuan R, Sun H, Soh KG, Mohammadi A, Toumi Z, Zhang Z. The effects of mental fatigue on sport-specific motor performance among team sport athletes: A systematic scoping review. Front Psychol [Internet]. 2023;14:1143618. doi: https://doi.org/10.3389/fpsyg.2023.1143618

5. Slimani M, Znazen H, Bragazzi NL, Zguira MS, Tod D. The effect of mental fatigue on cognitive and aerobic performance in adolescent active endurance athletes: insights from a randomized counterbalanced, cross-over trial. J Clin Med [Internet]. 2018;7(12):1-10. doi: https://doi.org/10.3390/jcm7120510

6. Van der Linden D, Frese M, Meijman TF. Mental fatigue and the control of cognitive processes: effects on perseveration and planning. Acta Psychol (Amst) [Internet]. 2003;113(1):45-65. doi: https://doi.org/10.1016/S0001-6918(02)00150-6

7. Boksem MA, Tops M. Mental fatigue: costs and benefits. Brain Res Rev [Internet]. 2008;59(1):125-39. doi: https://doi.org/10.1016/j.brainresrev.2008.07.001

8. Smith A. Cognitive fatigue and the wellbeing and academic attainment of university students. Journal of Education, Society and Behavioural Science [Internet]. 2018;24(2):1-12. doi: https://doi.org/10.9734/JESBS/2018/39529

9. Sun H, Soh KG, Roslan S, Wazir MRWN, Soh KL. Does mental fatigue affect skilled performance in athletes? A systematic review. PloS one [Internet]. 2021;16(10):e0258307. doi: https://doi.org/10.1371/journal.pone.0258307

10. Gantois P, Caputo Ferreira ME, Lima-Junior Dd, Nakamura FY, Batista GR, Fonseca FS, et al. Effects of mental fatigue on passing decision-making performance in professional soccer athletes. Eur J Sport Sci [Internet]. 2020;20(4):534-43. doi: https://doi.org/10.1080/17461391.2019.1656781

11. Turkelson L, Mano Q. The current state of mind: A systematic review of the relationship between mindfulness and mind-wandering. Journal of Cognitive Enhancement [Internet]. 2022;6(2):272-94. doi: https://doi.org/10.1007/s41465-021-00231-6

12. Epel E, Daubenmier J, Moskowitz JT, Folkman S, Blackburn E. Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. Ann N Y Acad Sci [Internet]. 2009;1172(1):34-53. doi: https://doi.org/10.1111/j.1749-6632.2009.04414.x

13. Klein KP, Lancaster SL. Reexamining the association between facets of mindfulness and cognitive performance. Journal of Cognitive Enhancement [Internet]. 2017;1:345-51. doi: https://doi.org/10.1007/s41465-017-0037-0

14. Jones BJ, Kaur S, Miller M, Spencer R. Mindfulness-based stress reduction benefits psychological well-being, sleep quality, and athletic performance in female collegiate rowers. Front Psychol [Internet]. 2020;11:572980. doi: https://doi.org/10.3389/fpsyg.2020.572980

15. Moore A, Malinowski P. Meditation, mindfulness and cognitive flexibility. Conscious Cogn [Internet]. 2009;18(1):176-86. doi: https://doi.org/10.1016/j.concog.2008.12.008

16. Jha AP, Stanley EA, Kiyonaga A, Wong L, Gelfand L. Examining the protective effects of mindfulness training on working memory capacity and affective experience. Emotion [Internet]. 2010;10(1):54-64. doi: https://doi.org/10.1037/a0018438

17. Mardon N, Richards H, Martindale A. The effect of mindfulness training on attention and performance in national-level swimmers: An exploratory investigation. The Sport Psychologist [Internet]. 2016;30(2):131-40. doi: https://doi.org/10.1123/tsp.2014-0085

18. Ancoli-Israel S, Moore P, Jones V. The relationship between fatigue and sleep in cancer patients: a review. Eur J Cancer Care [Internet]. 2001;10(4):245-55. doi: https://doi.org/10.1046/j.1365-2354.2001.00263.x

19. Yaffe K, Falvey CM, Hoang T. Connections between sleep and cognition in older adults. Lancet Neurol [Internet]. 2014;13(10):1017-28. doi: https://doi.org/10.1016/S1474-4422(14)70172-3

20. Vitale KC, Owens R, Hopkins SR, Malhotra A. Sleep hygiene for optimizing recovery in athletes: review and recommendations. Int J Sports Med [Internet]. 2019;40(08):535-43. doi: https://doi.org/10.1055/a-0905-3103

21. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behavior research methods [Internet]. 2009;41(4):1149-60. doi: https://doi.org/10.3758/BRM.41.4.1149

22. Howell AJ, Digdon NL, Buro K, Sheptycki AR. Relations among mindfulness, well-being, and sleep. Personality and Individual Differences [Internet]. 2008;45(8):773-7. doi: https://doi.org/10.1016/j.paid.2008.08.005

23. Byun E, Gay CL, Lee KA. Sleep, fatigue, and problems with cognitive function in adults living with HIV. J Assoc Nurses AIDS Care [Internet]. 2016;27(1):5-16. doi: https://doi.org/10.1016/j.jana.2015.10.002

24. Zhang C, Shu P, Luo M, Liu X, Guo S, Pang B. The correlation between mindfulness traits and fatigue among Chinese civil aviation pilots. Industrial Engineering and Innovation Management [Internet]. 2022;5(10):31-5. doi: https://doi.org/10.23977/ieim.2022.051003

25. Cohen J. Statistical power analysis for the behavioral sciences. New York: Routledge; 1988. 198 p.

26. Patel HI, Rowe E. Sample size for comparing linear growth curves. Journal of Biopharmaceutical Statistics [Internet]. 1999;9(2):339-350. doi: https://doi.org/10.1081/BIP-100101180

27. Thienot E, Jackson B, Dimmock J, Grove JR, Bernier M, Fournier JF. Development and preliminary validation of the mindfulness inventory for sport. Psychology of Sport and Exercise [Internet]. 2014;15(1):72-80. doi: https://doi.org/10.1016/j.psychsport.2013.10.003

28. Tingaz EO. Adaptation Of The Mindfulness Inventory For Sport Into Turkish: A Validity And Reliability Study. Spormetre [Internet]. 2020;18(1):71-80. doi: https://doi.org/10.33689/spormetre.642682

29. Tekkurşun Demir G, Cicioglu Hİ, Yarayan YE. Developing the Scale of Physical and Cognitive Fatigue Perceived (SPCFP): Validity and Reliability Study. Mediterranean Journal of Sport Science [Internet]. 2023;6(3):715-26. doi: https://doi.org/10.38021/asbid.1220568

30. Driller MW, Mah CD, Halson SL. Development of the athlete sleep behavior questionnaire: a tool for identifying maladaptive sleep practices in elite athletes. Sleep Sci [Internet]. 2018;11(1):37-44. doi: https://doi.org/10.5935/1984-0063.20180009

31. Darendeli A, Diker G, Çinar Z. Athlete Sleep Behavior Questionnaire-turkish version: study of validity and reliability. Journal of Turkish Sleep Medicine-Turk Uyku Tibbi Dergisi [Internet]. 2019;6(2):43-8. doi: https://doi.org/10.4274/jtsm.galenos.2019.58076

32. George D, Mallery P. SPSS for windows step by step: A simple study guide and reference, 17.0 update, 10th ed. Chennai: Pearson Education India; 2011. 386 p.

33. Cao S, Geok SK, Roslan S, Qian S, Sun H, Lam SK, et al. Mindfulness-based interventions for the recovery of mental fatigue: A systematic review. Int J Environ Res [Internet]. 2022;19(13):1-15. doi: https://doi.org/10.3390/ijerph19137825

34. Kudesia RS, Pandey A, Reina CS. Doing more with less: Interactive effects of cognitive resources and mindfulness training in coping with mental fatigue from multitasking. Journal of Management [Internet]. 2022;48(2):410-39. doi: https://doi.org/10.1177/0149206320964570

35. Zhu Y, Sun F, Li C, Huang J, Hu M, Wang K, et al. Acute effects of mindfulness-based intervention on athlete cognitive function: An fNIRS investigation. J Exerc Sci Fit [Internet]. 2022;20(2):90-9. doi: https://doi.org/10.1016/j.jesf.2022.01.003

36. Zadkhosh SM, Zandi HG, Ghorbannejad M. The effects of Mindfulness-Based Cognitive Therapy (MBCT) on cognitive skills in young soccer players. Exerc Qual Life [Internet]. 2019;11(1):5-11. doi: https://doi.org/10.31382/eqol.190601

37. Derakshan N, Eysenck MW. Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. European Psychologist [Internet]. 2009;14(2):168-76. doi: https://doi.org/10.1027/1016-9040.14.2.168

38. Vago DR, Silbersweig DA. Self-awareness, self-regulation, and self-transcendence (S-ART): a framework for understanding the neurobiological mechanisms of mindfulness. Front Hum Neurosci [Internet]. 2012;6:296. doi: https://doi.org/10.3389/fnhum.2012.00296

39. Fullagar HH, Vincent GE, McCullough M, Halson S, Fowler P. Sleep and sport performance. J Clin Neurophysiol [Internet]. 2023;40(5):408-16. doi: https://doi.org/10.1097/wnp.0000000000000638

40. Pourhassan J, Sarginson J, Hitzl W, Richter K. Cognitive function in soccer athletes determined by sleep disruption and self-reported health, yet not by decision-reinvestment. Front Neurol [Internet]. 2023;13:872761. doi: https://doi.org/10.3389/fneur.2022.872761

41. Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Mental fatigue, work and sleep. J Psychosom Res [Internet]. 2004;57(5):427-33. doi: https://doi.org/10.1016/j.jpsychores.2003.12.001

42. Wensink M, Schaap G, Ten Klooster PM, Doggen CJ, van der Palen J, Vonkeman HE, Bode C. Physical and mental fatigue in post-COVID syndrome and their associations over time: A small-sample ESM-study to explore fatigue, quality of sleep and behaviours. J Psychosom Res [Internet]. 2023;164:111084. doi: https://doi.org/10.1016/j.jpsychores.2022.111084

43. Miyata S, Noda A, Ozaki N, Hara Y, Minoshima M, Iwamoto K, et al. Insufficient sleep impairs driving performance and cognitive function. Neurosci Lett [Internet]. 2010;469(2):229-33. doi: https://doi.org/10.1016/j.neulet.2009.12.001

44. Garcia S, Alosco ML, Spitznagel MB, Cohen R, Raz N, Sweet L, et al. Poor sleep quality and reduced cognitive function in persons with heart failure. Int J Cardiol [Internet]. 2012;156(2):248-9. doi: https://doi.org/10.1016/j.ijcard.2012.01.037

45. Lu J, An Y, Qiu J. Relationship between sleep quality, mood state, and performance of elite air-rifle shooters. BMC Sports Sci Med Rehabil [Internet]. 2022;14(1):32. doi: https://doi.org/10.1186/s13102-022-00424-2

46. Benkirane O, Delwiche B, Mairesse O, Peigneux P. Impact of sleep fragmentation on cognition and fatigue. Int J Environ Res [Internet]. 2022;19(23):1-20. doi: https://doi.org/10.3390/ijerph192315485

47. Liu J, Zhou G, Wang Y, Ai Y, Pinto-Martin J, Liu X. Sleep problems, fatigue, and cognitive performance in Chinese kindergarten children. J Pediatr [Internet]. 2012;161(3):520-5.e2. doi: https://doi.org/10.1016/j.jpeds.2012.03.018

48. Wilkes JR, Walter AE, Chang A-M, Miller SJ, Sebastianelli WJ, Seidenberg PH, et al. Effects of sleep disturbance on functional and physiological outcomes in collegiate athletes: A scoping review. Sleep Med [Internet]. 2021;81:8-19. doi: https://doi.org/10.1016/j.sleep.2021.01.046

49. Fullagar HH, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Med [Internet]. 2015;45(2):161-86. doi: https://doi.org/10.1007/s40279-014-0260-0

50. Nien J-T, Wu C-H, Yang K-T, Cho Y-M, Chu C-H, Chang Y-K, et al. Mindfulness training enhances endurance performance and executive functions in athletes: An event-related potential study. Neural Plast [Internet]. 2020:8213710. doi: https://doi.org/10.1155/2020/8213710