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Sports Practice, Sleep Quality, and Executive Functions in Young Adults: A Mediation Study Using Structural Equation Modeling

Práctica deportiva, calidad de sueño y funciones ejecutivas en jóvenes adultos. Un estudio de mediación mediante modelo de ecuaciones estructurales

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Abstract

Introduction. Current evidence highlights the significant cognitive and physiological benefits of regular sports engagement, with well-established positive impact on both sleep quality and executive functions (EF).

Objective. The present study aimed to compare sleep quality parameters between young adults practicing individual and team sports, as well as to examine the direct and indirect structural relationships among sports participation indicators, sleep quality, and executive functioning.

Method. The sample consisted of 132 young adults aged 18 to 40 years (M = 23.89, SD = 4.93). A sociodemographic and sports questionnaire was employed, along with the Pittsburgh Sleep Quality Index (PSQI) and the Adult Executive Functioning Inventory (ADEXI). Data analysis included Confirmatory Factor Analysis (CFA), Pearson's r correlation analyses, MANCOVA, and Structural Equation Modeling (SEM). Bootstrapping with 5000 resamples was used to test mediation effects.

Results. The CFA supported the two-factor structure of the ADEXI —working memory and inhibition— with acceptable fit. Sports participation was associated with distinct sleep quality profiles. Specifically, individual sports practitioners reported better sleep quality and shorter sleep latency, team sports practitioners exhibited higher sleep efficiency. Structural equation modeling indicated that sleep quality statistically mediated the relationship between sports participation indicators (current sports practice, weekly hours, and total years of practice) and EF. Additionally, an earlier age of initiation into sports directly predicted fewer EF difficulties, independent of sleep quality, suggesting that early sports participation may contribute to the development of a resilient cognitive reserve.

Conclusion. Regular sports engagement, especially when it begins early in life, is associated with better subjective sleep quality and executive functioning. These findings highlight the potential protective role of sports in promoting cognitive health among young adults and support the incorporation of regular sports participation into public health and health promotion strategies aimed at preserving executive functioning.

Keywords

Sports participation; sleep quality; executive functions; young adults.

Resumen

Introducción. Diversas investigaciones han demostrado que la práctica deportiva regular se asocia con efectos positivos bien establecidos sobre la calidad del sueño y en las funciones ejecutivas (FE).

Objetivo. Comparar la calidad del sueño entre jóvenes adultos que practican deportes individuales y de equipo, así como examinar las relaciones estructurales directas e indirectas entre los indicadores de la práctica deportiva, la calidad del sueño y el funcionamiento ejecutivo.

Método. La muestra estuvo constituida por 132 adultos jóvenes de 18 a 40 años (M = 23.89, DE = 4.93). Se empleó un cuestionario sociodemográfico y deportivo, el Índice de Calidad de Sueño de Pittsburgh (PSQI) y el Inventario de Funcionamiento Ejecutivo, ADEXI. Se utilizaron análisis factorial confirmatorio (AFC), análisis de correlación de Pearson, MANCOVA y modelos de ecuaciones estructurales (SEM). Para evaluar la significancia de los efectos de mediación, se utilizó el método de *bootstrapping* con 5000 remuestreos.

Resultados. El AFC reveló un ajuste aceptable del modelo de dos factores del ADEXI, correspondientes a memoria de trabajo e inhibición. La práctica deportiva se asoció con perfiles diferenciados de calidad del sueño, mientras que quienes practicaban deportes individuales reportaron una mejor calidad del sueño y una menor latencia, los de deportes colectivos reportaron una mayor eficiencia. Los modelos de ecuaciones estructurales mostraron que la calidad del sueño medió estadísticamente la relación entre los indicadores deportivos (práctica deportiva actual, horas semanales y años totales de práctica) y el funcionamiento ejecutivo. Adicionalmente, una edad de inicio más temprana en la práctica deportiva predijo directamente menores dificultades ejecutivas, independientemente de la calidad del sueño, lo que sugiere que la práctica deportiva temprana puede contribuir al desarrollo de una reserva cognitiva.

Conclusión. La práctica deportiva regular, especialmente cuando se inicia a edades tempranas, favorece la calidad del sueño subjetiva y las habilidades ejecutivas. Estos hallazgos destacan el potencial papel protector del deporte en la promoción de la salud cognitiva en adultos jóvenes y respaldan la incorporación de la práctica deportiva regular en estrategias de promoción de la salud orientadas a preservar el funcionamiento ejecutivo.

Ethics statement
This study was approved by the Research Ethics Committee of the Universidad Adventista del Plata (approval no. 71/25). All participants provided written informed consent prior to participation.

Data availability
All data supporting the findings of this study are available within the article. For additional details, please contact the corresponding author.

Author Contributions
Josué Díaz Saint Pere: conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft, writing – review & editing.
Vanessa Arán Filippetti: conceptualization, data curation, formal analysis, investigation, methodology, supervision, writing – original draft, writing – review & editing.

Generative AI declaration
During the preparation of this manuscript, the authors used Grammarly, an AI-based language assistance tool, solely for English grammar, spelling, and language editing. The tool was not used to generate scientific content, interpret results, create figures, or perform data analyses. The authors reviewed and edited the manuscript and take full responsibility for the accuracy and integrity of the final content.

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Palabras clave

Práctica deportiva; calidad del sueño; funciones ejecutivas; adultos jóvenes.

Introduction

In recent years, physical activity has emerged as a key factor in enhancing cognitive functioning and improving sleep quality, thereby supporting biological recovery processes. Indeed, targeted interventions have been found to enhance specific cognitive outcomes [1], improve sleep quality [2], and may be effective in reducing symptoms of sleep disorders [3]. This becomes particularly relevant during young adulthood, a crucial period characterized by intense academic, professional, and social challenges. Within the broad spectrum of physical activity —which encompasses any bodily movement— both exercise and sport represent structured, goal-directed modalities. In this regard, team sports are characterized as team-based games governed by official rules, involving groups of individuals with distinct roles who compete against another group under the same criteria to reach a common objective [4]. On the other hand, individual sports rely primarily on psychomotor action [5], where the participant acts independently. In this modality, performance depends not on teamwork but on emotional management and self-regulation [6,7].

In the context of young adulthood, recent theoretical frameworks have integrated both physical activity and sleep quality as critical factors for understanding the optimization of executive functions (EF) [8]. While sleep hygiene involves behavioral and environmental practices that promote healthy sleep (e.g., exercise, avoidance or moderation of alcohol and caffeine consumption) [9], sleep quality is a complex construct encompassing factors such as sleep latency, duration, efficiency, daytime disturbances, and overall satisfaction with rest [10]. Concurrently, EF refer to higher-order cognitive processes that enable the control and regulation of cognition, emotion, and behavior, supporting decision-making and adaptable responses to changing situations [11,12]. Structurally, EF comprise three interconnected yet distinct dimensions —working memory/updating, inhibition, and shifting— consistent with the "unity-but-diversity" view [13]. These cognitive skills, which are central to academic, professional, and social success, are linked to activity within the prefrontal cortex and related neural networks [14].

Regarding empirical evidence on the effects of sports practice on sleep quality, Johnston et al. [15] found that participation in team sports improves sleep quality in young adults, leading to a significantly greater reduction in depression levels compared to aerobic dance. Similarly, a systematic review by Alnawwar et al. [3] concluded that regular physical activity improves sleep quality, efficiency, and duration across diverse populations. Evidence also indicates a strong connection between sports and EF. Specifically, Quintero-López et al. [16] observed that sports practice enhances executive functioning regardless of age, gender, or socioeconomic status. Sánchez-García et al. [17] reported differences in EF across sports; open-skill sports such as soccer or hockey promote better EF development than closed-skill sports. The authors also distinguish between "cool" and "hot" executive functions, emphasizing the importance of sports during childhood and adolescence for developing both. Complementarily, it has been observed that this impact is not uniform but is influenced by factors such as the athlete's age and sporting experience. Consistent with these findings, a recent meta-analysis by Ren et al. [18] consistently confirmed that athletes have superior EF, including inhibitory control and working memory, compared to non-athletes. These cognitive benefits tend to increase with greater sports experience. Additionally, the study reported that open-skill athletes outperform closed-skill athletes in working memory and cognitive flexibility. Taken together, this scientific evidence suggests that the effect of sport on overall well-being is a complex phenomenon conditioned by the nature of the task, accumulated experience, and individual characteristics.

Beyond the context of sports, from a neurobiological perspective, the integrity of sleep is fundamental to maintaining optimal executive control [19]. Sleep deprivation negatively impacts prefrontal cortex activity [20] and reduces glucose metabolism in key brain areas, thereby impairing cognitive functions [21], especially EF. Indeed, a meta-analysis by Lowe et al. [22] showed that sleep restriction significantly impairs these higher-order cognitive processes, sustained attention, and long-term memory. Interestingly, recent investigations have suggested that sleep may serve as one of the underlying mechanisms explaining the cognitive benefits of physical activity. For instance, Wilckens et al. [23] found that sleep efficiency mediates the relationship between physical activity and executive control in adults. Consistently, evidence indicates that sleep duration can modulate the impact of varying intensities of physical activity on cognitive function [24], suggesting that the benefits of exercise on EF are contingent upon an optimal balance between physical exertion and recovery. Thus, sleep not only serves a physical restorative function but also underpins the mental capacities necessary for flexible adaptation to shifting contexts. Taken together, these findings provide a foundation for further investigating the relationships among physical activity, multiple dimensions of sleep quality, and their combined influence on EF.

Based on the above, the objectives of the present study were (1) to explore whether differences exist in subjective sleep quality parameters among young adults who practice individual sports, team sports, or do not participate in sports; and (2) to examine the direct and indirect structural relationships between different indicators of sports participation (i.e., age of onset, hours of practice, and years of practice), subjective sleep quality, and EF skills. Accordingly, two hypotheses were proposed. H1: Young adults engaged in sports are expected to report better sleep quality (indicated by lower PSQI scores) compared to those who do not participate in sports, with sleep parameters varying according to the type of sport practiced (individual vs. team sports). H2: Sport practice indicators are anticipated to relate to executive functioning through either direct or indirect pathways (statistically mediated by subjective sleep quality), depending on the sport indicator examined.

Method

An associative, cross-sectional study with a predictive design was conducted [25]. Specifically, it evaluated a theoretical model of relationships among sports participation, sleep quality, and executive functions (EF) using Structural Equation Modeling (SEM).

Participants

The sample consisted of 132 adults (59.1% female) from the province of Entre Ríos, Argentina. Participants ranged in age from 18 to 40 years ($M = 23.89$, $SD = 4.93$, $n = 131$), with one missing value due to a data-entry inconsistency. Most of the participants (91.6%) were aged between 18 and 30 years. They were selected through a non-probability convenience sampling method. The sample was divided into two groups based on the type of sport (team vs. individual), together with a control group of young adults who did not participate in any sport (Non-practitioners). The inclusion criteria were (a) regular participation in sports at least twice per week, (b) continuous participation during the previous few months, and (c) absence of any health condition that could interfere with performance in the participant's sport. Although a non-probability approach was utilized, this sample size is considered adequate for the complexity of the proposed SEM. According to simulation criteria for structural models, samples between 80 and 150 participants are sufficient to obtain precise and unbiased parameter estimations when models are highly parsimonious and exhibit clear structural pathways [26].

Instruments

Sports Practice Questionnaire

To assess sociodemographic characteristics and sports practice, an *ad hoc* questionnaire was designed for the present study. This instrument included questions regarding sociodemographic variables (e.g., age and sex) and sports-related variables, such as the type of sport practiced, age at the onset of sports practice, weekly frequency (practice days per week), training volume (practice hours), years of experience, and the competitive level achieved.

Adult Executive Functioning Inventory (ADEXI)

This instrument consists of 14 items scored on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The total score ranges from 14 to 70. It assesses two core executive functions: working memory (9 items) and inhibition (5 items), where higher scores indicate greater executive difficulties in daily life. The internal consistency of the ADEXI is high ($\alpha = 0.87$), indicating that the Spanish adaptation is a valid and reliable measure for assessing executive functions in the general population for both clinical and research purposes [27].

Pittsburgh Sleep Quality Index (PSQI)

The PSQI consists of 24 questions, 19 of which are self-reported and five of which are completed by a bed partner or roommate (although only the 19 self-reported items are used in the quantitative scoring) [28]. The 19 self-reported items are organized into seven components assessing distinct dimensions of sleep: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The sum of these components yields a global score (ranging from 0 to 21) derived from the seven individual components, each scored from 0 to 3. A higher numerical output reflects a greater degree of sleep dysfunction. Following standard clinical validation, a cumulative score above 5 distinguishes poor sleepers from good sleepers, with higher ranges indicating increasing difficulties in achieving restorative rest. The instrument, validated in Argentina, demonstrates moderate internal consistency in both paper-based ($\alpha = 0.752$) and virtual ($\alpha = 0.754$) formats [29].

Ethical procedures and data collection

The present study was conducted in accordance with the ethical principles established in the Declaration of Helsinki [30]. The study was submitted for evaluation and approved by the Research Ethics Committee of the Universidad Adventista del Plata (Resolution No.: 71/25), ensuring the alignment of all practices with ethical standards of integrity, respect, and participant safety. The data collection process started with contacting universities and sports clubs to introduce the study and its aims. Subsequently, informed consent was obtained from the participants, who received information regarding their participation, the study's objectives, and the measures adopted to ensure confidentiality and anonymity. All data were coded for analysis.

Statistical procedures

Descriptive statistics were used for the sociodemographic characterization of the sample and the preliminary examination of the study variables. To assess the univariate normality of the variables, skewness and kurtosis indices were analyzed. The values for the EF variables and the PSQI global index presented skewness (0.55 to 0.90) and kurtosis (-0.07 to 0.35) indices that were well within the acceptable thresholds to justify parametric procedures. Additionally, bivariate relationships between the variables were examined using Pearson's r correlation coefficient. To evaluate significant differences in sleep quality according to the type of sport practiced, a Multivariate Analysis of Variance (MANOVA) was conducted. The assumption of homogeneity of covariance matrices was verified using Box's M test. Due to the high sensitivity of Box's M to unbalanced group sizes, Pillai's trace was selected as the robust multivariate statistic. Following a significant multivariate effect, univariate ANOVAs were examined, applying the Bonferroni correction for all subsequent *post hoc* comparisons to control for Type I error inflation. Additionally, a Multivariate Analysis of Covariance (MANCOVA) was performed as a complementary analysis to control for potential confounding effects of clinical history, incorporating clinical diagnosis as a covariate. Finally, Structural Equation Modeling (SEM) was employed to analyze the structural relationships between constructs using AMOS Graphics (version 23.0) [31]. Multivariate normality was assessed using Mardia's coefficient; multivariate skewness and kurtosis values were below 2, indicating compliance with multivariate normality and justifying the use of Maximum Likelihood estimation in SEM. Indirect effects in the SEM models were assessed through bootstrapping with 5,000 samples, reporting 95% bias-corrected (BC) confidence intervals to determine the significance of the mediations. Data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 22.0).

Results

Sociodemographic Description of the Sample

Table 1 presents the sociodemographic characteristics of the sample (n = 132, M_{age} = 23.89, SD = 4.93). Regarding sex, 59.1% of the participants were female, 40.2% male, and 0.8% identified as other. In terms of academic major, most participants were enrolled in the Social Sciences and Humanities or Health Sciences. Regarding occupation, 40.91% of the sample were students, 29.55% were employed, and 29.55% were both studying and working simultaneously. To ensure sex and occupation did not introduce confounding bias, preliminary multivariate analyses of variance (MANOVAs) were conducted. Pillai's trace revealed no significant main or interaction effects on the study variables based on these sociodemographic variables (all p > .05). Consequently, the subsequent analyses were performed, assuming these variables do not bias the examined relationships. In terms of health history, 92.4% of the sample reported no significant clinical conditions, while 7.6% had a controlled psychiatric or neurological diagnosis. Regarding sleep medication, 1.5% reported using hypnotics, compared to 98.5% who did not. Regarding the study variables, the overall PSQI mean was 6.68 (SD = 3.47), while sleep parameters (duration, efficiency, and latency), as well as global executive functioning (ADEXI total score), varied descriptively across non-practitioners, team sports, and individual sports groups (see Table 1 for detailed stratification).

Table 1. Sociodemographic Variables (N = 132).

	M ± SD or n	%
Age	23.89 ± 4.93	
Sex		
Female	78	59.1
Male	53	40.2
Other	1	0.8
Academic major		
Social sciences / Humanities	34	25.8
Health sciences	34	25.8
Natural sciences	2	1.5
Technology / Engineering	9	6.8
Economics	11	8.3
Art/Design	7	5.3
Education	18	13.6
Other	17	12.9
Clinical history		
None	122	92.4
Psychiatric diagnosis	8	6.1
Neurologic diagnosis	2	1.5
Sleep medication (Hypnotics)		
Yes	2	1.5
No	130	98.5
Sleep disorder diagnosis		
Yes	15	11.4
No	117	88.6
Father's educational level		
Elementary school	25	18.9
Secondary school	38	28.8
Tertiary	18	13.6
University degree	26	19.7
Postgraduate degree	19	14.4
Other/Not sure	6	4.5
Mother´s educational level		
Elementary school	17	12.9
Secondary school	31	23.5
Tertiary	36	27.3
University degree	38	28.8
Postgraduate degree	9	6.8
Other/Not sure	1	0.8

Employment status/occupation		
Student	54	40.9
Employed	39	29.5
Student and employed	39	29.5
Sleep duration (hh:mm)		
Non-practitioners	7:46 ± 2:05	
Team Sports	7:54 ± 1:34	
Individual Sports	8:14 ± 1:13	
Sleep efficiency (%)		
Non-practitioners	81.09 ± 15.87	
Team Sports	86.57 ± 9.80	
Individual Sports	84.58 ± 13.16	
Sleep onset latency (min)		
Non-practitioners	31.64 ± 23.87	
Team Sports	28.98 ± 30.86	
Individual Sports	22.56 ± 21.24	
Sleep quality (Global PSQI)		
Non-practitioners	8.85 ± 3.86	
Team Sports	6.49 ± 2.82	
Individual Sports	5.50 ± 3.16	
Executive functions (ADEXI)		
Non-practitioners	32.64 ± 10.01	
Team Sports	33.64 ± 10.28	
Individual Sports	29.25 ± 9.82	

Descriptive Statistics for Sports Participation

Table 2 presents the frequencies for variables related to sports participation among active participants (n = 99). The mean age of onset for lifelong sports activity was 14.59 years (SD = 8.09).

Table 2. Distribution of Sports Participation. Variables (n = 99).

	n
Type of sport	
Individual	52
Team sports	47
Competitive level/Status	
Federated	24
Non-federated	75
Club membership/Affiliation	
Member	57
Non-member	42

Participation in competitions	
Yes	51
No	48
Years of sports practice	
Less than 1 year	7
1 to 2 years	13
3 to 5 years	25
6 to 12 years	22
More than 12 years	32
Competitive level achieved	
Beginner	20
Intermediate	41
Advanced	36
Expert/elite	2

Confirmatory Factor Analysis (CFA) of the ADEXI Scale

To examine the structure of the ADEXI scale within the study sample, a Confirmatory Factor Analysis (CFA) was conducted. The two-factor model demonstrated acceptable fit with a Comparative Fit Index (CFI) of 0.90. Additionally, both the Standardized Root Mean Square Residual (SRMR) and the Root Mean Square Error of Approximation (RMSEA) fell within acceptable ranges (χ^2/df = 1.76; SRMR = .06; RMSEA = .077) (see Figure 1).

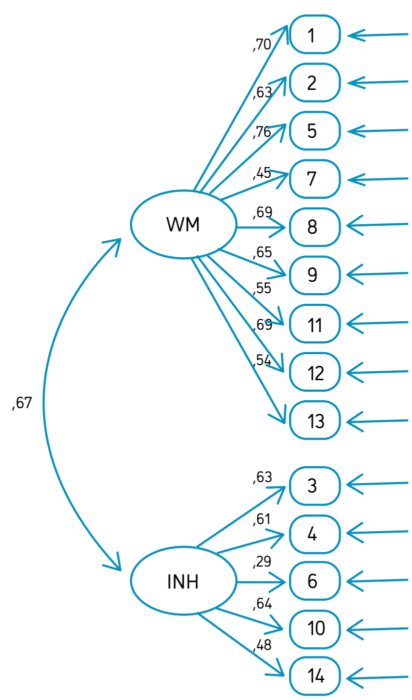

Figure 1. CFA of the ADEXI in the study sample.

Note. WM = Working memory INH= Inhibition.

Effects of Sports Practice on Sleep Quality

To analyze the effect of sports practice on sleep quality, a MANOVA was employed. Regarding the assumptions, the homogeneity of covariance matrices was assessed using Box's *M* test, which indicated a deviation from the assumption (p = .014). However, as stated, due to the unbalanced group sizes, Pillai's trace was used to interpret the multivariate effects, revealing a significant overall effect of sports practice on sleep quality, V = .223, $F(14, 248) = 2.221$, p = .008, η_p^2 = .111. Furthermore, to rule out potential confounding effects from clinical history, a complementary multivariate analysis was performed, including clinical diagnosis as a covariate. Results confirmed that clinical diagnosis did not exert a significant multivariate effect on sleep parameters, V = .095, $F(7, 122) = 1.833$, p = .087, whereas the main effect of sports practice remained highly robust, V = .227, $F(14, 246) = 2.247$, p = .007, η_p^2 = .113. Univariate analyses showed significant differences regarding subjective sleep quality, $F(2, 129) = 8.08$, $p < .001$, η_p^2 = .111; sleep latency, $F(2, 129) = 5.99$, p = .003, η_p^2 = .085; sleep duration, $F(2, 129) = 5.46$, p = .005, η_p^2 = .078; sleep efficiency, $F(2, 129) = 4.01$, p = .020, η_p^2 = .059; sleep disturbances, $F(2, 129) = 3.54$, p = .032, η_p^2 = .052; and daytime dysfunction, $F(2, 129) = 3.29$, p = .040, η_p^2 = .049.

To account for potential Type I error inflation due to multiple comparisons, post hoc contrasts were conducted using the Bonferroni correction. According to these analyses, in Component 1 (subjective sleep quality), significant differences were observed between young adults who do not practice sports and those who practice individual sports ($p < .001$), as well as between team sports and individual sports (p = .036). In Component 2 (sleep latency), significant differences were found between young adults who do not practice sports and those who practice individual sports (p = .002). In Component 3 (sleep duration), significant differences were observed between young adults who do not practice sports and both those who practice team sports (p = .044) and individual sports (p = .005). Regarding Component 4 (sleep efficiency dysfunction), significant differences were noted between young adults who do not practice sports and those who practice team sports (p = .018). In Component 5 (sleep disturbances), significant differences were found between young adults who do not practice sports and those who practice individual sports (p = .028). Finally, in Component 7 (daytime dysfunction), significant differences were observed between young adults who do not practice sports and those who practice individual sports (p = .044) (see Table 3).

Table 3. Means and Standard Deviations of Sleep Quality Components by Sports Participation.

	Sport practice					
	Non-practitioners (n = 33)		Individual sports (n = 52)		Team sports (n = 47)	
Quality of sleep	*M*	*SD*	*M*	*SD*	*M*	*SD*
C1. Subjective sleep quality	1.42	0.90	0.75	0.74	1.15	0.72
C2. Sleep latency	1.82	0.91	1.12	0.86	1.43	0.97
C3. Sleep duration	1.30	0.95	0.75	0.68	0.87	0.71
C4. Sleep efficiency	1.15	1.18	0.73	0.95	0.55	0.72
C5. Sleep disturbances	1.27	0.45	1.04	0.34	1.15	0.42
C6. Use of sleeping medication	0.33	0.82	0.10	0.45	0.23	0.70
C7. Daytime dysfunction	1.55	1.06	1.02	0.87	1.11	0.96

Note. The PSQI provides a global score (0–21) derived from seven individual components, each measured from 0 to 3. A higher numerical output reflects a greater degree of sleep dysfunction.

Executive Functions in Relation to Sports Participation and Sleep Quality

A significant correlation was found between the age of onset of sports participation and EF. Specifically, an earlier age of onset was associated with lower difficulties in WM ($r = -.222$, $p < .05$), and fewer inhibition difficulties ($r = -.342$, $p < .01$). Furthermore, poorer sleep quality was associated with greater executive difficulties in both WM ($r =.208$, $p < .05$) and inhibition ($r = .208$, $p < .05$), and greater overall EF difficulties ($r = .236$, $p < .01$). Other variables related to sports practice did not show significant associations with executive skills ($p > .05$).

Structural Equation Modeling

To analyze the effect of sports practice on sleep quality and EF, Structural Equation Modeling (SEM) was employed. The assessment of normality showed univariate skewness and kurtosis indices with C.R. < ±5. Likewise, Mardia's multivariate coefficient yielded values lower than 2.0 across all models, indicating a multivariate normal distribution.

Model 1 examined the relationship between current sports participation, sleep quality, and the latent EF construct ($\chi^2/df = 0.59$; $p = .808$; CFI = 1.00; GFI = 1.00; SRMR = .004; RMSEA = .000), a significant negative relationship was found between sports practice and sleep quality ($p < .001$). Specifically, sports practice was associated with lower global PSQI scores, indicating better sleep quality. Furthermore, a significant positive relationship ($p =.016$) was observed between sleep quality and EF; lower global PSQI scores (better sleep quality) were associated with fewer executive difficulties. The mediation analysis using SEM (5000 bootstrap resamples) revealed a significant indirect effect of sports practice on the latent construct of EF, mediated by sleep quality (PSQI) ($\beta = -0.11$, $p = .007$; 95% BC CI [−0.237,−0.026]). Given the absence of a significant direct effect of sports on EF ($\beta = 0.04$, $p = .736$), the results indicate a full mediation.

Model 2 examined the relationship between weekly hours of sports participation, sleep quality, and EF ($\chi^2/df = 0.970$; $p = .325$; CFI= 1.00; GFI= .996; SRMR = .018; RMSEA = .000), a significant negative relationship was found between hours of practice and sleep quality ($p = .005$). A higher number of practice hours was associated with lower global PSQI scores (better sleep quality). Furthermore, a significant positive relationship ($p =.017$) was found between sleep quality and EF; specifically, lower global PSQI scores were associated with fewer executive difficulties. The bootstrapping results (5000 resamples) indicated a significant full mediation ($\beta = -0.07$; 95% BC CI [−0.177,−0.012]; $p = .009$). Since the latent EF variable was modeled using deficit indicators, the negative coefficient confirms that physical activity significantly reduces global executive difficulties through the improvement of sleep quality, with no remaining significant direct effect ($p >.05$).

Model 3 examined the relationship between years of sports participation, sleep quality, and EF ($\chi^2/df = 0.09$; $p = .925$; CFI= 1.00; GFI= 1.00; SRMR = .002; RMSEA = .000), a significant negative relationship was found between years of practice and sleep quality ($p = .001$). More years of practice were associated with lower global PSQI scores (better sleep quality). Furthermore, a significant positive relationship was found between sleep quality and EF ($p = .005$). The mediation analysis of Model 3 revealed that years of sport experience exert a highly significant impact on EF through the mediation of sleep quality ($\beta = -0.09$, $p = .009$; 95% BC CI [−0.208,−0.026]). Since no significant direct effect was found ($p = .088$), a full mediation is confirmed.

Model 4 examined the relationship between the age at the onset of sports participation, sleep quality, and EF ($\chi^2/df = 0.604$; $p = .437$; CFI= 1.00; RMSEA = .000), a significant negative relationship was found between the age of onset and EF ($p = .004$). Unlike the previous models, the age of onset did not significantly predict sleep quality ($p = .533$), thus ruling out a mediation effect. Therefore, an earlier start in sports practice is associated with lower EF difficulties, independent of sleep quality (See Figure 2)

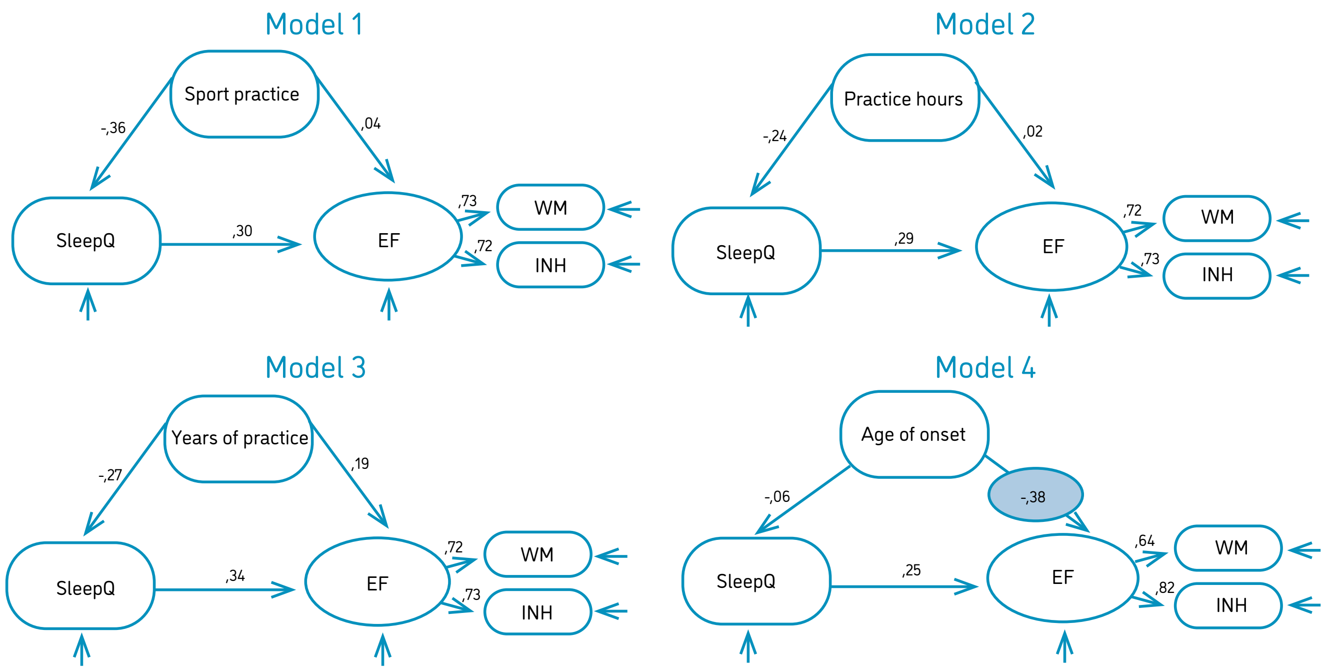

Figure 2. Effects of Sports Practice and Sleep Quality on Executive Functions.

Note. SleepQ= Sleep quality; EF= Executive functions. Higher scores on both the sleep quality index and the EF scale indicate poorer sleep quality and lower executive skills.

Discussion

This study aimed to examine the association between sports participation, sleep quality, and executive functions (EF) in young adults. Crucially, we evaluated both direct and indirect pathways (statistically mediated by sleep quality) linking sport indicators to EF skills, including age of onset, practice hours, and years of practice. Our findings indicate that engaging in sports is associated with improved sleep quality, with variations depending on the type of sport (individual vs. team). Moreover, SEM analyses revealed that sleep quality mediates the structural association between specific sports practice indicators (i.e., hours and years of practice) and executive functioning. Conversely, starting sports at an earlier age was directly associated with lower EF difficulties.

Firstly, the findings regarding the benefits of physical activity on sleep align with those of Johnston et al. [15], who found that participating in team sports is associated with improvements in sleep quality and lower depression levels in young adults. Similarly, the review by Alnawwar et al. [3] underscored that regular exercise improves sleep quality by increasing efficiency and duration. These effects can be explained through various physiological mechanisms, including changes in body thermoregulation and sleep architecture. In this regard, a meta-analysis by Stutz et al. [32] demonstrated a significant increase in slow-wave sleep after exercise, even when performed in the evening. Furthermore, physical activity appears to reduce sleep onset latency and improve nocturnal rest parameters [33]. Interestingly, our results indicate that these benefits vary depending on the sport type—individual versus team sports. Compared to non-participants in sports, those involved in individual sports report better subjective sleep quality and shorter sleep latency. Furthermore, engagement in any sport modality (individual or team) was linked to fewer sleep duration difficulties. In contrast, team sports were associated with greater sleep efficiency, possibly reflecting the greater physical fatigue and cognitive demands associated with tactical decision-making and coordinated team play.

In terms of sports practice and its relationship with EF, our results indicated that among the sports variables analyzed, only the age of onset exhibited a direct relationship with lower EF difficulties. This positive influence of sport aligns with the review of Quintero-López et al. [16], which concluded that regular exercise is positively linked to inhibitory control, WM, and attention. Similarly, Sánchez-García et al. [17] emphasize that open-skill sports—like team sports—encourage the development of EF due to changing cognitive demands and the need for quick decision-making during competition. Among the possible mechanisms underlying this relationship, several have been proposed: (1) the cognitive challenges inherent in the structure of goal-oriented exercise [34]; (2) neurophysiological adaptations and systematic changes in cerebral blood flow [35]; and (3) the cognitive load required for the execution and coordination of complex movements, which demands prefrontal cortex activity [36]. Physical activity also induces structural and functional brain plasticity, supporting neuron maintenance and growth, along with the release of growth factors like brain-derived neurotrophic factor (BDNF) that promote neuronal repair and strengthen synaptic plasticity [37].

Finally, the effect of sports practice on EF through sleep quality observed in our SEM results is consistent with current empirical evidence. Indeed, Li et al. [38] found that subjective sleep quality and sleep efficiency are key mediators between physical activity and inhibitory control in young adults and university students. This mediation mechanism through sleep efficiency, rather than duration alone, was also validated by Wilckens et al. [23], who demonstrated that this relationship spans the life cycle, also benefiting older adults in processes such as WM and switching. Conversely, Zhang et al. [24] suggest that sleep duration may serve as a moderator that modulates the relationship between physical activity and cognitive function depending on exercise intensity (moderate vs. vigorous). From this perspective, sports practice would act as a protective factor for executive functioning, not only through physiological activation and intrinsic cognitive demand but also by promoting restorative rest, which is indispensable for synaptic homeostasis and the restoration of higher brain functions [23]. Complementary to these previous studies, and while different sport modalities may impose distinct cognitive challenges, our structural analyses targeted the overarching impact of overall sport practice indicators. Specifically, our findings extend the understanding of the relationship between these constructs by demonstrating that not only current sport practice (Model 1) but also specific sports practice indicators (i.e., daily hours in Model 2 and years of practice in Model 3) are significantly linked to better subjective sleep quality, which in turn lowers EF difficulties. Additionally, Model 4 provides a relevant developmental nuance by indicating that an earlier age of onset in sports predicts better self-reported executive skills later in life, regardless of sleep quality. This finding suggests that beginning sports earlier in life may capitalize on sensitive periods of neurocognitive development during childhood and adolescence, contributing to long-term executive functioning. Taken together, these data suggest that the benefit of sport on self-regulation is not an isolated effect but a multidimensional process: while current sleep quality optimizes EFs through restorative rest, historical precocity in sports practice would contribute to the formation of a more efficient cognitive reserve. In this sense, it is important to note that these multidimensional benefits were observed in a sample of both team and individual sports across various performance levels, primarily representing amateur practitioners. Consequently, these findings provide valuable insights into the impact of sports on the general young adult population, although they may not be directly generalizable to the specific physiological and competitive contexts of elite athletes.

Limitations, Practical Implications, and Future Research Directions

Regarding the study's limitations, it is important to note its ex-post facto and cross-sectional design, which prevents establishing causality. Additionally, some results should be viewed with caution, as the correlations were weak, indicating that other unmeasured confounding variables may influence outcomes. For instance, variables like stress, anxiety, and depression — common in young adults and linked to poor sleep [39,40]— were not controlled. Similarly, the consumption of stimulants like nicotine and caffeine [41], as well as pre-sleep screen exposure —all capable of significantly interfering with sleep parameters [42]— were also not measured in this study. An additional limitation is the lack of data on the specific timing of sports practice (e.g., morning versus evening). However, our descriptive data show that the sports-practicing groups exhibit healthier sleep profiles than non-practitioners, highlighting shorter sleep latency in individual disciplines and optimized sleep efficiency in team sports. This suggests that, despite differences in training times, physical activity overall positively relates to sleep quality in this sample. Lastly, the reliance on self-report measures (PSQI and ADEXI) introduces perception bias, and using convenience sampling limits generalizability and increases selection bias. Despite these limitations, the sample size provided sufficient statistical power for the complexity of the current SEM model.

Our study holds significant implications across various fields. In the field of education, our data supports the importance of promoting sports practice as a strategy for fostering cognitive health. Clinically, integrating physical activity into interventions could aid in improving self-regulation and sleep in young people with executive difficulties or sleep issues. In sports science, our findings emphasize the importance of considering cognitive and sleep factors in athlete performance and well-being. Future research should employ longitudinal and experimental designs to track changes in EF and sleep quality over time. It is furthermore recommended to use objective measures, like performance-based tasks, alongside self-reports to minimize potential perception biases. Finally, exploring sex-based differences to determine how these factors modulate the relationship between physical activity, sleep, and cognition would also be beneficial.

Conclusions

This study provides empirical support for the complex relationship among sports practice, sleep quality, and EF. A key contribution of our work lies in demonstrating that sleep profiles are differently nuanced depending on the type of sport practiced. While individual sports appear to benefit a wider range of sleep dimensions, team sports stand out as a targeted factor for maximizing sleep efficiency. Furthermore, the capacity of both modalities to regulate sleep duration reinforces the role of physical activity as a non-pharmacological tool for sleep hygiene. These findings suggest that sports could serve as a protective factor for cognitive health in young adults, with sleep parameters playing a crucial role in consolidating these advantages. This finding suggests that beginning sports earlier in life may capitalize on sensitive periods of neurocognitive development during childhood and adolescence, contributing to long-term executive functioning.

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