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Effects of a Sleep Hygiene Intervention Period on Match Performance Indicators of Male University-Level Football Players During a Tournament

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ABSTRACT
Background. Performance indicators (PIs) are crucial in football for providing accurate data that helps players and coaches improve their performance. Sleep deprivation is a common issue in football, and it can significantly impact game results. **Objectives.** This study examined how a sleep hygiene protocol impacts various football match PIs. **Methods.** A tertiary team comprising twenty male university-level football players (average age: 22.2 ± 3 years; height: 167.6 ± 6.4 cm; weight: 62 ± 6.6 kg) completed a 4-week sleep hygiene intervention period (SHP). During the SHP, players followed at least ten sleep hygiene rules and completed a daily sleep diary. The performance indicators of the team and their opponents were recorded and analyzed over 14 matches, divided into a quasi-experimental repeated measures design (comprising five matches completed without the sleep intervention (nSHP), four matches with SHP, and again five matches with nSHP). The Pittsburgh Sleep Quality Index (PSQI) was utilized two weeks before SHP began, and three weeks into the intervention for subjective sleep measures. **Results.** A significant decrease in overall PSQI scores ($P = 0.03$, $g = 0.6$) was noted. There were also significant positive changes in the number of dribbles ($P = 0.004$, $g = 1.9$, $M_{diff} = 47.3\%$), network passes ($P < 0.001$, $g = 1.6$, $M_{diff} = 37.9\%$), successful passes ($P < 0.001$, $g = 1.3$, $M_{diff} = 21.6\%$), and crosses ($P = 0.02$, $g = 1.4$, $M_{diff} = 28.6\%$) compared to nSHP. Successful passes were strongly linked with shots on target and network passes, while penalty-area shots were connected to dribbles (all $P < 0.001$). **Conclusion.** In this cohort and setting, SHP was associated with improvements in several offensive PIs; however, findings are preliminary and require replication with objective sleep measures and more matches.

INTRODUCTION

Student-athletes face a unique set of challenges as they strive to balance rigorous academic, social, and financial responsibilities alongside demanding athletic commitments (1, 2). The cumulative burden of these stressors has been linked to reduced energy levels and impaired sleep quality, which may negatively impact both academic performance and athletic recovery (1, 2). Although 7 to 9 hours of sleep is the general recommendation per night, athletes are advised to obtain between 9 and 10 hours of sleep to allow adequate recovery and peak performance (3). Unfortunately, this is not the case for student-athletes, with the majority reporting less than 7 hours of sleep per night (4). Up to 70% of football players experience sleep deprivation before major competitions, losing an average of 2.5 hours of sleep per night during these periods (5).

Multiple factors contribute to sleep loss in athletes, including pre-competition anxiety, mood disturbances, late-night matches, congested schedules, environmental disruptions (e.g., light and noise), travel fatigue, and the use of stimulants or alcohol (6-8). A strong positive association exists between sleep and athletic performance, including sports-specific skill execution (9). Sleep deprivation can lead to heightened levels of perceived exertion and impaired cognitive processing, resulting in poor concentration and attention, reduced arousal and motivational levels, and decrements in physical performance (10). While sleep is essential for physiological recovery and cognitive function in athletes, particularly football players, the current literature lacks evidence on the effectiveness of sleep-based interventions and their impact on match performance during congested tournament schedules, especially among student-athletes (2, 4, 11).

Sleep is vital for athletes in terms of enhancing their decision-making capacity, cognitive recovery, and restoration of the metabolic and neural costs during the waking period (12, 13). In this regard, the National Sleep Federation typically recommends seven to nine hours of sleep for complete restoration (14). However, athletes often report getting less than seven hours of sleep per night (14). To combat the negative consequences of poor sleep, researchers and scientists have developed various guidelines to promote better sleep, collectively referred to as "sleep hygiene" (7). The implementation of a sleep hygiene protocol (SHP) can entail creating a cool (19 ± 2°C) and dark (60 ± 12 watts) environment, minimising noise, and distraction, creating a comfortable place without any electronic devices, appropriate napping (five to 30 minutes), and a 30- to 60-minutes period of quiet, relaxation before bedtime (15). Furthermore, consistent sleep patterns, active daytime behaviours (massages, stretching, electrical stimulation, and active recovery), using red-light treatment, and dawn simulation (to slightly increase the illuminance before waking up in the morning) have also been reported to create a favourable SHP environment (3, 6, 9, 16, 17).

Several studies have demonstrated the efficacy of sleep extension protocols in enhancing athletic performance. Mah et al. reported significant improvements in sprint time, reaction time, and shooting accuracy among basketball players following a sleep intervention (18). Similarly, Schwartz and Simon observed a marked increase in serve accuracy in tennis players after one week of sleep extension (19). Roberts et al. found a 3% improvement in cycling time trial performance following three consecutive nights of extended sleep (20). In support of these findings, Cunha et al. systematically reviewed 25 intervention studies and concluded that sleep extension and napping were the most effective strategies for improving both physical and cognitive performance across sports (21). Walsh et al. further emphasized that elite athletes are particularly vulnerable to sleep inadequacy and that individualized, multifaceted approaches, including sleep education, screening, napping, and sleep banking, are essential to optimize recovery and performance (9). Although general sleep hygiene interventions can improve subjective sleep quality (7, 9, 21-23), their effects on objective performance remain inconsistent. Notably, there is limited research examining sleep hygiene interventions during competitive periods, and none have specifically investigated performance metrics in football.

Performance in football is typically assessed through offensive indicators (e.g., shots, passes, dribbles), defensive actions (e.g., fouls, cards, corners against), and contextual variables (e.g., match location) (24). Performance indicators are defined as "*the selection and combination of variables that define some aspects of performance and help achieve athletic success*" (13). Kubayi and Toriola observed that losing teams demonstrated higher ball possession, total passes, accurate passes, and corners than winning teams during the Africa Cup of Nations, while passing success rates were similar across winners and losers (25). In contrast, winning teams recorded higher values for total shots, shots on target, offsides, fouls, and disciplinary actions, suggesting that assertive play may contribute to success. Supporting this, Yang et al. found that top-ranked teams committed more fouls, suggesting a link between aggressive tactics and competitive advantage (26). Performance indicators (PIs) provide valuable insight into team strategies and outcomes. However, the role of sleep quality and SHP in influencing these indicators remains underexplored. There are few in-competition football studies using interventions; existing soccer studies either examine acute strategies (6, 9, 23, 27) or use objective sleep measures, but rarely link to match PIs.

The latter aspect is concerning, as the physiological and cognitive benefits of improved sleep, such as enhanced reaction time (18, 28), decision-making (29), and emotional regulation (30, 31), could plausibly influence game-related outcomes. In this regard, improved sleep may increase passing accuracy, reduce unforced errors, and improve shot precision by optimizing motor control and focus (29, 31). Defensively, well-rested players may exhibit faster response times and better tactical awareness (28-30) as well as a reduced frequency of late tackles and cards. Improved sleep may also buffer stress and enhance emotional regulation (28, 29), leading to fewer impulsive behaviors and improved discipline.

Previous research on sleep and athletic performance has relied mainly on observational or correlational designs, which limit causal inference and are often confounded by uncontrolled variables such as training load, psychological stress, and individual sleep habits. These studies typically identify associations between sleep quality and performance, but cannot determine whether sleep interventions directly influence match outcomes or performance indicators. Therefore, implementing a structured sleep hygiene protocol in a quasi-experimental design represents a logical and necessary progression, allowing for controlled observation of sleep-related changes in performance within a real-world competitive setting.

Based on the limited evidence regarding sleep extension in football, the primary objective of this study was to determine the effect of a sleep hygiene period on match performance indicators and subjective sleep quality in university-level male football players during a sub-elite tournament consisting of 14 matches. A secondary objective was to examine the relationships between performance indicators and the sleep intervention period to assess whether the intervention could favourably influence the magnitude and direction of these associations.

MATERIALS AND METHODS

Experimental Approach. A quasi-experimental repeated-measures, quantitative intervention research design was conducted over an entire football tournament. Data were collected during a sub-elite tournament during the 2022 season, comprising 16 matches completed over 16 weeks (one match per week, excluding semi-finals and finals), of which 14 matches (n = 14) were used in the final analysis. Ethical approval was obtained from the institutional review board (NWU-0299-21-A1) before data collection.

Participants. A convenient sample technique was used in the proposed study. Twenty (n = 20) male university-level football players (average age: 22.2±3 y; stature: 167.6±6.4 cm; mass: 62±6.6 kg) from a tertiary institution took part in the study. All participants provided signed informed consent before data collection. The starting line-up remained the same throughout the testing period. Due to potential variability in team tactics, opponent strategies, injuries, and substitutions across matches, individual player observations may not reliably reflect the effects of sleep hygiene intervention. Therefore, team-level video analysis was employed, as the entire squad underwent the intervention, minimizing confounding factors and allowing for consistent evaluation of collective performance indicators. Their team's Key PI metrics were obtained from matches analyzed against the respective opponents throughout 14 matches.

Tournament structure. Of the 16 competitive matches played weekly in a regional league, fourteen matches (n = 14) were used in the final analysis of the tournament (ABC Motsepe League, 2022, B-string, North West, South Africa). During the tournament, teams faced off against one another twice: once at home and once on the road. The PIs of the primary team, which formed part of the intervention, as well as their respective opponents, were recorded and analyzed following each match. Five matches were designated as no-intervention matches (no intervention took place), with the following four matches constituting the intervention period, separated by a 1-week wash-out period. The last five matches were again designated no-intervention measures (13). Therefore, ten matches were used for baseline measures, with four matches (over four weeks) set aside for SHP. The additional two matches were set aside in case any errors might occur (cancellation or postponement of matches, poor video capturing, players getting injured, sick, or for any other reason that prevented them from completing all the league games) during any of the previous matches.

Match performance indicators. In football, various match performance metrics can be measured through video analysis. The various offensive and defensive performance metrics, along with their definitions, examined in the study, are listed in Table 1 (32, 33). In addition, as requested by the head coach, network passes were also recorded (three or more consecutive successful passes). The location was marked as "home" or "away" depending on where the team played. Data were collected over 90 minutes (including injury time) (24).

Table 1. Definitions of match-related performance indicators.

Performance indicator	Definition
Total shots	Shots (attempted) at the opposing goal, including shots that are not on goal.
Shots on target	Shots on goal, including goals. Excludes crossbar and goalpost contacts that do not lead to a goal.
Shots inside the penalty area	Shots attempted from within the penalty box area.
Passes	The sum of all the passes completed.
Successful passes	All successful passes are added together during the game.
Network passes	Three or more successful consecutive passes.
Passes in the opposition half	Completed passes in the offensive team's half.
Fouls received	The opposing team is penalised by the referee for any infringement.
Dribble	The attacking player in possession of the ball attempts to beat the opponent.
Crosses	Constitutes when a pass between the sideline and edge of the goalbox is made and travels into the central area in the penalty box.
Corners	When the ball passes over the goal line, it has touched a player from the defending team.
Offsides	The player being in an offside position results in a free kick for the opposing team.
Yellow cards	A player can be shown a yellow card by the referee for handball, time-wasting, persistent infringement, dangerous play, etc.
Red cards	When the referee sanctions a player with a straight red card, or because of a second yellow card.

SportsCode video analysis software (SportsCode v. 8.9, Sportster, Australia) was used by two analysts to evaluate all the recorded games using the tagging functions. Percentage errors were used to conduct both intra-observer and inter-observer reliability (34). The principal analyst assessed intra-observer reliability by re-analysing three random matches to guarantee a sufficient degree of reliability. A second qualified analyst, with the same familiarity and experience with the software, re-analyzed all the matches to assess inter-observer reliability, yielding an intraclass correlation coefficient (ICC) score of 0.84-0.90 across the PI's calculations. The original test (A) was then compared with the retest (B) of inter- and intra-analysis to calculate the percentage differences, with the expected limit of agreement being less than 5%, which is in line with previous studies (34).

Sleep Hygiene intervention Period (SHP). During the no-Sleep Hygiene intervention Period (nSHP), which consisted of five matches before and five matches after the intervention period, the football players followed their own sleep routine, thereby acting as their own control group. Within these conditions, players were allowed to self-regulate their exposure to electronic equipment, pre-bed light (60 ± 12 Watts), and sleep patterns. The sleep intervention period began a week before the first intervention match (16, 23). The SHP was completed over four weeks (with a weekly match taking place) to measure any significant changes accurately. A week of no intervention followed the intervention period to serve as a wash-out period (13). After this, participants continued with their usual routines and weekly matches for the follow-up period.

During the intervention period, participants were asked to adhere to at least 10 of the listed sleep hygiene recommendations in their home setting (see Table 2). Participants were asked to record daily which recommendations they adhered to, which consisted of a variety of science-based (i.e., sleep hygiene principles supported by circadian physiology, thermo-regulation, and controlled studies) and advice-based (i.e., sleep hygiene principles having limited or mixed evidence, mostly traditional or anecdotal in nature). Lastly, participants were requested to abstain from ingesting any drugs or engaging in strenuous physical activity that could affect their physical or physiological responses for at least 48 hours prior to the scheduled matches.

Table 2. Sleep Hygiene Components adhered to over 4 weeks

SHP Component	Recommendation
1	Avoid all electronic stimulants (TV, mobile phones, and computers) from 20:00 (7, 35)
2	If unable to avoid all electronic stimulants from 20:00, avoid them 30 minutes before going to bed (6, 16, 23)
3	Changed any electronic screens to a "cool" light setting from 19:00 (7)
4	Wear glasses with short-wavelength filters before going to bed (6)
5	Minimize excess light from 21:00 to 21:30 by only having a bed lamp on (6, 16)
6	Change the bed lamp to a low-wattage globe (6, 16)
7	Manipulate the room temperature to 19-20ºC (3, 6, 7, 9, 16, 23)
8	Avoid consuming caffeine or any supplements from 17:00 (3, 7, 9)
9	Have the last large meal at least two to three hours before sleep (3, 9)
10	Consume a glass of lukewarm milk before going to bed (6, 7)
11	If unable to consume a glass of milk due to lactose intolerance, consume a glass of chamomile tea before going to bed (35)
12	Take a warm bath or shower before going to bed (7, 35)
13	Keep the room dark and wear eye masks whilst sleeping (3, 7, 9, 16, 23)
14	Keep the room quiet and wear earplugs whilst sleeping (3, 7, 9, 23)
15	Remove any timing instruments (i.e., clock) from the room (3, 6)
16	Avoid any sleep disruptions (i.e., bathroom timings) – limit fluid and food intake (3, 7)
17	Sleep at least 8 hours (3, 7, 9)
18	Avoid napping from 14:00, and keep naps brief (30min) (3, 6, 7, 9)

SHP = Sleep Hygiene Protocol

Data collection procedures. A week prior to the intervention and three weeks into it, participants completed the Pittsburgh Sleep Quality Index questionnaire (PSQI), which has demonstrated test-retest reliability (r = 0.87) (36). Their sleep durations, disturbances, latency, efficiency, quality, and daytime dysfunction scores were calculated to compute the global PSQI score. Global scores can range from 0 to 21, with higher scores indicating poorer sleep quality. Adherence to each SHP component was also monitored weekly, where participants were asked to record which SHP component they had managed to incorporate (see Table 2). Participants scored a point for each component adhered to daily over the SHP period. For example, if a participant managed to wear an eye mask (SHP component 13 [SHP13] in Table 2) every day during the first week (i.e., time-point 1 [TP1]), then a score of 7 would be recorded for TP1 for that participant. This process was completed for all components across all time points. No interference occurred during any matches, as each match was recorded and analysed afterward.

Eligible players were required to complete the 4-week sleep hygiene protocol, follow at least ten sleep hygiene rules, maintain a daily sleep diary, participate in all 14 matches, complete PSQI assessments, and consent to match video recording for performance analysis. Players were excluded if they had sleep disorders, used sleep-affecting substances, missed intervention sessions or matches, failed to adhere to the protocol, were injured, participated in other conflicting studies, or had irregular training schedules. For video analysis, team match performance indicators, rather than individual player data, were analyzed from complete match footage, with recordings excluded if the footage was incomplete or of insufficient quality. All analyses were conducted blindly to minimize bias.

Statistical Analyses. All analyses were completed using Statistical Package for Social Sciences (SPSS, IBM SPSS 26.0) and R (RStudio, version 2023.06.1, build 524, Posit Software, PBS). Descriptive statistics of each PI (per match, n = 14 matches) were drawn and reported as a median ± interquartile range unless otherwise stated. The Shapiro-Wilk test was used to evaluate the departure from normality ($P < 0.05$) for the PIs, with only yellow cards and offsides committed demonstrating significance. Therefore, for these variables alone, the Wilcoxon signed-rank analysis was performed. To examine the relationship between match-specific outcomes and the sleep hygiene protocol, we used a Poisson regression model (a type of generalised linear model [GLM]) with a log-link function. The variance of the count data was evaluated, and for instances where overdispersion was evident, a quasi-Poisson GLM was conducted. To contextualize the findings of the Poisson regression, the incidence rate ratio (IRR) was calculated as the exponent of the coefficient in the model, along with the 95% confidence intervals. Differences in PSQI scores, subscales, and PIs across conditions were evaluated using a paired t-test with Hedge's g serving as the standardized effect size. Hedge's g was qualitatively interpreted as: trivial (<0.10), very small (0.10–0.19), small (0.20–0.49), medium (0.50–0.79), large (0.80–1.19), and very large (>1.20) (37). To evaluate the potential relationship between performance indicators under control and experimental conditions, a Spearman's Rank correlation analysis was conducted. The absolute magnitude of the correlation coefficients was interpreted as follows: negligible (0.00-0.10), weak (0.10–0.39), moderate (0.40–0.69), strong (0.70–0.89), and very strong (0.90–1.00) (38). Statistical significance was accepted at $P < 0.05$.

RESULTS

The PSQI results revealed a significant decrease in the overall PSQI values (nSHP = 9.5 ± 3.5, SHP = 7.5 ± 4.3, M_{diff} = 2.00, P = 0.028, g = 0.58), which was driven by the sub-scores of sleep latency (P = 0.05, g = 0.51) and hours slept ($P < 0.001$, g = 0.96). The adherence to the different SHP components is shown in ranked order (Figure 1). Adherence to the sleep hygiene protocol varied across components and time points, with the highest and most consistent adherence observed for evidence-based strategies such as avoiding caffeine after 17:00, maintaining a dark and quiet sleep environment, ensuring a minimum of 8 hours of sleep, and limiting naps after 14:00. These components showed strong compliance across all four time points, suggesting participants prioritized scientifically supported practices. In contrast, advice-based components, such as consuming milk or chamomile tea and removing clocks from the room, demonstrated lower and more variable adherence, indicating reduced perceived relevance or practicality among participants.

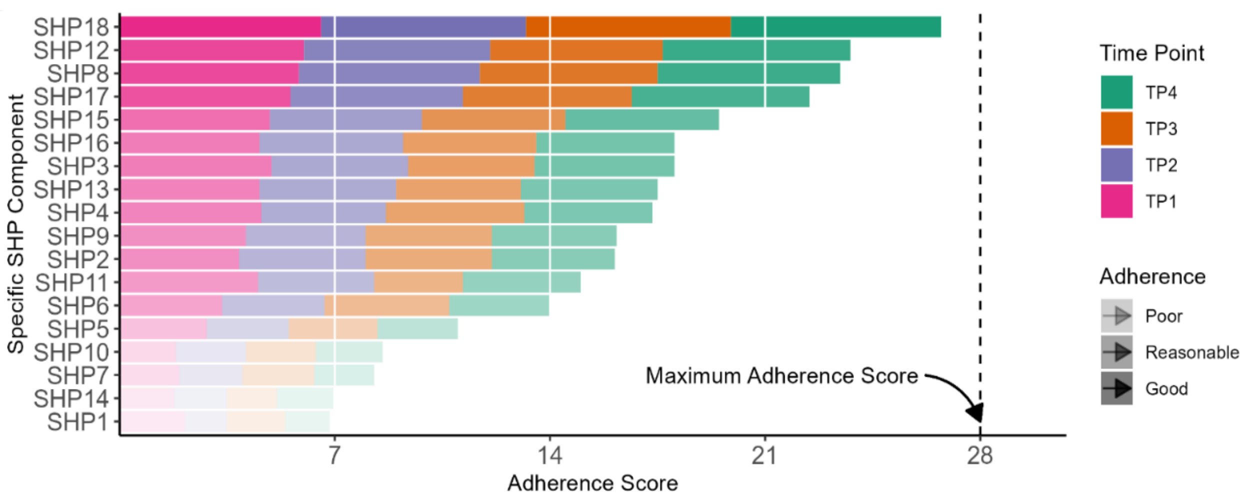

Figure 1. Sleep Hygiene Adherence over the 4 weeks. SHP = Sleep Hygiene Protocol; TP = Time Point

Table 3 provides a summary of the main PIs between the no-intervention and intervention periods, together with the mean, standard deviation values, and the percentage difference between the two experimental conditions. The overall magnitude of the sleep intervention's effect is presented in Figures 2 and 3. Those completing the SHP completed 1.89 more dribbles (P = 0.004, g = 1.89) than the nSHP condition. Similarly, under the SHP condition, 1.61 times additional network passes ($P < 0.001$, g = 1.61), 1.4 times more offensive crosses (P = 0.024, g = 1.4), and 1.28 times more successful passes ($P < 0.001$, g = 1.28) were completed compared to the nSHP condition.

Table 3. Descriptive statistics of PIs between intervention and no-intervention matches.

Performance Indicator	nSHP (n = 10)	SHP (n = 4)	% Difference (SHP *vs.* No-SHP)	P-value	ES (95% CI)
Successful Passes	220.9 ± 33.4	281.8 ± 91.5	21.6%	<0.001	1.28 (1.19 – 1.40)
Successful Passes - opponent's half	92.5 ± 31.7	103.0 ± 39.7	10.2%	0.07	1.1 (0.99 – 1.30)
Unsuccessful Passes	73.1 ± 21.0	76.5 ± 13.6	4.4%	0.50	1.05 (0.92 – 1.19)
Network Passes	34.6 ± 11.0	55.8 ± 25.8	37.9%	<0.001	1.61 (1.36 – 1.91)
Total Shots	11.9 ± 3.0	13.0 ± 4.1	8.5%	0.60	1.09 (0.78 – 1.50)
Shots on Target	5.1 ± 1.7	4.5 ± 3.1	-11.8%	0.65	0.88 (0.51 – 1.48)
Shots in the Penalty Area	5.5 ± 2.9	7.3 ± 4.1	24.7%	0.23	1.32 (0.83 – 2.05)
Fouls	13.9 ± 4.1	13.8 ± 6.6	0.7%	0.47	0.89 (0.64 – 1.21)
Offsides	3.2 ± 0.6	2.0 ± 1.8	37.5%	0.23	0.63 (0.27 – 1.29)
Yellow Cards	1.9 ± 1.4	2.3 ± 1.7	17.3%	0.68	1.18 (0.51 – 2.55)
Dribbles	4.9 ± 2.3	9.3 ± 2.6	47.3%	0.004	1.89 (1.22 – 2.89)
Crosses	12.5 ± 5.4	17.5 ± 8.5	28.6%	0.02	1.4 (1.04 – 1.87)
Corners	4.0 ± 1.5	3.8 ± 3.0	-5.0%	0.83	0.94 (0.5 – 1.67)
Fouls (opponent)	14.5 ± 4.2	13.3 ± 5.6	8.3%	0.95	0.98 (0.72 – 1.34)
Corners (opponent)	4.5 ± 2.5	4.8 ± 4.5	6.3%	0.24	0.7 (0.37 – 1.23)
Crosses (opponent)	11.7 ± 4.5	10.8 ± 6.6	7.7%	0.76	0.95 (0.66 – 1.33)
Total shots (opponent)	14.0 ± 5.0	10.3 ± 3.6	-26.4%	0.04	1.37 (1.0 – 1.85)
Shots in Penalty Area (opponent)	8.0 ± 3.7	4.8 ± 2.1	-40.0%	0.41	1.19 (0.77 – 1.8)
Yellow Cards (Opponent)	1.7 ± 1.4	2.8 ± 1.5	39.3%	0.41	0.68 (0.25 – 1.58)

ES = Effect Size; CI = Confidence Interval; PI = Performance Indicator; nSHP = no-Sleep Hygiene Protocol; SHP = Sleep Hygiene Protocol

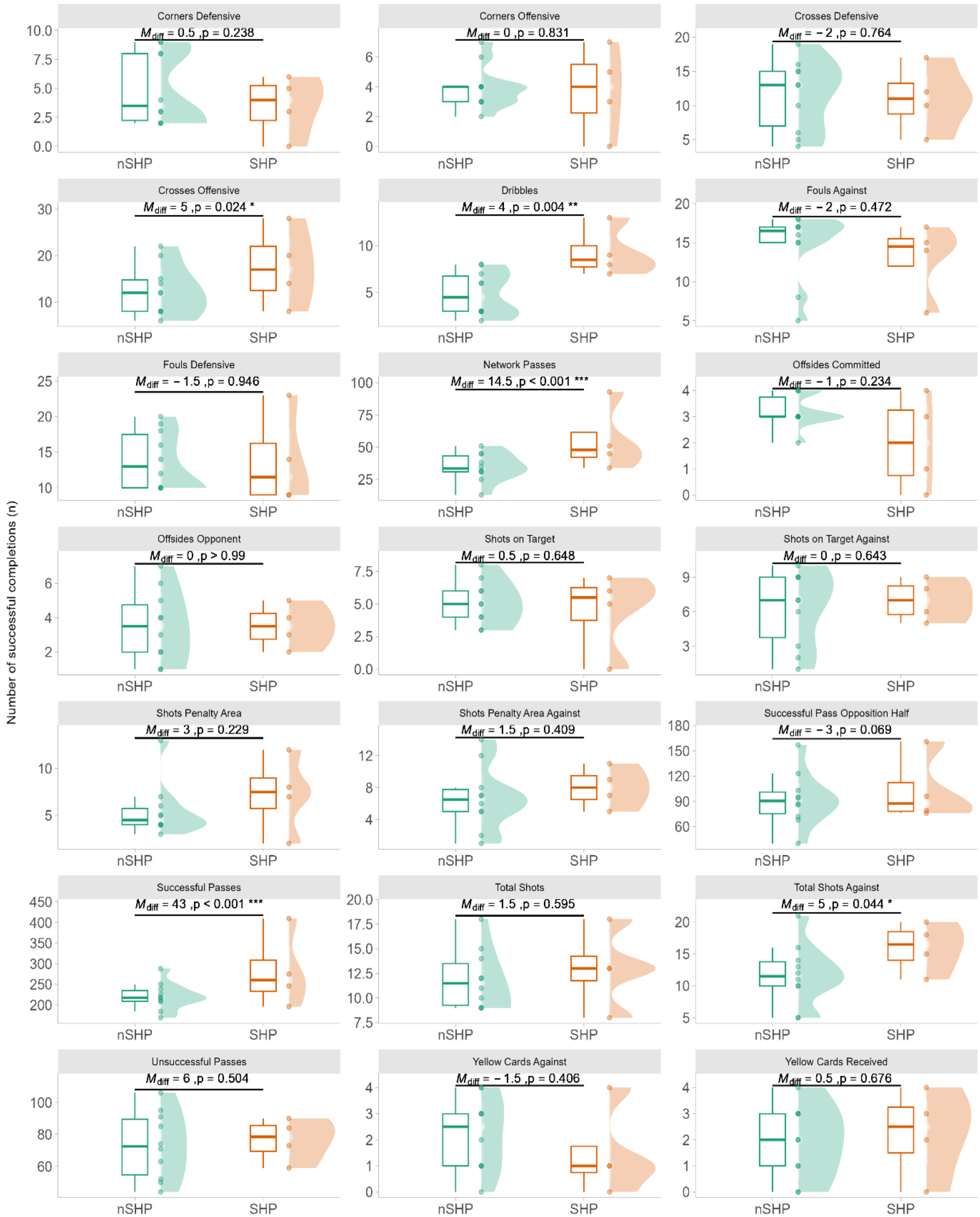

Figure 2. Median differences (M_{diff}) in main PIs between a sleep intervention and a no-intervention period. nSHP = no-Sleep Hygiene Protocol (n = 10 matches); SHP = Sleep Hygiene Protocol (n = 4 matches); M_{diff} = Median Difference. Asterisks indicate statistical significance: * : $p < 0.05$, ** : $p < 0.005$, *** : $p < 0.001$

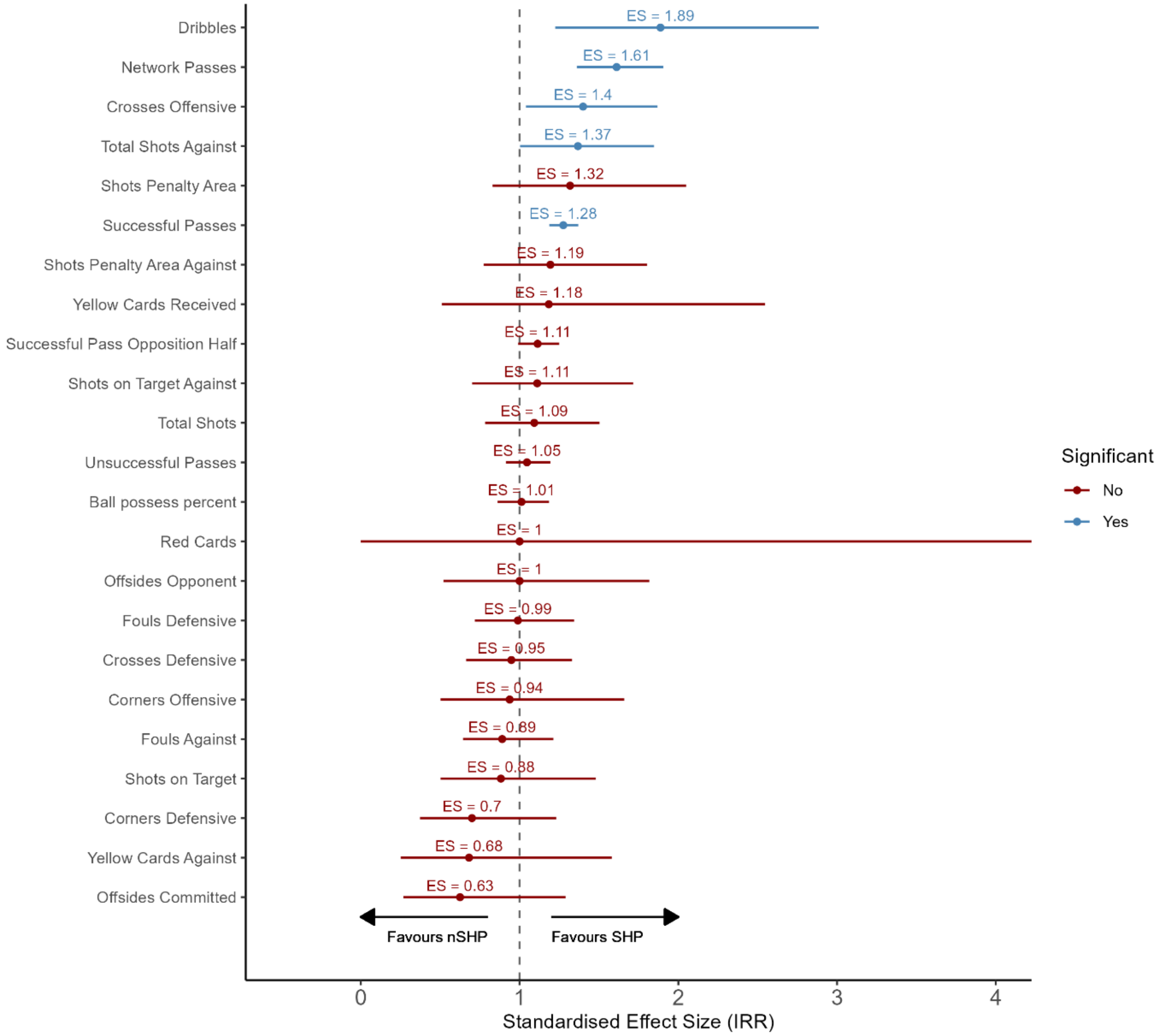

Figure 3. Standardised effect (incidence rate ratio [IRR]) of the sleep intervention on the main performance indicators. ES = Effect Size; nSHP = no-Sleep Hygiene Protocol (n = 10 matches); SHP = Sleep Hygiene Protocol (n = 4 matches), Significant = statistically significant

The correlation analysis revealed numerous relationships between PI's during the SHP compared to nSHP, as highlighted in Figure 4. The most significant observations were between the number of successful passes and both shots on target ($r = -1.0$, $P < 0.001$) and network passes ($r = 1.0$, $P < 0.001$). Network passes correlated additionally with shots on target ($r = -1.0$, $P < 0.001$). Shots taken from within the penalty area correlated with the number of dribbles ($r = -1.0$, $P < 0.001$) executed.

DISCUSSION

The primary aim of this study was to assess the impact of a four-week sleep hygiene protocol (SHP) on the physical performance indicators (PIs) of male university-level football players during a congested competitive tournament, which consisted of 14 matches. Although prior studies have examined post-match sleep and sleep extension (17), this study is the first to evaluate the direct impact of a sleep intervention on football performance under real-world tournament conditions, providing novel insights into sleep hygiene as a strategy to optimize performance during periods of high physical and psychological demand.

One of the primary findings of the present study was that a four-week sleep hygiene intervention significantly enhanced key *offensive* performance metrics in university-level football players. Under the sleep hygiene protocol (SHP), players executed more offensive crosses, dribbles, and network passes, and completed more successful passes compared to their baseline routines. During the SHP setting, players increased their dribble count by 47.3%, which may reflect enhanced cognitive functioning, particularly in decision-making, motor coordination, and reaction time domains, known to deteriorate with sleep deprivation and improve with adequate sleep (10, 17, 20, 21, 39, 40). This cognitive enhancement may have enabled players to allocate mental resources toward tactical discipline and ball control, contributing to increased offensive activity without a proportional rise in shots on target (41), suggesting a more deliberate playing style (40). Additionally, improvements in passing accuracy, dribbling efficiency, and shot execution under SHP align with the role of executive functions such as attention and working memory, which are sensitive to sleep quality and duration (40, 42-44). The increased number of successful passes and network passes, rising by 21.6% and 37.9%, respectively, indicates a probable improvement in in-game information processing and team coordination, although these latter aspects were not directly evaluated (42-44).

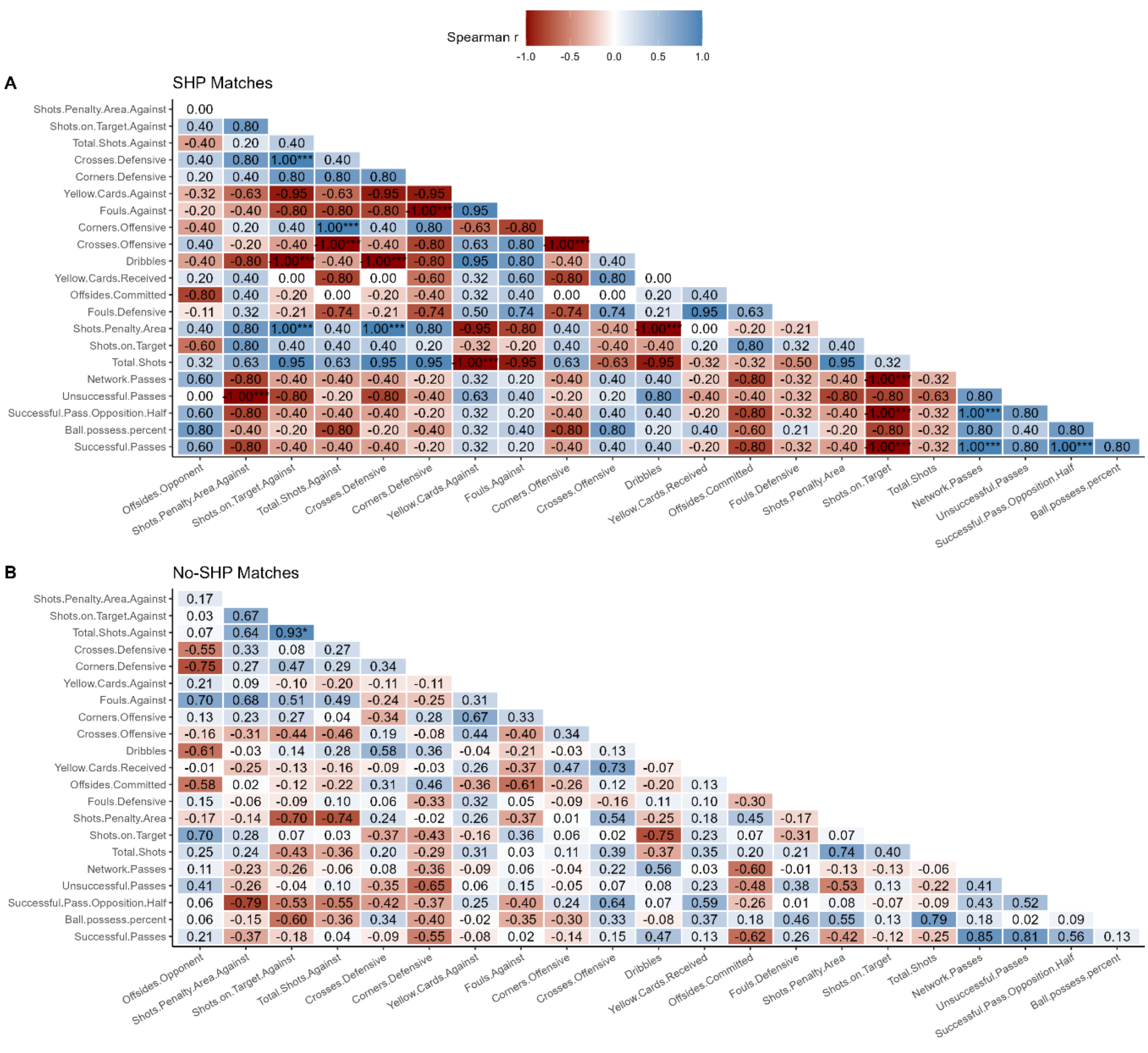

Figure 4. Correlation analysis between key performance indicators under the SHP and nSHP conditions. nSHP = no-Sleep Hygiene Protocol (n = 10 matches); SHP = Sleep Hygiene Protocol (n = 4 matches). Asterisks indicate statistical significance: * : p < 0.05, ** : p < 0.005, *** : p < 0.001.

The improvements align with existing evidence that sleep influences athletic performance through its effects on cognitive processing, emotional regulation, and physiological recovery (6, 15). The results of the current study are supported by similar research in basketball players, which found that longer total sleep time and higher subjective sleep quality were positively associated with improved in-game performance (41). Fox et al. found that better sleep quality significantly predicted increases in assists, rebounds, and blocks among semi-professional athletes (41). Similarly, Mah et al. reported that a 5–7-week sleep extension program enhanced mood, sprint performance, and reaction time in collegiate basketball players (18). On the other spectrum, Hefzollesan et al. demonstrated that 30 hours of sleep deprivation significantly impaired passing and shooting accuracy in young football players (45). A follow-up study showed that 36 hours of sleep loss also reduced dribbling performance (46). Collectively, these results may be partially explained by research indicating that adequate sleep likely enhances neuromuscular coordination, reaction time, and accuracy (18, 19), all of which are key components of fine motor skills linked to actions such as dribbling and shooting (47, 48). These findings suggest that well-rested players tend to favor purposeful possession and effective attacking actions (15, 18), whereas fatigue may impair individual execution and performance (17). These parallels reinforce the current findings and support the broader applicability of sleep hygiene interventions across team-based sports (15). While improvements in sleep hygiene have been associated with enhanced cognitive and physical performance, the observed changes in match-specific performance indicators may have been moderated by contextual factors such as team tactics, psychological readiness, and variability in opponent strength (49). These elements, which were not directly controlled or measured in the present study, could have influenced the extent to which sleep-related benefits translated into observable match outcomes (49).

The secondary findings of the study stem from the correlation analyses, which suggest the potential benefits of the SHP condition. The number of network passes (three-pass sequences) was strongly and positively associated with successful passing, and negatively, though not significantly, associated with the number of offside infractions. These relationships were not observed under the non-SHP condition. The observed improvements may reflect enhanced cognitive functioning, including attention, decision-making speed, and working memory, all of which are linked to adequate sleep (6, 42). Network passes, in particular, require coordinated team effort and precise communication, both of which depend on sustained cognitive performance (50). Under the SHP condition, players demonstrated fewer dribbles and more shots on goal, compared to increased dribbling and reduced shooting under normal sleep conditions. Dribbling was negatively correlated with shots on target under nSHP, potentially indicating inefficient ball use; however, this link was weaker under SHP, suggesting a more strategic and decisive play. Improved sleep hygiene is associated with decision-making and technical execution in university-level football players (51). Collectively, these findings indicate that well-rested players may favor purposeful possession and effective attacking actions(41), while fatigue may impair individual execution (47). High-effort outputs of the same testing population during the sleep hygiene phase, as indicated by GPS metrics (greater total distances covered for all intensity zones), have been previously reported in Prevoo et al. (52). The findings align with current video-based observations of increased offensive efficiency and reduced fatigue-related behaviors (41).

Although not directly measured in the present study, physiological restoration through sleep, including hormonal regulation and muscle recovery (53), likely contributed to the increase in high-effort actions such as dribbles and offensive transitions observed during the SHP period. Such an interpretation may be rationalized, at least partially, by the clear signal-to-noise ratios ascribed to the results. Additionally, improvements in passes and crosses align with evidence that sleep may enhance visuospatial processing and anticipatory skills (33, 43), both of which are essential for dynamic team-based play. By improving sleep quality, players may have sharpened their field awareness and decision-making (28), enabling them to anticipate opponents' movements more accurately and identify passing opportunities more effectively. Although prior research emphasizes the benefits of extended sleep duration and strategic napping, these results demonstrate that even short-term behavioral sleep hygiene interventions can yield meaningful improvements in skill execution during competitive play (41, 54). Within this context, the current results demonstrated a decrease in the global PSQI score following a structured sleep program. The findings suggest that participants were more likely to adhere to sleep hygiene practices supported by strong empirical evidence (such as avoiding caffeine, keeping a dark and quiet sleeping environment, and implementing napping only at certain times), particularly those directly linked to sleep quality and performance. Advice-based components (such as drinking milk or chamomile tea), while potentially beneficial, were less consistently followed, highlighting the importance of emphasizing scientifically validated strategies in future interventions. These components are relatively simple to implement and monitor, and appear to have been effective within the bounds of the current study, highlighting the importance of emphasizing scientifically validated strategies in future interventions (Refer to TABLE 2 for scientific studies investigating either evidence- or advice-based sleep hygiene components).

Despite promising findings, several limitations should be acknowledged. While individual performance indicators improved under the SHP condition, overall match outcomes (e.g., wins/losses) remained unchanged, highlighting the multifactorial nature of competitive success, which is influenced by tactical execution, team dynamics, opponent strength, and officiating. The absence of objective sleep measures (e.g., polysomnography or actigraphy) limited the ability to verify adherence to the SHP and quantify sleep depth and duration. Future studies should incorporate wearable sleep monitoring devices (e.g., Actiheart, wrist-based actigraphy) to enhance measurement accuracy and precision. Individual variability in sleep need, chronotype, baseline habits, and psychological stress may have contributed to differential responses to the intervention. Personalized sleep monitoring and subjective well-being assessments are recommended to tailor sleep strategies more effectively. Additionally, the use of the PSQI, which assesses sleep over a month, may not have captured short-term fluctuations relevant to tournament settings. Athlete-specific tools, such as the Athlete Sleep Screening Questionnaire and the Athlete Sleep Behavior Questionnaire, should be considered in future research.

Control over external variables, including diet, training load, travel schedules, and match timing, was limited, potentially introducing confounding influences. Although efforts were made to standardize team routines, future studies should aim to monitor or control these factors to strengthen causal inference. Contextual influences such as team tactics, psychological readiness, and opponent variability were not accounted for and may have impacted performance outcomes. Integrating these variables would improve ecological validity and interpretability. Furthermore, the short wash-out period (one week and one match) may not have sufficiently mitigated carryover effects between intervention phases. Lastly, the generalizability of these findings is limited by the sample characteristics, which included university-level athletes from a single team and a small number of intervention matches. As such, caution should be exercised when applying these results to other athletic populations or competitive environments, which may constrain generalizability; replication in elite or professional settings is warranted to assess applicability at higher levels of competition.

CONCLUSION

In conclusion, this study suggests that a structured four-week sleep hygiene protocol may support improvements in selected physical performance indicators during competitive football tournaments. Enhancements in dribbling, passing, and offensive activity were observed, potentially reflecting the cognitive and physiological benefits of improved sleep. However, match outcomes were not significantly affected, and the limited number of intervention matches, single-team sample, and potential confounding factors restrict the generalizability and strength of causal inference. While sleep hygiene may contribute to performance optimization at both the individual and team levels, its direct impact on competitive success remains uncertain and is likely influenced by a range of contextual and tactical variables. Future research should explore the long-term effects of sleep interventions, incorporate objective sleep monitoring, and examine interactions with other modifiable factors such as nutrition, training load, and psychological readiness.

APPLICABLE REMARKS

- A four-week sleep hygiene intervention was associated with improvements in subjective sleep scores, suggesting that structured sleep routines may support recovery during high-demand tournament phases. However, these findings should be interpreted with caution due to the reliance on self-reported measures and the absence of objective sleep tracking.
- Exposure to the sleep protocol coincided with measurable changes in selected performance indicators, indicating that sleep may play a supportive role in athletic output and fatigue management. Nonetheless, the influence of other uncontrolled variables and the limited sample size warrant careful interpretation.
- Positive associations between sleep hygiene and performance outcomes suggest that sleep-focused strategies could be a useful component of athlete support programs. However, their contribution to competitive success remains uncertain and likely depends on a broader set of contextual and performance-related factors.

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AUTHORS' CONTRIBUTIONS

All authors contributed to the conception and design of the study. Broodryk, Prevoo, and Kramer performed material preparation, data collection, and analysis. Prevoo wrote the first draft of the manuscript, and all authors commented on previous versions of the manuscript. Broodryk finalized the final version of the article. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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ETHICAL CONSIDERATION

Ethical approval was obtained from the Institutional Ethics Committee of the Faculty of Health Sciences, North-West University, South Africa (NR: NWU-0299-21-A1). The research was conducted in strict accordance with the ethical standards laid out in the Declaration of Helsinki, ensuring the highest levels of ethical consideration and participant safety throughout the study.

ROLE OF THE SPONSOR

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The authors of the present study did not utilize any artificial intelligence-based software for the conceptualization, data analysis, or writing of the paper, except for general-purpose language models used for proofreading or editing assistance, where applicable.

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