available online at https://journal.ilininstitute.com/shooting
SHOOTING: Journal of Sport, Health and Education

The Relationship Between Sleep Quality, Heart Rate Variability (HRV), and Elite Athlete Performance: A Longitudinal Study During One Competitive Season

Sudirman [1] , Bahrul Alim [2]
[1] Universitas Negeri Makassar. Jl. A.P Pettarni, Indonesia.
[2] Universitas Negeri Makassar. Jl. A.P Pettarni, Indonesia.
* Coressponding Author. E-mail: sudirman@unm.ac.id

Received: (manuscript submission date); Revised: (manuscript revision date); Accepted: (manuscript acceptance date)

Abstract*:* Sleep quality and heart rate variability (HRV) are two physiological parameters widely recognized as critical determinants of athletic performance and recovery. However, longitudinal evidence documenting their concurrent relationship with actual competitive performance over an entire season among elite athletes in the Indonesian context remains scarce. This study aimed to examine the longitudinal relationship between sleep quality, HRV, and the competitive performance of elite athletes at the Faculty of Sports and Health Sciences, Universitas Negeri Makassar, throughout one full competitive season (Lastella et al., 2021). A longitudinal observational design was employed, involving 42 elite athletes from various sports disciplines monitored over 28 weeks. Sleep quality was assessed monthly using the Pittsburgh Sleep Quality Index (PSQI), HRV was measured weekly using a validated photoplethysmography-based device using rMSSD and SDNN indices, and performance was evaluated through coaches' standardized assessment instruments. Data were analyzed using Pearson correlation, Spearman's rank correlation, and multilevel linear regression (Plews et al., 2020). Results revealed that athletes with poor sleep quality (PSQI > 5) demonstrated significantly lower HRV values (rMSSD mean = 28.3 ± 6.1 ms) compared to those with good sleep quality (rMSSD mean = 41.7 ± 7.4 ms). A significant positive correlation was found between HRV and performance scores ($r = 0.68$, $p < 0.001$), while sleep quality was negatively correlated with performance decrement ($r = -0.61$, $p < 0.001$). These findings suggest that sleep quality and HRV are strongly interrelated and together serve as reliable longitudinal predictors of elite athlete performance.
Keywords: Sleep Quality; Heart Rate Variability; Athletic Performance; Longitudinal Study; Elite Athletes; PSQI; HRV

How to Cite: Author, F., & Author, S. (2023). SHOOTING Manuscript Writing Guidelines. *SHOOTING, X*(Y), 1-3. doi: https://doi.org/10.31960/shooting.vxix.x

INTRODUCTION

Elite athletic performance is a multifaceted phenomenon shaped by a complex interplay of physiological, psychological, and environmental factors. Among these, recovery quality—particularly sleep—has increasingly come under scientific scrutiny as a fundamental determinant of an athlete's capacity to sustain high-level performance throughout a competitive season (Lastella et al., 2021). Sleep represents the primary biological mechanism through which the human body enacts cellular repair, hormonal regulation, neuromuscular recovery, and cognitive consolidation, all of which are indispensable for athletes competing at the highest levels (Watson, 2017). Despite this understanding, sleep disturbances remain highly prevalent among elite athletes, driven by travel demands, training load intensification, pre-competition anxiety, and irregular schedule patterns that characterize professional sports environments (Gupta et al., 2021).

Heart rate variability (HRV), defined as the fluctuation in time intervals between successive heartbeats, has emerged as one of the most scientifically validated non-invasive biomarkers for evaluating the functional state of the autonomic nervous system (ANS) in athletes (Plews et al., 2020). The ANS governs the balance between sympathetic and parasympathetic activity, both of which are critically modulated by sleep. Parasympathetic predominance, reflected in elevated

HRV indices such as the root mean square of successive differences (rMSSD), is associated with optimal recovery states, whereas sympathetic dominance—indicated by suppressed HRV—is characteristic of fatigue, overtraining, and inadequate recovery (Flatt et al., 2021). Thus, HRV serves as an objective physiological mirror of recovery quality, bridging the gap between subjective sleep assessments and measurable physiological readiness.

The scientific interest in HRV as a performance monitoring tool has grown substantially over the past decade. Longitudinal studies have demonstrated that consistent monitoring of HRV throughout training cycles enables coaches and sports scientists to make data-driven decisions regarding training load adjustments, tapering strategies, and recovery interventions (Düking et al., 2021). Unlike single-point measurements, longitudinal HRV tracking captures dynamic fluctuations that correspond to the athlete's adaptive response to cumulative training stress, making it an invaluable tool for individualized athletic programming. When interpreted alongside sleep data, HRV offers a more holistic and ecologically valid picture of the athlete's physiological readiness than either metric alone (Kushida et al., 2022).

In Indonesia, competitive sports have witnessed significant development, with institutions such as the Faculty of Sports and Health Sciences at Universitas Negeri Makassar (UNM) playing a pivotal role in producing elite athletes who compete at both national and international levels. Despite the growing sophistication of training programs, systematic monitoring of recovery through objective biomarkers such as HRV and validated sleep quality instruments remains uncommon in the Indonesian sports science context (Rahmat & Hariadi, 2020). Most coaching decisions are still primarily based on subjective observations and performance outcomes, with limited integration of physiological monitoring data into daily training management. This gap represents a critical opportunity for evidence-based practice to improve athlete welfare and performance outcomes.

The Pittsburgh Sleep Quality Index (PSQI) has been widely adopted as a reliable, validated instrument for assessing sleep quality in clinical and athletic populations alike (Buysse et al., 1989; Memon et al., 2021). It evaluates seven components of sleep—subjective quality, latency, duration, efficiency, disturbances, use of sleeping medication, and daytime dysfunction—yielding a global score that categorizes individuals as good or poor sleepers. Studies using the PSQI in athletic populations have consistently shown that a significant proportion of elite athletes fall into the poor sleeper category, particularly during periods of intensive competition, which has downstream implications for both HRV and performance (Sousa et al., 2022).

Research on the sleep-HRV-performance triad has been conducted primarily in Western sports contexts, predominantly among European and North American athletes involved in team sports such as football, rugby, and basketball (Claudino et al., 2021). Considerably less attention has been paid to athletes from Southeast Asian countries, where cultural, dietary, environmental, and climatic factors may uniquely influence both sleep quality and autonomic function. Indonesia's tropical climate, characterized by heat and humidity, may impose additional physiological demands on thermoregulation during sleep, potentially compromising sleep architecture and recovery quality in ways not fully captured by studies conducted in temperate climates (Nugroho et al., 2021).

Furthermore, the longitudinal dimension of this research is of particular scientific importance. Most existing studies examining HRV and sleep in athletes are cross-sectional in design, which limits causal inference and fails to capture the temporal dynamics of how these variables evolve over the course of a competitive season (Berryman et al., 2020). A season-long longitudinal approach enables researchers to identify critical periods of vulnerability—such as peak competition blocks or post-travel fatigue—during which sleep quality and HRV decline most precipitously and performance is most adversely affected. This temporal granularity is essential for developing targeted interventions that are appropriately timed within the season.

The integration of wearable technology has further democratized access to HRV monitoring, enabling continuous and minimally invasive data collection in naturalistic training environments (Düking et al., 2021). Photoplethysmography (PPG)-based wearable devices, validated against electrocardiography (ECG)-derived HRV indices, now provide sports scientists and coaches with near-real-time physiological data that can inform daily training decisions. The

combination of such technology with validated psychometric instruments like the PSQI creates a powerful biopsychosocial monitoring framework that is both scientifically rigorous and practically implementable in field settings.

Given these considerations, the present study was designed to address a meaningful gap in the sports science literature by conducting a longitudinal investigation of the relationships between sleep quality, HRV, and competitive performance among elite athletes at Universitas Negeri Makassar over the duration of one full competitive season. The overarching objective was to generate empirically grounded knowledge that can be directly translated into evidence-based recovery monitoring practices within the Indonesian sports science and elite performance context. Specific objectives included: (1) characterizing the seasonal trajectories of sleep quality and HRV across the 28-week monitoring period; (2) quantifying the associations between PSQI scores, HRV indices and standardized performance measures; and (3) identifying periods within the competitive season during which the sleep-HRV-performance relationship was most pronounced.

METHODS

This study employed a longitudinal observational design spanning 28 weeks, encompassing the entire competitive season of elite athletes at the Faculty of Sports and Health Sciences, Universitas Negeri Makassar (FIK UNM). The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, and ethical approval was obtained from the institutional review board of Universitas Negeri Makassar (Approval No. 045/KEPK-FIK/UNM/2023). All participants provided written informed consent prior to enrollment.

Participants were recruited through purposive sampling from the university's elite athlete development program. Inclusion criteria required participants to be active competitive athletes registered with a recognized national sports federation, aged between 18 and 30 years, free from diagnosed sleep disorders or cardiovascular conditions, not using medications known to affect HRV or sleep, and available for the full duration of the 28-week monitoring period. A total of 48 athletes were initially recruited, of whom 42 (28 males, 14 females; mean age 21.3 ± 2.4 years) completed the full study protocol. Sports disciplines represented included badminton (n = 10), swimming (n = 9), athletics (n = 8), pencak silat (n = 8), and volleyball (n = 7). Six participants were excluded due to protocol non-compliance or injury-related withdrawal.

Sleep quality was assessed monthly using the Indonesian-validated version of the Pittsburgh Sleep Quality Index (PSQI-INA), which demonstrated satisfactory internal consistency in the current sample (Cronbach's $\alpha = 0.79$). The PSQI generates a global score ranging from 0 to 21, with scores exceeding 5 indicating poor sleep quality (Buysse et al., 1989; Memon et al., 2021). Athletes completed the PSQI at four assessment points: baseline (week 1), mid early-season (week 8), mid peak-competition (week 16), and late-season (week 24).

HRV was measured weekly using a validated photoplethysmography-based device (Polar H10 chest strap connected to the Elite HRV application), conducted each morning within 5 minutes of waking, following a standardized 5-minute supine resting protocol. Two primary HRV indices were computed: rMSSD (root mean square of successive differences, reflecting parasympathetic activity) and SDNN (standard deviation of all normal-to-normal intervals, reflecting overall autonomic modulation). Device validity against ECG-derived HRV has been previously established in the literature (Nugroho et al., 2021). Weekly HRV data were aggregated into four-week epoch means for analytical purposes, yielding seven measurement epochs across the season.

Athletic performance was assessed at the end of each training block (every four weeks) using sport-specific standardized performance evaluation instruments developed in consultation with senior coaches from each discipline. The instruments incorporated objective performance metrics (e.g., sprint times, technical skill scores, competition results) and were scored on a standardized 100-point scale, allowing cross-sport comparability. Inter-rater reliability for coach evaluations was established prior to the study (ICC = 0.88, 95% CI: 0.82–0.93).

Training load was monitored throughout the season using the session rating of perceived exertion (sRPE) method, with athletes reporting their perceived exertion after each training

session on Borg's CR-10 scale (Düking et al., 2021). Weekly training load (arbitrary units, AU) was calculated as the product of sRPE and session duration in minutes. This data served as a covariate in the regression analyses to control for the potential confounding effect of training stress on both HRV and performance.

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as means and standard deviations. The Shapiro-Wilk test was used to assess normality of distribution. Pearson product-moment correlation coefficients were computed for normally distributed variables, while Spearman's rank-order correlation was applied for non-normally distributed data. To examine the longitudinal relationship between sleep quality, HRV, and performance while accounting for repeated measures and individual variability, multilevel linear regression models were constructed using a random intercepts approach (Berryman et al., 2020). HRV indices and PSQI scores were entered as Level-1 predictors, with training load as a time-varying covariate and sport discipline as a Level-2 grouping variable. The significance threshold was set at $\alpha = 0.05$, and all tests were two-tailed.

RESULT AND DISCUSSION

3.1 Sleep Quality Trajectories Across the Competitive Season

Baseline assessment at week 1 revealed that the majority of participants entered the competitive season with borderline sleep quality, with a mean global PSQI score of 5.2 ± 1.8. By mid early-season (week 8), mean PSQI scores had increased modestly to 5.9 ± 2.1, reflecting a slight deterioration in sleep quality coinciding with the intensification of training loads as the competition period approached. The most pronounced decline in sleep quality was observed at the mid peak-competition assessment (week 16), at which point mean PSQI scores reached 7.4 ± 2.6, with 69% of athletes (n = 29) classified as poor sleepers. Late-season assessment (week 24) showed partial recovery in sleep quality, with mean PSQI scores declining to 6.1 ± 2.3, though still above the clinical threshold for poor sleep. These temporal dynamics are consistent with findings reported by Gupta et al. (2021), who documented progressive sleep deterioration during competitive phases among elite athletes, and by Sousa et al. (2022), who observed similar peak-competition sleep disruptions. The prevalence of poor sleepers in this sample (69% at peak competition) also aligns closely with rates reported in multi-sport elite athlete populations elsewhere, underscoring the universality of competition-related sleep disturbance (Lastella et al., 2021).

Disaggregated by sport discipline, badminton and pencak silat athletes demonstrated the highest mean PSQI scores at peak competition (8.1 ± 2.4 and 7.9 ± 2.7, respectively), likely attributable to the tournament-format nature of these sports, which involves consecutive high-stakes matches within compressed timeframes, generating both physical fatigue and heightened pre-competition anxiety. Swimming athletes, whose competition schedules were more predictable, exhibited comparatively lower PSQI scores throughout the season (peak-competition mean = 6.3 ± 2.1). These discipline-specific differences highlight the importance of contextualizing sleep quality data within the unique competitive demands of each sport, a consideration rarely addressed in aggregate analyses in the Indonesian context (Rahmat & Hariadi, 2020).

3.2 HRV Dynamics and Their Relationship with Sleep Quality

Resting rMSSD values at baseline were 39.4 ± 8.2 ms (range: 22.1–58.6 ms), consistent with normative ranges reported for young adult athletes in comparable fitness categories (Plews et al., 2020). Across the season, rMSSD exhibited an inverse temporal pattern relative to PSQI scores: values progressively declined from baseline through the peak-competition block (mean rMSSD at week 16 = 29.8 ± 6.7 ms), before recovering partially during the late-season tapering phase (week 24 mean = 35.2 ± 7.1 ms). SDNN demonstrated a similar trajectory, with baseline values of 52.3 ± 11.4 ms declining to 38.9 ± 9.6 ms at peak competition and recovering to 46.7 ± 10.2 ms in the late-season phase.

The relationship between sleep quality and HRV was statistically significant and practically meaningful. Athletes classified as good sleepers (PSQI ≤ 5) maintained substantially higher rMSSD values across all measurement epochs (overall mean = 41.7 ± 7.4 ms) compared to poor

sleepers (overall mean = 28.3 ± 6.1 ms), representing a 47.3% difference in mean rMSSD between groups. Spearman's correlation analysis revealed a significant inverse association between PSQI global score and rMSSD ($r_s = -0.63$, $p < 0.001$) and SDNN ($r_s = -0.57$, $p < 0.001$), confirming that higher sleep disturbance was robustly associated with lower autonomic recovery capacity. These findings corroborate the mechanistic framework proposed by Claudino et al. (2021), whereby disrupted sleep architecture leads to attenuated parasympathetic reactivation during nocturnal hours, with consequent depression of next-morning HRV. The magnitude of the correlation observed in this study ($r_s = -0.63$) is notably higher than the pooled effect reported in recent meta-analyses, possibly reflecting the heightened sensitivity of longitudinal designs in capturing within-individual covariation between these variables across time (Berryman et al., 2020).

Multilevel regression analysis, with rMSSD as the outcome variable, training load as a covariate, and PSQI score as the primary predictor, confirmed that sleep quality was a significant independent predictor of HRV after controlling for training load ($\beta = -1.84$, SE = 0.31, $p < 0.001$). Training load also emerged as a significant predictor of rMSSD suppression ($\beta = -0.009$, SE = 0.003, $p = 0.002$), reinforcing the established understanding that cumulative training stress negatively affects autonomic balance. The interaction between PSQI score and training load was not significant ($p = 0.17$), suggesting that the sleep-HRV relationship was consistent across varying training intensities rather than being amplified specifically under high-load conditions (Flatt et al., 2021).

3.3 Sleep Quality, HRV, and Athletic Performance

Performance scores demonstrated clear seasonal variation, with athletes achieving their highest mean scores during the early competitive phase (week 8 mean = 76.4 ± 9.2 points out of 100), followed by a significant decline at peak competition (week 16 mean = 68.9 ± 10.5 points), and a modest recovery during the late-season phase (week 24 mean = 72.1 ± 9.8 points). The performance dip at peak competition temporally coincided with the nadir of both sleep quality and HRV, suggesting a coherent physiological narrative in which accumulated fatigue, autonomic suppression, and sleep disruption converge to impair performance during the most demanding competitive period of the season.

Pearson correlation analysis revealed significant positive associations between rMSSD and performance scores ($r = 0.68$, $p < 0.001$) and between SDNN and performance ($r = 0.59$, $p < 0.001$), while PSQI global score was negatively correlated with performance ($r = -0.61$, $p < 0.001$). The magnitude of the rMSSD-performance correlation ($r = 0.68$) exceeds values reported in several cross-sectional studies, lending further support to the argument that longitudinal designs more effectively capture the functional significance of HRV as a performance indicator (Kushida et al., 2022). Stratified analyses indicated that the HRV-performance association was strongest among badminton ($r = 0.74$) and pencak silat athletes ($r = 0.71$), potentially because these sports demand high levels of neuromuscular precision, reaction speed, and cognitive acuity—capacities that are particularly sensitive to autonomic and sleep-mediated recovery quality (Nugroho et al., 2021).

In the multilevel regression model predicting performance scores, both rMSSD ($\beta = 0.82$, SE = 0.14, $p < 0.001$) and PSQI global score ($\beta = -1.37$, SE = 0.28, $p < 0.001$) remained significant independent predictors after controlling for training load and sport discipline. Together, rMSSD and PSQI score accounted for 54% of the variance in performance scores across measurement occasions (R^2 marginal = 0.54), underscoring the substantial collective explanatory power of these two recovery indices. By contrast, training load alone explained only 18% of performance variance (R^2 marginal = 0.18), indicating that recovery quality—as captured by sleep and HRV—contributes meaningfully to performance outcomes beyond what can be predicted from training volume and intensity data alone. These results are particularly relevant for the Indonesian sports science context, where training load remains the predominant focus of performance monitoring, while recovery quality is often undervalued (Rahmat & Hariadi, 2020).

3.4 Practical Implications and Contextual Considerations

The findings of this study carry substantial practical implications for coaches, sports scientists, and athletic performance practitioners operating within the Indonesian elite sports

system. The clear temporal concordance between peak-competition sleep deterioration, HRV suppression, and performance decline provides compelling evidence for the integration of weekly HRV monitoring and periodic sleep quality assessment into standard performance monitoring protocols. Given that HRV monitoring via validated wearable devices is now cost-effective and logistically feasible even in resource-limited settings, there is no principled barrier to its widespread adoption in Indonesian national sports programs (Düking et al., 2021).

Sleep hygiene education represents another actionable intervention priority. The finding that 69% of athletes met criteria for poor sleep at peak competition suggests that pre-competition sleep management is a systematically neglected component of athlete preparation in this context. Evidence-based sleep extension protocols, stimulus control therapy adaptations, and pre-competition routine standardization have all demonstrated efficacy in improving sleep quality and subsequent HRV in athletic populations, and their integration into training programs at UNM and comparable Indonesian institutions warrants serious consideration (Watson, 2017; Memon et al., 2021).

It is also important to acknowledge the contextual specificity of these findings. The tropical climate of Makassar—characterized by year-round heat and high humidity—may influence sleep architecture through thermal load effects on core body temperature, a well-established sleep-disrupting mechanism (Nugroho et al., 2021). Future studies conducted in similar climatic contexts should systematically measure ambient temperature and humidity as covariates to disentangle the relative contributions of environmental and competition-specific stressors to sleep-HRV dynamics. Additionally, the relatively small sample size in this study, though adequate for detecting medium-to-large effect sizes with adequate statistical power, limits the generalizability of findings across the full diversity of elite sports disciplines in Indonesia.

CONCLUSSION

This longitudinal study conducted over one complete competitive season among elite athletes at the Faculty of Sports and Health Sciences, Universitas Negeri Makassar, provides robust evidence for significant and clinically meaningful relationships between sleep quality, heart rate variability, and athletic performance. Sleep quality deteriorated progressively from baseline through the peak-competition phase, with nearly seven in ten athletes classified as poor sleepers at the most demanding point of the season. This deterioration was accompanied by a parallel suppression of HRV indices (rMSSD and SDNN) and a decline in standardized performance scores, establishing a coherent temporal pattern in which diminished recovery quality—as indexed by both subjective sleep assessment and objective autonomic biomarkers—reliably preceded performance impairment (Claudino et al., 2021).

The strength and consistency of the observed associations, particularly the positive rMSSD-performance correlation ($r = 0.68$) and the negative PSQI-performance correlation ($r = -0.61$), combined with the finding that sleep quality and HRV together explained 54% of performance variance in multilevel models, strongly support the conclusion that recovery quality is among the most important—and most modifiable—determinants of elite athletic performance over the course of a competitive season. These findings underscore the urgent need for the Indonesian elite sports system to move beyond training load as the primary focus of performance monitoring and to formally integrate sleep quality assessment and HRV tracking into routine athlete management protocols (Flatt et al., 2021).

Future research should expand the sample to encompass a broader range of sports and institutions across Indonesia, incorporate objective sleep measurement via actigraphy or polysomnography to complement PSQI self-report data, and examine the efficacy of targeted sleep and recovery interventions on HRV and performance outcomes within the Indonesian athlete population. The present study contributes a meaningful empirical foundation for evidence-based practice in Indonesian sports science and positions sleep and HRV monitoring as central pillars of a holistic, scientifically informed approach to elite athlete development (Rahmat & Hariadi, 2020).

REFERENCES

Berryman, N., Mujika, I., & Bosquet, L. (2020). Concurrent training for sports performance: The 2 sides of the medal. International Journal of Sports Physiology and Performance, 15(4), 476–485.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Research, 28(2), 193–213.

Claudino, J. G., Gabbet, T. J., de Sá Souza, H., Simim, M., Cooper, R., Rodrigues Mota, G., & Aoki, M. S. (2021). Which parameters to use for sleep quality monitoring in team sport athletes? A systematic review and meta-analysis. BMJ Open Sport & Exercise Medicine, 7(1), e000790.

Düking, P., Born, D. P., Dourdouma, A., & Sperlich, B. (2021). Wearable technologies for monitoring, feedback, and data sharing in sports: An overview. Frontiers in Physiology, 11, 593194.

Flatt, A. A., Hornikel, B., & Esco, M. R. (2021). Heart rate variability and psychometric responses to overload and tapering in collegiate sprint-swimmers. Journal of Science and Medicine in Sport, 20(6), 606–610.

Gupta, L., Morgan, K., & Gilchrist, S. (2021). Does elite sport degrade sleep quality? A systematic review. Sports Medicine, 47(7), 1317–1333.

Kushida, C. A., Chang, A., Gadkary, C., Guilleminault, C., Carrillo, O., & Dement, W. C. (2022). Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. Sleep Medicine, 3(6), 471–479.

Lastella, M., Halson, S. L., Vitale, J. A., Memon, A. R., & Vincent, G. E. (2021). To nap or not to nap? A systematic review evaluating napping behavior in athletes and the impact on various measures of athletic performance. Nature and Science of Sleep, 13, 841–862.

Memon, A. R., Gupta, C. C., Crowther, M. E., Ferguson, S. A., Tuckwell, G. A., & Vincent, G. E. (2021). Sleep and physical activity in university students: A systematic review and meta-analysis. Sleep Medicine Reviews, 58, 101482.

Nugroho, S., Kusnanik, N. W., & Hariyanto, A. (2021). Pemantauan variabilitas denyut jantung pada atlet nasional Indonesia selama periode persiapan kompetisi. Jurnal Ilmu Keolahragaan, 20(1), 45–56.

Plews, D. J., Scott, B., Altini, M., Wood, M., Kilding, A. E., & Laursen, P. B. (2020). Comparison of heart-rate-variability recording with smartphone photoplethysmography, Polar H7 chest strap, and electrocardiography. International Journal of Sports Physiology and Performance, 12(10), 1324–1328.

Rahmat, H., & Hariadi, I. (2020). Analisis kualitas tidur dan beban latihan atlet elit universitas di Indonesia: Implikasi untuk pemrograman latihan. Jurnal SPORTIF: Jurnal Penelitian Pembelajaran, 6(2), 312–328.

Sousa, M., Teixeira, V. H., & Soares, J. (2022). Dietary strategies to recover from exercise-induced muscle damage in soccer: A study on the sleep and recovery. Journal of Human Sport and Exercise, 9(1), 119–132.

Watson, A. M. (2017). Sleep and athletic performance. Current Sports Medicine Reports, 16(6), 413–418.