The Effects of Sleep On Performance And Injury Of Professional Athletes: A Systematic Review

Rushil Ghimire[1*]
[1]Oak Park High School, Oak Park, California USA

Research Question:
How can the quality and the quantity of sleep affect performance and injury in professional athletes?

Abstract:

This systematic review investigates sleep and its impact on professional athletes. It is hypothesized that higher quality and longer duration of sleep will facilitate an athlete's ability to perform at a higher level and recover from their injuries more effectively. Due to the nature of their work, athletes push their bodies to the extreme limits of their physical abilities; therefore, they require more rest than many other occupations. Because of this, a deviation from standard levels and length of sleep will affect athletes in a significant manner. While studies have shown the importance of sleep in everyday activities, few studies explore the performance results due to a lack of high-quality sleep. By analyzing research that explores the effects of sleep as well as the physiological factors that impact the performance of an athlete, a connecting conclusion can be drawn between the two. This systematic review sorted through over 6,000 articles before selecting 16 that met the criteria. 87.5% of the 16 studies found a direct correlation between sleep and athlete performance and injury. A stronger understanding of this correlation could encourage the sports industry to reevaluate the importance of sleep to athlete performance. Coaches can designate more time for athletes to rest and recover from their exertion, increasing their ability to return to optimal performance. A larger focus on the importance of sleep will lead to healthier athletes and improved performance.

Keywords: Sleep, Athlete, Performance, Sport, Injury

1. Introduction

Sleep is a vital part of life. All mammals need sleep in order to rest and recharge their bodies. In today's technologically driven society, some basic human needs have become overlooked. In the constant working mindset of today's world, people are spending less time resting their bodies. Rest is important for people in all industries, however, it may be especially important in the realm of sports. Elite athletes strive to perform at their best day after day. In order to do that, they need sleep to recover. Sleep is defined as the body's rest cycle. During sleep, the body slows down, replenishing cells, tissues, and muscles (Chennaoui et al., 2021). Sleep improves memory recall, regulates glucose metabolism, reduces mental fatigue, and plays an important role in tissue repair, synaptic homeostasis, and immune-inflammatory responses (Chennaoui et al., 2021). Both the growth hormone and prolactin are at their highest levels during sleep, whereas cortisol, epinephrine, and norepinephrine, are at the lowest point during sleep hours between 11 pm and 7 am (Chennaoui et al., 2021). Prolactin helps to balance the body's hormones while cortisol is a stress hormone. Epinephrine and

norepinephrine raise adrenaline and blood pressure. Without enough sleep, the body may have too much or too little hormone exchange and not be ready for the next day's events.

Sleep can be characterized in two ways: quantity and quality. Quantity of sleep refers to the amount of time between when a person goes to bed and when they wake up. It is a numerical value that is measured in hours and minutes. Quality of sleep is a harder statistic to calculate. Quality of sleep refers to the amount of time spent in the deep sleep stage of the REM sleep cycle (Carley & Farabi, 2016). The brain sends out its slowest wavelengths during the deep sleep stage and this is when the body recovers the most as it returns to homeostasis. External factors such as noises, and temperature as well as internal factors such as bad dreams, urge to urinate, and nightmares can affect a person's quality of sleep (Altun & Cinar & Dede, 2012).

Sleep problems are very prevalent in sports. In a cross-sectional study by Khallai et al., consisting of over 100 professional soccer players, 68.5% suffered poor sleep quality with 27.0% of the players meeting the threshold to have insomnia (Khallai et al., 2019). Professional athletes reported poorer sleep quality in PSQI (Pittsburg Sleep Quality Index), compared to an age-matched cohort, which is likely due to the stress of competition, training, and traveling (Cameron & Perera & Fulcher, 2021). This lack of sleep impacts the athlete's ability to stay healthy and injury free. In physically demanding occupations or athletic populations, those who slept ≤ 4 hours were 2.35 times more likely to experience a musculoskeletal injury than those who slept ≥ 8 hours (Grier et al., 2020). Musculoskeletal injury refers to injury to bones, joints, ligaments, tendons, or muscles. An injury to any one of these body parts can prevent an athlete from participating in competitions.

Another study shows that sleep durations of <= 7 hours sustained for periods >= 14 days have been associated with a 70% increase in musculoskeletal injuries (Huang & Ihm, 2021). Sleep loss impedes the growth of muscle protein and the ability of skeletal muscle to adapt and repair, which likely limits training adaptations (Fullagar et al., 2015). Myoglobin, a common biomarker of muscle damage, was found at higher levels after only one night of sleep deprivation (Mejri et al., 2017).

Physical injury is not the only threat to an athlete due to a lack of sleep. The physiological effects of sleep loss are linked to reduced immune function via reductions in natural killer T cells (Reilly & Edwards, 2007). Killer T cells kill bacteria and viruses within the body. A reduction in their numbers makes a person more susceptible to illness. In a study following athletes over a one-year period, athletes that slept greater than 8 hours or had higher sleep quality levels were less likely to suffer illness (Hamlin & Deuchrass & Olsen, 2021).

While sleep results may differ between age ranges and professions, sleep durations between male (average 8.2 ± 1.0 h/night (mean ± SD)) and female (average 8.2 ± 1.1 h/night) professional athletes are very similar (Hamlin & Deuchrass & Olsen, 2021). However, professional athletes often have to travel to play games. One study showed that kickoff and travel time had the greatest effect on sleep variations in athletes (Leduc & Weaving & Owen, 2022). The lifestyle of an athlete is always changing as they have to move from location to location. This constant travel demonstrably affects both sleep and athletic performance.

National Basketball Association (NBA) teams tended to outscore their typical average by 1.6 points when they had more than 1 day off between games (Huyghe et al., 2018). The same study of the NBA found that an optimal recovery window of 72 hours following games and practices is needed for an athlete or team to return to optimal levels of performance (Huyghe et al., 2018). Unfortunately, the scheduling of games can often prevent athletes from getting adequate rest for their bodies. A study found faster sprint and reaction times, improved shooting

accuracy, energy, and mood after approximately 3 weeks of sleep extension (mean +110 minutes) in 11 basketball players (Fullagar et al., 2015). 110 extra minutes of sleep each day proved to have dramatic increases in the athletic ability of these basketball players. Sleep also plays a major role in other sports. For example, soccer players who exhibit lower sleep quality experience an increased number and severity of musculoskeletal injuries; 44% of the total variance in the number of injuries can be explained by sleep efficiency (the ratio of sleep time to total time in bed) and 47% of the total variance in the injury severity can be explained by sleep efficiency (Silva et al., 2020). In another study, professional cyclists were tested for their athletic performances based on sleep variations. One group of cyclists got 7 hours of sleep nightly while the other group was restricted to only 4 hours of sleep. The sleep-restricted group had reaction times that were 5% slower than the standard sleep group (Mah et al., 2019). Slower reactions can be expected to lead to more crashes and more injuries. The group with 7 hours of sleep had a vertical jump that was 5% higher as well as joint flexibility and coordination that was 15 degrees higher than that of the group with 4 hours of sleep (Mah et al, 2019).

The goal of this systematic review is to determine if there is a correlation between an athlete's sleep and their recovery after a sports-related injury. We have sifted through data across a variety of international sports. Our intention is to raise awareness of the importance of sleep in terms of performance and injury recovery, particularly in elite athletes.

Main Hypothesis:

1. More high-quality sleep will allow athletes to perform better and recover from injuries more efficiently.

Supplementary Hypotheses:

1. Shorter durations of sleep will lead to increased sports-related injuries
2. Shorter durations of sleep will negatively affect athlete performance
3. Higher quality of sleep will lead to fewer sports-related injuries
4. Higher quality of sleep will positively impact athlete performance

2. Methods

A systematic review of the research literature was performed to evaluate published, peer-reviewed studies examining the association between the quality of sleep, the quantity of sleep, the injury recovery of an athlete, and the performance of an athlete.

2.1 Article Selection

A comprehensive search for suitable research articles published between January 1, 1970, through June 1, 2022, was performed. The following online databases were used in this search: PubMed, Google Scholar, and ScienceDirect. Search terms were: "sleep duration" OR "sleep quality" OR "sleep" AND "exercise recovery" OR "injury recovery" OR "injury" OR "pain" OR "recovery" OR "rehabilitation" OR "athletic ability" OR "athletic capacity" OR "sport" OR "athlete" OR "performance" OR "quality" OR "capacity" OR "sleep deprivation" OR "exercise" OR "health" OR "strength". In order to be included, studies were required to: (1) incorporate original data, (2) include participants over the age of 18, (3) include participants who participated in their sport at a professional level, (4) report measures of sleep (either quality or quantity), (5) be clinical trials, controlled trials, randomized control trials, observational studies, comparative studies,

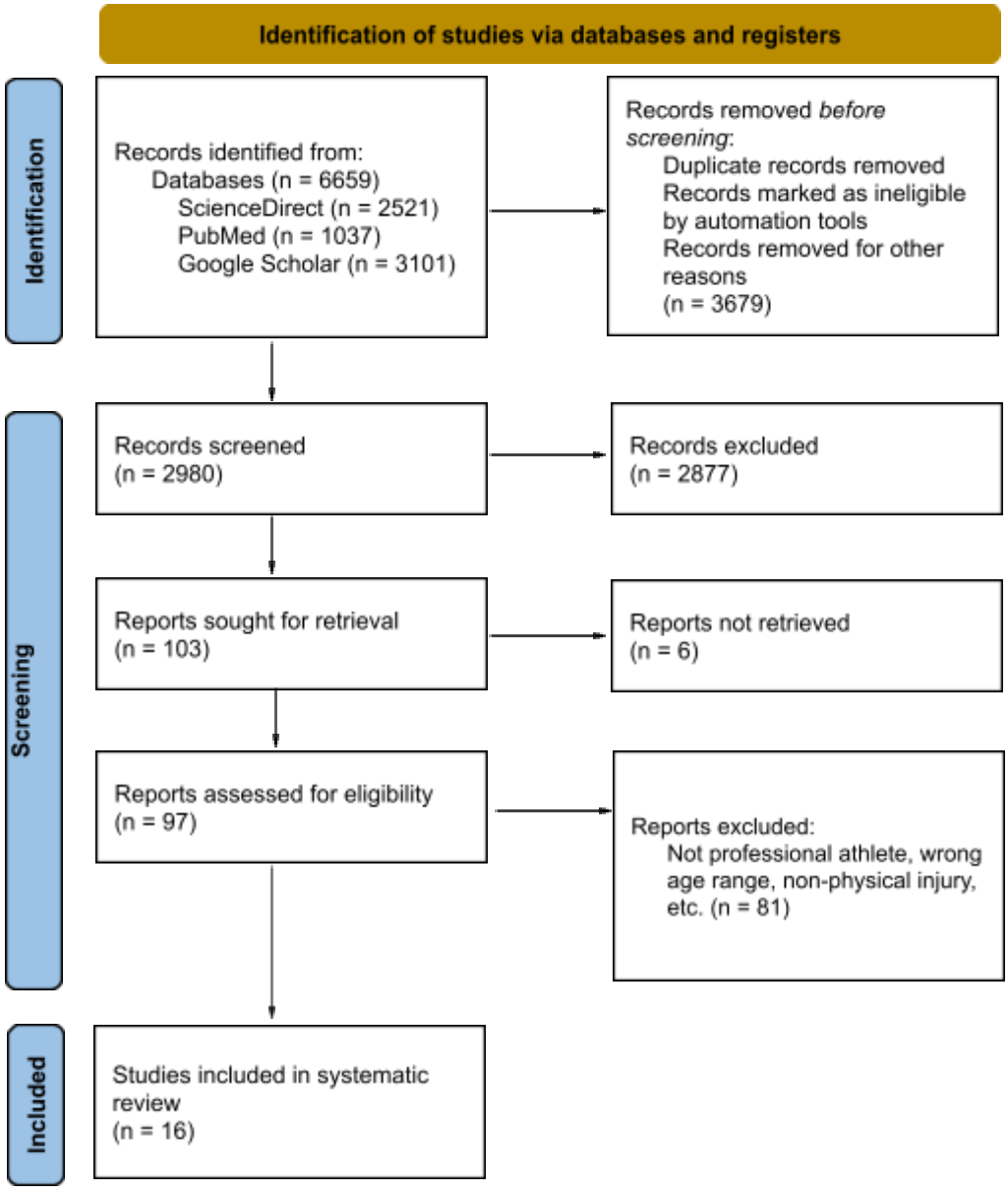
longitudinal studies, cross-sectional studies, or case reports, and (6) report some connection or lack thereof between injuries sustained by the athletes, their recovery processes, or their level of athletic performance. Literature was rejected when: (1) subject groups were comprised of children or adolescents (17 years of age or younger), (2) participants were amateur or non-professional athletes, (3) sleep was a secondary or adjunctive factor of the study, rather than a direct factor in the study, (4) injury data reported was focused on non-muscular injuries, namely brain trauma and concussions, (5) publications were encyclopedias, book chapters, conference abstracts, book reviews, case reports, conference info, poster presentations, correspondence, discussions, editorials, mini-reviews, news, practice guidelines, other unpublished work, or short communications, or (5) studies reported sleep-related measures as an outcome of injury or athletic performance and exercise, instead of a causal factor for changes in these behaviors.

Over 6,000 article titles and abstracts were individually sorted through in the search for relevant research that passed the inclusion criteria for this systematic review. All relevant literature on the three databases of PubMed, Google Scholar, and ScienceDirect, was sorted into a spreadsheet with its title, author, publishing date, and DOI. Duplicate and inaccessible records (due to updating or removal) were removed from consideration. The sheet was closely examined multiple times to account for maximum accuracy. The remaining records underwent a screening process that reviewed their titles and abstracts. If the abstracts and titles did not contain enough information to judge the eligibility, the full texts were read. Following this initial inspection, the selected articles were investigated once more to confirm their validity according to the inclusion criteria of the paper. Once this full-text review was completed, the final valid articles that followed all of the eligibility criteria were identified and moved to a data extraction stage.

2.2 Data Extraction

In the data extraction process, the studies were sorted into two groups depending on if they pertained to injury recovery or athletic performance. For each included article, the authors, the number of participants, the age of the participants, the country of the participants, the sport of the athletes, sleep quality numbers, sleep quantity numbers, injury-related findings, and performance-related findings were documented. This data was summarized in tables for comparison. The means and standard deviations for age, sleep efficiency, sleep time, and PSQI were also included. These values were used as a baseline to identify outliers within the data.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram of search strategy



2.3 Definitions of related terminology and parameters

The Pittsburgh Sleep Quality Index (PSQI) is a self-reported questionnaire that reports sleep quality and sleep disturbance. It consists of 19 questions that form 7 components before finalizing in one global score (Buysse et al., 1989). The Epworth Sleepiness Scale (ESS) is a self-reported questionnaire that calculates average sleep propensity (ASP). ASP characterizes how much daytime sleepiness a person suffers (Johns, 1991). SLEEP-50 is a self-reported questionnaire assessing the intensity of subjective sleep complaints. It consists of 50 questions and screens for a variety of sleep disorders (Spoormaker et al., 2005). Sleep Efficiency, which is a ratio of sleep time to total time in bed, that is measured in percentages, was also used in

some studies (Reed & Sacco, 2016). The Fatigue Severity Scale (FSS) is a self-reported questionnaire that evaluates a person's level of fatigue. It consists of 9 questions, answered on a scale of 1-7 (Krupp et al., 1989). The Athens Insomnia Scale (AIS) - a self-reported questionnaire that evaluates a person's insomnia – consists of 8 questions answered on a scale from 0 to 3 (Soldatos et al., 2000). The Athlete Sleep Screening Questionnaire (ASSQ) is a self-reported questionnaire developed specifically for athletic populations in order to calculate the sleep scores of athletes as opposed to the general populations (Bender et al., 2018). The Sleep Hygiene Index (SHI) is a 13-item self-reported measure designed to assess the practice of sleep hygiene behaviors. The components are evaluated on a scale from zero to four (Mastin et al., 2006).

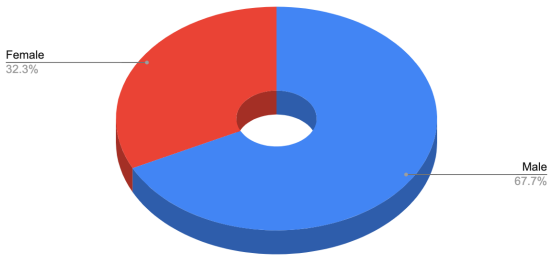
3. Results

The search strategy resulted in 16 relevant studies. As noted in Figure 1, the search began with over 6,000 pieces of literature. The selected studies included participants from the United Kingdom, various Middle Eastern countries, various European nations, various African nations, Brazil, the United States, Australia, and India. A total of 820 participants were involved. The studies were published between 2015 and 2022. The studies involved athletes from a variety of sports, including soccer, rugby, track and field, swimming, basketball, fencing, cycling, volleyball, wrestling, running, rowing, martial arts, and weightlifting.

The mean age of all of the athletes in the final selection of studies was 25.7 (2.16) years. 591 of the athletes were male (72.1%), while the remaining 229 were female (27.9%) [see Figure 2]. Out of the 820 athletes, the mean PSQI was 5.09 (0.76) [see Table 2]. The mean sleep efficiency (ratio of sleep time to total time in bed) was 85.48% (3.0) [see Table 1]. The mean sleep time for professional athletes was 7.48 hours (0.35) also known as 7 hours and 29 minutes [see Table 3]. Out of the 16 studies, 14 (87.5%) found a correlation between sleep and performance or injury recovery. Only 2 of the studies (12.5%) did not find any significant connection between sleep and athletes. These 2 studies had two of the smallest sample sizes of the entire group with 21 and 22 participants, respectively.

The main hypothesis that more high-quality sleep allows athletes to perform better and have healthier bodies was verified as the studies where athletes got more sleep resulted in better performance and fewer injuries. The supplementary hypotheses stated that shorter durations of sleep will lead to an increased amount of sports-related injuries, shorter durations of sleep will negatively affect athlete performance, higher quality of sleep will lead to fewer sports-related injuries, and higher quality of sleep will positively impact athlete performance, were also supported.

Figure 2. Breakdown of Participants by Gender



There were no relevant publications prior to 2015 within a search window from 1970 to 2022. [see Figure 3]. This may be because of the rise in awareness about the importance of sleep in specific athletic populations. As this rise occurred, more people began to research this subject, leading to all the qualified studies being published within the last seven years. Before this time, there was less attention to this field, especially as it pertains to athletes.

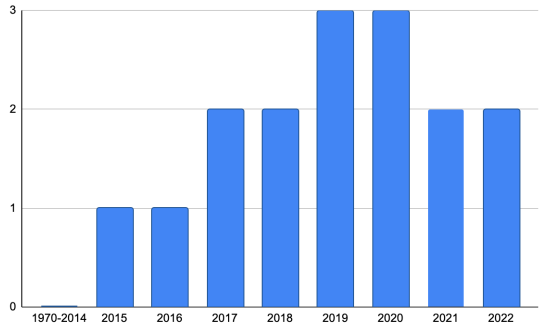


Figure 3. Relevant Publications by year

The vast majority of the athletes chosen were male. Athletics and sporting populations tend to be heavily favored by males. Men's sports are much more prevalent than women's sports as most of the world's largest sports leagues are male-dominated. The mean sleep time of 7 hours and 29 minutes, meant that most athletes tended to get decent amounts of sleep. A mean sleep efficiency of 85.48% showed that professional athletes tend to have healthy sleep habits. The mean PSQI of 5.09 is on the border between good and poor sleep. (Scores > 5 on the PSQI are considered poor.) However, while their scores were not clearly "good," athletes had higher scores than the global average (5.64 (SD = 2.79)) (Dietch et al., 2016). This shows how professional athletes tend to take care of their bodily needs slightly more than the average human. Given that professional athletes need to be in superior physical shape, this slightly better quality of sleep makes sense.

The cutoff time for good sleep duration was around 7 hours. Any athlete who slept for less than 7 hours in a night was more prone to injury risk and performed worse (Antunes et al., 2017). With a mean sleep time of 7 hours and 29 minutes, many professional athletes were getting enough sleep to decrease their risk for injury and increase their athletic performance.

4. Discussion

Two of the 16 studies did not agree with the correlation between sleep and injury. One study stated that injury incidence was not significantly affected by sleep duration, sleep efficiency, or a combination of these factors (Dennis et al., 2016). Another study came to a similar result, concluding that low sleep quality and quantity had a trivial or minor impact on neuromuscular function and recovery (Leduc et al., 2016).

On the other hand, 14 of the 16 studies agreed with the hypothesized correlation. One study found that total sleep time was significantly related to EFF (basketball performance efficiency statistic), which provides support for the hypothesis that higher total sleep time is related to better match performance in some individuals (Staunton et al., 2017).
Many other studies echoed this idea. MMA (mixed martial arts) athletes with consistent sleep times demonstrated stronger performance testing during the fight-camp period (Peacock et al., 2018). The inverse effects of sleep restriction were also shown by multiple studies. Consecutive days of sleep restriction impaired maximal vertical jump, decreasing jump height by 1.95 cm (Mah et al., 2019). While performance was increased with additional sleep, the reverse was also true. Sleep restriction led to worse athletic performance. Professional athletes reporting good sleep quality presented higher values of Wmax, VO2max, and lower values of HRmax (maximum work capacity, oxygen intake, and maximal heart rate) when compared to athletes with altered sleep (Antunes et al., 2017). For athletes, lower O2 uptake and lower resting heart rates are associated with poorer sleep quality (Stavrou et al., 2020). Another study showed that 38.89% (n =14) of professional athletes needed extra sleep or daytime rest/sleep (Yadav et al., 2019).

Changes in sleep quality and quantity also lead to injury and negative health effects. New injury risk significantly increased with fewer than 7 hours of sleep each day and significantly decreased with greater than 7 hours of sleep each day (Johnston et al., 2020). In addition, consecutive days of less than 7 hours of sleep have been shown to increase the risk of developing an upper respiratory tract infection (Cohen et al., 2009). Athletes with clinically defined sleep problems were more likely to report worse sleep hygiene and more general health complaints (Biggins et al., 2019). Because of this, it is essential for coaches and scientists to monitor and educate both individual and team sports athletes to facilitate sleep prior to important competitions (Juliff & Halson & Peiffer, 2015). Sleep will help to keep athletes healthy and injury-free.

Sleep was shown to play a large role in injury recovery and prevention over time as well. Athletes with better sleep quality at 3 months, 4.5 months, and 6 months were more likely to meet the discharge criteria from ACL (Anterior cruciate ligament) reconstruction therapy (Khalladi et al., 2021). Another study compared relative injury rates between two groups of athletes. The group with good sleep quality showed a mean of 1.0 injuries in the six months, while the group with poor sleep quality showed a mean of 2.5 injuries over the same duration (Silva et al., 2020). Multiple studies showed that increasing sleep quantity helped prevent injuries. An increase in sleep quantity during the 2 nights following a soccer match was significantly associated with a lower relative risk of injury (Delaval et al., 2022). Given the acknowledged importance of sleep to recovery and performance, this investigation emphasizes the worth of educating athletes on the principles of sleep health (Caia et al., 2018). There is reason to suppose that the more sleep education given to the athletes, the healthier they will stay in the future.

4.1 Consideration of Weaknesses

The review does not take all of the possible literature into account. Only three of the major scientific databases were used in order to compile all of the data. No gray literature was used. Sleep is an extremely variable factor. Many factors affect sleep. It is nearly impossible to control all of these factors. Diet, temperature, and lighting can all influence how well a person sleeps. The same factors work in terms of injury and performance. External factors such as diet, temperature, and environment affect if someone gets injured or how well they play. Sleep is not the only variable at play. There is not enough control with these variables within the studies to confirm the direct relationship between sleep, injury, and performance.

4.2 Broad Implications

The results of this review bring awareness to the importance of sleep. Elite professional athletes are among the fittest humans on the planet. Since sleep problems are universal, the information gathered can be extended to help all athletes. Coaches can be educated about the importance of sleep. They can give athletes more opportunities to rest and recover. This helps to prevent malpractice within the sporting industry. Once athletes have been educated about the importance of sleep, they can begin taking greater precautions in order to obtain enough sleep. This will decrease the number of injuries they suffer and will improve their in-game performance.

With the information presented, sports leagues around the world could begin to alter their rules, regulations, recommendations, or guidelines in a way that provides optimal support for the performance and health of athletes. For fans, they get a better viewing experience of the sport when the athletes are playing injury-free and are operating at peak performance. The athletes are able to stay healthy for longer and can remain in their respective leagues for more time, prolonging their careers and earning more money for their families. For the teams, they will get added viewership and more quality of play as their athletes remain healthy and perform better. When the importance of sleep is fully acknowledged, everyone in and around this industry will benefit.

There have been a few review articles that have covered the idea of sleep and its relation to athletes, however, this one covers both the topics of injury and performance while limiting the range to only professional athletes. The review provides an overview of the status quo of research pertaining to athletes and sleep.

The next steps are to further study the causal effects of sleep on injury and performance. Studies that study the outcome rather than the causation of sleep on performance and injury would further establish a connection between the subjects. Do injured athletes sleep worse than healthy athletes? Do athletes sleep worse after a bad performance? These connections can help to determine how much sleep affects us and how much we affect our sleep. These conclusions in the athletic population might be extended to the general population of humans, helping to progress the sleep health of all of humanity.

5. Acknowledgements

I would like to thank my mentor Jazmin Mogavero for guiding me through the process of developing my research paper. I would also like to thank my parents and Polygence for giving me the opportunity to complete this project.

Table 1 Sleep efficiency in athletes

Author	Year	n	Sleep Efficiency	Sport	Male/ Female	Age	Publication	Country
Dennis et al.	2016	22	82 ± 7%	soccer	male	23.8 +/- 3.2 y	longitudinal	Australia
Staunton et al.	2017	17	79 ± 7% & 92 ± 4%	basketball	female	N/A	longitudinal	Australia
Caia et al.	2018	24	89.6 ± 3.9 %	rugby	male	25.4 +/- 3.3 y	longitudinal	Australia
Leduc et al.	2022	21	80.7 +/- 6.0 %	rugby	male	21.0 +/- 1.3 y	longitudinal	UK

Table 2 PSQI in athletes

Author	Year	n	PSQI	Sport	Male/ Female	Age	Publication	Country
Juliff et al.	2015	283	5.195 +/- 1.04	multisport	male/ female	24 +/- 5 y	cross sectional	Australia
Antunes et al.	2017	27	6.75 +/- 1.2	athletics	male	29 +/- 5 y	cross sectional	Brazil
Yadav et al.	2019	36	4.2 +/- 2.36	weightlifting	male	19.78 +/- 4.71 y	pilot study	India
Stavrou et al.	2020	42	4.9 +/- 2.7 & 3.0 +/- 1.0	soccer	male	21.6 +/- 5.4 y	cross sectional	Greek
Khalladi et al.	2021	89	6.8 +/- 2.5 to 5.3 +/- 2.6 @6m & 5.5 +/- 2.3 to 4.3 +/- 2.3 @6m	multisport	male	23.8 +/- 5.3 y	cohort study	African, Asian, Caucasian
Murphy et al.	2021	18	5.61 +/- 3.13	rugby	male	30 +/- 5 y	longitudinal	UK

Table 3 Sleep Length for athletes

Author	Year	n	Sleep Length	Sport	Male/ Female	Age	Publication	Country
Juliff et al.	2015	283	7:42 +/- 0:54 h	multisport	male/ female	24 +/- 5 y	cross sectional	Australia
Dennis et al.	2016	22	7.28 +/- 1.01 h	soccer	male	23.8 +/- 3.2 y	longitudinal	Australia
Staunton et al.	2017	17	7.6 +/- 1.5 h	basketball	female	N/A	longitudinal	Australia
Antunes et al.	2017	27	7.0 +/- 1.6 h	athletics	male	29 +/- 5 y	cross sectional	Brazil

Caia et al.	2018	24	8:08 +/- 00:55 h	rugby	male	25.4 +/- 3.3 y	longitudinal	Australia
Mah et al.	2019	11	7.4 +/- 0.5 h	cyclists	male	28.8 +/- 4.5 y	longitudinal	USA
Johnston et al.	2020	95	6.9 +/- 0.9 h	multisport	male/ female	42 +/- 10 y	prospective study	Ireland
Murphy et al.	2021	18	7.06 +/- 1.30 h	rugby	male	30 +/- 5 y	longitudinal	UK

6. References

1. Khalladi, K., Farooq, A., Souissi, S., Herrera, C. P., Chamari, K., Taylor, L., & El Massioui, F. (2019). Inter-relationship between sleep quality, insomnia and sleep disorders in professional soccer players. BMJ open sport & exercise medicine, 5(1), e000498. https://doi.org/10.1136/bmjsem-2018-000498

2. Cameron, A., Perera, N., & Fulcher, M. (2021). Professional Athletes Have Poorer Sleep Quality and Sleep Hygiene Compared With an Age-Matched Cohort. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine, 31(6), 488–493. https://doi.org/10.1097/JSM.0000000000000795

3. Grier, T., Dinkeloo, E., Reynolds, M., & Jones, B. H. (2020). Sleep duration and musculoskeletal injury incidence in physically active men and women: A study of U.S. Army Special Operation Forces soldiers. Sleep health, 6(3), 344–349. https://doi.org/10.1016/j.sleh.2020.01.004

4. Huang, K., & Ihm, J. (2021). Sleep and Injury Risk. Current sports medicine reports, 20(6), 286–290. https://doi.org/10.1249/JSR.0000000000000849

5. Chennaoui, M., Vanneau, T., Trignol, A., Arnal, P., Gomez-Merino, D., Baudot, C., Perez, J., Pochettino, S., Eirale, C., & Chalabi, H. (2021). How does sleep help recovery from exercise-induced muscle injuries? Journal of Science and Medicine in Sport, 24(10), 982–987. https://doi.org/10.1016/j.jsams.2021.05.007

6. Fullagar, H. H., Duffield, R., Skorski, S., Coutts, A. J., Julian, R., & Meyer, T. (2015). Sleep and Recovery in Team Sport: Current Sleep-Related Issues Facing Professional Team-Sport Athletes. International journal of sports physiology and performance, 10(8), 950–957. https://doi.org/10.1123/ijspp.2014-0565

7. Hamlin, M. J., Deuchrass, R. W., Olsen, P. D., Choukri, M. A., Marshall, H. C., Lizamore, C. A., Leong, C., & Elliot, C. A. (2021). The Effect of Sleep Quality and Quantity on Athlete's Health and Perceived Training Quality. Frontiers in sports and active living, 3, 705650. https://doi.org/10.3389/fspor.2021.705650

8. Leduc, C., Weaving, D., Owen, C., Lacome, M., Ramirez-Lopez, C., Skok, M., Tee, J. C., & Jones, B. (2022). The Effect of Rugby Union Match Play on Sleep Patterns and Subsequent Impact on Postmatch Fatigue Responses. International journal of sports

physiology and performance, 1–10. Advance online publication. https://doi.org/10.1123/ijspp.2021-0421

9. Huyghe, T., Scanlan, A. T., Dalbo, V. J., & Calleja-González, J. (2018). The Negative Influence of Air Travel on Health and Performance in the National Basketball Association: A Narrative Review. Sports (Basel, Switzerland), 6(3), 89. https://doi.org/10.3390/sports6030089

10. Mejri, M. A., Yousfi, N., Hammouda, O., Tayech, A., Ben Rayana, M. C., Driss, T., Chaouachi, A., & Souissi, N. (2017). One night of partial sleep deprivation increased biomarkers of muscle and cardiac injuries during acute intermittent exercise. The Journal of sports medicine and physical fitness, 57(5), 643–651. https://doi.org/10.23736/S0022-4707.16.06159-4

11. Silva, A., Narciso, F. V., Soalheiro, I., Viegas, F., Freitas, L., Lima, A., Leite, B. A., Aleixo, H. C., Duffield, R., & de Mello, M. T. (2020). Poor Sleep Quality's Association With Soccer Injuries: Preliminary Data. International journal of sports physiology and performance, 15(5), 671–676. https://doi.org/10.1123/ijspp.2019-0185

12. Balk, Y. A., de Jonge, J., Oerlemans, W. G., & Geurts, S. A. (2019). Physical recovery, mental detachment and sleep as predictors of injury and mental energy. Journal of health psychology, 24(13), 1828–1838. https://doi.org/10.1177/1359105317705980

13. Mah, C. D., Sparks, A. J., Samaan, M. A., Souza, R. B., & Luke, A. (2019). Sleep restriction impairs maximal jump performance and joint coordination in elite athletes. Journal of sports sciences, 37(17), 1981–1988. https://doi.org/10.1080/02640414.2019.1612504

14. Charest, J., & Grandner, M. A. (2020). Sleep and Athletic Performance: Impacts on Physical Performance, Mental Performance, Injury Risk and Recovery, and Mental Health. Sleep medicine clinics, 15(1), 41–57. https://doi.org/10.1016/j.jsmc.2019.11.005

15. Biggins, M., Purtill, H., Fowler, P., Bender, A., Sullivan, K. O., Samuels, C., & Cahalan, R. (2019). Sleep in elite multi-sport athletes: Implications for athlete health and wellbeing. Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine, 39, 136–142. https://doi.org/10.1016/j.ptsp.2019.07.006

16. Khalladi, K., Farooq, A., Sas, B., Chtourou, H., Bouras, R., Racinais, S., Souissi, S., Gaoua, N., Chamari, K., & El Massioui, F. (2021). Sleep and psychological factors are associated with meeting discharge criteria to return to sport following ACL reconstruction in athletes. Biology of sport, 38(3), 305–313. https://doi.org/10.5114/biolsport.2021.99704

17. Stavrou, V. T., Astara, K., Daniil, Z., Gourgoulianis, K. I., Kalabakas, K., Karagiannis, D., & Basdekis, G. (2020). The Reciprocal Association between Fitness Indicators and Sleep Quality in the Context of Recent Sport Injury. International journal of environmental research and public health, 17(13), 4810. https://doi.org/10.3390/ijerph17134810

18. Johnston, R., Cahalan, R., Bonnett, L., Maguire, M., Glasgow, P., Madigan, S., O'Sullivan, K., & Comyns, T. (2020). General health complaints and sleep associated with new injury within an endurance sporting population: A prospective study. Journal of science and medicine in sport, 23(3), 252–257. https://doi.org/10.1016/j.jsams.2019.10.013

19. Murphy, C. J., Hartescu, I., Roberts, I. E., Leicht, C. A., & Goosey-Tolfrey, V. L. (2021). Sleep Characteristics of Highly Trained Wheelchair Rugby Athletes With and Without a Cervical Spinal Cord Injury During the Competitive Season. Frontiers in sports and active living, 3, 643233. https://doi.org/10.3389/fspor.2021.643233

20. Peacock, C. A., Mena, M., Sanders, G. J., Silver, T. A., Kalman, D., & Antonio, J. (2018). Sleep Data, Physical Performance, and Injuries in Preparation for Professional Mixed Martial Arts. Sports (Basel, Switzerland), 7(1), 1. https://doi.org/10.3390/sports7010001

21. Carley, D. W., & Farabi, S. S. (2016). Physiology of Sleep. Diabetes spectrum : a publication of the American Diabetes Association, 29(1), 5–9. https://doi.org/10.2337/diaspect.29.1.5

22. Altun, I., Cınar, N., & Dede, C. (2012). The contributing factors to poor sleep experiences in according to the university students: A cross-sectional study. Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences, 17(6), 557–561.

23. Bender, A. M., Lawson, D., Werthner, P., & Samuels, C. H. (2018). The Clinical Validation of the Athlete Sleep Screening Questionnaire: an Instrument to Identify Athletes that Need Further Sleep Assessment. Sports medicine - open, 4(1), 23. https://doi.org/10.1186/s40798-018-0140-5

24. Mastin, D. F., Bryson, J., & Corwyn, R. (2006). Assessment of sleep hygiene using the Sleep Hygiene Index. Journal of behavioral medicine, 29(3), 223–227. https://doi.org/10.1007/s10865-006-9047-6

25. Soldatos, C. R., Dikeos, D. G., & Paparrigopoulos, T. J. (2000). Athens Insomnia Scale: validation of an instrument based on ICD-10 criteria. Journal of psychosomatic research, 48(6), 555–560. https://doi.org/10.1016/s0022-3999(00)00095-7

26. Krupp, L. B., LaRocca, N. G., Muir-Nash, J., & Steinberg, A. D. (1989). The fatigue severity scale. Application to patients with multiple sclerosis and systemic lupus erythematosus. Archives of neurology, 46(10), 1121–1123. https://doi.org/10.1001/archneur.1989.00520460115022

27. Spoormaker, V. I., Verbeek, I., van den Bout, J., & Klip, E. C. (2005). Initial validation of the SLEEP-50 questionnaire. Behavioral sleep medicine, 3(4), 227–246. https://doi.org/10.1207/s15402010bsm0304_4

28. Johns M. W. (1991). A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep, 14(6), 540–545. https://doi.org/10.1093/sleep/14.6.540

29. Buysse, D. J., Reynolds, C. F., 3rd, 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. https://doi.org/10.1016/0165-1781(89)90047-4

30. Reilly, T., & Edwards, B. (2007). Altered sleep–wake cycles and physical performance in athletes. Physiology & Behavior, 90(2-3), 274–284. https://doi.org/10.1016/j.physbeh.2006.09.017

31. Yadav, N., Kumar, A., Mahajan, U., & Datta, K. (2019). Post-intense exercise sleep concerns in weightlifters: A pilot study. Medical Journal Armed Forces India, 75(3), 325–329. https://doi.org/10.1016/j.mjafi.2018.09.005

32. Caia, J., Scott, T. J., Halson, S. L., & Kelly, V. G. (2018). The influence of Sleep Hygiene Education on sleep in professional rugby league athletes. Sleep Health, 4(4), 364–368. https://doi.org/10.1016/j.sleh.2018.05.002

33. Reed, D. L., & Sacco, W. P. (2016). Measuring Sleep Efficiency: What Should the Denominator Be?. Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine, 12(2), 263–266. https://doi.org/10.5664/jcsm.5498

34. Antunes, B. M., Campos, E. Z., Parmezzani, S. S., Santos, R. V., Franchini, E., & Lira, F. S. (2017). Sleep quality and duration are associated with performance in Maximal Incremental Test. Physiology & Behavior, 177, 252–256. https://doi.org/10.1016/j.physbeh.2017.05.014

35. Cohen, S., Doyle, W. J., Alper, C. M., Janicki-Deverts, D., & Turner, R. B. (2009). Sleep habits and susceptibility to the common cold. Archives of internal medicine, 169(1), 62–67. https://doi.org/10.1001/archinternmed.2008.505

36. Dennis, J., Dawson, B., Heasman, J., Rogalski, B., & Robey, E. (2016). Sleep patterns and injury occurrence in elite Australian footballers. Journal of Science and Medicine in Sport, 19(2), 113–116. https://doi.org/10.1016/j.jsams.2015.02.003

37. Staunton, C., Gordon, B., Custovic, E., Stanger, J., & Kingsley, M. (2017). Sleep patterns and match performance in elite Australian Basketball Athletes. Journal of Science and Medicine in Sport, 20(8), 786–789. https://doi.org/10.1016/j.jsams.2016.11.016

38. Juliff, L. E., Halson, S. L., & Peiffer, J. J. (2015). Understanding sleep disturbance in athletes prior to important competitions. Journal of Science and Medicine in Sport, 18(1), 13–18. https://doi.org/10.1016/j.jsams.2014.02.007

39. Delaval, B., Abaïdia, A. E., Delecroix, B., Le Gall, F., McCall, A., Ahmaidi, S., & Dupont, G. (2022). Recovery During a Congested Schedule and Injury in Professional Football. International journal of sports physiology and performance, 1–8. Advance online publication. https://doi.org/10.1123/ijspp.2021-0504

40. Dietch, J. R., Taylor, D. J., Sethi, K., Kelly, K., Bramoweth, A. D., & Roane, B. M. (2016). Psychometric Evaluation of the PSQI in U.S. College Students. Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine, 12(8), 1121–1129. https://doi.org/10.5664/jcsm.6050