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Sleep Deprivation as a Risk Factor for Injuries in Athletes

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Abstract:

Introduction: In recent years, sleep deprivation has increasingly been recognized as a significant factor influencing athletic performance. The basal sleep requirement for healthy adults slightly differs from the sleep needs of individuals who regularly engage in sports. Furthermore, athletes frequently experience sleep loss due to their active and busy schedules. The impact of insufficient sleep on physical and cognitive functions can significantly impair the body's functioning and lead to serious consequences.

Purpose of the study: The aim of the study was to emphasize the prevalence of sleep deficiency among athletes, demonstrate how insufficient sleep affects various body functions, and explore its impact on injury risk across different sports disciplines.

Materials and methods: A literature review was conducted using PubMed and Google Scholar. Articles were selected based on specific keywords and then assessed for their relevance and suitability for inclusion in this review.

Results: The findings indicate that athletes frequently experience sleep problems due to factors such as training schedules, stress, night performances, and travel, with individual sport athletes getting less sleep compared to those in team sports. Sleep deprivation negatively impacts physiological and cognitive functions and is significantly associated with increased injury incidence in sports like soccer, volleyball, and basketball, although results are inconsistent in swimming, cycling, and running, highlighting the need for further research considering factors like training load and individual sleep variability.

Keywords: sleep deprivation; athletes; injury

Introduction

According to National Institutes of Health (NIH) sleep deficiency is defined by not getting sleep enough. Several determinants, including genetic, environmental, and societal factors influence the habitual sleep duration of an individual. Sleep needs are defined as the regular amount of sleep obtained in the absence of any pre-existing sleep debt. Under this definition, the basic sleep requirement for healthy adult humans typically ranges from 7.5 to 8.5 hours per day. [1] However, the sleep needs of individuals, who regularly participate in sports vary slightly. Athletes are advised to get 7-9 hours of sleep, mostly at night, to recover well after training. [2] Although this recommendation, it has recently been suggested, appropriate sleeping duration may differ individually for athletes. [3] It's particularly challenging to obtain due to various lifestyle factors, including early morning training sessions, frequent travel, caffeine consumption. [4] Suboptimal sleep can impair cognitive functions such as attention and learning, as well as physical performance attributes like strength and speed. [5] Many studies have shown that poor sleep is a predictor for a variety of injuries. [6] This article focuses on highlighting the prevalence of sleep deprivation among athletes across various disciplines and presenting current research on the relationship between sleep deprivation and injury risk among them.

Sleep problems in athletes

Athletes represent a heterogeneous group of individuals. Nevertheless, they commonly experience sleep problems. There are numerous of reasons why this group is especially vulnerable to sleep deprivation. Changing training schedules, [3] stress, [7] night performance, long distance travels, [8] as well as spending nights in new places or in buses or trains instead of bed [9] are only a few examples. Pradzynska et al., [10] in their literature review found that the cause of sleep deprivation in athletes may vary depending on their discipline and level of performance, but the lack of sleep is a significant recurring issue. The life of an elite athlete involves participating in competitions, for which they often prepare through rigorous training, entailing numerous sacrifices. For this reason, sport contestants often experience nervousness, racing thoughts about the competition, and difficulty falling asleep right before important sporting events. This frequently results in a reduction of their total nighttime sleep duration. [11] Even though sleep is essential for post-exercise recovery and reducing fatigue after workouts, [3] athletes tend to sleep less than ordinary people. [12] A study which compared

athletes from individual and team sports showed that the first group went to bed earlier, woke up earlier and obtained less sleep (individual vs team; 6,5 vs 7,0 h) than the second group. [13] Sargent et al. [14] reported that over 14 nights assessed with actigraphy, athletes recorded an average of 6.5 hours of sleep per night. Recently, Mah et al. [15] indicated that 39.1% of athletes reported < 7 hours by self-report what is also below the recommended sleep duration.

How sleep deprivation changes physiological and cognitive functions

Sleep deprivation is not neutral for the human body. Numerous studies have been conducted demonstrating its impact on both physiological, cognitive, and psychological functions. It is well-established that a reduced amount of sleep adversely affects glycogen repletion, which is crucial for muscle function and work capacity. This can result in a decline in athletic performance. Extended periods of wakefulness increase sympathetic and decrease parasympathetic cardiovascular modulation, potentially leading to overtraining. Sleep deprivation effects on hormonal and endocrine responses are unclear. However, there is some evidence that not getting sleep enough increases concentration of blood-cortisol which may cause increase in muscle catabolism and reduce in protein synthesis. This leads to conclusion that sleep deprivation inhibits muscle recovery. [8] Additionally, it can lead to an increased perception of effort during physical activity. [6] Another important consideration is that sleep loss disrupts appetite regulation and affects energy expenditure, both of which are important for athletic performance. [16] Appropriate sleep is also important for improvement in motor learning, [8] meaning that sleep deprivation prevents athletes from progressing. Additionally, the connection between the restorative aspects of sleep and the immune system is well-documented. Even a slight reduction in sleep is linked to a notable rise in the release of proinflammatory cytokines, [17] which may result in a catabolic effect on various types of tissues, particularly skeletal muscle. Another potential consequence of sleep deprivation in female athletes is irregular menstruation. It is highly suspected that lack of sleep elevates state anxiety levels which affects estrogen concentration. [18] Hormonal fluctuations throughout the menstrual cycle changes laxity, strength, body temperature, and neuromuscular control, among others. This fact causes women to constantly adapt to hormonal variations, which exposes them to a higher risk of sports injury. [19] Hugh H. K. Fullagar et al., in their 2015 review article, [8] discuss numerous studies demonstrating a link between shorter sleep duration (<7 hours) and impaired cognitive abilities, such as alertness, reaction time, memory, and decision-making. The neuroanatomical mechanisms underlying this relationship are complex. It is suspected that

sleep deprivation slows metabolism in areas of the central nervous system, including the prefrontal cortex, occipital, temporal, cerebellum, and thalamus. Reduced activity in these regions correlates with decreased cognitive abilities, confirming the association between sleep deprivation and cognitive impairment.

Sleep deprivation and injury risk in athletes

Sleep deprivation has been increasingly recognized as a significant factor that can negatively impact athletic performance and overall health. In particular, growing body of research suggests a strong correlation between insufficient sleep and an elevated risk of injuries among athletes. Understanding the extent and nature of this relationship is crucial for developing strategies to enhance athlete health and performance. In this chapter, we will explore several studies that have examined the impact of sleep deprivation on injury risk in athletes. There are studies that have observed a correlation between sleep deprivation and an increased risk of sports injuries. Von Rosen et al. [20] examined 340 young elite athletes during their autumn school semester and they showed that athletes sleeping > 8 h of sleep in average during weekdays reduced the odds of new injury with 61% (OR, 0.39; 95% CI, 0.16–0.99) whereas Milewski et al. [21] showed that athletes who sleep more (6-9 h) have decreased injury risk. An irregular sleep pattern, causing transiently impaired recovery, may also elevate the risk of sports injuries. However, there are numerous studies that question this relationship. Burke, Tina M. et al., in their study, demonstrated a lack of significant correlation between sustained injuries and shorter sleep duration among college football players during the competitive season. [22] Devon A. Dobrosielski, in 2021, published a systematic review of 12 prospective cohort studies, demonstrating a limited association between sleep deprivation and injuries in adult athletes. [23] Since then, few studies have been conducted on this topic. F. Viegas et al. [24] in 2022 published the results of their 6-month study involving a group of 19 adolescent athletes of both genders. They analyzed the participants' sleep during three phases: mid-season (1), competitive period (2), and school vacation while maintaining sports training (3). The results showed that the total sleep duration was shortest during phase 2 (416.41 ± 46.44 min) and longest during phase 3 (453.1 ± 56.96 min), which constitutes a significant difference between them [$F(2,36)=5.062$; $p=0.012$]. As for musculoskeletal injuries, there were 9 in phase 1, 6 in phase 2, and 4 in phase 3. This study does not demonstrate a clear correlation between sleep

deprivation and increased risk of injuries, nor does it exclude it. However, it does indicate that adolescent athletes tend to sleep less, especially during the competitive period. Furthermore, one of the key findings of a recent study published by K. Riegler et al. [25] was that insufficient sleep in student-athletes was associated with an increased risk of prospectively sustaining a sport-related concussion (SRC). In this study, over 600 young athletes were divided into two groups based on sleep duration: sufficient sleepers (>7.07 hours) and insufficient sleepers (\leq 5.78 hours). Participants in the insufficient sleep group at baseline were nearly twice as likely (15.69%) to sustain an SRC compared to those in the sufficient sleep group (8.79%).

We decided to search for studies in several specific sports to ascertain the extent of research conducted on sleep deprivation and its impact on injury risk, and to determine whether this risk varies depending on the sport.

Soccer is one of the most popular sports, played professionally by both men and women. Several studies have been conducted on the impact of insufficient sleep duration on soccer players. Research indicates that lower total sleeping time during off-season and inadequate sleep quality are associated with a higher occurrence of soccer injuries among professional players. [26] Moreover, poor sleep quality and duration have been linked to an increased number and severity of musculoskeletal injuries in elite soccer players. [27] In a broader context, a study on adults found that various aspects of sleep health, such as sleep quantity, quality, and feeling rested upon waking, are strongly associated with different types of injuries, including sports-related injuries. [28] Additionally, poor sleep quality was prevalent among professional soccer players, emphasizing the importance of addressing sleep issues to enhance athletic performance and reduce injury risk. [29] In a recently published study, 24 women soccer players who participated during the Fall 2019 season were examined. The participants were divided into three groups: an injury/illness-free group (12 participants), a mild to moderate injury/illness occurrence group (7 participants), and a heavy injury/illness occurrence group (5 participants). The findings indicated that players from the heavy injury group had significantly less sleep compared to the other groups.[30]

Volleyball is also a very popular discipline both in Poland and around the world. Despite being a non-contact sport, injuries are not uncommon. Knowledge regarding the relationship between insufficient sleep and injury risk in volleyball players is not well documented. We found one very old study that examine 12 young men volleyball players who participated in over 61 hours lasting volleyball marathon game. [31] After the match players experienced different psychological and physiological symptoms. The majority of the somatic disturbances were musculoskeletal overstrain trauma, which may suggest that prolonged sleep deprivation

in athletes contributes to injuries. In 2021, K. Haraldsdottir et al. [32] examined 17 female volleyball players over a 9-month competitive season. During the study period, 54 injuries were recorded, each preceded by shorter nighttime sleep duration compared to days when no injuries occurred. The study concluded that sleep deprivation is an independent risk factor for injuries. Basketball is a contact sport with complex movements including jumps, turns and changes in direction, which cause frequent musculoskeletal injuries in many different regions of the body. [33] We found one interesting study related to this discipline. During 2 consecutive seasons, 19 male National Collegiate Athletic Association Division I basketball players reported their sleep duration (hours) while all time-loss injuries were recorded by the team athletic trainer. During the study period, 32 injuries were recorded. In the initial separate prediction models, in-season injury was significantly predicted by sleep duration (OR, 0.57; 95% CI, 0.49-0.66; $P < .001$). In the multivariable models, sleep duration remained a significant, independent predictor in each of the subsequent multivariable models (OR, 0.52-0.69; $P < .001$ for all). They found that a 1-hour increase in sleep duration was associated with a 43% decrease in injury risk the following day. The conclusion is consistent with the statement that decreased sleep duration increases the risk of injuries. [34]

The next sport that we want to discuss is cycling. Some studies have investigated the correlation between sleep and injury risk in this physical activity, emphasizing the essential role of sufficient sleep in ensuring athlete safety and optimal performance. In 2022, A. C. Smith et al. [35] identified 7 latest papers discussing sleep patterns in ultra-endurance racing cyclists. They concluded that sleep deprivation is a very common issue for them, however, there was no evidence of associated increased injury risk. Since then, no studies have been published on this topic among professional cyclists. Additionally, we found a large cross-sectional study among over 17,000 Korean adolescent participants (ages 12 to 18), which demonstrated a strong association between sleep deprivation and bicycle riding accidents, as well as slips and falls in various situations at home and school. However, no significant relationship was found between the lack of sleep and dental injuries in this study. The limitation of this study is that it did not distinguish between athletes and non-athletes in the examined group. We did not find any studies that unequivocally identify sleep deprivation as a risk factor for injuries in cyclists.

Swimming is another high-injury sport. [36] The correlation between sleep deprivation and increased injury risk in swimmers remains unproven. One study demonstrated that short total sleep time preceding early morning training sessions may indicate a pattern of insufficient rest,

potentially contributing to fatigue and decreased physical readiness, which could predispose swimmers to injuries. However, the research paper does not directly address the causal relationship between sleep loss and injuries in swimmers. [37] Additionally, another study of 12 young university swimmers conducted by Rakesh Tomar et al. [38] found no significant correlation between sleep duration and the incidence of injuries.

The final group of athletes we closely examined regarding sleep deprivation and its impact on injury risk are runners. Running is a diverse sport discipline. Some runners specialize in short-distance sprints, others run middle distances such as 800 meters, and still others participate in marathons or ultramarathons that span many kilometers. [39], [40], [41] Regardless of the distance, optimal sleep has been shown to positively affect injury prevention. [42], [43] Graham et al. [44] investigated sleep patterns during a 120-mile, three-day Arctic ultramarathon. Using the Brunel Mood Scale questionnaire, they found that participants averaged 4.07 hours of sleep per day. This amount of sleep was not correlated with either injury rates or mood changes. The authors concluded that the extensive psychological and physiological preparation required for such a challenging race likely mitigates the impact of sleep deprivation. Another study on 1,154 finishers from two ultramarathons found, that increasing sleep duration before the race was associated with a lower prevalence of falls during the race. [45] Unfortunately, we did not find any more studies addressing the impact of sleep deprivation on injury risk in runners.

Conclusions

Sleep deprivation and its impact on injury risk in athletes is a topic that needs further research. In the previous sections we have presented studies, that provides valuable information about the correlation between insufficient sleep and its impact on getting an injury in different sports disciplines but there are still gaps in knowledge that need to be addressed. The study on soccer players that we have investigated revealed a significant association between sleep deprivation and a higher incidence of injuries among participants. Similar results were found in volleyball and basketball players, emphasizing the importance of adequate rest to prevent injuries in these athletic disciplines. In contrast, the research on swimming and cycling were not that coherent. Some of these studies demonstrates a lack of evidence supporting an increased injury risk associated with sleep deprivation. Additionally, certain studies of running indicate a positive correlation between increased sleep duration and lower prevalence of falls

during ultramarathons, while others suggested that the psychological and physiological preparation for such races may mitigate the impact of sleep deprivation on injury rates. The greatest limitation of these researched studies was that the most of them were conducted on small groups of participants, who differed in many aspects, such as gender or age and the follow-up period was often relatively short, which also makes the results difficult to analyze. Because the in-depth and comprehensive understanding of the interplay between sleep patterns and injury susceptibility in athletes is crucial for the development of targeted interventions and strategies to optimize athletic performance and minimize the risk of sports-related injuries, further and more detailed studies are necessary. Future research should aim to explore these associations in greater detail, considering factors such as training load, recovery practices, and individual variability in sleep needs among athletes.

Disclosure

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All authors have read and agreed with the published version of the manuscript.

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