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Don't Sleep on Sleep: A Clinical CASE Report From a Division I Heptathlete

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A female National Collegiate Athletic Association Division I track athlete experienced nonlocalized shin pain midway through her first season, which was diagnosed as medial tibial stress syndrome. Treatments included strengthening and range of motion exercises, reduced training volume, and pain control modalities, but symptoms worsened. It was revealed she had been suffering from severe sleep deprivation (<3 hours/night) contributing to bilateral tibial and fibular stress reactions. Months of trial and error eventually resulted in the implementation of sleep interventions which improved her total body bone mineral density and bilateral stress reactions. Two years after successful sleep interventions, this athlete has remained injury-free and continues to set personal bests in her events. Our standard injury screening protocols did not include questioning sleep quality and quantity early in the process, and in this case, we highlight the need for these measures to be considered initially and throughout the treatment and recovery phases of sports-related injuries.

Key Words: heptathlon, stress-reaction, sleep disturbances

Key Points

- Impaired sleep quality and quantity negatively affect skeletal metabolism and can delay rehabilitation efforts for athletes but is rarely assessed initially.
- In this case, we highlight the importance of adding sleep screening to initial injury assessment protocols and continuing to monitor this vital resource throughout the rehabilitation process.

Medial tibial stress syndrome (MTSS), commonly known as *shin splints*, is a common injury seen in repetitive sports like track and field and cross-country. Medial tibial stress syndrome is typically a diagnosis of exclusion, meaning it is made by ruling out other possible causes of a patient's symptoms through tests and examination, resulting in a diagnosis, usually marked by gradual nonlocalized pain along the tibia. Medial tibial stress syndrome can be challenging to differentiate between tibial stress fractures or reactions because of their overlapping symptoms and because the tibia is the most common site for these injuries.[1] Pain is generally at its worst with impact activity like running or jumping but decreases with reduced training volume, causing it to be difficult to treat effectively in athletic populations.[2] Risk factors for MTSS can include participating in a repetitive sport, decreased core and hip muscle control, rapid increases in exercise intensity and volume, changing of training surfaces, and pes cavus foot with increased navicular drop.[1,2] A commonly overlooked risk factor when it comes to MTSS is sleep. Sleep plays a critical role in bone metabolism, as seen by many who have noted impaired sleep results in uncoupled bone formation and increased fracture risk.[3,4] However, sleep is often not initially evaluated by sports medicine staff when screening athletes after a bone injury has been sustained.

In this clinical CASE report, we will highlight the critical role of sleep in managing lower limb injuries in athletes and detail the process the athlete and all support staff undertook to gain these insights. We hope that, after understanding this long process of elimination, other sports medicine professionals will consider adding sleep consultation to initial testing batteries when athletes present for potential bone injuries.

CASE PRESENTATION

Patient

An 18-year-old female Division I collegiate track athlete began having symptoms in October 2021; for the complete treatment timeline of this clinical CASE report, see Figure 1. The athletic training staff intervened when she broke down

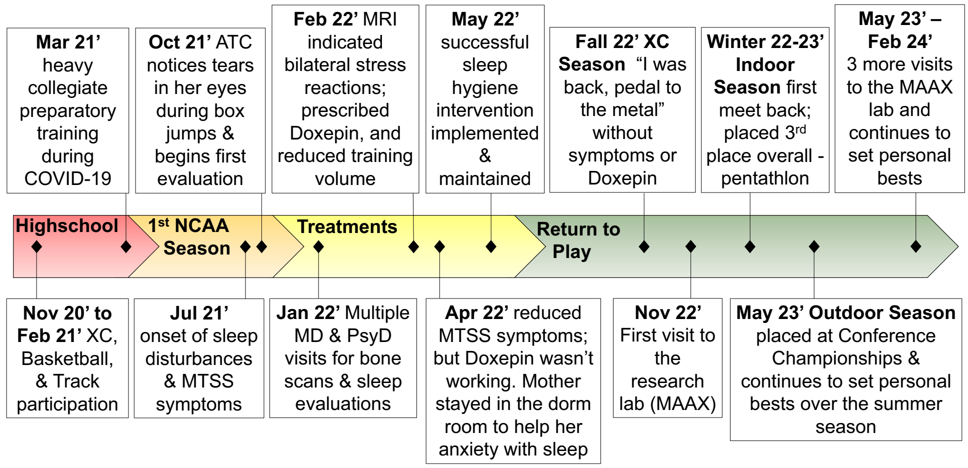

Figure 1. A detailed timeline of the athlete's road to recovery.

in tears during box jumps in the weight room due to the severity of the pain. The athlete revealed she had been suffering from shin pain since beginning collegiate training in August 2021 but did not report it, believing she could "tough it out." Examination revealed nonlocalized pain along both tibial shafts, without any specific point of pain or tenderness to palpation. She reported previous issues with shin splints in high school, but they were not as severe as her current condition. She had no history of stress fractures or reactions. All lower extremity manual muscle tests were normal, and pain was only provoked during impact activities like plyometrics or running. After this initial evaluation, she was diagnosed with MTSS.

Intervention

Once identified, she began regular rehabilitation and treatment sessions in the athletic training room 3 to 4 times per week. Her practice volume was reduced, and she engaged in low-impact cross-training activities such as swimming and stationary biking. Her rehabilitation plans included exercises to strengthen the ankle and core, improve hip stability, and improve intrinsic foot muscles. Despite these efforts that are commonly used to treat MTSS, her pain persisted. After winter break, discussions with her coaches and athletic training staff revealed that her pain levels had decreased considerably. Her goal was to compete in the indoor track and field season, and she gradually returned to training while continuing rehabilitation sessions several times a week. However, her pain intensified after competing in a few indoor meets in January 2022.

Further discussions with the athletic training staff revealed severe sleep deprivation, with her sleeping less than 3 hours per night. She reported sleep-induced anxiety, with her heart rate increasing to around 130 beats/min when thinking about going to sleep. She began medication to improve her self-reported sleep quality. Her pain persisted despite reduced training and additional rest, leading to further examination. Bilateral x-rays showed no evidence of fractures, but a subsequent bone scan revealed a stress reaction in her tibia and fibula, as shown in Figure 2. Consequently, she wore a walking boot for 5 weeks and continued rehabilitation exercises focusing on core, hip, and lower limb strengthening. To address her sleep disturbances, she implemented strategies such as minimizing blue light exposure before bedtime, adhering to a strict sleep and wake cycle, and ensuring daily physical exhaustion through training and activities before beginning her nighttime sleep hygiene routine.

Comparative Outcomes

Authors of similar studies focusing on sleep disturbances and bone health have provided foundational evidence for the case presented here. Milewski et al (2014) demonstrated that athletes sleeping less than 8 hours per night were more prone to injuries.[5] Similarly, Swanson et al (2022) found clear linkages between poor sleep quality, impaired bone formation, and increased fracture risk, with recovery sleep mitigating some effects in fracture-prone military personnel.[4] In the case of this collegiate athlete, her severe sleep deprivation likely exacerbated her injury and hindered recovery.

To further evaluate the athlete's recovery condition, she visited the Musculoskeletal Adaptations to Aging and eXercise laboratory (MAAX Lab). Before any testing, she provided voluntary informed consent, which was approved by the Oklahoma State University Institutional Review Board (#22-113-STW). She underwent multiple dual-energy x-ray

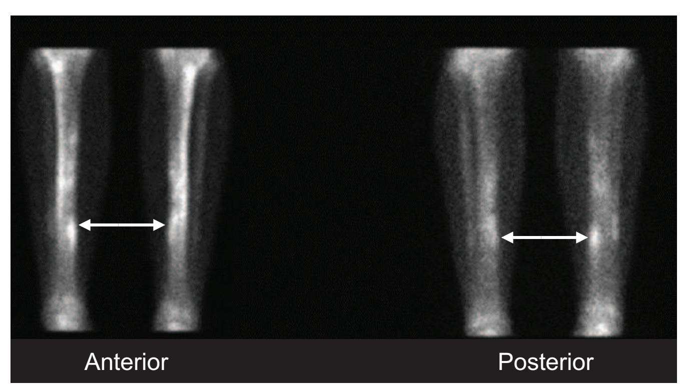

Figure 2. Displays nuclear bone scans of the lower leg's anterior and posterior compartments. Brighter white areas along the medial portion of the tibia, indicated by the white arrows, show areas of high bone turnover, indicating the area has both a stress reaction and an increased risk of fractures.

Table. Athlete's Bone and Body Composition Changes Over Time[a]

Visit Date	BMD Z-Score	Lumbar 1–4 Z-Score	Mean Hip Z-Score	Lean Mass to Fat Mass	Body Fat, %
November 2022	−0.8	−0.1	0.8	3.5	21.7%
May 2023	−0.6	0.3	1.0	4.1	19.0%
November 2023	−0.4	0.2	1.1	3.9	20.8%
January 2024	−0.6	0.2	1.1	4.0	19.5%

Abbreviation: BMD, bone mineral density.

[a] Data are from dual-energy x-ray absorptiometry scans across 4 laboratory visits. Z-scores are sex, age, and ethnicity-matched total body bone mineral density scores. Clinically, Z-scores above −2.0 are considered normal; however, in weight-bearing athlete groups, a threshold of 0.0 has been suggested. Lean mass to fat mass is the ratio of lean mass to fat mass; numbers greater than 1.0 indicate the amount of muscle compared with fat mass.

absorptiometry (DXA) scans of her total body, lumbar spine vertebrae 1–4, and both hips. Additionally, questionnaires were administered to gain new information on her physical activity, exercise regimens, dietary habits, menstrual history, injury history, and sleep quality using the Pittsburgh Sleep Quality Index (PSQI).[6]

Bone and body composition results from the DXA are shown in the Table. Over time, she improved her total body, lumbar spine, and total hip bone mineral density (BMD) Z-scores, with her best scores being around the November 2023 time point. Her body fat was maintained within recommended ranges for athletes of her age.[7] Initial assessments of sleep quality (PSQI) indicated she had clinically relevant poor sleep (scores $>$ 5), but throughout the course of the intervention, she improved her scores by 6 points, with her scores being considered clinically normal in November 2023, as shown in Figure 3A. Another factor to consider would be her energy availability (EA), which is the number of daily calories per kilogram of lean mass from DXA. Values under 30 $\text{kcal}\cdot\text{kgLM}^{-1}\cdot\text{d}^{-1}$ have been considered a threshold for underfueling.[8] During all assessments, she reported severe underfueling, as seen in Figure 3B.

After not competing in the outdoor track season, she was sent home with an exercise program and continued to see a physical therapist. Upon returning to campus in August 2022, she reported no pain and routinely slept 6 to 8 hours per night. She trained throughout the fall of 2022 and competed in the 2023 indoor track season without a reduced training load. Her pain dramatically reduced, though she sometimes experienced manageable increased shin pain. By Winter 2022–2023, she began competing again and placing at meets, and she set 4 personal records by January 2024.

DISCUSSION

Medial tibial stress syndrome, tibial stress reactions, and tibial stress fractures commonly affect runners, but it has been estimated that training errors may contribute to 50% of these injuries.[2] Treatments vary in effectiveness, but reduced training volume, cryotherapy, stretching, and strengthening exercises are routine in athletic populations.[2,9] Despite tapering loads being commonly recommended, it may not be feasible for competitive athletes in cross-country and track and field, who often have multiple competitive seasons each year and minimal off-season or recovery time to achieve full recovery without considering other pertinent factors associated with injury etiology and rehabilitation progress. Additionally, George et al (2024) completed a scoping review in which they identified numerous factors of bone stress injury (BSI) identification from load management, biomechanics, muscular strength and flexibility, relative EA, and menstrual health. They noted that all these factors are extremely important variables to manage to attenuate the onset of BSI and support the notion that, although sleep is the recovery activity we spend the most time on, it can be easily overlooked when not evaluating the whole athlete.[10]

It has been well established that sleep is vital for athletes, affecting cognition, tissue repair, and recovery, but is rarely part of initial testing batteries for injured athletes.[11] For instance, athletes sleeping under 7 hours nightly face a 1.7

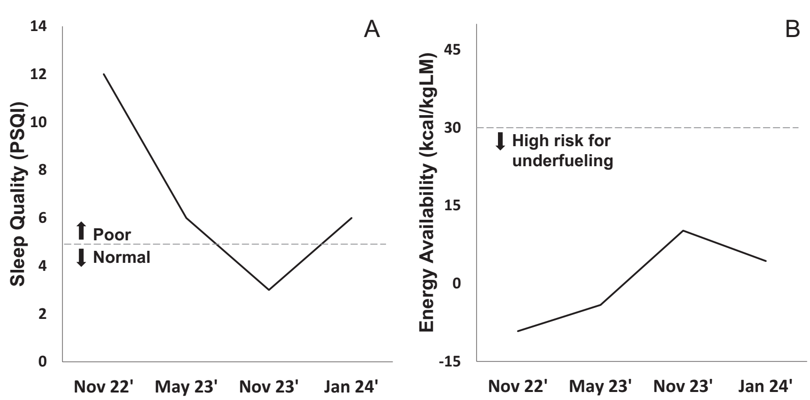

Figure 3. A (left), Pittsburgh Sleep Quality Index (PSQI) across 4 laboratory visits. B (right), Depicts the athlete's energy availability; <30 $\text{kcal}\cdot\text{kgLM}^{-1}\cdot\text{d}^{-1}$ has been used as a threshold for underfueling and subsequent physiologic dysfunction.

times greater likelihood of injury, while getting 8 or more hours of sleep per night may reduce injury risk by over 60%, but athletes often report worse sleep than nonathletes.[11,12] Medical staff should assess sleep quality and quantity during preparticipation physical evaluations and throughout an athlete's career. While wearable technologies are excellent tools for this purpose, they may not be accessible to all institutions or individuals. Fortunately, free questionnaires such as the PSQI and Epworth Sleepiness Scale (ESS) are available for widespread use.[6,13] The PSQI provides valuable insights into sleep quality, with scores ranging from 0 to 21. A score of 5 or below classifies someone as a *clinically good sleeper*, while scores above 5 indicate *clinically poor sleep* and suggest potential sleep disturbances.[6] The ESS scores range from 0 to 24, with less than or equal to 10 indicating *normal sleepiness* and greater than 10 suggesting *excessive daytime sleepiness*, with higher scores reflecting greater severity.[13] These questionnaires provide valuable insights into sleep quality and daytime sleepiness, helping to identify disturbances and inadequate sleep duration. Ideally, combining wearable technology with these questionnaires would provide the most comprehensive data, as both methods require minimal time and yield usable results. In this clinical CASE report, we support these views, as the patient's BMD Z-scores were highest during November 2023, corresponding to when her sleep scores were considered normal and her EA was highest. However, it should be noted that, while BMD Z-scores above −2.0 are considered clinically normal, recently, Jonvik et al (2022) suggested changing these values to 0.0 for athletes engaging in high-impact sports.[14] Using this more conservative threshold, this athlete would still fall below or near the low bone mass category for total body scores, but she had superior scores for her mean hip BMD.

Another key factor to consider that may have affected her skeletal recovery is energy status. While her EA did increase, it remained below 30 $kcal \cdot kgLM^{-1} \cdot d^{-1}$, which is a threshold that has been used to indicate elevated risk for relative energy deficiency in sports (REDs).[8] With this in mind, this athlete would be considered at high risk for REDs at all observation points. However, BMD improved despite her low energy status, and these changes coincided with sleep quality improvements, suggesting the skeletal responses may have been more greatly affected by sleep than energy status. Furthermore, Jeukendrup et al (2024) recently argued that low EA as the sole driver of various health disruptors is overly simplistic.[15] This athlete worked closely with her coaches, medical support team, and researchers to recover sleep quality, and many recommendations can be made from these experiences. She worked hard to establish a regular bedtime routine, aiming for at least 8 hours of sleep each night and limiting or avoiding naps, especially after 3 PM. Additionally, athletes should reserve their bedroom for sleep and intimacy, keeping it quiet, dark, and calm while minimizing caffeine and alcohol intake, avoiding smoking or nicotine, and refraining from high-intensity exercise close to bedtime. Lastly, limit screen time before bed and avoid computers, TVs, and phones.[11] It is important to recognize that athletes may respond differently to these interventions. For example, this athlete tried the following strategies, with little to no success: journaling before bed, white noise while trying to fall asleep, reduction in training load, melatonin supplementation, and doxepin prescription. In this clinical CASE report, we demonstrate how an athlete's team of support personnel can all work together and overcome great challenges when all parties have the athlete's best interest in mind.

Clinical Bottom Line

In this clinical CASE report, we highlight the importance of sleep screening in the evaluation of BSIs. The link established between sleep hygiene and clinical improvements in this patient warrants further exploration. Most injury screenings examine the athletes' training frequency, intensity, and recovery strategies while ignoring sleep, BMD, and dietary measures unless the athletes themselves bring problems forth. This approach leaves our athletes vulnerable to numerous long-term health complications such as osteopenia or osteoporosis from a lack of early interventions after initial DXA screening. Additionally, poor sleep and dietary quality are key determinants of many major health outcomes such as cardiovascular disease, neurological disorders, and obesity-related outcomes. It is essential to assess all aspects of an athlete's health, not only to enhance their current performance but also to support their overall well-being long after they exit competitive sports.

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