








Sleep, nutrition, hydration and rest: The equal importance of external factors outside of training and practice for sports injury prevention

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ABSTRACT

Training and practice preparation have long received attention as the largest factors for injury prevention. While proper training and practice programs are a crucial component of injury prevention, they only represent a piece of a larger puzzle. External factors outside of training and practice such as sleep, nutrition, hydration, and rest are equally important for injury prevention due to athletes spending a majority of their day outside of their sport. These external factors have been shown to have powerful effects relating to injury epidemiology. They have also been shown to have major effects on the body's autonomic and hormonal regulation systems. Due to athletes spending a majority of their day outside of training and practice, it is necessary that equal importance be given to external factors outside of sport, especially in regards to sleep, nutrition, hydration, and rest for optimal injury prevention strategies.

Keywords: Sport medicine, Injury prevention, Nutrition, Sleep, Hydration, Rest.

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INTRODUCTION

Training and practice preparation have long been emphasized as key factors in sports injury prevention (Beato et al., 2021; Petushek et al., 2019; Lauersen et al., 2018). While a structured training program is important regarding injury prevention (Beato et al., 2021; Petushek et al., 2019; Lauersen et al., 2018), it is just part of a much larger puzzle. Athletes ultimately spend a majority of their day outside of training and practice, since this time may only be a few hours out of an athlete's entire day. Training and practice are critical for injury prevention; however, external factors outside of sport during the remaining majority of the day such as sleep (Huang & Ihm, 2021), nutrition (Turnagöl et al., 2021), hydration (Judge et al., 2021), and rest (Orlando et al., 2011) are just as equally important for injury prevention. This opinion article aims to emphasize that multiple external factors outside of sport (sleep, nutrition, hydration, and rest) are of equal importance in helping to prevent injuries.

SLEEP

Sleep is an essential part of homeostasis that aids with the body's metabolic, immunologic, and endocrine functions. Most experts recommend that adults should get at least eight hours of sleep per night (Van Dongen et al., 2003). However, many professional athletes experience poor sleep habits upon study (Leeder et al., 2012). This is measured as the time to fall asleep, as well as with subjective reports on sleep quality (Leeder et al., 2012). Poor sleep hygiene leads to fatigue and increases the likelihood of musculoskeletal injury (Luke et al., 2011).

Additionally, several studies have linked short-term sleep deprivation to poor immunologic function (Bollinger et al., 2010). Since sleep promotes recovery and preparation for high-intensity training and competition, it is essential to promote better sleep habits in athletes for prevention and recovery (Samuels, 2008). Traveling for games and competitions also makes athletes more susceptible to poor sleep quantity and quality. Travel disrupts sleep schedules and increases variability which predisposes athletes to be more fatigued and prone to injuries during training and competition (Peacock et al., 2018). To explore interventions and correct sleep disruptions, several studies have found napping to be an effective sleep extender (Faraut et al., 2011).

Sleep deprivation has been associated with increased basal cortisol levels (Nollet et al., 2020). This becomes crucial when considering adolescent pre-collegiate and collegiate athletes. In addition to the physical stress of high-intensity training and competition, the long-term health detriments of sleep deprivation in athletes undergoing development must be considered with equal importance.

Sleep recommendations

Due to the increased risk of sport-related injuries with sleep deprivation, it is imperative that athletes at all levels are cognizant of healthy sleeping habits. We recommend the incorporation of educational programs for athletes as a part of pre-season conditioning that focuses on the importance of adequate sleep quantity and quality.

During travel for away competitions, coaches and athletic staff must account for the sleeping challenges that come with travel when planning meals, curfew and wake-up calls. This is especially important if there is a time change. In addition, appropriate travel accommodations and times for napping prior to competition should be implemented to reduce the risk of injury. Athletes can benefit from sleep supplementation in the form of napping. Previous research has shown that a 30-minute post lunch nap after partial sleep loss (4 hours less than normal) significantly improved 20-m sprint performance and subjective alertness (Bird, 2013).

Additionally, increasing sleep by two hours for athletes, with a goal of up to nine total hours of sleep in elite athletes, should be prioritized to increase the overall well-being of athletes and optimize performance (Vitale et al, 2019). A study that was conducted on the Stanford University men's basketball team had 11 players obtain extra sleep with a goal of 10 hours per day for a 5-7 week period. Ultimately, the players were found to have enhanced basketball performance (Bird, 2013). The players who obtained extended sleep also reported improved alertness and mood, as well as less sleepiness and fatigue (Bird, 2013).

Sleep hygiene recommendations include maintaining a regular sleep schedule by minimizing bedtime and waketime variability, avoiding coffee, alcohol, and nicotine in the hours before bed, napping appropriately (limiting naps to 30 minutes and avoiding late-afternoon naps), maintaining proper hydration, avoiding high-intensity exercise right before bed, and utilizing nightshades and earplugs if needed (Vitale et al, 2019). Other sleep hygiene recommendations include minimizing blue light close to bedtime, reducing stress through meditation, and taking melatonin as a supplement (Vitale et al, 2019). Additionally, educational programs for athletes as a part of pre-season conditioning should focus on the importance of adequate sleep quantity and quality. These sleep hygiene recommendations are used to maximize well-rested sleep in athletes of all levels and have proven to enhance performance.

With today's technological advances, the use of smartphone applications for sleep tracking and schedules can help monitor the efficacy of these interventions. Although many of the current applications only offer limited features, athletic programs should establish an agreement to provide their athletes with discounted subscription plans. Integrating a majority of these sleep hygiene recommendations will help maximize vital body function and help athletes perform at their best.

Finally, as part of the annual sports physical, athletic teams should reserve time to evaluate the sleep habits of the athlete. Annual physicals and questionnaires provide opportunities to identify athletes in need of supplemental aid with their sleep schedules. Interventions geared towards education, continuous feedback by sleep tracking, and the incorporation of annual investigations can help athletes develop healthy long-term sleep habits while also providing opportunities to intercede when athletes might still be suffering.

NUTRITION

While there has been a shift to improving nutrition at the professional sports level and higher collegiate athletic levels, nutrition problems persist throughout all levels of sport. Proper nutrition is typically considered a balance of macronutrients and micronutrients (Holt, 1993; Purcell, 2013); however, there can be variances to the typical numbers needed depending on the athlete. Many athletes at the collegiate level might face imbalances in regards to macronutrients (proteins, fats, carbohydrates) and micronutrients (vitamins and minerals) without proper guidance (Riviere et al., 2021; Lambert et al., 2022). Many of the larger collegiate and professional sports have emphasized nutrition and the associated proper recommendations from nutritionists for their athletes (Andrews et al., 2016). Meanwhile at the lower collegiate levels, nutrition knowledge amongst athletes may be inadequate, which could lead to decreased energy (Andrews et al., 2016) and an associated lower performance. While most sports at the professional level have recently started to emphasize nutrition, professional minor league baseball nutrition remains poor. Many athletes in minor league baseball may struggle financially (Pifer et al., 2020), and may have barriers regarding education, resources, and costs of food. The struggle to acquire proper nutrition could impact their performance, as many of these prospects are still working to develop efficiently. Many of these barriers exist at smaller collegiate institutions and at the amateur level as well. Interventions should consider these potential barriers.

Several studies have shown that nutritional programs may help to decrease sport injuries, as it helps with the energy, recovery, and growth of athletes (Turnagöl et al., 2021; Pyne & Verhagen, 2014). Proper nutrition guidance through a sports dietitian, or nutritionist, has the ability to increase recovery and athletic performance (Turnagöl et al., 2021; Pyne & Verhagen, 2014; Hull et al., 2017). Proper nutrition is, therefore, critical for improving physical fitness (Malsagova et al., 2021). Supplements such as creatine may also help with building lean muscle mass and improving performance (Hall et al., 2021). Nutrition is also essential in helping to maintain proper hormonal regulation (Dinu et al., 2020). Hormonal regulation is necessary for proper body system functions. Nutrition induced hormonal imbalances can be seen in eating disorders (Schorr & Miller, 2017).

Nutrition recommendations

Nutrition is a complex topic, and optimal nutrition recommendations are difficult to calculate. At the professional level and collegiate level, nutritionists should be involved in developing the proper dietary and supplementation plan for athletes. Larger collegiate and professional programs are using nutritionists to help with meal preparation; however, smaller colleges and some professional sports such as minor league baseball still struggle. Baseball organizations should emphasize nutrition to help aid in the development of their prospects, as this nutritional guidance would be an investment in injury prevention and performance. One previous recommendation in the literature is that lower level collegiate athletics should provide nutritional courses and education from professionals (Andrews et al., 2016). This can act to aid in the immediate nutritional consumption, as well as provide a long-term education on the topic that athletes can utilize throughout their lives. The amateur level sees similar barriers as the lower level collegiate athletics. Nutritional education should be improved within primary school systems to help better guide the building blocks for these athletes. Undergraduate or other online courses in nutrition could be a future way to help athletes improve their nutrition.

Technology is one important factor that could play a role in nutrition. With growing technologies and the development of many virtual platforms, technology may be a solution for nutrition education access. iPhone nutrition applications, such as calorie counters or virtual coaching, may also play a role in helping with following nutrition (Dunne et al., 2022; König et al., 2021). This is the most practical option for most athletes across lower level college sports and amateur sports. Nutrition may be the hardest intervention to plan for due to the potential cost barriers and education barriers that exist; however, online courses and, in turn, expansion of education on the topic may help athletes optimize their nutrition.

HYDRATION

Hydration is another critical factor in injury prevention due to its effects on recovery and hormones. Proper hydration can play a large role in assisting with athlete recovery from competition or training (Judge et al., 2021; Shirreffs & Sawka, 2011). Hypohydration could potentially lead to increased stress levels (Maughan & Meyer, 2013). Increased stress levels have been associated with increased cortisol release (Yaribeygi et al., 2017), and chronic states of high cortisol could lead to an increased risk of injury (Perna & McDowell, 1995). Hypohydration has many negative effects and can lead to an increased risk of injuries and decreased athletic performance (Sawka et al., 1995). Several studies have found high levels of hypohydration amongst athletes at multiple levels of sports (Chapelle et al., 2020; Volpe et al., 2009). Proper hydration levels are crucial for athletes engaging in training or competition to reduce injury effects and changes to their hormonal regulatory systems.

An additional consideration when assessing hydration at the collegiate level is the possible high levels of alcohol consumption (Volpe et al., 2009). High levels of alcohol consumption and binge drinking have been noted in college athletes (Nelson & Wechsler, 2001). Alcohol consumption has many negative effects on the human body (Standridge et al., 2004). It can lead to increased injury levels (O'Brien & Lyons, 2000) and potentially delay recovery from training or sport (Vella & Cameron-Smith, 2010). Alcohol causes dehydration due to its blocking effects on water resorption in the kidneys (Vella & Cameron-Smith, 2010). Due to the high levels of alcohol usage at the collegiate level, it is important that intervention is undertaken to reduce alcohol intake for better hydration levels and protection from injury.

Hydration recommendations

Hydration is necessary to help athletes recover and reduce injury. Hydration testing strategies should be implemented by coaches and athletes in order to evaluate proper hydration levels. There are many external factors that affect hydration such as weather/environment, type of exercise, and duration of exercise (Velval et al., 2019). Coaches should aim to optimize these factors in order to maintain hydration levels. The most practical way of tracking hydration levels involves body weight tracking and urine colour tracking (Velval et al., 2019). Coaches and athletes should be educated on these factors. Other interventions include weight charts, and posters that may serve as a reminder for athletes and coaches to emphasize hydration. The National Strength and Conditioning Association (NSCA) recommends that athletes should consume 20-24 ounces of fluids for every pound of body weight lost (Campbell et al., 2011). The American College of Sports Medicine (ACSM) and NSCA both recommend that athletes should consume drinks with electrolytes and carbohydrates during competition, due to the losses through sweat (Campbell et al., 2011; American College of Sports Medicine et al., 2007). The NSCA also recommends avoiding alcohol after the first few hours of competition due to its effects on recovery (Campbell et al., 2011). Coaches and athletes should be educated on these values and track these values for optimal recovery.

Due to alcohol having many negative effects on the body and predisposing the athlete to injuries (Nelson & Wechsler, 2001; O'Brien & Lyons, 2000), interventions should be undertaken to reduce alcohol intake. Counselling resources and education should be available to both athletes and coaches to reduce alcohol intake. These counselling resources could also be useful for athletes who struggle with alcohol use disorder. Awareness of the effects of alcohol on athletic recovery and injuries is necessary for all athletes, but collegiate athletes in particular due to the high rates of consumption.

REST

Rest is a critical component of recovery. There are still many overuse injuries that are occurring throughout all levels of sport (Franco et al., 2021; Roos et al., 2015), particularly in the collegiate setting (Roos et al., 2015). The youth level has seen increased attention due to excessive sports schedules, where they may be playing year round or without any time to rest (Luke et al., 2011). This can result in an increase in injuries in the youth population (Luke et al., 2011) and it can cause long-term complications to occur later in life.

One particular topic of interest regarding excessive training is overtraining syndrome. Overtraining syndrome is a common syndrome that athletes can face due to training too much without adequate rest (Luke et al., 2011). Overtraining syndrome can lead to disruptions of immune function, neurological function, and disruptions of the hypothalamic-pituitary-adrenal axis. Overtraining syndrome can result in fatigue, poor performance in athletes (Kreher, 2016) and can lead to increased levels of injuries (Gabbett, 2016). The balance between training and rest is necessary for ultimate athlete health and performance.

A second major challenge in rest is the current state of athletes' competition schedules. Youth athletics in particular has seen excessive schedules with little rest in recent years (Luke et al., 2011). Many travel league schedules pack in many competitions into a weekend, and some athletes may do this all year round. Youth athletes are particularly susceptible to overuse injuries and may see injuries due to overuse and overscheduling (Luke et al., 2011; Bean et al., 2014). Some youth athletes may specialize early in a particular sport, and never have any breaks from sport throughout the year. This does not allow time for rest and recovery (Jayanthi et al., 2013). While college athletes play a lot of games, the most critical time frame is during the postseason, when there are minimal days off, after a long season. Increasing days off and reducing a packed schedule will allow athletes to play rested and may lead to decreased injuries and improved performance for athletes at all levels (Orlando et al., 2011; Caparrós et al., 2016; Mason et al., 2022).

College athletes and amateur athletes face additional pressure and stress outside of the demands of sport. This stems from additional tasks such as maintaining grades and other extracurricular activities (Lopes Dos Santos et al., 2020). Stress can induce a state of change to many of the body's organ systems (Yaribeygi et al., 2017). This state of stress can lead to increased release of cortisol (Yaribeygi et al., 2017; Lee et al., 2015) as previously mentioned. Increased and prolonged states of elevated cortisol leads to fatigue, and the breakdown of muscles and bones (Hannibal & Bishop, 2014). It has long been shown that chronic stress can lead to reduced recovery and an increased risk of injuries in athletes (Perna & McDowell, 1995). Therefore, it is necessary that collegiate athletes have time to rest, in order to allow for the reduction of stress. This reduction of stress can lead to the normalization of cortisol levels, and a corresponding reduction in the negative effects of chronic cortisol.

Rest recommendations

Rest is a necessity for athletes. We highlight several key recommendations to improve rest. The first is to increase tracking of athletes practice hours. Currently, there are several devices that athletes can wear to track their overall workloads (Seshadri et al., 2019). These devices can be used to monitor workloads, in order to optimize the balance in workloads and recovery. Strength coaches, sport coaches, and athletes should work together to track practice hours, proper periodized training, and allow for days off to rest (Kreher, 2012). These steps have been noted as important in regards to the early detection of overtraining syndrome. There often may be disconnect between strength coaches and sport coaches at the collegiate and amateur levels regarding this; however, working together is crucial to ensure athletes do not experience overtraining syndrome.

The second recommendation that we have is for youth sport coaches to schedule time off from competition for youth athletes. With many youth athletes playing all year round or with excessive schedules (Luke et al., 2011; Bean et al., 2014; Jayanthi et al., 2013), they do not receive necessary time to rest. Scheduling time off from competition could be crucial for athletes to heal, and to properly allow time for them to train and implement injury prevention strategies. The third recommendation is for increased time intervals between competitions due to its ability to decrease injuries (Orlando et al., 2011; Caparrós et al., 2016; Lopes Dos Santos et al., 2020). All levels of sport should aim to maximize the interval between competitions, in order to optimize rest and recovery for athletes.

The final recommendation that we have is for athletes and coaches to work with their educational departments to create study plans, and mental wellness counselling. This study time will allow athletes to dedicate time to complete their course work and may help to reduce the stress that may come from cramming for an exam or to finish an assignment on time. Mental wellness resources should also be offered, due to its ability to help manage stress in other populations (Green & Kinchen, 2021). We believe that athletes and

coaches should work on this from the youth level all the way to the collegiate level. Working together will allow for athletes to excel on the field and in the classroom, which is the goal of all student-athletes.

DISCUSSION AND CONCLUSIONS

Many studies have shown how important training and practice are for injury prevention (Beato et al., 2021; Petushek et al., 2019; Lauersen et al., 2018). It is true that these are critical for injury prevention; however, many other factors are also in play. Studies have individually looked at the effects of sleep, nutrition, hydration, and rest as they relate to injury epidemiology (Huang & Ihm, 2021; Turnagöl et al., 2021; Judge et al., 2021; Orlando et al., 2011), but data is lacking in regards to assessing these factors together in conjunction with training and practice. Knowing that all of these factors outside of training and practice have major effects on the body's hormonal regulation systems (Nollet et al., 2020; Dinu et al., 2020; Maughan & Meyer, 2013; Yaribeygi et al., 2017; Kreher, 2016; Kreher, 2012), it is important to consider that they may be equally important to an athlete's overall health. This is partially because athletes only spend a portion of their day at training and practice. With the majority of the day occurring outside of sport practice, it is crucial that we give the necessary attention to sleep, nutrition, hydration, and rest as critical players in injury prevention.

The literature compiled, as well as the recommendations, are a good starting place to initiate simple interventions that will help athletes and other related parties use these external factors for a clear advantage. The recommendations highlight many changes that athletes, coaches, and parents can easily incorporate into their plan. As technology advances and as our understanding of these external factors grows, these recommendations will adapt to follow the best available data. With modern day athletes continually pushing the ceiling of physical human capabilities, we must study and learn more about how to maximize these external factors for interventions in the future.

This paper highlighted some of the numerous effects that these outside factors can have in regards to physiological changes within the body's organ systems. A state of chronically high cortisol is clearly one that can cause numerous acute and chronic issues that could be detrimental to the body (Hannibal & Bishop, 2014). Chronically high cortisol levels can be due to a few of the external factors mentioned. While the body is good at attempting to adapt to acute and chronic stress, we know that too much stress can ultimately negatively impact the body's organ systems (Hannibal & Bishop, 2014). All of these external factors work together to play a role in controlling this hormonal balance, and when used properly, they can enhance injury prevention by allowing for recovery of the body. Due to the positive effects of these external factors, it is necessary that we give them more attention than they have received historically in comparison to training and practice. Training and practice have remained the biggest emphasis; however, a shift to emphasizing these external factors as equals should be the next big change to sports injury prevention strategies.

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