International Journal of EXERCISE SCIENCE

Original Research

The Impact of Early Morning Training Sessions on Total Sleep Time in Collegiate Athletes

BRANDON MERFELD[1*], AUSTIN MANCOSKY[2†], JOEL LUEDKE[2‡], SHALYNN GRIESMER[2*], JACOB L. ERICKSON[1‡], VICTORIA CARVALHO[2†], and ANDREW R. JAGIM[1,2‡]

[1]Exercise & Sport Science, University of Wisconsin-La Crosse, La Crosse, WI 54601; [2]Sports Medicine, Mayo Clinic Health System, La Crosse, WI 54601

*Denotes undergraduate student author, †Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 15(6): 423-433, 2022. Early morning training sessions may affect sleep quantity in athletes. The purpose of this study is to examine differences in total sleep time of collegiate athletes on nights prior to early morning training sessions relative to non-training nights. Wristwatch monitors equipped with photoplethysmography and accelerometer technology were worn by 18 NCAA Division III collegiate athletes (Age: 20.1 ± 1.6 years, Height: 1.81 ± 0.02 m, Body Mass: 91.2 ± 6.5 kg, Body Fat %: 20.8 ± 1.6%) during a two-week period of training to monitor total sleep times. Athletes recorded time in and out of bed using a sleep diary, anxiety levels due to having to wake up in the morning, and perceived recovery status (PRS) upon waking the next day. The data were divided into: nights before non-training days (NT) and Training days (TD). Data were analyzed using univariate analysis. All athletes obtained significantly less total sleep on nights before TD relative to NT (NT: 8:15 ± 1:03 vs. TD: 6:08 ± 0:59 hh:mm; $p < 0.05$). There was a positive relationship between total sleep time and recovery status ($p < 0.01$). Anxiety scores were inversely related to total sleep time ($p < 0.01$). Next-day recovery status was inversely related to anxiety scores ($p < 0.001$). College athletes obtained significantly less total sleep time on nights before early morning training sessions (< 0700) during the off-season, regardless of sex and sport. Coaches should consider later training sessions or promote optimal sleep quantity in order to minimize the risks associated to early morning training sessions.

KEY WORDS: Sleep, anxiety, recovery status, college athletes

INTRODUCTION

Throughout an athlete's career, adequate sleep may be one of the most influential components of an athlete's overall health and performance as it underpins an essential physiological requirement for adequate recovery. Sleep is often characterized by means of evaluating sleep quantity or total sleep time, and sleep efficiency (quality), which takes into consideration sleep architecture or the amount of time spent in each sleep stage, in addition to sleep latency, time spent awake, and restlessness (31). Total sleep time and quality of sleep have been strongly associated with physical and cognitive performance, injury risk, and illness (31, 32). Conversely, sleep deprivation has been shown to negatively affect not only performance, but also accuracy, endurance, vigor, submaximal strength and reaction times (14, 29). While there continues to be debate regarding the specific amount of total sleep required for most athletes, it is generally agreed upon that > 8.5 hours per night is optimal (6, 31). However, there has been evidence suggesting that as low as 7-8 hours of sleep per night is still adequate for athletes, with neurobehavioral and performance deficits potentially starting to become evident over time when total sleep times are consistently below this threshold (25, 31). Additionally, the amount of sleep the night prior to competition has been identified as a strong predictor of injury risk in athletes; even more so than the hours of practice an athlete has participated in (18, 30, 31). Similarly, a lack of sleep may also compromise the body's innate immune system in its ability to naturally regulate the inflammatory cascade brought on by periods of intensive training, resulting in suppressed immune function (3). As such, inadequate sleep may contribute to low-grade systemic inflammation (11), subsequently hindering an athlete's ability to fight against both infection and exercise-induced inflammation throughout periods of intensive training.

Although the importance of sleep for athletic performance and health is well-known, current evidence indicates that most athletes often fail to meet the current sleep recommendations (9). In a recent review, it was reported that 50-78% of elite athletes experienced sleep disturbances and 22-26% had highly disturbed sleep schedules (31). Similarly, a recent study found that athletes slept less than the recommended 8-hours, 88% of the time (23). While there are several barriers to optimal sleep practices for athletes, such as living situations, travel, practice schedules and poor sleep hygiene, an athlete's sleep schedule is often not prioritized when training and practice schedules are developed, which may lead to the scheduling of early morning training sessions. Unfortunately, previous research has indicated this may, in turn, negatively affect the quantity and quality of sleep that collegiate student-athletes are able to obtain on nights prior to early morning workouts, thereby leading to daytime sleepiness and fatigue (22, 23).

Subjective measurements of recovery status have become a popular strategy among applied sport science settings as a way to gauge an athlete's current state of recovery and level of preparedness for upcoming training. The perceived recovery status (PRS) is a validated, noninvasive psychobiological tool to assess recovery status and has been shown to correspond to changes in performance, independent of other psychological and physiological factors (15). It is currently unknown how reductions in total sleep time may influence indices of next-day perceived recovery status and readiness to train, beyond the ratings of increased fatigue that have been previously noted. Additionally, there are several factors beyond the limitations of schedules and traveling that may also influence sleep and recovery status in athletes. Previous work has indicated that state and situational anxiety may negatively influence sleep in athletes (21), particularly prior to notable competitions and travel (8). Further, prior to an early morning training session, the pressure to fall asleep, but not oversleep, may create situational anxiety, potentially disrupting sleep. In occupational settings, when workers are on call, they often report higher ratings of state anxiety for fear of oversleeping or not waking up to an alarm (27). These increased ratings of anxiety often worsen sleep quality, which has been associated with reductions in cognitive performance and work performance (27). It is unknown whether this same phenomenon may occur with athletes when faced with an early morning training session, and whether or not the fear of oversleeping or missing an alarm may heighten ratings of anxiety the night before. Heightened states of anxiety may therefore influence sleep quantity and quality and subsequently ratings of perceived recovery the following day, if sleep was found to be disrupted (21).

The recent rise in popularity of wearable activity monitors has created novel opportunities to evaluate the sleep habits of athletes (24, 26). As previous work has indicated collegiate student-athletes often fail to meet the recommendations for sleep, it is important to continue examining barriers that are making it challenging for athletes to get sufficient sleep, and specifically how early morning training sessions may negatively influence the total sleep time of collegiate athletes across different teams. Furthermore, little information is available regarding any sex differences in total sleep time in collegiate athletes. Lastly, concerns of oversleeping may promote feelings of anxiety the night before, subsequently influencing total sleep time and perceived recovery status the following day. Therefore, the purpose of the current study was to examine the effects of early morning training sessions on total sleep time in men and women collegiate athletes, both as a group and assessed independently. A secondary aim of the current study was to examine differences in subjective levels of anxiety and next-day perceived recovery status. We hypothesize that there will be less total sleep time recorded on nights preceding early morning training sessions.

METHODS

Participants

Eighteen NCAA Division III men (n = 9) and women (n = 9) athletes participated in the current observational study. The men athletes were members of the football team, participating in their spring practice portion of the off-season. The women athletes were members of the volleyball team, participating in a structured off-season training program. Inclusion criteria for this study included participation in an off-season strength and conditioning program, free of any injuries, and free of any diagnosed sleep disorders or neurological conditions. The off-season period was chosen because the athletes were participating in a structured training program, which included regularly scheduled early morning training sessions without any team travel for out of town competitions. This study was conducted according to the Declaration of Helsinki guidelines and all procedures were approved by the University's Institutional Review Board for use of human participants in research. Written consent was obtained from all subjects prior to data collection.

Protocol

Wrist worn activity monitors equipped with photoplethysmography and triaxial accelerometers technology were distributed to 18 Division III college athletes over a 14-day period. Total, sleep time and interruptions were recorded using the activity monitors, while electronic questionnaires were distributed daily to assess self-reported ratings of anxiety and perceived recovery status (PRS) upon waking. All data were coded and allocated into one of two categories: nights before non-training days (NT) and Training days (TD). Total sleep time was the primary dependent variable with self-reported ratings of anxiety and perceived recovery status serving as secondary outcomes. Training day type (NT or TD) was the independent variable.

Activity Monitors: All athletes were equipped with a Polar Ignite™ wrist-worn activity monitor (Polar Electro Oy, Kempele, Finland) throughout the duration of the study period. All athletes were allowed the select the preferred wrist to wear the activity monitor on; each selection was then noted in the software program per the manufacturer recommendations. The activity monitors automatically assess total sleep time based on proprietary algorithms and movement patterns. Previous research has indicated that a similar wearable activity monitor, also using accelerometry and body movements to automatically detect sleep, provided an acceptable measure of total sleep time estimation in athletes when compared to criterion measures of polysomnographic recordings of sleep (7, 26).

Questionnaires: Athletes were also instructed to complete an internally developed electronic questionnaire each night, designed to assess the construct of state anxiety prior to bedtime. The electronic questionnaire consisted of a 10-point Likert scale with verbal anchor descriptions ranging from 1 = no anxiety; 3 = mild anxiety; 5 = medium anxiety; 7 = moderate anxiety; and 10 = extreme anxiety. Athletes also completed an electronic questionnaire each morning to assess their perceived recovery status (PRS) upon waking using a previously validated survey which consisted of short phrases anchored to each value using a ranking system (0–10) (Figure 1.) (15). The PRS scale has previously been shown to be associated with changes in performance when used following warm up (r = -0.63) and be able to predict performance outcomes within a reasonable degree of accuracy (15). The players were instructed to rate how they physically felt in terms of recovery from the preceding day's training and their perceived readiness for the upcoming training session. Both questionnaires were sent to them daily (in the evening and next morning), using an electronic survey distribution program (Qualtrics, Utah, USA).

Statistical Analysis

Nightly monitoring periods were allocated to categorical data sets and univariate analysis was used to analyze differences in total sleep time, anxiety and perceived recovery status between the NT and TD conditions. Data are reported as mean ± SD and significance was determined at $p < 0.05$. Cohen's d was calculated and used to examine the effect sizes for differences in sleep, recovery and anxiety values between each day type. The effect sizes were interpreted using the following criteria: 0.2 = trivial, 0.2 – 0.6 = small, 0.7 – 1.2 = moderate, 1.3 – 2.0 = large, and > 2.0 = very large. Pearson correlation coefficients were calculated to examine relationships between total sleep time, anxiety scores, and next-day perceived recovery status. All data were analyzed using the Statistical Package for the Social Sciences (SPSS, Version 25.0; SPSS Inc., Chicago, IL).

RESULTS

Total Sleep Time: A summary of subject demographics are presented in Table 1. Overall, athletes recorded more total sleep time 8:09 ± 1:12 hh:mm on non-training nights compare to the 5:58 ± 0:59 hh:mm of sleep on nights preceding early morning training sessions ($p < 0.05$; ES = 2.80). When separated by sex, both men and women athletes obtained significantly less ($p < 0.05$) total sleep time on nights preceding early morning training sessions relative to non-training days (Table 2). No significant differences in total sleep time between men and women independent of day type were observed ($p > 0.05$). A summary of total sleep time and interruptions for all athletes and men and women athletes by day type is presented in Table 2.

Recovery Status and Ratings of State Anxiety: Overall, athletes reported significantly ($p < 0.05$) lower perceived recovery statuses on mornings of early-morning training sessions compared to non-training days (Table 2). When separated by sex, men reported significantly ($p < 0.05$) lower perceived recovery statuses on mornings of early-morning training sessions compared to non-training days (Table 2). Men also reported significantly higher ($p < 0.05$) ratings of anxiety on nights preceding early morning training sessions (Table 2). No significant differences ($p > 0.05$) in perceived recovery status or ratings of anxiety were observed for women.

Table 1. Summary of subject demographics. Data presented as Mean ± SD.

Variable	Men	Women
Age (yrs.)	20.75 ± 1.9	19.29 ± 0.75
Height (m)	1.86 ± 0.05	1.71 ± 0.07*
Body weight (kg)	111.5 ± 11.8	66.2 ± 6.1*
Body Fat %	20.4 ± 9.4	21.21 ± 3.0

*Signifies $p < 0.05$

Table 2. Summary of sleep data, recovery scores and ratings of anxiety for training and non-training days. Data presented as Mean ± SD.

Sex	Day type	Total (hh:min)	Interruptions (hh:min)	Recovery Status	Anxiety Scores
All	Non-training	8:09 ± 1:12	0:36 ± 0:15	5.72 ± 2.05	3.20 ± 1.81
	Training	5:58 ± 0:59*	0:22 ± 0:09*	4.79 ± 1.75*	3.79 ± 1.74
	Effect Size	2.80	1.13	0.49	-0.33
Men	Non-training	8:22 ± 1:06	0:43 ± 0:13	5.93 ± 2.19	2.38 ± 1.57
	Training	6:00 ± 1:06*	0:26 ± 0:10*	4.88 ± 1.36*	3.44 ± 1.89*
Effect Size		2.09	2.17	0.57	-0.61
Women	Non-training	7:52 ± 1:16	0:28 ± 0:13	5.48 ± 1.89	4.16 ± 1.60
	Training	5:57 ± 0:52*	0:19 ± 0:08*	4.67 ± 2.22	4.28 ± 1.41
Effect Size		2.17	0.83	0.39	-0.61

*Signifies $p < 0.05$; Effect size = Cohen's *d* effect size.

There was a positive relationship between total sleep time and next-day recovery status ($r = 0.274$; $p < 0.01$) as seen in Table 3. Self-reported ratings of anxiety were inversely related to total sleep time ($r = -0.283$; $p < 0.01$). Next-day recovery status was inversely related to anxiety scores ($r = -0.441$; $p < 0.001$).

Table 3. Relationships between total sleep time, and ratings of recovery and anxiety.

		Total Sleep	Anxiety Score	Recovery Status
Total Sleep	Correlation coefficient	1	-0.283**	0.274**
	Significance level		0.003	0.003
Anxiety Score	Correlation coefficient		1	-0.441**
	Significance level			<0.001
Recovery Score	Correlation coefficient			1
	Significance level			

*Signifies $p < 0.05$; **Signifies $p < 0.01$

DISCUSSION

The widespread availability of wearable technology has allowed for novel insight into the daily activities and sleep habits of athletes. The primary aim of the current study was to examine differences in total sleep time when athletes were scheduled for early morning training sessions compared to nights without an early morning session the next day. The main findings from the current study indicate that when analyzed as a group, men and women athletes recorded less total sleep time on nights before early morning training sessions (< 0700) compared to non-training days, which supports our hypothesis. Further, as noted by the very large effect size (Table 2), this was a practically meaningful difference in the total amount of sleep time recorded by all athletes between the two day types. When analyzed independently, both men and women athletes experienced practically meaningful reductions in total sleep time on nights preceding early morning training sessions (ES = 2.09 and 2.17, respectively). On non-training nights, athletes recorded approximately 8:10 hh:mm of sleep, which is in alignment with established sleep recommendations for athletes (2). However, athletes only recorded ~6 hrs. of sleep on nights preceding early morning training sessions, which is far below that which is recommended for athletes. It is appears as though the athletes in the current study likely failed to modify bed times to account for the early morning training sessions, thereby reducing their window for total sleep time accrual. The findings from the current study are novel in that this is the first study examining collegiate men and women athletes competing at the NCAA Division III level, yet they are also in agreement with previous work, which has similarly demonstrated that athletes often record less sleep on nights prior to early morning training sessions (4, 22, 23). In a similar study, Sargent et al. (23) reported that athletes recorded an average of 6:30 hh:mm of sleep per night prior to training days, which was 18 minutes shorter compared to nights prior to non-training days. Further, of the 926 sleep periods that were recorded in the study by Sargent et al. (23), 88% were below the recommended 8 hours of sleep and 60% were below the minimum recommendation of 7 hours. Interestingly, the magnitude of difference in total sleep time between day types in the current study is substantially larger than that reported by Sargent et al. (23). It's worth noting the athletes in the study by Sargent et al. (23) were competing at the elite level on a national team or nationally ranked compared to the collegiate student-athletes from the current study, which may influence the consistency of schedules and daily routines.

A secondary aim of the current study was to examine differences in ratings of pre-sleep anxiety and next-day ratings of perceived recovery status on days of early morning training sessions versus non-training days. Athletes in the current study self-reported higher ratings of anxiety on nights preceding early morning training sessions compared to non-training days. In turn, the higher ratings of anxiety may have also negatively influenced total sleep time and the subsequent measures of perceived recovery status the next-day. Interestingly, this effect was only observed in the men, however the effect sizes were identical with both sexes, indicating the practical relevance of how total sleep time influences recovery status may be comparable across both sexes. It is difficult to discern primary causality between whether or not the reductions in total sleep time were a byproduct of the restricted sleep window due to the early morning training session, or a result of the elevated state anxiety the night before. There was a *very strong* effect size observed for differences in the number of interruptions experienced by the athletes between day types, which may also be a reflection of the higher levels of anxiety reported prior to early morning training days as increased anxiety levels may have led to more restless sleep. As perceived recovery status was lower on days of early morning training sessions, and lower ratings of recovery status were associated with reduced total sleep time (Table 3), a lack of sleep may have compromised the athletes' ability to adequately recover and feel prepared to train the next day. It is also possible that the higher ratings of anxiety the night before early morning training sessions also had a negative effect on recovery status as indicated by the negative relationship between recovery status and ratings of anxiety (Table 3). Similar findings have been noted prior to competitions, in that reductions in total sleep time were associated with increased ratings of fatigue and lower ratings of vigor the next day (14). Together, with the results of the current study and previous findings, it appears as though reductions in total sleep time negatively affect various indices of recovery prior to both training sessions and competitions. There may be acute and chronic implications that could arise following reductions in total sleep time with frequent early morning training sessions. While the athletes in the current study, only reported perceived recovery status, previous research has also observed marked reductions in physical performance, cognitive ability and reaction time following disrupted sleep (28). In extreme cases, when sleep is restricted the night prior to a training session, athletes tend to report poorer mood, higher levels of fatigue and greater perceptions of effort during training compared to nights when athletes logged the recommended 8 hours of sleep (1, 20, 28, 31). Over time, poor sleep may lead to persistent fatigue, which is a common symptom of inadequate recovery and frequently reported by athletes who are overtraining (5). Furthermore, athletes who sleep less than 8 hours per night, have been found to be 1.7 times more likely to suffer an injury compared to athletes who sleep more than 8 hours (18). However, improvements in total sleep time through targeted sleep improvement interventions have been directly linked with various aspects of performance improvements among athletes (12, 13, 19). Thereby indicating that continued focus on improving sleep can likely reverse any negative trends in recovery and performance brought on by disrupted sleep patterns.

It is important to identify strategies to overcome barriers and to improve the night time sleep habits of athletes. Previous research has indicated the average bedtime for a college student is 0020 (17), which highlights an obvious challenge for athletes who have early morning (< 0700) training sessions or classes. In order for a student athlete to obtain the necessary amount of sleep before a 0700 training session, an athlete would need to be asleep by ~2200. This may be problematic for some student-athletes, as academic work, social events and extracurricular activities may be prioritized over sleep as these activities are frequently listed as patterns and predictors of sleep disturbances among collegiate students (31). Consequently, these predictors likely underpin the high prevalence of inadequate sleep quantity frequently identified among student-athletes. Moreover, as most early morning training sessions and classes are often mandatory, student-athletes may opt to sacrifice sleep in order to engage in social activities, whether they fully comprehend the physiological consequences or not. Additionally, college athletes are subjected to a plethora of stressors, derived from academic, financial, social and athletics-related stressors for those competing in sports (16). Previous research has indicated that 95 and 85% of male and female collegiate athletes, respectively, self-reported higher levels of stress when compared to non-athlete student controls, of whom only 52% self-reported being stressed (16). This added stress may also contribute to a lack of sleep and may be a byproduct of the intense physical training, hectic schedules and potentially also fueled by a lack of sleep itself. Subsequently, higher stress levels may signify a bi-directional relationship with disrupted sleep patterns, potentially representing a contributing factor for poor sleep quality and an outcome of reduced total sleep time (10).

This study is not without limitations. The activity monitors used to obtain sleep data have not been found to be valid measures of sleep architecture, which requires the use of polysomnography. As such, only inferences regarding total sleep time were possible, rather than details on how early training sessions affected specific sleep cycles and overall sleep quality. Additionally, wearable activity monitors may overestimate total sleep time (26) as an individual may be still, but not sleeping, which could be inadvertently recorded as sleep. However, in the current study, this would further exacerbate the issue of the low total sleep times recorded by the athletes. The small sample size is another limitation of the current study. As a result, an expanded sample size could provide more insight into the population as a whole, while allowing for a better examination across different sport types and sex. Another limitation was the short duration of monitoring period during which sleep was monitored. It is important to note that the current findings may not extend to all phases of an annual training cycle as travel, competitions, and academic work are likely to influence ratings of anxiety, recovery status and sleep habits. Similarly, these findings may not be generalizable to all levels of collegiate competition as some programs may have more training facilities to better accommodate multiple teas and therefore schedules may not be as constricted. Additionally, these relationships may also change throughout a student-athletes athletic career as daily routines, stress levels, and living situations are likely to fluctuate which may subsequently influence these outcomes. Future research should address additional strategies to mitigate the deleterious effects of reductions in total sleep time among athletic populations and practical ways to promote optimal sleep habits. Additionally, future research should further examine the accuracy of wearable technologies for the assessment of sleep quantity and quality while also examining the subsequent effects on indices of recovery or player readiness, such as heart rate variability in addition to subjective and performance-based indicators of recovery status.

Conclusion: Results of the current study indicate that early morning training sessions appear to compromise total sleep time in collegiate athletes. This reduction in total sleep time was similarly observed in both men and women athletes. The sleep deprivation resulting from the early morning training sessions may negatively impact an athlete's physical and cognitive performance, potentially predisposing them to greater injury risks and negatively affect their general health. In order to minimize the detrimental effects of the diminished sleep duration, coaches should consider later workout sessions if possible or encourage athletes to practice optimal sleep hygiene in an attempt to combat the lack of sleep on nights preceding early training sessions. Further, higher self-reported ratings of anxiety were associated with shorter sleep duration and lower next-day recovery status. Relaxation techniques designed to reduce anxiety levels may be warranted to help promote sleep onset. Coaches, strength staff, and athletic directors should seek strategies for developing training schedules with a goal of minimizing the number of early morning training sessions for athletes, thus extending an athlete's potential for greater sleep duration.

REFERENCES

1. Belenky G, Wesensten NJ, Thorne DR, Thomas ML, Sing HC, Redmond DP, Russo MB, and Balkin TJ. Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. J Sleep Res 12: 1-12, 2003.

2. Benjamin C, Adams, W., Curtis, R., Sekiguchi, Y. Early morning training impacts previous night's sleep in NCAA division I cross country runners. Women in Sport and Physical Activity Journal 28: 27-33, 2019.

3. Besedovsky L, Lange T, and Haack M. The sleep-immune crosstalk in health and disease. Physiological Reviews 99: 1325-1380, 2019.

4. Brauer AA, Athey AB, Ross MJ, and Grandner MA. Sleep and health among collegiate student athletes. Chest 156: 1234-1245, 2019.

5. Budgett R. Fatigue and underperformance in athletes: the overtraining syndrome. British Journal of Sports Medicine 32: 107-110, 1998.

6. Burke TM, Lisman PJ, Maguire K, Skeiky L, Choynowski JJ, Capaldi VF, 2nd, Wilder JN, Brager AJ, and Dobrosielski DA. Examination of sleep and injury among college football athletes. Journal of Strength and Conditioning Research 34: 609-616, 2020.

7. Chinoy ED, Cuellar JA, Huwa KE, Jameson JT, Watson CH, Bessman SC, Hirsch DA, Cooper AD, Drummond SPA, and Markwald RR. Performance of seven consumer sleep-tracking devices compared with polysomnography. Sleep 44, 2021.

8. Erlacher D, Ehrlenspiel F, Adegbesan OA, and El-Din HG. Sleep habits in German athletes before important competitions or games. Journal of Sports Sciences 29: 859-866, 2011.

9. Fullagar HH, Skorski S, Duffield R, Hammes D, Coutts AJ, and Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Med 45: 161-186, 2015.

10. Han K, Kim, L., Shim, L. Stress and sleep disorder. Experimental Neurobiology 21: 141-150, 2012.

11. Irwin MR, Olmstead R, and Carroll JE. Sleep disturbance, sleep duration, and inflammation: A systematic review and meta-analysis of cohort studies and experimental sleep deprivation. Biol Psychiatry 80: 40-52, 2016.

12. Juliff LE, Halson SL, Hebert JJ, Forsyth PL, and Peiffer JJ. Longer sleep durations are positively associated with finishing place during a national multiday netball competition. Journal of Strength and Conditioning Research 32: 189-194, 2018.

13. Kirschen GW, Jones JJ, and Hale L. The impact of sleep duration on performance among competitive athletes: A systematic literature review. Clin J Sport Med 30: 503-512, 2020.

14. Lastella M, Lovell GP, and Sargent C. Athletes' precompetitive sleep behaviour and its relationship with subsequent precompetitive mood and performance. Eur J Sport Sci 14 Suppl 1: S123-130, 2014.

15. Laurent CM, Green JM, Bishop PA, Sjokvist J, Schumacker RE, Richardson MT, and Curtner-Smith M. A practical approach to monitoring recovery: development of a perceived recovery status scale. Journal of Strength and Conditioning Research 25: 620-628, 2011.

16. Lopes Dos Santos M, Uftring M, Stahl CA, Lockie RG, Alvar B, Mann JB, and Dawes JJ. Stress in academic and athletic performance in collegiate athletes: A narrative review of sources and monitoring strategies. Front Sports Act Living 2: 42, 2020.

17. Lund HG, Reider BD, Whiting AB, and Prichard JR. Sleep patterns and predictors of disturbed sleep in a large population of college students. J Adolesc Health 46: 124-132, 2010.

18. Milewski MD, Skaggs DL, Bishop GA, Pace JL, Ibrahim DA, Wren TA, and Barzdukas A. Chronic lack of sleep is associated with increased sports injuries in adolescent athletes. J Pediatr Orthop 34: 129-133, 2014.

19. Reilly T and Edwards B. Altered sleep-wake cycles and physical performance in athletes. Physiol Behav 90: 274-284, 2007.

20. Ritland BM, Simonelli G, Gentili RJ, Smith JC, He X, Oh H, Balkin TJ, and Hatfield BD. Sleep health and its association with performance and motivation in tactical athletes enrolled in the Reserve Officers' Training Corps. Sleep Health 5: 309-314, 2019.

21. Romyn G, Robey E, Dimmock JA, Halson SL, and Peeling P. Sleep, anxiety and electronic device use by athletes in the training and competition environments. Eur J Sport Sci 16: 301-308, 2016.

22. Sargent C, Halson S, and Roach GD. Sleep or swim? Early-morning training severely restricts the amount of sleep obtained by elite swimmers. Eur J Sport Sci 14 Suppl 1: S310-315, 2014.

23. Sargent C, Lastella M, Halson SL, and Roach GD. The impact of training schedules on the sleep and fatigue of elite athletes. Chronobiol Int 31: 1160-1168, 2014.

24. Sargent C, Lastella M, Halson SL, and Roach GD. The validity of activity monitors for measuring sleep in elite athletes. Journal of Science and Medicine in Sport 19: 848-853, 2016.

25. Sargent C, Lastella M, Halson SL, and Roach GD. How much sleep does an elite athlete need? International Journal of Sports Physiology and Performance: 1-12, 2021.

26. Sargent C, Lastella M, Romyn G, Versey N, Miller DJ, and Roach GD. How well does a commercially available wearable device measure sleep in young athletes? Chronobiol Int 35: 754-758, 2018.

27. Sprajcer M, Jay SM, Vincent GE, Vakulin A, Lack L, and Ferguson SA. How the chance of missing the alarm during an on-call shift affects pre-bed anxiety, sleep and next day cognitive performance. Biol Psychol 137: 133-139, 2018.

28. Taheri M and Arabameri E. The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. Asian J Sports Med 3: 15-20, 2012.

29. Vitale KC, Owens R, Hopkins SR, and Malhotra A. Sleep hygiene for optimizing recovery in athletes: Review and recommendations. Int J Sports Med 40: 535-543, 2019.

30. von Rosen P, Frohm A, Kottorp A, Friden C, and Heijne A. Too little sleep and an unhealthy diet could increase the risk of sustaining a new injury in adolescent elite athletes. Scand J Med Sci Sports 27: 1364-1371, 2017.

31. Walsh NP, Halson SL, Sargent C, Roach GD, Nedelec M, Gupta L, Leeder J, Fullagar HH, Coutts AJ, Edwards BJ, Pullinger SA, Robertson CM, Burniston JG, Lastella M, Le Meur Y, Hausswirth C, Bender AM, Grandner MA, and Samuels CH. Sleep and the athlete: narrative review and 2021 expert consensus recommendations. British Journal of Sports Medicine, 2020.

32. Watson AM. Sleep and athletic performance. Curr Sports Med Rep 16: 413-418, 2017.