SSE #113

Sports Science Exchange (2013) Vol. 26, No. 113, 1-4

GATORADE SPORTS SCIENCE INSTITUTE

SLEEP AND THE ELITE ATHLETE

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KEY POINTS

- Sleep is essential for athletes, both for preparing for, and recovering from, training and competition.
- Sleep disturbances in elite athletes can occur both during training and following competition.
- Sub-maximal, prolonged exercise appears to be more affected by sleep deprivation than short, maximal efforts.
- Sleep extension and napping can be effective means of enhancing performance in athletes.
- Athletes should focus on utilizing good sleep hygiene to improve sleep and potentially athletic performance.

INTRODUCTION

Although the function of sleep is not fully understood, it is generally accepted that it serves to recover from previous wakefulness and/or prepare for functioning in the subsequent wake period. An individual's recent sleep history therefore has a marked impact on their daytime functioning. Restricting sleep to less than 6 h per night for four or more consecutive nights has been shown to impair cognitive performance and mood (Belenky et al., 2003), disturb glucose metabolism (Spiegel et al., 1999), appetite regulation (Spiegel et al., 2004) and immune function (Krueger et al., 2011). This type of evidence has led to the recommendation that adults should obtain 8 h of sleep per night to prevent neurobehavioual deficits (Van Dongen et al., 2003).

While there is considerable data available related to the amount of sleep obtained by adults in the general population, there are few published data related to the amount of sleep obtained by elite athletes. This appears to be a considerable oversight given that sleep has been recognized as an essential component of preparation for, and recovery from high-intensity training (Reilly & Edwards, 2007; Robson-Ansley et al., 2009; Samuels, 2008).

SLEEP OVERVIEW

Sleep Stages

Sleep can be defined as a reversible behavioural state where an individual is perceptually disengaged from and unresponsive to the environment (Carskadon & Dement, 2011). Sleep is a complex physiological and behavioural state which has two primary states based on physiological parameters. These are rapid eye movement (REM) and non-REM (NREM) stages. An electroencephalogram (EEG) where electrodes measure brain electrical activity is used to identify the two states (Figure 1). NREM sleep is divided into four stages (1-4) and is associated with a progressive increase in the depth of sleep (Carskadon & Dement, 2011). REM sleep is characterised by muscle atonia (lack of normal muscle tension), bursts of rapid eye movement and dreaming. Therefore, REM sleep is considered an activated brain in a paralyzed body.

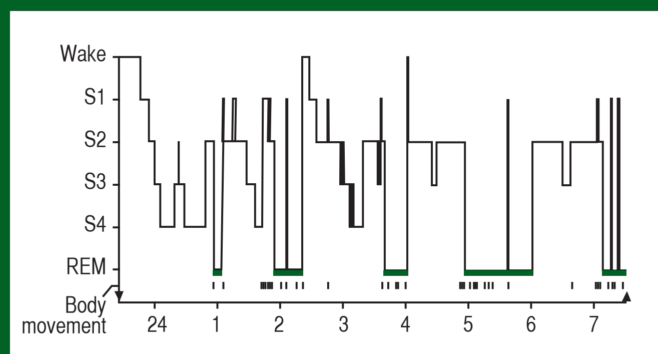

Figure 1. The progression of sleep stages across a single night in a normal young adult volunteer is illustrated in this sleep histogram. The text describes the ideal or average pattern (Carskadon & Dement, 2011).

Recently it has been hypothesized that sleep and in particular slow-wave sleep (SWS, or deep sleep), is important for recovery in athletes. SWS consists of stages 3 and 4 of NREM sleep. Evidence in support of this theory includes the synchrony of growth hormone release with SWS in humans, the suggestion that optimum conditions for anabolism prevail during sleep, and studies showing SWS duration to be proportional to preceding wakefulness (Shapiro et al., 1981).

Shapiro et al. (1981) investigated sleep prior to and following a 92 km marathon in six subjects. Results indicated total sleep time increased significantly over control times on each of the four nights after the marathon. Wakefulness was greatest on the night of the marathon, suggested to be related to muscle pain. The percentage of SWS increased on both nights 1 and 2. The quantitative increase in total sleep time and particularly in SWS and the qualitative shift toward more stage 4 sleep immediately after metabolic stress supports the theory that sleep (particularly SWS) is important for recovery in athletes.

Measuring Sleep

There are two commonly used methods to assess sleep, Actigraphy and Polysomnography. Actigraphy is a non-invasive method of monitoring sleep and involves wearing wrist activity monitors, which are devices worn like a wristwatch that continuously record body movement (usually stored in 1-min epochs). Sleep diaries are also collected where participants record the start and end date/time for all sleep periods (i.e., night-time sleeps and daytime naps). Data from sleep diaries and activity monitors are used to determine when participants are awake and when they are asleep. Essentially, all time is scored as wake unless (i) the sleep diary indicates that the participant was lying down attempting to sleep, and (ii) the activity counts from the monitor are sufficiently low to indicate that the participant was immobile. When these two conditions are satisfied simultaneously, time is scored as sleep. Actigraphy is useful for understanding sleep patterns as it is non-invasive and relatively easy to collect data over significant periods of time (commonly two weeks of monitoring).

The second method is Polysomnography (PSG) which is a sleep study in which body functions such as EEG, eye movements, muscle activity and cardiac activity are measured. PSG provides information on sleep staging and is considered the “gold standard” for assessing sleep quality and quantity. PSG can be expensive and is labour intensive and is often used primarily for assessing clinical sleep disorders.

PERFORMANCE EFFECTS OF SLEEP DEPRIVATION AND SLEEP EXTENSION

Sleep Deprivation

There are a limited number of studies which have examined the effects of sleep deprivation on athletic performance. From the available data it appears that several phenomena exist. First, the sleep deprivation must be greater than 30 h (one complete night of no sleep and remaining awake into the afternoon) to have an impact on anaerobic performance (Skein et al., 2011). Second, aerobic performance may be decreased after only 24 h (Oliver et al., 2009) and third, sustained or repeated bouts of exercise are affected to a greater degree than one-off maximal efforts (Blumert et al., 2007; Reilly & Edwards, 2007). For example, peak power has been shown to be unchanged after 24 h of wake; however, they were impaired after 36 h without sleep (Souissi et al., 2003). Isokinetic performance has also been shown to decrease significantly following 30 h of sleep deprivation (Bulbulian et al., 1996). Skein et al. (2011) reported significant decreases in mean and total sprint time following 30 h of sleep deprivation in 10 male team sport athletes. Blumert and colleagues (2007) examined the effects of 24 h of sleep deprivation in nine U.S. college-level weightlifters in a randomised counter-balanced design. There were no differences in any of the performance tasks (snatch, clean and jerk, front squat and total volume load and training intensity) following 24 h of sleep deprivation when compared to no sleep deprivation (Blumert et al., 2007). However, mood state as assessed by the Profile of Mood States was significantly altered, with confusion, vigour, fatigue and total mood disturbance all negatively affected by sleep deprivation.

While much of the research has focused on anaerobic performance, reductions in endurance running performance have been observed following 24 h of sleep deprivation (Oliver et al., 2009). Interestingly, this occurred without any changes in physiological parameters and pacing.

The mechanism behind the reduced performance following prolonged sustained sleep deprivation is not clear; however, it has been suggested that an increased perception of effort is one potential cause. While the above studies provide some insight into the relationship between sleep deprivation and performance, most athletes are more likely to experience acute bouts of partial sleep deprivation where sleep is reduced for several hours on consecutive nights.

Partial Sleep Deprivation

A small number of studies have examined the effect of partial sleep deprivation on athletic performance. Reilly and Deykin (1983) reported decrements in a range of psychomotor functions after only one night of restricted sleep; however, gross motor function such as muscle strength, lung power and endurance running were unaffected. Reilly and Hales (1988) reported similar effects in females following partial sleep deprivation, with gross motor functions being less affected by sleep loss than tasks requiring fast reaction times.

The effect of 2.5 h of sleep per night over 4 nights was measured in eight swimmers (Sinnerton & Reilly, 1992). No effect of sleep loss was observed when investigating back and grip strength, lung function or swimming performance. However, mood state was significantly altered with increases in depression, tension, confusion, fatigue and anger and decreases in vigour.

Reilly and Percy (1994) found a significant effect of sleep loss on maximal bench press, leg press and dead lifts, but not maximal bicep curl. Sub-maximal performance however, was significantly affected on all four tasks and to a greater degree than maximal efforts. The greatest impairments were found later in the protocol, suggesting an accumulative effect of fatigue from sleep loss (Reilly & Percy, 1994).

From the available research it appears that sub-maximal prolonged tasks may be more affected than maximal efforts, particularly after the first two nights of partial sleep deprivation (Reilly & Percy, 1994).

Effects of Sleep Extension

Another means of examining the effect of sleep on performance is to extend the amount of sleep an athlete receives and determine the effects on subsequent performance. Mah et al. (2011) instructed six basketball players to obtain as much extra sleep as possible following two weeks of normal sleep habits. Faster sprint times and increased free-throw accuracy were observed at the end of the sleep extension period. Mood was also significantly improved, with increased vigour and decreased fatigue (Mah et al., 2011). The same research group also increased the sleep time of swimmers to 10 h per night for six to seven weeks and reported that 15 meter sprint, reaction time, turn time and mood all improved. The data from this small number of studies suggests that increasing the amount of sleep an athlete receives may significantly enhance performance.

Effects of Napping

Athletes suffering from some degree of sleep loss may benefit from a brief nap, particularly if a training session is to be completed in the afternoon or evening. Waterhouse et al. (2007) are one of the only groups to investigate the effects of a lunchtime nap on sprint performance following partial sleep deprivation (4 h of sleep). Following a 30-minute nap, 20 m sprint performance was increased (compared to no nap), alertness was increased and sleepiness was decreased. In terms of cognitive performance, sleep supplementation in the form of napping has been shown to have a positive influence on cognitive tasks (Postolache et al., 2005). Naps can markedly reduce sleepiness and can be beneficial when learning skills, strategy or tactics in sleep-deprived individuals (Postolache et al., 2005). Napping may be beneficial for athletes who have to routinely wake early for training or competition and for athletes who are experiencing sleep deprivation (Waterhouse et al., 2007).

HABITUAL SLEEP DURATION

According to a 2005 Gallup Poll in the USA, the average self-reported sleep duration of healthy individuals is 6.8 h on weekdays and 7.4 h on weekends (National Sleep Foundation, 2006). However, the sleep habits of elite athletes have only recently been investigated. Leeder et al (2012) compared the sleep habits of 47 elite athletes from Olympic Sports using actigraphy over a four-day period to that of age and sex-matched non-sporting controls. The athlete group had a total time in bed of 8:36 ± 0:53 hr:min, compared to 8:07 ± 0:20 in the control group. Despite the longer time in bed, the athlete group had a longer sleep latency (time to fall asleep) (18.2 ± 16.5 min vs. 5.0 ± 2.5 min), a lower sleep efficiency (estimate of sleep quality) than controls (80.6 ± 6.4 % vs. 88.7 ± 3.6 %), resulting in a similar time asleep (6:55 ± 0:43 vs. 7:11 ± 0:25 hr:min). The results demonstrated that while athletes had a comparable quantity of sleep to controls, significant differences were observed in the quality of sleep between the two groups (Leeder et al., 2012).

While the above data was obtained during a period of normal training without competition, athletes may experience disturbed sleep prior to important competition or games. Erlacher et al. (2011) administered a questionnaire to 632 German athletes to assess possible sleep disturbances prior to competition. Of these athletes, 66% (416) reported that they slept worse than normal at least once prior to an important competition. Of these 416 athletes, 80% reported problems falling asleep, 43% reported waking up early in the morning and 32% reported waking up at night. Factors such as thoughts about competition (77%), nervousness about competition (60%), unusual surroundings (29%) and noise in the room (17%) were identified as reasons for poor sleep (Erlacher et al., 2011).

Therefore it appears that sleep disturbances in athletes can occur at two time points: 1) prior to important competitions and 2) during normal training. This sleep disruption during normal training may be due to a poor routine as a consequence of early training sessions, poor sleep habits (i.e., watching television in bed), nocturnal waking to use the bathroom, caffeine use and excessive thinking/worrying/planning. While not documented in the literature, anecdotal evidence also suggests that athletes such as footballers who compete at night also have significant difficulties falling asleep post competition.

PRACTICAL APPLICATIONS

Athletes should focus on utilising good sleep hygiene to maximise sleep. Strategies for good sleep include:

- The bedroom should be cool, dark and quiet. Eye masks and earplugs can be useful, especially during travel.
- Create a good sleep routine by going to bed at the same time and waking up at the same time.
- Avoid watching television in bed, using the computer in bed and avoid watching the clock.
- Avoid caffeine approximately 4-5 h prior to sleep (this may vary among individuals).
- Do not go to bed after consuming too much fluid as it may result in waking up to use the bathroom.
- Napping can be useful; however, generally naps should be kept to less than one hour and not too close to bedtime as it may interfere with sleep.

SUMMARY

Sleep is extremely important for numerous biological functions and sleep deprivation can have significant effects on athletic performance, especially sub-maximal, prolonged exercise. From the available evidence it appears that athletes may be obtaining less than 8 h of sleep per night and that increasing sleep (sleep extension) or napping may be useful to increase the total number of hours of sleep and thereby enhance performance.

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