sleep for performance and recovery in athletes

Rest, and specifically sleep, play a major role in athletic performance.

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In their quest for excellence, athletes have to cope with tough training programmes, and perform well in competitions on a regular basis. Players from top clubs may have additional commitments such as inter-provincial league matches and tournaments, or representing their country in international competitions. The repetitive and seemingly unrelenting match fixtures, often combined with the stress of travel, might push athletes beyond their physiological and psychological limits.

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Numerous authors have mentioned the importance of the various factors that can influence an athlete's performance, with non-training elements having a major influence on training itself. Therefore, factors outside the realm of training should also be considered for their role in the complete regeneration of the elite athlete. For instance, food and sleep are seen as two of the most crucial physical essentials for maintaining a sound and healthy state of living.[1,2] In a recent South African survey involving 890 elite players from field hockey, netball, rugby and soccer, respondents indicated that they view sleep as the most important strategy for recovery.[3] However, information on sleep hygiene is often neglected or athletes are given brief, simplistic recommendations.

The circadian rhythm

Most human behavioural and physiological processes are characterised by daily rhythms that match a 24-hour day-night cycle. These daily rhythms are internally generated and not just reactions to alarm clocks, sunsets or external temperature changes, and persist under constant environmental conditions.[4] They are also referred to as circadian rhythms; the term is derived from the Latin *circa*, which means *about*, and *dies*, meaning *day*.[5]

The circadian system is acutely sensitive to environmental photic cues, with natural light being one of the universal and predominant environmental time cues, or *zeitgebers*. The suprachiasmatic nucleus (SCN) within the hypothalamus regulates the body's circadian system and has been established as the master circadian pacemaker or master clock. The SCN cells have receptors for melatonin. As darkness falls, melatonin is secreted, and its vasodilatory effect causes body temperature to fall and other physiological functions to slow down to prepare for sleep. Exposure to light thus inhibits the release of melatonin.[6,7]

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The circadian rhythm of sleep and waking is also closely coupled to the daily rhythm of body temperature. Body temperature is at its lowest in the early hours of the morning (about 04:00), then rises throughout the day to peak between 17:00 and 21:00. Sleep onset normally occurs as distal skin blood flow starts to increase and the core body temperature starts to drop. Research has shown that when subjects are isolated from time cues, they can only fall into long periods of sleep when they are near their minimal body temperature. Evidence from physiological and neuroanatomical studies indicated that changes in body temperatures trigger brain areas to initiate sleep. Extreme temperatures in the sleeping environment will thus disrupt sleep. This is often why individuals find it difficult to sleep in very hot or cold weather, or after a very hot bath or shower. Sleeping under very thick bedding, in lots of clothes or with a heater on high may also maintain an individual's core body temperature and affect the quality of sleep. Room temperatures higher than 24°C or lower than 10°C could decrease the quality of sleep.[8]

Napping

When the sleep-wake cycles of subjects in isolation chambers were studied, it was found that subjects spontaneously took naps when they were allowed to sleep whenever they wanted to. These naps were taken relative to body temperature cycles. Longer sleep began prior to the minimum temperature, while shorter sleep or naps (*siestas*) occurred near the maximum temperature. If the 24-hour day was divided into four 6-hour zones, the probability of sleep onset and wakefulness could be projected relative to

the phase of the circadian temperature cycle. A high probability of a short sleep or siesta was found between 13:00 and 18:00.[9,10]

The time around 15:00, where individuals usually experience a high level of fatigue and greater feeling of sleepiness, is also referred to as the 'breaking point' or 'postlunch dip'.[11]

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Feelings of fatigue and sleepiness occur approximately 8 hours after termination of the long consolidated nocturnal sleep. Napping at any other time may have negative effects on sleep in the next consolidated sleep period of the 24-hour day. Naps 10 - 12 hours after the major sleep period are particularly likely to disturb subsequent nocturnal sleep.[12]

Athletes should be advised to take a mid-afternoon nap, also called recovery break, micro-rest, or power nap.[13] A 20-minute nap in the mid-afternoon has shown an improvement in performance level, self-confidence and daytime vigilance level in young healthy adults.[14] It was also reported that daytime naps can be beneficial to the learning of visual and motor skills. With reference to athletic training, immediate performance after waking from a longer sleep bout (>60 minutes) might result in short-term performance impairments due to sleep inertia. It is therefore important for the athlete to plan the timing and duration of the nap well.[15]

Factors affecting the quality of sleep

Sleep serves multiple purposes. It has been shown that sleep helps with physical growth and repair, as sleep is one of the most powerful non-pharmacological stimuli to initiate the secretion of growth hormone.[16] While learning new skills, athletes often believe that practice is the only prerequisite for improvement. Although correctly repeating a new task will result in learning benefits, it has been shown that the human brain continues to learn in the absence of further practice, and this delayed improvement develops during sleep.[15] Although the complexities of sleep are not yet fully understood, it is clear that sleep is essential for physical and emotional health and psychological restoration and recovery, conservation of energy, memory consolidation, discharge of emotions, brain growth, and maintenance of the immune system, among others.

Numerous studies have shown that mood is strongly affected by sleep deprivation, and poor sleep is associated with depressed mood and reduced motivation. A reduced ability to deal with emotions is usually the first symptom associated with sleep deprivation. Sleep-deprived subjects consistently show increased levels of depression, stress, anxiety, worry, frustration, irritability, and difficulty coping with new environmental stressors. With even minimal sleep loss, perceived exertion is increased and the threshold for containing anger is lowered.[17] Lack of sufficient sleep thus adds to the emotional challenges inherent in athletic competition.

Various factors could make it difficult for athletes to sleep well. They might not be totally sleep deprived, but may feel the consequences of 'fragmented sleep', where the quality of their sleep is adversely affected by various factors. Some of the factors relate to psychological stressors, e.g. deadlines, examinations, job crisis, or marital conflict.[18]

Adults are sensitive to their sleep environment and might find it difficult to fall asleep in a strange setting. Noises such as road traffic and ventilators can cause awakenings or make sleep shallower, although it was shown that traffic noise (intermittent and fluctuating) was more disturbing for sleep quality than ventilation noise. It is recommended that athletes should select a bedroom next to the courtyard in a hotel (even if there is ventilation equipment) rather than one that is located next to a busy road.[19]

A regular sleep-wake rhythm is also important for optimal efficiency during wakefulness. Inconsistent sleep patterns disrupt the internal biological clock, and tend to increase the length of time it takes to fall asleep. Changing the schedule for more than 2 days or sleeping 1 hour longer on weekends disrupts the biological clock. It usually takes 4 - 5 days to adjust to a particular bedtime. The individual should get up in the morning at the same time, even if he or she experienced low-quality sleep the previous night, and thus establish consistent sleep and wake-up times.[20]

Travel

Long journeys usually cause tiredness and travel fatigue in athletes. This might be due to cramped conditions, dehydration as a result of low humidity on board a plane, air turbulence, reduced barometric pressure, vibration, noise, flight anxiety, and whole-body stiffness due to relative inactivity while travelling. The athlete might also feel stressed due to the generally high level of activity surrounding any long trip, transport arrangements at departure and arrival, and control checks when crossing national borders. These symptoms of travel fatigue can be reversed relatively quickly once athletes reach their destinations and usually do not persist beyond the first 24 hours after arrival.[6,21]

A bigger problem arises when the athlete has to cross multiple time zones rather than covering the same distance in a northerly or southerly direction. Athletes may experience various symptoms including an inability to sleep at the local time, bowel irregularities, increased incidence of headaches, irritability and moodiness, fatigue, reduced cognitive skills, and poor psychomotor co-ordination. This psychophysiological impairment of well-being and performance is known as circadian dysrhythmia or jet lag. The severity of jet lag is directly related to the direction of flight (worse after flying eastwards compared with westwards), and the number of time zones crossed. Allowing 1 day for each time zone crossed to adjust usually accommodates most athletes, although inter-individual variations in this rate do exist. Coping with jet lag has been dominated by problems with the sleep-wake cycle, with the focus on how to improve nocturnal sleep, how to eliminate sleep disturbances, and how to promote adjustments of the body clock.[2,6,21]

Management staff and athletes can implement a behavioural approach to cope with jet lag. The importance of optimal flight arrangements should be emphasised. Itineraries for athletes should be planned to allow sufficient time for the body clock to adjust before competitions. Arrival times at the destination should be in the late afternoon or evening. Athletes will then have the opportunity to take a full night's sleep in the new time zone immediately after arrival.[22]

In-flight activities should be arranged bearing in mind the local time at the destination. Watches of the team should be reset as a group, and eat and sleep cycles should be planned in accordance with destination time. Sleep and naps during the journey should be attempted only if it is night at the final destination.[2]

A structured sleep schedule can improve nighttime sleep after eastward flights. Athletes often go to bed after arriving on an overnight flight. They will then fall asleep, but for a relatively short time, because they tend to awake at a time corresponding to late morning at their own home. Athletes are advised to limit sleep and only take a brief nap if they are exhausted.[21]

Although there are suggestions that a breakfast high in protein and mainly carbohydrate in the evening after arrival at the destination can hasten adjustment to the new time, athletes are advised to rather focus on the timing of the meals to fit in with habitual routines. The effect of such a dietary intervention seems to be small, and appropriate times of exposure to, and avoidance of, bright light might be better alternatives.[23] Management is advised to make arrangements for activity or training at the destination, although morning exercises should be avoided for a few days after an eastward flight, because it could produce a counter-productive response.[22]

In an attempt to cope with jet lag, athletes and managers might want to follow a pharmacological approach to ease the effects, such as hypnotics or amphetamines. However, the latter might be unacceptable for travelling athletes because they might be on the list of banned substances of the World Anti-Doping Agency (WADA). An alternative choice is melatonin. The vasodilatory effects of melatonin promote sleep without having marked effects on sleep EEG. Melatonin has hypnotic properties, and is marketed commercially for the relief of jet lag and insomnia. Athletes should, however, be cautioned about the purity of the melatonin bought off the shelf.[22]

It has also been suggested that natural daylight or bright artificial light, when appropriately timed, is more effective at phase resetting than melatonin. Exposure to daylight might enhance the phase adjustment process and lessen the jet lag experience. Appropriately timed light exposure and light avoidance can therefore be effective in the treatment of jet lag symptoms.[21]

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In a nutshell

- Quality sleep serves multiple purposes and is essential for athletic performance and regeneration.
- A lack of sleep or fragmented sleep can cause a decrease in work capacity, increased feelings of fatigue, and increased difficulty in coping with stressors.
- Athletes should benefit from a 20 - 30-minute mid-afternoon nap.
- The circadian system is acutely sensitive to environmental photic cues: bright light will delay the onset of sleep.
- External temperatures of higher than 24ºC and lower than 10ºC can decrease the quality of sleep.
- Crossing time zones when travelling disturbs the athlete's circadian rhythm, causing jet lag.
- Jet lag can be managed through non-pharmacological means, focusing on timed exposure to sunlight.
- Melatonin might be of benefit for the relief of jet lag.
- Athletes should be educated in terms of sleep hygiene and the factors affecting sleep quality, as well as the use of methods such as progressive relaxation and music to enhance sleep quality.