SLEEP AND SPORTING PERFORMANCE

– *Written by Yann Le Meur and Christophe Hausswirth, France*

Many high-performance athletes are involved in regular, intense training programmes aimed at stimulating psychophysiological adaptations in order to improve their capacity for performance. Intense training maximises the role of recovery both in the short-term, between training sessions[1], and in the medium-term, for example during tapering phases[2]. In the longer-term, sleep also appears to play an important role in preventing the occurrence of overreaching or even overtraining syndrome[3]. It is clear that sleep plays a major role in recovery, which explains why it is considered to be a key factor in sporting success[4].

SLEEP QUANTITY AND QUALITY IN TRAINED ATHLETES

While sleep is known to contribute to athletes' recovery, few data are available on the characteristics of sleep in high-performance athletes. Recently, a study carried out at the English Institute of Sport investigated sleep in 47 athletes preparing for the Olympic Games[5]. These athletes were from various disciplines (canoeing, diving, rowing, speed skating) and their sleep quality and quantity were compared to the same parameters in 20 sedentary subjects over 4 nights. During these 4 nights, subjects were equipped with an actimeter on their wrist. On the whole, the time spent in bed was equivalent for the two groups (8:07±0:20 for the sedentary group vs 8:36±0:53 for the athletes). However, for all the other parameters assessed, sleep quality was poorer in the elite athletes (Table 1).

Although these results suggest that high-performance athletes potentially have a lower quality of sleep, the values reported are not within the interval of values recorded for subjects suffering from deep sleep disorders[6]. However, some specific contexts appear to accentuate this effect. Recently, Sargent et al[7] characterised how the quantity and quality of sleep was affected in seven Australian swimmers during an intensive 2-week training camp.

Table 1

Group	n	Time in bed (h:min)	Sleep latency (min)	Time asleep (h:m)	Time awake (h:m)	Sleep efficiency (%)	Actual sleep (%)	Moving time (%)
Control	20	8:07 ± 0:20	5 ± 3	7:11 ± 0:25	0:50 ± 0:16	89 ± 4	90 ± 3	9 ± 2
Elite athletes	46	8:36 ± 0:53*	18 ± 17*	6:55 ± 0:43	1:17 ± 0:31*	81 ± 6*	84 ± 6*	18 ± 6*

Table 1: Sleep actigraphy data comparing athletes with non-athletic controls. Values are means ± standard deviation. *Significantly different from control. Adapted from Leeder et al[5].

This training camp was part of the athletes' preparation for the Beijing Olympic Games in 2008. Over the 14 days, the swimmers trained on 12 days – starting at 6 am – and had 2 recovery days. On training days, swimmers had an average bedtime of 10.05 pm and woke up at 5.48 am, with an effective sleep time of 5.4 hours. During recovery days, these times were shifted to 12.32 am and 9.47 am, respectively, with an effective sleep duration of 7.1 hours. These results show that during the nights preceding training days, swimmers slept significantly less, thus indicating that starting training early reduced the time athletes spent asleep. Given that sleep restriction, with less than 6 hours of sleep per night, is likely to affect the body's psychophysiological response capacity, it is possible that starting training too early could hinder adaptation to the training workload.

HOW THE TRAINING WORKLOAD AFFECTS SLEEP QUALITY

Despite survey-based health research reporting associations between regular moderate physical activity and better sleep[8], a few studies have reported alterations in sleep quality in response to highly demanding training programmes[5,9]. Taylor et al[9] measured sleep using polysomnography during the 'onset of training', 'heavy training' and 'pre-competition taper' training periods in elite female swimmers. Sleep onset latency, time awake after sleep onset, total sleep time, rapid eye movement and deep sleep times were similar during all three training phases. In contrast, the number of movements during sleep was significantly higher (6%) when the training workload was higher, suggesting some effects on sleep. Nevertheless, the improved performance times and low levels of tension and anger at peak training suggest that the swimmers were not in a functionally overreached state in the conditions studied. Recently, Fietze et al[10] used wrist actigraphy to study sleep patterns in 24 classical ballet dancers during a 67-day period of high physical and mental stress before a ballet premiere performance. Their results showed a small but significant reduction in sleep duration (-6%), in sleep efficiency (-2%), in time spent in bed (-3%) and an increase in wakefulness after sleep onset (+3%); sleep onset latency was not affected. Nevertheless, these authors did not report changes in physical performance in response to the overload programme prescribed. This makes it difficult to draw clear conclusions on sleep disruption in overreached athletes. Previous studies have, however, reported signs of decreased sleep quality in overreached or overtrained endurance athletes. For example, Jurimaë et al11 monitored the recovery-stress state in competitive male rowers over a 6-day training camp in response to an approximate 100% increase in training load compared to average weekly loads.

> *Heavy training workloads may have a negative effect on sleep quality*

Table 2

Situation	Probability of falling asleep			
Sitting and reading	0	1	2	3
Watching television	0	1	2	3
Sitting inactive in a public place (e.g. theatre, cinema, meeting)	0	1	2	3
As a passenger in a car (or public transport) for one hour without a break	0	1	2	3
Lying down to rest in the afternoon when circumstances permit	0	1	2	3
Sitting and talking to someone	0	1	2	3
Sitting quietly after a lunch without alcohol	0	1	2	3
In a car, while stopped for a few minutes in traffic	0	1	2	3
TOTAL				

Table 2: Assessing the degree of daytime sleepiness using the Epworth questionnaire[103]

Using the Recovery-Stress-Questionnaire for Athletes (RESTQ-Sport), these authors showed decreased levels of perceived sleep quality, suggesting that recovery may not have been adequate during this training camp[12]. This could lead to performance impairment and generate a high level of perceived fatigue (i.e. overreaching). However, without objective markers such as sleep actimetry, it is difficult to associate sleep disruption with overloading based on perceived sleep quality alone. In a similar vein, Matos et al[13] recently reported that difficulty sleeping was one of the physical symptoms most frequently reported by athletes. These athletes also experienced persistent daily fatigue and a significant decrease in performance lasting for long periods of time. Altogether, these results suggest that heavy training workloads may have a negative effect on sleep quality, but to date a limited number of studies have provided objective data on changes in sleep characteristics during periods of confirmed functional overreaching. Overall, among the few studies during which sleep was monitored in athletes who demonstrated clear signs of overreaching (i.e. high level of perceived fatigue and decreased performance), most involve self-reporting of subjective parameters such as perceived sleep quality[11,14]. Recently, Hausswirth et al[t] used nocturnal actimetry to study a group of trained triathletes who completed an overload training programme followed by a 2-week taper period. These athletes developed symptoms of functional overreaching while control counterparts showed no signs of training intolerance. The most important finding of this study indicated a progressive decrease in the indices of sleep quality, alongside small reductions in sleep quantity, during the overload period in the functionally overreached athletes. These effects were progressively reversed during the subsequent taper period.

Although these results suggest that functionally overreached athletes do suffer from a modest decrease in quality and quantity of sleep during the overload period, their sleep quality and quantity still remained considerably better than that experienced by patients with sleep disorders[16], extreme sleep deprivation[17] or by athletes with jet lag[18] or after hypoxic exposure[19]. Halson et al[20], in a similar study, reported a greater sleep deficiency during the period leading to overtraining (< 6 hours per night) in a talented female sprint cyclist

7 tips for effective sleep

1. Plan very intense training for before 6 pm

To help you go to sleep rapidly, it is preferable to plan intense training sessions early in the day rather than late in the evening. Indeed, the greater the workload, the greater the stress for the body and the more time it will need to return to a basal state. This explains why programming intense training late in the day can affect going to sleep.

2. Stick to regular sleep hours

Adopting behaviour in line with your biological clock is one of the main pre-requisites for good quality sleep. To do this, several strategies should be respected:

- *Go to bed and get up at regular hours. Frequently changing your sleep times has a negative effect on sleep quality. Later than usual bedtimes and lie-ins at the end of the week can affect sleep quality during the night over the following week by offsetting the biological rhythm. We therefore recommend avoiding changing sleep hours by more than 1 hour at the weekend. Similarly, it appears wise to progressively shift your bedtime and waking time when preparing for a competition which will require you to rise earlier than usual.*
- *Have a nap to compensate for lost sleep. It is preferable to have a nap when you feel tired, rather than delaying the time at which you get up. This strategy avoids changes to the biological rhythm and thus reduces the risk of insomnia which could result from effects on the circadian rhythm. The nap should not last more than 30 minutes so as not to initiate a deep sleep cycle which could lead to a lethargic state during the remainder of the day.*
- *Fight against drowsiness after dinner. If you feel drowsy after your evening meal, it is preferable to fight against going to sleep by adopting a mildly stimulating activity. Going to bed too early, in fact, may compromise your ability to go back to sleep if you wake during the night.*

who developed signs of overtraining (i.e. persistent fatigue and underperformance over a number of months). Nevertheless, we cannot exclude that the moderate changes observed with the functional overreaching during the study by Hausswirth et al[15] would not unduly affect performance in elite athletes, where very minor differences in performance can have a large impact on the outcome of competitions[21]. It also remained unclear during this study whether sleep disturbance was involved in the aetiology of overreaching, or simply a symptom of it. Further research will be required to determine the relationship between sleep, training tolerance and adaptation, especially in athletes developing maladaptation to training (i.e. overreaching, overtraining).

All of these results on the physiological effects of lack of sleep confirm the primary role played by sleep in the context of post-exercise recovery. Although a growing number of recovery aids is available to athletes, these data remind us of the primary and irreplaceable role of sleep and show that no recovery method is likely to compensate for a lack of sleep. It thus appears wise to assess sleep quality in athletes to prevent and diagnose the onset of overreaching (Table 2)[22].

A sleep quality questionnaire can be answered for the various situations presented, by responding to the following single question:

How likely are you to doze off or fall asleep in the following situations, in contrast to just feeling tired?

- 0: would never doze
- 1: slight chance of dozing
- 2: moderate chance of dozing
- 3: high chance of dozing.

A score greater than 10 is generally a indicator of a sleep deficit and should lead the subject to reflect on a reorganisation of their timetable.

EFFECTS OF LACK OF SLEEP

Sleep deprivation and performance capacity

Due to an often heavily loaded timetable, the competitions in which they participate, long journeys sometimes associated with these, or even the anxiety to which they may be subject, athletes often experience sleep disorders[23,24]. The effects on the sleep cycle can range from moderate insomnia (2 to 4 hours) to disturbance of the whole night's sleep. Sleep disorders increase the psychophysiological stress associated with exercise and lead to a prolongation of the period necessary for post-exercise recovery[17]. When this occurs during a period when the training workload is high, or during a competition extending over several days, there is a greater risk of overreaching and the performance level can be compromised[25].

Various studies, in particular in the 1980s, investigated the effects of sleep deprivation on performance and physical fatigue. These included a broad spectrum of sporting activities, from weightlifting to endurance sports through extended sprint events, like the Wingate test. As is often the case, the results reported in by these studies are difficult to compare due to the range of different experimental protocols used (duration of sleep deprivation, type of exercise). To simplify matters, we can distinguish between high intensity exercises (jumps, sprints, throws) and prolonged efforts. Overall, high intensity exercises

3. Adopt a good diet & appropriate hydration strategies

- *Avoid hyper-caloric dinners. Meals which are rich in fat taken late in the evening can affect sleep by increasing digestive activity and by promoting maintenance of a high body temperature, which negatively affects sleep onset.*
- *Limit caffeine intake. Caffeine can have an effect up to 12 hours after its ingestion. It is therefore preferable to limit its consumption after before sleep, particularly after 6pm.*
- *Avoid drinking a lot in the evening. Consuming large quantities of water, fruit juice, tea or any other drink before going to bed affects the quality of the night's sleep by obliging you to wake frequently to use the bathroom.*
- *Limit alcohol consumption. Alcohol consumed up to 6 hours before going to bed leads to fragmented sleep patterns.*
- *Drink a cup of sweetened warm milk before going to bed. This old wives' remedy has several virtues. It ensures a significant intake of tryptophan – the precursor of melatonin – and carbohydrates, which promote tryptophan uptake by the brain. Thus, taking a hot drink triggers thermolysis mechanisms that cause a drop in body temperature, promoting the onset of sleep.*

4. Develop a relaxing bedtime routine

Going to bed in a relaxed state promotes rapid falling asleep and deep sleep. With this in mind, it is wise to develop a relaxing bedtime routine:

- *Turn off the television. Many people have a habit of watching television before going to bed. However, this has a stimulating effect, which does not promote going to sleep, particularly when watching noisy or even violent programmes.*
- *Take a hot bath or shower before going to bed. This triggers thermoregulation mechanisms which cause a drop in body temperature. This process promotes sleep onset.*

are not overly affected by 1 or 2 sleepless nights[26-29], but with longer durations of deprivation (64 hours), explosive strength and dynamic (isokinetic) strength does drop slightly[30]. The same observation applies to cycling sprints; laboratory performances are not altered by a single sleepless night[29,31-34]. However, they do decline if intensity and duration are combined. For example, if subjects are asked to repeat sprints every minute for 1 hour, a regression is observed[17]. Duration is therefore a key parameter in wakefulness during the night. This is confirmed in the context of predominantly aerobic activities[35-37]. For example, a study by Martin in 1981[38] showed an 11% drop in performance levels during running exercise performed following 36 hours of sleep deprivation. Although athletes do not often encounter these extreme conditions in their daily routine, a deleterious effect of lack of sleep on physical performance has also been reported for lesser perturbations. For example, it appears that a drop in the duration of sleep caused by a later bedtime and/or waking earlier can degrade the aerobic performance level after only 2 days of perturbation[37].

Many theories have been advanced as to the source of this drop in performance: alteration of the cardiorespiratory system (Table 3), reduced endurance of respiratory muscles[39], later sweating[40], increased metabolic acidosis[41], reduced efficacy of enzymes involved in aerobic metabolism[42], reduced yield. All these phenomena have been observed, but we do not know which are truly influential. Some researchers suggest that the explanation may simply be psychological. Thus, the drop in aerobic performance as a result of sleep deprivation could be linked to a lower tolerance to exercise. In support of this, we have observed an increased level of perceived effort after 1 or 2 sleepless nights[29,33,38,43]. However, other studies appear to contradict this[33,44]. The increased perceived effort generally results in alterations to sub-maximal performance[45,46]. The increase in difficulty could also be due to the production of inflammatory substances, which exacerbate pain, during acute sleep deprivation[47] or chronic sleep restriction[48]. Indeed, a study by Martin et al[38] indirectly suggests that psychological factors could explain a large part of the drop in performance noted in sleep deprivation conditions as exercise performed at an intensely cold temperature minimised the effects of deprivation. According to these authors, the stress related to a competition would have the same effect as cold and lack of sleep should not hinder performance in a major championship. This conclusion is undoubtedly valid for short and intense efforts, but may not apply for endurance efforts[49]. In the future, new studies should help to answer this question.

Effects of lack of sleep on physiological responses

In parallel to the effects of a lack of sleep on the body's response to exercise, several studies have shown a deleterious effect of sleep deprivation on many other physiological mechanisms involved in post-exercise recovery.

Metabolism and energetic recovery

Skein et al[17] recently showed that a sleepless night leads to a drop in muscle glycogen stores compared to a control night, even with a normalised carbohydrate intake. These authors suggested that this difference is mainly linked to the energy expended by athletes during their forced wakefulness. Thus, the sleep disturbance in athletes during a period of intense training or a competition is likely to interfere with their performance capacity by affecting recovery of energy stores. In sporting disciplines requiring significant energy expenditure, it is therefore important to ensure that the athletes get enough sleep, since depletion of glycogen reserves is a direct cause of the onset of overreaching[50].

Endocrine response and muscle recovery

Some authors have shown that a lack of sleep can affect an athlete's recovery by altering their post-exercise endocrine response[51]. This is because a reduction in sleep duration is associated with an increase in blood cortisol levels and decreased growth hormone release, both of which contribute to creating a catabolic state[52]. In other words, lack of sleep in athletes contributes to a negative protein balance by reducing muscle protein resynthesis mechanisms and stimulating those resulting in muscle degradation. The medium-term consequences of a recurrent lack of sleep have never, as yet, been investigated, but it is highly likely that it increases the risk of muscle injury by reducing the athlete's capacity to recover after exercises inducing muscle damage[51].

Immune defences

The effect of sleep on immune function is, today, well documented and shows that getting enough sleep is essential to preserving the immune defences[53]. Several studies have shown that a chronic lack of sleep leads to effects on the immune system. It remains, however, to be determined whether these modifications are linked to sleep perturbation per se, to effects on the circadian rhythm of hormonal secretion or whether they represent a response to general stress which itself leads to a lack of sleep[54-56]. Whatever the cause, it is essential for athletes to maintain the intimate balance between sleep and the immune defences. Indeed, several authors have shown that a prolonged increase in workload can lead to a drop in the immune defences[57]. Thus, for example, athletes having completed an ultra-endurance event are known to have an increased prevalence of upper respiratory infections due to a state of immune depression during the weeks following the race[58]. In some circumstances, aggravating factors can enhance the drop in an athlete's immune defences. For example, during one study on military commandos, Tiollier et al[59] showed that salivary immunoglobulin A – which is a good indicator of the body's defences against infection – drops in response to chronic exposure to altitude (2500 to 3000 m). Similarly, the risk of getting sick is increased in winter due to the circulation of certain viruses which

TABLE 3

Situation	*Parameter*	*Effects of sleep deprivation*
Resting	*Oxygen consumption*	↑↑
	Breathing	↑
	Heart rate	↓
	Blood pH	↓
At sub-maximal intensity	*Oxygen consumption*	↑
	Breathing	↑
	Heart rate	↓
	Blood pH	↔
At maximal intensity	*Oxygen consumption*	↓
	Breathing	↓
	Heart rate	↓
	Blood pH	↔

Table 3: Main modifications induced by a lack of sleep on the functioning of the cardiorespiratory system. Adapted from Millet[49]

challenge the body's defence capacities[57]. Finally, periods during which the training workload is high also frequently lead to a drop in the body's defences[60,61]. All these data reinforce the greater importance of sleep to athletes compared to sedentary subjects and suggest that recurrent infections in this population could be a sign of poor sleep hygiene.

Effects of lack of sleep on psychological responses

Lack of sleep causes bad mood, irritability, mental fatigue and loss of motivation[62]. Perturbation of the sleep cycle, triggered, for example, by going to bed late, leads to greater drowsiness[63] and effects emotions. Athletes who lack sleep generally report a greater level of fatigue and an increased feeling of confusion, which coincides with a drop in performance[62,64,65] and pain tolerance[66]. Lack of sleep also negatively affects several cognitive functions. Thus, the more complex the task to be performed, the greater the impact of lack of sleep[67]. This effect is also observed even for simple and monotonous tasks involving low environmental stimulation[68-70]. For athletes, we can therefore hypothesise that a lack of sleep is likely to interfere with learning of techniques, as this generally requires frequent repetition of tasks involving precise movements combined with a high attention level to stabilise them. Similarly, learning strategic approaches, which particularly involve attention resources[63,71], memorisation[63,72] and logical reasoning[64,73], are significantly affected by partial sleep deprivation[74]. Some studies have, in addition, shown sleep-deprived subjects to have a lower capacity to solve complex tasks. This effect appears to be linked to disturbances in the activity of the prefrontal region of the brain, which is particularly involved in decision-making[75]. Finally, lack of sleep also affects proprioceptive capacity and thus significantly increases the risk of injuries, such as sprains[76].

NUTRITION, HYDRATION AND SLEEP

Nutrition and sleep

Several studies have revealed a strong link between nutrition and sleep[4,77]. It appears that a lack of sleep can affect the secretion of hormones controlling appetite. Epidemiological studies in particular have demonstrated that chronic lack of sleep affects food choices and that reduced duration of sleep is associated with metabolic disorders and a greater prevalence of obesity[78]. In other words, individuals who do not sleep well generally tend to eat poorly. This association has been shown in children[79], adolescents[80] and adults[81]. People who sleep poorly therefore show a greater tendency to eat energy-dense foods, to favour foods with a high glycaemic-index or foods rich in fat and to omit fruit and vegetables from their diet. These individuals generally also have a more irregular feeding pattern and tend to eat more frequently between meals.

The relationship between nutrition and sleep works both ways. Thus, some nutritional strategies can in turn promote

5. Organise your bedroom to promote sleep

- *Favour a calm environment. Even though sensitivity to noise can differ between individuals, favouring a calm environment makes going to sleep easier. Indeed, studies have shown that maintaining a noisy atmosphere during the night affects sleep, even if it does not necessarily lead to the subject waking up.*
- *Keep the bedroom dark and cool. When it is time to go to sleep, lie down in a completely dark room. All sources of light, including television and computer screens, can affect the biological clock by promoting maintenance of a wakeful state. Thus, opaque curtains, which block the passage of light through windows, should be used or a mask should be worn over the eyes when this is not possible, for example in a hotel room. Similarly, an excessively high temperature in the bedroom can hinder sleep onset. It is therefore advisable to create a cool environment (approximately 18°C) with adequate ventilation.*
- *Choose comfortable bedding. The choice of a comfortable mattress and a sufficiently large bed is essential to allow good quality sleep. In particular, the mattress should be changed if stiffness of the neck and back are observed upon waking.*

6. Release stress beforehand to fall asleep more easily

It is very difficult to fall asleep when we feel stressed or worried. When this is the case and sleep has been affected for several days in a row, it is important to identify what is causing the stress and to try to find a solution during the day. When this is not possible, it is important to learn to direct your thoughts. For example, it may be interesting to analyse your worries to assess whether they are realistic and to determine whether they can be replaced by more productive thoughts. In addition, relaxation techniques can help to achieve a serene state of mind and facilitate falling asleep. These include, in particular:

- *the use of deep breathing, based on a slow rhythm and a large inspiration volume.*
- *use of muscle relaxation. For example, contract your muscles as hard as possible and then release them, starting with the toes right up to the muscles in the neck.*
- *visualise a calm and restful place.*

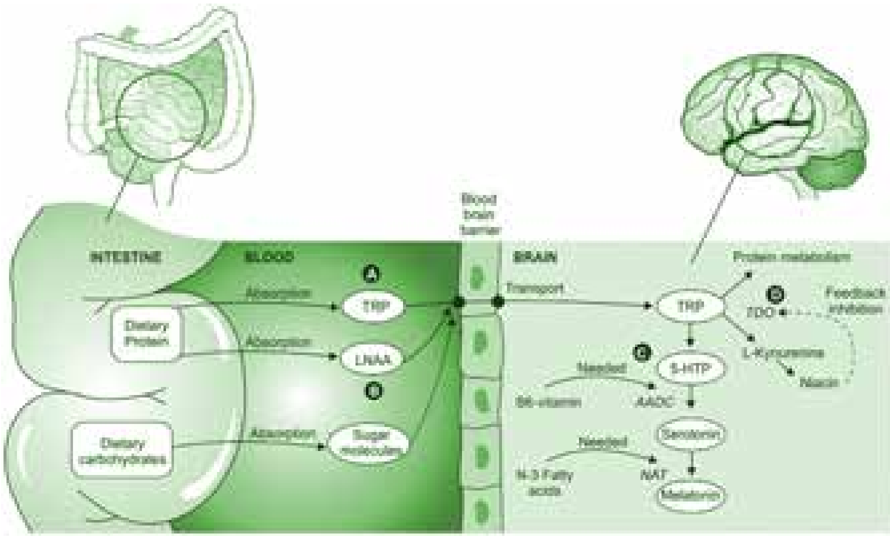

Figure 1: Influences of the nutrients provided by the diet on serotonin and melatonin synthesis. A) protein intake directly contributes to increasing the amount of free TRP in the blood. B) carbohydrate intake, by triggering insulin release, contributes to the uptake of TRP into the brain, by favouring the uptake of other amino acids by other cells. C) the increased TRP concentration in the brain leads to an increase in serotonin and melatonin synthesis, which promotes sleep. Adapted from Peukhuri et al[102]. TRP=tryptophan, LNAA=large neutral amino acids, TDO= tryptophan 2,3-dioxygenase, NAT= arylalkylamine-N-acetyltransferase, AADC= aromatic L-amino acid decarboxylase, 5-HTP=5-hydroxytryptophan.

drowsiness and sleep, while others, in contrast, have a stimulating effect. The phases of wakefulness and sleep through which we pass on a daily basis are, indeed, controlled by neuro-hormonal mechanisms which can be modulated by what we eat.

Several macronutrients affect sleep quality, in particular tryptophan. This amino acid is a precursor of serotonin (a neurotransmitter) and melatonin (a hormone which also acts as a neurotransmitter), both of which promote sleep[82,83]. The amount of serotonin produced by the brain is influenced by the concentration of free tryptophan present in the central nervous system: the more free tryptophan present in the brain, the greater the rate of serotonin synthesis and the higher the melatonin levels in the brain, both of which promote sleep (Figure 1). One study in particular, showed that consuming tryptophan was associated with a 45% reduction in sleep onset latency[82]. Conversely, Arnulf et al[84] showed that after a day following a tryptophan-depleted diet, sleep was more fragmented and there were more periods of rapid eye movement sleep. In seeking to understand the relationship between tryptophan and the diet, some researchers have hypothesised that sleep could be promoted by increasing the amount of tryptophan provided by the diet[85]. Thus Markus et al[85] studied how consuming milk proteins – which are very rich in tryptophan – before going to bed affected attention and vigilance the following morning. Their analysis showed that this dietary approach increased the ratio of free tryptophan to other circulating branched-chain amino acids by 130% compared to a placebo condition. Interestingly, their results indicated that taking tryptophan reduced drowsiness and enhanced cognitive performance the next morning compared to the control conditions.

Other studies have shown that the uptake of free tryptophan by the central nervous system is stimulated by a high ratio of plasma tryptophan to other amino acids, such as tyrosine, phenylalanine, leucine, isoleucine, valine and methionine[86]. In addition, carbohydrate consumption can modify the concentrations of these amino acids thanks to its effect on insulin release. Consuming carbohydrates leads to the removal of other amino acids from the blood and facilitates the entry of tryptophan into the brain, where it can produce a sedative effect (Figure 1)[87]. An effective means to promote relaxation is thus to consume protein-containing foods, such as milk, in combination with glucose-rich foods, as it is unlikely that eating protein-containing foods alone could induce a high enough tryptophan level to effectively promote sleep. Thus, combining intake of carbohydrates and proteins during the same meal increases the availability of free tryptophan and helps with sleep onset[87].

Hydration and sleep

Late hyper-hydration and sleep

An athlete's sleep quality can be affected by hydration strategies. Given that it is essential to compensate for the loss of water caused by sweating during training or competition, some athletes may consume large volumes of drinks late in the day[4]. Although the need to rehydrate is unquestionable, it is important to underline that this strategy can affect sleep quality by obliging the athlete to get up to urinate during the night. This is why athletes should be reminded that it is preferable to rehydrate regularly during the day and to consume drinks containing sodium after exercise, rather than trying to compensate for dehydration in one bout.

Negative effects of alcohol on sleep

Consuming alcohol before going to bed affects sleep quality through two contradictory influences. On the one hand, consuming alcohol 30 to 60 minutes before going to bed reduces sleep onset latency[88]. This explains why many people think that alcohol improves the quality of sleep. However, beyond this positive effect, consuming alcohol significantly reduces the duration of the phases of deep sleep, during which true recovery takes place[89]. This is all the more worrying as these effects persist until the alcohol has been fully metabolised by the body. As the blood alcohol level drops at a rate of around 0.1 g.hour-1, it is easy to imagine to what extent sleep quality can be affected during the night following an evening of overindulgence. Several studies have also shown that consuming alcohol causes a rise in heart rate, an increase in respiratory frequency, intestinal disorders and headaches[90], all of which are highly likely to affect sleep quality. Given the major role played by quality of sleep on the recovery processes in athletes, it is advisable to limit alcohol consumption, particularly during intense training periods.

7. Keep your cool when sleep will not come

It is normal to wake briefly during the night. However, it can sometimes be difficult to fall back asleep afterwards. Three strategies can be used to help this.

- *Keep calm. The key to falling back asleep rapidly is to remain in a relaxed state of mind and try, as far as possible, not to get annoyed. Stress and anxiety are, in fact, signals which encourage the body to remain in a wakeful state. The best thing is to remain concentrated on what you feel, rather than thinking about worries or about the next day.*
- *Aim to relax rather than to sleep. When you encounter difficulties falling asleep, it is possible to use relaxation techniques such as visualisation, deep breathing or meditation, which can be performed without getting out of bed. In addition, you must keep in mind that even if they cannot replace sleep, rest and relaxation are also good recovery methods for the body.*
- *Engage in a calm, non-stimulating activity. If you cannot get back to sleep after 15 minutes of wakefulness, you can get up and engage in a relaxing activity, such as reading a book, while waiting for the desire to go back to sleep to return. In this case, it is important to avoid brightly-lit screens and strong lights. A light snack or herbal tea can help you to relax.*

This recommendation is all the stronger given that consuming alcohol also delays restoration of glycogen reserves, favours dehydration and affects muscular recovery[91]. In terms of body composition, frequent consumption of alcohol-containing products also leads to an increase in adipose tissue and[92].

Stimulants and sleep

An individual's quantity and quality of sleep can be affected by the consumption of stimulating substances found in the daily diet. Caffeine, present especially in coffee, tea, in some popular sodas and in energy drinks can affect sleep, even if there are significant inter-individual differences in terms of sensitivity. Bonnet and Arand[93] explain that consuming caffeine in the 2 hours preceding going to bed (for doses exceeding 100 mg i.e. approximately one or two coffees) can increase sleep onset latency while also reducing the time spent in deep sleep as well as total sleep time. Shilo et al[94] have since confirmed this result by showing that melatonin secretion is significantly affected by caffeine consumption. Hindmarch et al[95], however, demonstrated that these deleterious effects were mainly observed in people not used to consuming caffeine. On the whole, we can conclude that caffeine consumption should be limited after 6 pm, as otherwise the athlete's sleep quality may be affected.

THE VIRTUES OF THE NAP

In many cultures, the early afternoon is associated with a period of relaxation. Indeed, it is well described that drowsiness increases and physical and cognitive performance drop during this stage of the day[96,97]. As this drop in performance does not appear to be affected by the composition of the midday meal[98], it is generally attributed to the biological rhythm[99]. The nap is an interesting strategy to take advantage of this period of the day in preparation for the activities which will follow later.

Waterhouse et al[63] studied how an early-afternoon nap affected performance in athletes suffering from a lack of sleep. In this study, 10 male subjects performed a battery of physical and cognitive tests in two different experimental conditions. In the first condition, participants were tested on their reaction times, short-term memory and sprints after a short night's sleep (4 hours sleep) with no nap. In the second condition the protocol was similar, but subjects took a 30 minute nap after lunch. The results showed the nap to have a positive effect on the state of perceived alertness and on performance during memorisation and rapid decision-making tests. In contrast, no effect was noted during simple reaction tests. Thus, performance was improved during sprints over 2 and 20 m after a nap compared to the control condition (1.019 vs 1.060 seconds and 3.878 vs 3.971 seconds, during 2 and 20 m sprints, respectively). These results indicate that taking a nap after lunch is an effective strategy to improve athletes' performance during the afternoon, particularly when they must rise early in the morning and if they have difficulty meeting their sleep needs at night. Other authors have confirmed these data by showing benefits of a nap even in individuals getting enough sleep during the previous night[100]. Thus, having a nap appears to represent a simple and effective recovery strategy in athletes. Unless sleep deprivation is very marked, or during periods of particularly intense training, the nap should remain of short duration (less than 30 minutes), so as not to enter into a deep sleep phase, as this is likely to lead to a lethargic state during the remainder of the day[101].

PRACTICAL RECOMMENDATIONS TO IMPROVE SLEEP QUALITY

Despite the importance of sleep in restoring physiological and cognitive functions, sleep hours are often sacrificed by athletes with a very full timetable. A lack of sleep can thus be caused by insomnia which occurs when the athlete is anxious or is in the initial stages of overreaching due to a high training workload[4]. In these circumstances, the best solution is to get a good night's sleep by adopting habits that will favour sleep onset. The included breakout boxes list simple strategies that can be used to restore effective sleep.

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Yann Le Meur Ph.D.
Sport Scientist

Christophe Hausswirth Ph.D.
Head of the Research Department
Director of the Laboratory of Sport
Research Department
Laboratory of Sport, Expertise and Performance – INSEP
Paris, FRANCE