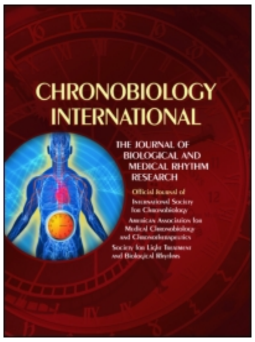

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2016 Rio Olympic Games: Can the schedule of events compromise athletes' performance?

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ABSTRACT
The organizing committee of the 2016 Rio Olympic Games recently announced that some of the preliminary and final competitions will be held at night. The present article discusses the potential harmful effects of these late-night competitions on sleep, circadian rhythms and athletic performance during the Olympic Games. Specifically, night-time competition could lead to injury and may compromise an athlete's decision-making, attentional, physiological and other processes. Consequently, these impacts could negatively affect the performance of athletes and their teams. Thus, it is suggested that technical commissions take special care when creating strategies to minimize harm to the athletes by considering factors such as light exposure, melatonin intake, sleep hygiene and scheduled naps, and training at local competition time. Furthermore, it is necessary for specialists in chronobiology and sleep to engage with members of the national teams to develop an activity schedule for physical, technical, tactical and psychological preparation that accounts for circadian rhythms, thereby creating the best possible environment for the athletes to achieve their ideal performance.

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Athletic performance; circadian rhythm; sports

Background

The city of Rio de Janeiro (Brazil) will be hosting the world's largest sporting event, the 2016 Olympic and Paralympic Games, which invites the world's best athletes to compete in high-performance sports. The organizers recently announced the event schedule. The preliminary and final competitions of some sports, such as swimming, beach volleyball, and track and field (IAAF, 2015), will be held late at night.

Circadian rhythms have a direct influence on several elements relevant to sports performance, including muscle strength (Reilly et al., 2000), flexibility (Gifford, 1987), sensory and motor control, and perceptual and cognitive functional aspects (Winget et al., 1985). The importance of circadian variations in sports was previously discussed by Atkinson and Reilly (1999); in general, some sports records are broken in the early evening (Atkinson, 1994).

Based on the circadian rhythm of hormones, gene expression and core body temperature, the best performance in terms of strength, flexibility, alertness and anaerobic power output will occur in the late afternoon (Cappaert, 1999; Wright et al., 2002). Physical performance is greater in the early evening when the peak core body temperature is reached, improving muscle compliance and increasing metabolism (Teo et al., 2011). Nerve conduction velocity, joint mobility, glucose metabolism and muscular blood flow are also at higher levels during this time (Hayes et al., 2010). However, the reaction time to acoustic or visual stimuli has been shown to be shorter in the evening (between 5:00 and 6:00 p.m.), coinciding with increased body temperature (Reilly et al., 1997).

Each athlete has a preferred time to sleep and to perform certain tasks at specific times of the day. However, inter-individual differences in circadian rhythmicity have been attributed to factors such as age, gender, social and lifestyle factors, amongst others (Vink et al., 2001). These characteristics are called chronotypes and can be divided into morning-type and evening-type (Ellis et al., 2009). The morning-type person prefers an early wake-up and is more alert in the early morning than in the evening (Cavallera & Giudici, 2008; Vink et al., 2001). Evening-type people prefer to wake up late

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and sleep later because they are more alert at night (Cavallera & Giudici, 2008; Vink et al., 2001). Research has demonstrated physiological and psychological differences in chronotype with regard to body temperature (Lack et al., 2009), subjective alertness and melatonin (Baehr et al., 2000; Waterhouse et al., 2001). If circadian preference and sleep time are not respected and are out of phase, the quantity and quality of athletes' sleep can be affected (Samuels, 2009).

During the 2016 Olympic Games, some competitions will be held at times when athletes would normally be preparing to rest or sleep for the night (Figure 1). The human body, as a dynamic, biological system, may be influenced by changes to the sleep–wake cycle. The endogenous circadian clock is integrated with metabolic processes (Bass, 2012), and variations in the light–dark cycle may affect some metabolic pathways. For example, according to the time of day (asleep or awake), the pancreatic tissue clock promotes insulin secretion during the wake-feeding period (Marcheva et al., 2010). However, fat accumulation occurs during both sleep and wake periods and is mediated by the adipose tissue clock. Environmental disruptions like changes in diet, time of feeding, time zone travel, sleep restriction or jet lag may disturb this integration between the endogenous circadian clock and metabolic processes (Roenneberg et al., 2012).

For athletes, the Olympic Games represent the best possible outcomes they could ever obtain. For a vast majority of sports, the games reflect the most important event of an athlete's career (Radicchi, 2012). Thus, the globally accepted sports regulations created to protect and heighten an athlete's performance (International Olympic Committee, 2014) are not being respected, and this might compromise the athlete's ability to achieve peak performance, win a gold medal or establish a new record.

The present commentary aims to discuss the potential harmful effects of late-night competitions on sleep, circadian rhythms and athletic performance during the Olympic Games, as some competitions will be held at times when athletes would normally be preparing for sleep.

Sleep deprivation is commonly observed in athletes, and some studies (Leeder et al., 2012; Sargent et al., 2014) suggest that elite athletes do not enjoy a sufficient amount of sleep during phases of training and competition, which might result in poor performance and impaired physical and cognitive recovery.

In recently published studies (Leeder et al., 2012; Sargent et al., 2014), the mean total sleep duration of athletes was approximately 7 hours; these studies highlighted the importance of sleep for an athlete's performance. In general, athletes

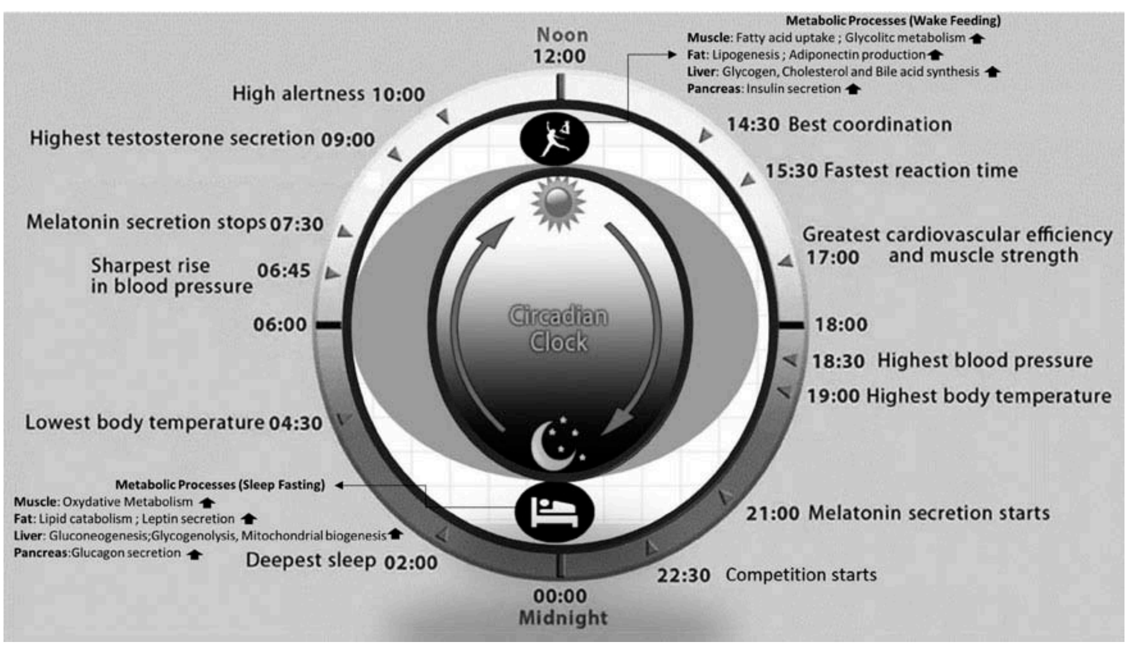

Figure 1. Relationship between psychobiological aspects and circadian rhythms over 24 hours.

had a lower total sleep duration than non-athletes (Leeder et al., 2012). Six Australian swimmers who were selected to participate in the 2008 Beijing Olympics exhibited significantly different wake–sleep behaviours on training days and resting days. On the nights before training days, athletes slept an average of 5.4 hours. On the nights before resting days, the average total sleep time was 7.1 hours (Sargent et al., 2014). According to a study published by Leproult and Van Cauter (2011), 5 hours of sleep for 1 week decreased testosterone levels by 10%–15%. Low testosterone levels, as result of sleep restriction, were associated with a decline in an individual's sense of well-being and in their mood and vigour.

However, during the Olympic Games, athletes may suffer from "extra sleep deprivation" due to competitions scheduled at times when they would normally be preparing for night-time rest; some athletes (swimming and track and field) will compete at approximately 1 am. After the competition, they have commitments such as TV interviews, sponsor activities and doping tests. Afterwards, they return to the Olympic Village to eat and go to bed (3 am). The next day, preliminary competitions occur at approximately 1 pm, which requires waking up at approximately 9 am (roughly 6 hours of sleep). This example exemplifies how critical recovery time is and demonstrates the importance of determining sleep and recovery strategies.

For elite athletes to achieve peak sport performance, they must strike a balance between training and recovery (Leeder et al., 2012). Sleep represents one of the many available forms of recovery, and sleep loss can significantly affect athletic performance (Fullagar et al., 2015). To evaluate the impact of sleep debt, Soussi et al. (2013) investigated whether partial sleep deprivation at the beginning or end of the night can influence the peak performance of judo athletes, both before and after competition. They also evaluated whether this impact is dependent on the time of day. The athletes had a normal night of sleep (slept between 10:30 pm and 6:00 am), had one night of early partial sleep deprivation (slept between 3:00 am and 6:00 am) and one night of late partial sleep deprivation (slept between 11:00 pm and 2:00 am). Partial sleep deprivation of 4 hours at the end of the night affected typical daily variations, for example, caused a decrease in muscle strength and power in the afternoon (4:00 pm).

These findings are relevant given that consecutive nights of reduced total sleep duration can lead to deficits in neurobehavioral performance, increased daytime sleepiness and fatigue (Belenky et al., 2003; Dinges et al., 1997; Van Dongen et al., 2003) and reduced testosterone levels (Leproult & Van Cauter, 2011). In contrast, regular sleep and sleeping 7–8 hours per night results in quicker reaction time and lower levels of daytime sleepiness and fatigue (Kamdar et al., 2004).

The effect of extra hours of sleep on the mood and performance of young basketball athletes was evaluated in a study by Mah et al. (2011). The athletes exhibited significantly faster sprint times and improved free throw accuracy following sleep extension (up to 10 hours per night for 5–7 weeks). The subjects also reported lower daytime sleepiness and a better mood.

Although some studies have already demonstrated the negative impact of decreased total sleep time on athletic performance, Fullagar et al. (2015) show that the underlying mechanisms remain unclear and encourage further studies to evaluate the effects of deprivation/sleep restriction on elite athletes.

Brazilian Paralympic athletes were monitored and evaluated for sleep, chronotype and psychobiological factors from the preparatory cycle for the 2008 Beijing Paralympic Games until the London Paralympic Games. These observations show gradual improvement over the years, demonstrating the importance of managing these variables for athletes during the preparation process (Rodrigues et al., 2015; Silva et al. 2012).

Discussion

The schedule of Olympic Games competitions will have a direct effect on the technical commissions of the participating countries with respect to training strategies and planning. Planning is conducted in advance and is aimed at establishing the best training strategies within the time zone in which the competitions will be held, thus allowing the athletes to fully acclimatize to the time zone and environment of the host city (de Mello et al., 2004). Transcontinental travel may result in physiological problems, and Olympic teams may present with physical symptoms. Travel fatigue and jet lag may impair athletes' recovery and training due to symptoms that occur following time zone travel (Samuels, 2012). Depending on the individual, some pre-flight, in-flight and post-flight strategies may be used for management of jet lag and travel fatigue, including the use of melatonin, pre-flight adjustment to travel, timed light exposure and avoiding changes to training schedules (Samuels, 2012).

In addition to oscillations between times zones, there is also individual oscillation: athletes exhibit different chronotypes that are categorized as morning, intermediate and evening types (Horne & Ostberg, 1976); they also exhibit different needs in terms of sleep duration (long, intermediate and short sleeper) (Aeschbach et al., 2003). Notably, sleep induction is intimately related to a drop in body temperature as well as the light–dark cycle (Glotzbach & Heller, 1976). A study performed by Facer-Childs and Brandstaetter (2015) analysed athletes with different chronotypes who were subjected to physical performance tests at different times throughout the day. The results indicated that athletes with different chronotypes exhibit different performance patterns over the course of the day; athletic performance is approximately 26% worse during non-peak performance times than during peak performance times than during peak performance levels.

It is important to note that aside from sports, the Olympic Games also play a fundamental role in economic and urban development (Preuss, 2004; Waitt, 2003). The essence of sports is to compete fairly when athletes are in their best physical and psychological condition. However, the Olympic Commission did not match the schedules of some events to the city in which they take place but to the country that holds the broadcasting rights.

The schedule of the Olympic Games has been set, and for logistical reasons, athletes arrive weeks before the start of the competition to acclimatize to the time zone and environment of the host city. Nevertheless, the length of time necessary to adjust to a new time zone is different for each individual. Some Olympic teams have the option of always training at local competition time. The intention is to adapt the circadian rhythm to the stress of training and reduce the performance decrement at that time (Erdemir & Bozdogan, 2013; Sedliak et al., 2007). However, simply adopting this strategy may be insufficient, and other strategies could be implemented to improve sleep quality and recovery. These include exposure to light (Knaier et al., 2015), melatonin intake (Atkinson et al., 2003), sleep hygiene and scheduled naps (Nédélec et al., 2015; Sargent et al., 2014).

In addition, 66% of athletes report worse sleep during the pre-competition period (Halson, 2014). During this period, it is very common to share a bedroom. To enhance sleep quality, it is recommended that athletes avoid the use of electronic devices before sleep (Figueiroet al., 2009) and avoid consuming too much fluid, which may result in waking to use the restroom. Sleep in a hot environment increases wakefulness and decreases slow wave sleep (Okamoto-Mizuno & Mizuno, 2012). Therefore, maintaining a bedroom temperature between 60°F and 67°F (15°C and 20°C) is optimal for sleeping, with temperatures above 75°F (24°C) disrupting sleep (Sleepfoundation.org, 2015).

Conclusions

The schedule of the Rio 2016 Olympic Games, with preliminary and final competitions scheduled at approximately midnight, could lead to injury and may compromise the decision-making, attentional, physiological and other processes of Olympic athletes both before and during the games. Consequently, the performance of athletes and their teams might be negatively affected.

Thus, it is suggested that the technical commissions take these factors into consideration when creating strategies to minimize harm to athletes. It is also necessary for specialists in chronobiology and sleep to engage with members of the national teams to develop activities for physical, technical, tactical and psychological preparation that account for athletes' circadian rhythms, thereby creating the best possible environment for athletes to achieve their ideal performance.

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