The potential of blood flow restriction exercise to overcome Jetlag: Important implications for Tokyo 2020

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Abstract

The decision taken by the International Olympic Committee (IOC) to host the Olympic Games this summer brings new challenges for event organisers and athletes. One such measure taken by the IOC is to mandate that athletes may not enter the Olympic Village more than five days before competing at the Games in order to prevent the spread of COVID-19. As a result, athletes from around the globe that are unable to make alternative plans will need to travel to Tokyo and acclimatize within only 5 days before their event. Of particular concern are the adverse health and performance effects elicited by flight dysrhythmia, also known as jetlag, on those athletes travelling to the Olympic Games across multiple times zones. Blood flow restriction (BFR) is a safe exercise mode that can potentially diminish the impact of jetlag on performance through its numerous beneficial physiological adaptations that overlap with those of other jetlag mitigation strategies. Experimental data are required to confirm this intriguing possibility. The present commentary aims to encourage more research into the effects of BFR training in conjunction with other strategies to overcome the effects of jetlag prior, during and after a long-haul flight on the subsequent performance of elite athletes, particularly during these difficult times of the COVID19 pandemic.

The severe containment measures put in place in response to the COVID-19 pandemic are having an unprecedented impact on the world of sport, especially in terms of event organization and logistics. The decision taken by the International Olympic Committee (IOC) to host the Olympic Games this summer brings new challenges for event organisers and athletes. One such measure taken by the IOC is to mandate that athletes may not enter the Olympic Village more than five days before competing at the Games in order to prevent the spread of COVID-19. As a result, athletes from around the globe that are unable to make alternative plans will need to travel to Tokyo and acclimatize within only 5 days before their event. Of particular concern are the adverse health and performance effects elicited by flight dysrhythmia, also known as jetlag, on those athletes travelling to the Olympic Games across multiple times zones. It is well established that jetlag can have significant negative effects on the physiology, psychology, and cognition of travellers, particularly when travelling over more than 3 time zones[1,2]. Jetlag has been shown to dysregulate the circadian rhythm (Figure 1). This in turn can negatively influence important physiological functions such as hormone release (i.e., lower levels of melatonin, higher levels of cortisol and thyroid hormone), body temperature, heart rate, blood pressure and ventilation. These effects can last for as long as 7 days, depending on the number of time zones crossed and particularly when travelling eastbound[1-6].

As for athletes experiencing jetlag, the aforementioned irregularities of the circadian rhythms have been shown to increase drowsiness and negatively influence eating patterns, sleep, mood and cognition[1-4,6]. These disturbances can have detrimental effects on the well-being and performance, by inducing central and peripheral fatigue, and negatively affecting aerobic capacity, muscle strength and perception of effort[7,8]. Moreover, mood disturbances such as anxiety, depression and irritation as well as cognitive function impairments as evidenced by reduced reaction times and concentration have been found in athletes whose athletic performance was reduced by jetlag[1-4,7]. This insufficient adaptation may ruin years of preparation, and a call for action is needed to propose solutions and mitigate the consequences that jetlag can have on the athletes' mental and physical condition during the Tokyo Olympic Games as well as other upcoming athletic events.

The human circadian rhythms are endogenous cycles (the "body clock") synchronized by the earth's 24-hour light-dark cycle and coordinate human physiology and energy metabolism[1-4,7,9]. Recent studies investigating the underlying mechanisms regulating circadian rhythm have evidenced that the activity of the protein kinase mammalian target of rapamycin (mTOR) shows robust circadian oscillation in many tissues and cells including the hypothalamic suprachiasmatic nucleus (SCN), also known as the "central clock" in mammals[10]. As a matter of fact, studies on mice evidenced that mTOR activity in the SCN is high during the day and low at night[11]. This observation led to the hypothesis that mTOR could play a pivotal role in regulating photic entrainment and synchronization of the central circadian clock[9]. Specifically, mTOR inhibition lengthens the circadian period, whereas mTOR activation increases the circadian rhythms and escalates the clock oscillations in cells and tissues[7,9].

Blood flow restriction (BFR) training can be induced by exposing exercising limbs to supra-atmospheric pressure (e.g., 50 mmHg, thereby reducing blood flow by 13-20%) with positive functional adaptations to resistance training compared to nonischaemic training[12]. This improvement in functional capacity has been attributed to multiple factors such as an increase in muscle oxidative capacity, increased glycogen storage, increased capillarization, and greater crosssectional area of all fibre types[12]. BFR training can also be induced by applying inflation with a specific pressure of pneumatic equipment (tourniquet cuffs) proximally to the muscle that is being trained, with the aim of obtaining partial arterial and complete venous occlusion. This latter form of BFR in conjunction with low-load resistance training (RT) has been shown to induce similar hypertrophic adaptations to traditional high-load RT[13,14]. Intriguingly, BFR has also been proposed as an exercise technique which could be able to minimize the impact of jet lag for athletes. Over the last 60 years, numerous research studies have demonstrated the beneficial effects of BFR in muscle strength, muscle hypertrophy, sprint performance, aerobic capacity and neuromuscular adaptations in a variety of sports such as football, netball, basketball, sprint and endurance running[15]. Moreover, a single bout of BFR exercise has been shown to stimulate the mTOR signalling pathways (Figure 1), which is proposed to be a key physiological mechanism behind the increased protein synthesis and muscle mass adaptations observed with BFR[13,15-19]. Brandner *et al* also observed increased corticomotor excitability following a single bout of BFR, which could also be crucial in the modulation of cognitive functions[20]. Accordingly, a further study also observed increased cortical activation and cognitive function improvements (shorter reaction times) following BFR[21]. This was explained as being due to the hypoxic-induced activation of signalling in the brain and the subsequent accumulation of metabolites and hormonal secretions[21]. Such adaptations can potentially lead to an accelerated synchronization of the circadian rhythm in athletes, and therefore a faster restoration of homeostasis[21]. Notably, KAATSU is a form of BFR experimented by elite athletes from different sporting disciplines when flying long distances to compete. For example, the protocol displayed in Figure 2, reflects the procedures used with American Olympic athletes preparing for the 2020 Tokyo Olympics, performing incremental pressure cycles (one cycle = 8 x 30 inflation + 5 sec deflation) on both upper limbs (blue arrow) and lower limbs (red arrow) before, during and after the flight.

In summary, BFR exercise is a safe exercise mode that can potentially diminish the impact of jetlag on performance through its numerous beneficial physiological adaptations that overlap with those of other jetlag mitigation strategies. Experimental data are required to confirm this intriguing possibility. The present editorial aims to encourage more research into the effects of BFR training in conjunction with other strategies to overcome the effects of jetlag prior, during and after a long-haul flight on the subsequent performance of elite athletes, particularly during these difficult times of the COVID19 pandemic.

Declarations

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Illustrations

Figure 1: BFR effects on jetlag – potential physiological adaptations.

Red + represents stimulations; black – represents inhibition

Abbreviations: Melatonin (MEL), Cortisol (CORT), Growth Hormone (GH), Insulin Growth Factor 1 (IGF-1), mammalian target of rapamycin (mTOR), Vascular Endothelial Growth Factor (VEGF), Hypoxia (HYP), Blood Flow Restriction (BFR)

Figure 2: Illustration of the KAATSU protocol used during long flights by elite athletes. The protocol involves incremental pressure cycles (one cycle = 8 x 30 inflation + 5 sec deflation) on both upper limbs (blue arrow) and lower limbs (red arrow) before, during and after the flight.