MANAGING PERFORMANCE THROUGHOUT PERIODS OF TRAVEL

ABSTRACT:

Understanding the impact of travel on physical performance is an increasing area of interest for the strength and conditioning practitioner. Previous research surrounding the effect of travel on the physiology of an athlete has focused on sleep. Of particular concern to coaches and athletes are strategies to help attenuate any detrimental impact of travel on subsequent performance. The aim of this article is to provide informative practical guidelines for prior, during and post travel that can be implemented by coaches and athletes. The key coping strategies addressed include timed light exposure; managing sleep deprivation and nutritional recommendations.

INTRODUCTION:

Long distance travel for training camps and competition is becoming more common. The unique combination of physiological, psychological and environmental factors associated with travel may cause detrimental effects on an athlete's ability to recover and perform (8, 35, 39, 51). Dependant on the direction and length of the travel, these factors may include jet lag, disruption of circadian rhythm, joint stiffness, dehydration and sleep disruption (24, 35). While these undesirable side effects of travel are difficult to avoid, a greater understanding of the fatigue inducing mechanisms involved may help the strength and conditioning coach to implement strategies that reduce the potential decrement in performance. Therefore, throughout this review, the physiological mechanisms behind the performance effect of travel are outlined with the aim to discuss practical solutions to the raised concerns.

MECHANISMS OF TRAVEL FATIGUE

Desynchronosis dysrhythmia, commonly referred to as 'jet lag', is a set of transitory alternations in human physiological functions affected by rapid air travel across time zones leading to decrement in mental and physical performance (13, 52). Jet lag is found to be more complex and greater after trans meridian compared to trans latitudinal travel due to the changes in time zones (51). Jet lag can manifest as: sleep disturbances, daytime fatigue, lack of concentration, headaches, irritability, loss of appetite and gastrointestinal disturbances (28, 50). Most of the symptoms associated with jet lag mainly occur due to the desynchronization between the body's internal time-keeping system and the external environment (38). During eastwardly travel, there is a need for a circadian phase advance (sleep promotion), which is much more difficult to accommodate compared to a circadian phase delay (sleep deterrence) required for westward travel (16, 52). Subsequently, the effect of jet lag remains longer with eastbound compared to westbound travel (16, 52). However, irrespective of the direction of travel, the body's circadian rhythm can be resynchronised at the rate of approximately one time zone per day (51). In order to develop successful coping strategies, it is imperative to appreciate the intrinsic mechanisms of the human biological clock.

The circadian rhythm is governed by a 24-hour solar cycle which maintains both endocrine and metabolic processes. The endogenous mechanism that regulates circadian rhythm in humans is the superchiasmatic nuclei of the anterior hypothalamus (24). The circadian system is composed of the central oscillator located at the base of the hypothalamus and peripheral oscillators found in other areas of the hypothalamus and the endocrine system (20). The central oscillator is affected by the peripheral oscillators' feedback from environmental stimuli (24, 38). A disruption in the signal from the external environment can cause desynchronization (between central and peripheral oscillators) affecting body temperature, cardiovascular function, ventilation, gastrointestinal function, mood states and hormonal secretion (3). One important behaviour that affects normal physiological function is the sleep-wake cycle. The sleep-wake cycle is regulated by the hormone melatonin, secreted from the pineal gland. The secretion of melatonin is inhibited by exposure to natural light and, therefore it peaks during the hours of darkness (2, 31, 35). Core body temperature also works on a 24-hour cycle (35), peak body temperature is reached around 18:00 hrs before dropping to its lowest (nadir) during sleep (28). This decrease in core body temperature also coincides with increase in melatonin secretion causing a rise in endogenous melatonin levels and prompt sleep onset (12). This demonstrates a strong relationship between the circadian rhythms of melatonin secretion, sleep propensity, and the body's thermoregulation, all of which can be disrupted by rapid air travel across multiple time zones.

After travelling across several time zones, the delay in resynchronizing body's sleep-wake cycle according to environmental light-dark cycle of the new location induces sleep deprivation (37, 45). Although everyone will experience sleep deprivation induced by jet lag, the intensity and duration of this will depend on the number of time zones crossed, the direction of travel, sleep during traveling, local circadian time cues and individual tolerance levels (38). The departure time from the original location and arrival time at the destination may also have some influence on jet lag symptoms. In a study involving 85 participants travelling eastward crossing 10 time zones, evening departures/early morning arrivals had twice as much total sleep during flight compared to early morning departure/midday arrivals (49). However, early morning departure/midday arrival participants suffered fewer jet lag symptoms and less fatigue compared to their evening departures/early morning arrivals counterparts (49). It was proposed that early morning departure/midday arrivals enabled normal sleep quality (i.e., use of own bed during the night prior to departure) reducing the symptoms of jet lag. Whereas the evening departures/early morning arrivals reduced sleep quality due to the need to attempt sleep during travel (49). Although jet lag symptoms are the predominant factors contributing to fatigue in a travelling athlete, additional contributors include, stress from delays and detours, joint stiffness and muscle cramps from prolonged sitting in restricted postures (35, 36, 50). Therefore, symptoms of travel fatigue should be monitored and managed to ensure optimal performance and well-being. Support staff should therefore plan and implement appropriate strategies to alleviate these unfavourable scenarios.

IMPACT OF SLEEP DEPRIVATION ON PERFORMANCE

Sleep deprivation causes diurnal sleepiness, depressed mood, insomnia and declined mental performance (24). While sleep deprivation may be associated with jet lag, it is possible that travel such as trans longitudinal journeys have lesser effect on circadian rhythms, but do cause sleep deprivation if travel occurs overnight and sleep patterns are compromised. Although compelling evidence is lacking or inconsistent, some recent studies have reported the importance of adequate sleep in athletic performance. Skein et al., (42) reported diminished muscle glycogen levels and reduced intermittent sprint performance (15m sprint every minute for 50 minutes) with 30 hours of sleep deprivation in male team-sport athletes. Recently, Fowler, Duffield and Vaile (17) demonstrated that 24 hours of simulated international air travel had a negative effect on aerobic performance (Yo-Yo Intermittent Recovery Test Level 1) yet no impact on counter-movement jump (CMJ) (17). Results of this research suggest that maximal exertion or fatiguing aerobic tasks (intermittent sprint and Yo-Yo tasks) may be impacted to a greater degree when athletes experience a reduction in quality and quantity of sleep. Interestingly, Blumert et al., (9) investigated the effects of 24 hours of sleep deprivation in college-level weightlifters and found no differences in snatch, clean and jerk, front squat, total volume load, or training intensity. However, the authors reported negative mood disturbances among the weightlifters after acute sleep loss, indicating some psychological effects of sleep deprivation (9).

While results of this research indicate no performance decline, factors such as negative mood, may be exasperated in team environments where unity and organization are important for success and may provide further explanation of athlete motivation towards tasks requiring maximal aerobic exertion (17). This theory may be supported by the findings of Mah, Mah, Kezirian and Dement (27) who studied the effects of extended sleep in athletic performance among male varsity basketball players. The study reported reduced mood disturbances (tension, depression, anger and confusion), increased vigour, reduced fatigue and significant performance changes (faster sprint times and improved free throw shooting accuracies), following an extended sleep of (507.6 ± 78.6 minutes) per night compared to their regular sleep duration (400.7 ± 61.8 minutes per night). Furthermore, Waterhouse et al., (48) reported improved alertness, mental, and physical performance following a 30-minute nap compared to no nap. The performance tests included short-term memory, visual choice reaction time, handgrip strength and sprint performance (48). Results indicate that a short 30-minute nap produced significant improvement in sprint performance and visual choice reaction accuracy, but no improvement in hand grip strength or average reaction times compared to the no nap condition (48). Therefore, daytime fatigue and sleep deprivation may be considered as the key drivers that impact performance by causing impairments in cognitive function and decreased motivation (24).

Monitoring and managing the sleep-wake cycle of a travelling athlete is vital for maintaining optimal performance as it appears athletes require adequate sleep for optimizing physiological and psychological recovery and sports performance (7). However, the effect of sleep deprivation on performance is specific to the required task as a negative impact has been reported on aerobic performance, sprint performance and free-throw shooting, but not on CMJ and weightlifting performance (9, 17, 27).

NUTRITIONAL CHALLENGES

From a nutritional perspective, the challenge for strength and conditioning coaches is that travel may often create an enhanced likelihood of inadequate nutritional intake and subsequent decrements in performance at a time where performance implications are most significant (6, 33). Challenges may include limited access to the individual's habitual food types and food quantities; necessitating a reliance on food provided by hotels and restaurants. These may not sufficiently meet the daily nutritional requirements of the individual or may provide buffet style options, encouraging over-eating. Gastrointestinal illnesses are also more likely due to exposure to food and water with differences in hygiene standards. Some evidence suggests that more than half of athletes who travel internationally develop diarrhoea with primary sources of bacterial pathogens coming from food or water (18). The journey itself may also facilitate dehydration due to the dry air of flight cabins, which should be monitored throughout the travel process (36, 50).

COPING STRATEGIES

Minimizing the potential decrement in athletic performance caused by travel requires comprehensive management by both athletes and support staff. Educating the athlete on fundamental circadian rhythm responses and appropriate pre, during and post travel activities could influence athlete's awareness and behaviour during travel. Although limited, some research has attempted to provide some guidance in managing travel fatigue in athletes. The leading cause of circadian rhythm disruptions is the transition between time-zones and hence most of these strategies subsequently target resynchronization of circadian rhythms. However, if the length of stay at the new destination is short (< 3 days), it is recommended to maintain behavioural patterns to coincide with the original 'home' time (50). Also, if less than 3 time zones are crossed, then the jet lag symptoms are less severe, and hence, coping strategies differ compared to travel across 3+ time zones (50). Since the normal cycle of the human circadian rhythm is slightly longer than 24 hours, we have a natural tendency to accommodate lengthening of time zone (Westward) than shrinking (Eastward) and as such, coping strategies are based on the direction of travel and the number of time zones crossed (34, 39). Therefore, while the severity of jet lag symptoms increase in Eastward travellers after crossing 3 or more time zones, in Westward travellers this increase may occur when crossing 4 or more time zones (Figures 1 and 2). During planning, it is recommended that, if possible, at least one day per time zone should be allowed before competition for resynchronization of the internal body clock (48).

Managing Light Exposure

Upon arrival, depending on the timing, intensity and duration, exposure to bright light (especially natural light) can advance or delay the circadian phase (30). Since melatonin secretion is inhibited on exposure to bright light and increased during darkness, allowing or restricting light exposure would seem an ideal pre-requisite for altering melatonin secretion to suit circadian phase delay or advance, respectively. It has been demonstrated that fluorescent and blue light can also be used to effectively supress melatonin as they simulate the photic environmental stimuli associated with daytime light (14). For example, Wright, Lack and Partridge (53) found that different light-emitting diodes were effective in supressing melatonin, with the blue/green diode being more effective than any others. Desan, et al., (15) found that the Litebook light-emitting diode light therapy (which uses shortwave blue light) was an effective device for treatment of seasonal affective disorder, which could also be repurposed for extending melatonin suppression. Recently, intermittent transcranial light has also been researched, where exposure to bright light via the ear canal (4 x 12 minute per day) has been shown to have a positive effect on overall subjective jet lag symptoms after cumulative days of treatment (23), but no effect on circadian phase shifts after acute and short term treatment of 1 x 12 minute exposure (10). The exact physiological mechanisms are currently not understood, although transcranial bright light has been shown to have no effect on melatonin secretion yet a positive effect on brain (32, 43) and psychomotor function (47). Some practical guidelines from the literature on managing light exposure are provided in behavioural management plan (Figures 1 and 2).

However, timing of bright light is critical as the direction of the circadian system shift is dependent on the circadian phase and the timing of the core body temperature nadir. Subsequently, eastwardly travellers should avoid bright light before body temperature nadir occurs and seek bright light after (50). This becomes more and more challenging for eastwardly travellers as the number of time zones crossed increases. Dark goggles can be used to reduce exposure to bright light and induce melatonin secretion. Sasseville, Paquet, Sévigny and Hébert (40) found that blue blocker glasses significantly impede the capacity of bright light to suppress melatonin. Similarly, research carried out on night shift workers reported that wearing dark goggles during the morning commute to reduce light exposure has enabled adaptive circadian phase resetting (37). Such a critical stimulation of melatonin secretion can help increase the levels of endogenous melatonin, resulting in promotion of sleep propensity that is required to advance the circadian phase.

Coping with and Avoiding Sleep Deprivation

Sleep deprivation can have negative effects on athletic performance (17, 42) and can occur from both sleep loss during travel (overnight flights) and jet lag (the need for circadian phase advance or delay). Therefore, coping strategies to alleviate and avoid this deprivation are of high importance. When planning trans meridian travel, depending on the direction, pre-flight practices such as adjusting bedtime by 1 or 2 hours, 1 to 2 days prior to travel are recommended to promote partial adaptation to a new time zone (34) (Figures 1 and 2). Also, if possible, to mitigate travel fatigue by reducing sleep cycle interference, plan early morning departure and afternoon arrivals, which will enable the next night's sleep sooner compared to evening departures/early morning arrivals (49). In order to reduce the negative effects of the travel process, it is recommended that sleep during travel is maximized (29, 34, 39). Behavioural recommendations such as, keeping the cabin window shades down, turning the cabin lights off until an hour prior to arrival (29) and ensuring good sleep hygiene (avoiding caffeine, nicotine, food and brain stimulating activities) (7), can all be used to reduce sleep interference and reduce travel fatigue. These sleep hygiene recommendations should also be followed prior to and after travel to help reduce travel fatigue or to cause the desired circadian phase shift. Upon arrival, any athletes displaying symptoms of travel fatigue may be successfully managed using an appropriate napping strategy (48). Naps of less than 30 minutes are not susceptible to “sleep inertia”, the fatigued state experienced upon waking from sleep (22). Moreover, short naps (< 30 minutes) have been reported to improve alertness and cognitive performance following restricted nocturnal sleep (22). Naps were also found to be more effective with prior caffeine intake followed by bright light and face washing (21).

Nutritional Recommendations

Whilst travelling poses a number of nutritional challenges, many of these can be overcome prior to travel. Food requirements should be discussed with those who will provide catering at the new destination and during transit. If requirements are unable to be met then staff and athletes may need to travel with additional supplementation. During travel, the dry air circulated in flight cabins can increase the likelihood of dehydration, therefore special attention should be paid to athletes' fluid intake (36, 50). Upon arrival, if trying to adjust the circadian rhythm to the destinations time zone, meal times should coincide with that of the destination in order to aid circadian phase advances or delays (36). In order to minimize the risk of gastrointestinal illness, athletes should seek to avoid drinking local water (including ice cubes and water for brushing teeth) and the consumption of raw foods or those that may have been washed in contaminated water. Additionally, the adoption of good personal hygiene practices (i.e. frequent hand-washing, hand-sterilizers etc.) will also help to minimize the risk of illness and diarrhoea. Travelling athletes are often directed to avoid the intake of caffeinated beverages due to concerns regarding the potential diuretic effects of caffeine. However, whilst the general consensus of evidence suggests that moderate amounts of caffeine have minimal impact upon overall hydration status (1)**,** athletes should nonetheless avoid the consumption of caffeinated beverages due to the purported impact upon wakefulness and interference with the adjustment of circadian rhythms. Burke et al., (11) recently demonstrated that caffeine ingestion caused ~3 hour delay in the circadian melatonin rhythm, which could potentially induce poorer sleep quality and greater lethargy. Similarly, there is evidence that alcohol intake can also disturb normal sleep patterns (19) and should subsequently be avoided.

Clothing, Exercise and other Behavioural Changes

Timed exercise, appropriate clothing, and seating arrangements are hypothesized to reduce fatigue in a travelling athlete (30, 35). When possible, periods of mobilization should be practiced to promote blood flow and reduce the risk of venous thromboembolism, joint stiffness and muscle cramps that could result from long periods of inactivity during travel (5, 30, 41). Unfortunately, long haul flights do not provide the luxury of a 30-minute service stop. Thus, all activation and walking must be performed on the plane. In-flight activities such as simple stretching and mild isometric exercises while seated or walking in the cabin when it is safe to do so are recommended to reduce muscle stiffness, the risk for thrombosis and other discomforts associated with prolonged sitting (30). After arriving at the final destination, to benefit from exercise-induced circadian phase shifts, it is recommended to perform exercise early in the morning when body temperature is lowest to promote phase delays and in the evening to gain phase advances (30). However, some studies have reported that exercise might not reliably shift circadian rhythms, but could be beneficial for maintaining arousal levels post travel (25). Some guidelines on exercise and training a travelling athlete are compiled from the literature and produced in Figures 1 and 2.

Compression garments have also been suggested to provide beneficial effects in alleviating discomfort and difficulties associated with prolonged sitting in a cramped position during travel (35). Belcaro et al., (5) and Scurr et al., (41) propose that compression stockings when worn below the knee can significantly reduce the risk of blood pooling and venous thromboembolism. Recently, nerve stimulation has also been studied where electrical stimulation of the peroneal nerve has been shown to increase blood flow to the lower leg (46), enhance venous return by up to 95% (26), and be more effective than both water-aerobic exercise and passive rest at reducing muscle pain in young soccer players (44). Furthermore, Beaven et al., (4) reported enhanced self-assessed energy levels and enthusiasm when electrostimulation was combined with compression garments, and an accelerated return of creatine kinase to baseline levels after rugby competition when compared to compression garments alone. Subsequently, it may be logical to assume that the use of electrical stimulation during travel would have both a physiological benefit as well as a psychological benefit. However, little research exists in relation to the use of electrical stimulation on physiological performance after travel or periods of prolonged sitting.

**** Insert FIGURE 1 here***

**** Insert FIGURE 2 here***

INDIVIDUAL CONSIDERATIONS

Jet lag effects are influenced by a number of individual differences in people and these range from chronotype, age, fitness levels and adaptability of sleeping patterns (34). Chronotype refers to the behavioural manifestation of an individual’s underlying circadian rhythms. A person's chronotype is the propensity for the individual to sleep at a particular time during a 24-hour period. Morning type people who retire early and arise early are less affected flying eastward, whereas evening type people who retire late and wake up late have less difficulty flying westward (25). The influence of age on travel-related circadian rhythm disruptions should also be considered while planning coping methods. While older (50+ years) individuals may be less affected by jet lag symptoms, sleep and alertness levels of middle-aged travellers (37-52 years) are greatly affected after travel, compared to 18 to 25-year olds (25). Physically fitter individuals should experience less difficulty with jet lag as they adapt to travel and sleep disruption (51). Adaptability of sleeping patterns relates to an individual’s ability to adjust their times of sleeping, and are influenced less by the conditions in which they sleep. It is proposed that these factors would lessen the impact of jet lag on an individual who undertakes long haul travel (48). Further experimental support is required to verify these predictions and the impact these factors have upon individuals and their response to prolonged travel. However, although these differences are smaller in an athletic population (34), knowing this information on individual sleeping habits and circadian rhythms would assist in planning appropriate interventions.

Practical Applications

A travelling athlete creates unique challenges for strength and conditioning coaches in accomplishing effective total athlete management. However, awareness of the fundamental mechanisms of fatigue associated with travel and implementing recommended coping measures can provide some favourable outcomes. Available literature in this area suggests that a greater focus on strategic timings for sleep/nap, light exposure/avoidance and food/fluid intake can help alleviate the adverse effects of travel on physiological factors and athletic performance. Studies also propose that planned pre-travel adaptation measures, use of compression garments, timed exercise, practice of good personal hygiene and proper management of travel logistics (to avoid psychological stress and/or to gain from favourable departure & arrival timings) can be beneficial. In addition, further coping methods available to explore include nerve stimulation and transcranial light exposure, both of which require further research. Finally, understanding and considering an athlete's age and chronotype related differences can make the coping strategies more effective.

FIGURE LEGEND

Figure 1. Coping strategies for Eastward Travellers

Figure 2. Coping strategies for Westward Travellers

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