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Managing Transmeridian Travel: Guidelines for Minimizing the Negative Impact of International Travel on Performance

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ATHLETES AND TEAMS, whether part of an amateur or a professional organization, regularly travel long distances to prepare for and compete in major events or tournaments. There was a time, not so long ago, when the thought of traveling halfway around the world to compete in another country was a major stumbling block. Air travel was not as sophisticated as it is today, and international competition often required long trips by sea or over land to get to the competition venue. Fortunately, these days are now cast to the pages of history and nostalgia.

Athletes, teams, and all that goes along with them in the form of logistical support, are now easily loaded onto a plane, and they travel quickly in relative comfort to their chosen destination. For members of the elite professional sport entertainment business, chartered or private planes providing the comforts of business or first class cabins are mandatory. Although a wide range of creature comforts are available during the course of travel, the various symptoms of jet lag still take their toll on even the most seasoned traveler, and it is often the responsibility of the strength and conditioning coach to minimize these effects.

One of the negative aspects of air travel for the international competitor is the feeling of fatigue that manifests when traveling across a number of time zones (transmeridian as opposed to translatitudinal travel). This effect is often referred to as jet lag and is characterized by disruptions to the body's normal circadian rhythms, commonly referred to as the body clock. These rhythms are linked to time-giving signals associated with the local environment (10). Typical symptoms of jet lag are disrupted sleep, changes in mood state, loss of appetite, gastrointestinal disturbance, disorientation, and discomfort, which are all linked to the desynchronization of the circadian rhythms (2, 8, 10, 16). Age and level of fitness (10) can also influence the severity of these symptoms, but for all individuals symptoms will be more pronounced and will last longer when traveling in an easterly direction and will be influenced by the number of time zones crossed. Resynchronization takes approximately 1 day for each time zone crossed with exposure to the light-dark cycle of the new environment considered the primary stimulus for resetting (reentrainment of) the circadian system (16).

Jet lag is experienced by everyone traveling across international time zones and produces changes in the body's normal daily physiological rhythms (8). The most significant and obvious of these changes is in normal sleep patterns. This effect is particularly pronounced when traveling from one hemisphere to another. For example, when traveling from England to the east coast of Australia during the Southern Hemisphere summer there will be an 11-hour difference in time (phase adjustment). When it is 7:00 am in Sydney, Australia, it will be 8:00 pm on the previous night in London, England. In the winter, the difference will be 9 hours; the seasonal time differences are attributed to local variations in daylight savings times.

As a result, when arriving in Australia early in the morning the body would normally be prepar-

ing to sleep. These time differences produce transient deteriorations in sleep and mood. However, some researchers have suggested that the scientific evidence supporting these changes is neither consistent nor compelling (16). Notwithstanding individual variations, regaining "normal" sleep patterns will typically take 3–4 days but will be influenced by the number of time zones crossed. There is also considerable debate in the literature about the impact of transmeridian travel on performance.

Impact on Performance: A Brief Review of the Literature

The circadian system is synchronized primarily by the light-dark cycle of the earth's 24-hour rotation (16). Variations in components of sport performance (e.g., flexibility, muscular strength) also exhibit rhythmic daily variations, peaking in early evening in parallel with the daily maximum in body temperature (2). Although peak performance times can vary among individuals, for most athletes this period appears to be between 4:00 and 10:00 pm. Generally, peaks in reaction time, isometric hand grip strength, elbow flexion strength, back strength, total work performed in high-intensity constant exercise, lactate production, lowest levels of joint stiffness, and pain perception all reportedly occur at this time of day (8). As a result, a poor performance result may be attributed to an athlete or coach not taking into account these circadian variations and the peak time for optimal efficiency. For example, extended air travel across multiple time zones may mean that the athlete's body clock is significantly out of synchronization with the real time in the new location, thereby causing disruptions in the circadian system. Taking these circadian rhythms into consideration could produce significant improvements in performance. Manfredini et al. (8) suggested that selection of the best circadian time could produce a 10% increase in performance and could benefit tasks involving endurance, physical strength, and mental function. In their excellent review of circadian variations in sport performance, Atkinson and Reilly (2) cited research supporting the implementation of training programs for endurance and strength in the afternoon or early evening. In contrast, there were also findings supporting the need to implement the learning of motor skills in the morning.

These various findings suggest that extended national or international travel across time zones can negatively impact sport performance because of a shift in the circadian peak window. Atkinson and Reilly (2) stated that the shift in the body clock time relative to real time in the new location is a major influencing factor in research into sport performance after air travel. Jehue et al. (6) examined win-loss records for 27 National Football League teams during 1978–87 and reported that teams that traveled from west to east (with a 3-hour time advance) and played games commencing at 1:00 pm eastern standard time showed a decrease in performance compared with their performance in games played within the same time zone. A similar result was reported when teams from the west competed in the central time zone where the time advance was 2 hours. Jehue et al. (6) suggested that these findings are consistent with a deleterious effect of jet lag on performance. However, west-coast teams appear to have an advantage when games played in central or eastern time zones are played at night, closer to their normal afternoon peak performance times. These findings appear to be supported by Worthen and Wasde (15). They examined data from the 1996 National Collegiate Athletic Association football season and reported that teams that traveled eastward and crossed at least one time zone scored fewer points, conceded more points, and had a greater margin of defeat in each quarter of play compared with teams that traveled westward.

In three separate studies involving the USA women's soccer team traveling to Taiwan, a group of North American students traveling to western Europe, and a group of European students traveling to North America, Hill et al. (5) reported that mood state, anaerobic power and capacity, and dynamic strength were affected by rapid transmeridian travel. These effects were essentially eliminated after 3–4 days. However, Youngstedt and O'Connor (16) argued that inferences relating to performance decrements cannot be made from two of these studies because of major methodological flaws relating to the lack of performance assessments prior to transmeridian travel. They also suggested that there is no compelling evidence supporting the notion that transmeridian travel has a negative impact on sport performance. In an earlier review of the literature, O'Connor and Morgan (9) reported that distance running and sprinting performance and dynamic muscular strength and endurance of the elbow flexors was impaired by west-to-east travel across 6 time zones in untrained individuals. However, there was no evidence suggesting that these findings could be generalized across athletes.

O'Connor and Morgan (9) also reported that anecdotal evidence exists supporting the notion that transmeridian travel has an adverse effect on mood state. East-to-west travel across 6 time zones adversely affected mood states for 1 day. Given the role of mood state in sport performance, any adverse effect on mood state resulting from transmeridian air travel could negatively affect sport performance (9). A number of studies have supported this proposition (3, 14).

Disruption in normal sleep habits appears to play a major role in mood changes resulting from a desynchronization between the circadian system and the sleep-wake cycle (16). However, the scientific evidence supporting the effects of sleep deprivation on performance is unclear and inconsistent (9). For example, some researchers have found improvements in mood state and decreases in muscle soreness in competitive swimmers after translocation in both directions over 4 time zones (2). Further, Youngstedt and O'Connor (16) concluded that there is little evidence showing that sleep deprivation of up to 72 hours impairs sport performance and that the high levels of motivation usually associated with major sport events is likely to counter any adverse effects of sleep deprivation. Although gross motor performance may not be adversely affected by partial sleep deprivation of up to 2–3 days, the same is not true for tasks requiring decision making, which can be adversely affected by 1 night in which sleep is restricted to 3 hours (12).

Strategies for Minimizing Jet Lag

Pharmacological and behavioral interventions have been utilized in an effort to speed up the resynchronization of the circadian system after translocation to a new environment (11, 13). Simple behavioral changes can promote sleep during air travel over multiple time zones (9). These changes include sleeping as much as possible during the flight, eliminating caffeine consumption, keeping the cabin window shades down, and turning the cabin lights off until 1 hour prior to arrival at the final destination. In addition, the research (9) has shown that the administration of L-tryptophan (an amino acid) during the flight and at 10:00 pm each night for the first 3 nights in the new environment promoted sleep on the first night in the new environment. However, treated individuals did not sleep any longer during the flight or on the remaining 2 nights when compared with those who took a placebo.

Some researchers have suggested that slow-release caffeine and melatonin might be used to diminish the consequences of jet lag and to promote faster resynchronization of circadian rhythms (7). In individuals using these pharmacological interventions, static physical performance (hand grip strength test) was maintained after eastward travel across 7 time zones; slow-release caffeine actually increased static performance (dominant hand) from day 1 in the new location. In contrast, the placebo produced a decrease in static performance with the dominant hand during the first 4 days of resynchronization. Melatonin, which plays a role in hastening the adjustment of circadian rhythms, can also ameliorate the subjective feelings of jet lag (1, 7). However, melatonin has a hypnotic effect that may be deleterious to sport performance and, when taken with menstrual cycle hormones, may also lead to amenorrhoea, which has health implications for female athletes (11). Other hypnotic agents (e.g., benzodiazepines) have been administered to travelers crossing multiple time zones, but the hangover effects of such substances makes them questionable for athletes (11).

Adjusting the sleep-wake cycle prior to departure appears to be largely ineffective (8, 11) because of the practical problems associated with trying to manipulate the environment (e.g., light, social influences, work schedules). Taking long naps in the new time zone may delay adaptation in the new setting because it will tend to anchor the circadian rhythms to the home time (8), thus slowing the rate of entrainment to the new local time. As a result, naps should be avoided if at all possible after arrival in the new time zone.

Exercise has been clearly demonstrated to improve mood (4). Reilly (10) reported that the symptoms of jet lag can be reduced by following a systematic exercise regime immediately after disembarkation. However, timing of exercise in the new environment needs careful planning and should be scheduled after giving due consideration to the changes in body temperature associated with the new light-dark cycle of the new time zone. Exercise can also play a role in reducing the effect of drowsiness and transient fatigue experienced in the early period of adaptation to the new time (11). Some researchers have used bright lights in an attempt to advance the re-entrainment of the circadian system, but this approach has not been used on athletes, and there is still some doubt about its effectiveness (8, 11).

A high-carbohydrate, low-protein meal may induce drowsiness

and sleep because of the brain's uptake of tryptophan and its conversion to serotonin (8). Conversely, a high-protein, low-carbohydrate meal may increase arousal levels because of the enhanced uptake of tyrosine and its conversion to adrenaline. Thus, jet lag problems may be reduced by the ingestion of high-protein meals in the morning (to help elevate arousal level) and high-carbohydrate meals in the evening (to promote sleep). Similarly, caffeine ingestion in the morning might be helpful but would be contraindicated in the evening prior to retiring. Alcohol is also contraindicated because of its diuretic properties, which can have negative effects on sleep (11).

■ Practical Guidelines for Minimizing the Negative Effects of Jet Lag

Mental Attitude

Tell your athletes to adopt a positive mental attitude before getting on the plane. The flight should be seen as a means to an end. The use of personal in-flight entertainment units available on most planes combined with some reading and generally relaxing can help even long flights pass quickly. The key is to encourage your athletes to adopt a passive mind set. Advise them not to let distractions around them cause unnecessary anxiety or tension. At all times they should keep things in perspective. Delays can be a part of being in transit; simply roll with the punches and do not let delays get you or your athletes down.

Time Difference

Get your athletes to change their watches to the local time at their proposed destination as soon as they get on the plane. This will help them to start adjusting sleeping and eating patterns. When scheduling travel arrangements, give consideration to the amount of lead time needed in the new time zone prior to the first competition, as a means of facilitating adaptation of the circadian system. If the budget allows it, a lead time of 1 day for each time zone crossed is ideal.

Contact With Home

Make sure family and friends are aware of the time difference that exists between home and the new time zone. Ask them to avoid phoning at a time that may interfere with sleep patterns upon arrival in the new environment. Be sure cellular phones are turned off at night during sleep times. This will limit the chance of friends or family ringing in the middle of the night.

In-Flight Exercise

During the flight, encourage your athletes to get up and walk around the cabin every couple of hours (the exception being when asleep or when the fasten-seatbelt sign is on). Simple stretching exercises can be completed while in the seat or in the available space near toilets and in the plane's galley area; examples of the recommended exercises are typically provided in the in-flight magazine. If there is a stopover for a few hours, use this time to have a good walk around. Avoid simply sitting down for the entire stopover, but tell your athletes to take it easy and put their legs up after they have had a chance to walk around and stretch their legs. Most airports will have plenty of spots where your athletes can find some space to themselves to stretch. When stretching, pay particular attention to the lower back, legs, neck, and shoulders. Muscles and connective tissue will become shortened during the flight, making them feel stiff. Stretching will help to relax the muscles while increasing blood flow and delivering oxygen and other nutrients to the muscles.

In-Flight Clothing

Wear comfortable loose-fitting clothing, such as a track suit and polo shirt, on the plane. Encourage your athletes to wear something that is easily removed in case they feel warm or uncomfortable. When traveling on long flights with brief stopovers, take a change of shirt, underwear, and socks and essential toiletries in carry-on baggage. Some airports provide access to shower facilities.

Seating

Economy-class travel usually means cramped conditions, particularly for larger and taller athletes. However, airlines will often accommodate athletes with aisle seating or seating near the bulkhead or emergency exits where there is more legroom. However, these requests must be made when actually booking the flight. There is nothing worse than having to constantly disturb other passengers by leaving and returning to your seat throughout the flight.

Sleep, food, and drink in flight

Keeping in mind the time difference at the intended destination, encourage your athletes to get as much sleep as possible, even if it is only light dozing. The amount of sleep-need differs among individuals. If traveling in a group, advise your athletes to respect the attempts of others trying to rest/sleep. Other members of the group should not be disturbed unless it is clear that they are awake. Purchase some high-quality earplugs to help reduce background noise from the plane's engines. Sleep

a

Player name: _____

ENGLAND U21 – Player Diary
RICOH Southern Hemisphere U21 Championship, Sydney - Australia

Date June 2001	Time	Activity	BW (kg)	Approx' Fluid/Day (Litres)	Approx' Hours Sleep	Sleep Quality (Tick appropriate box) Poor	Broken	Good	Waking Heart Rate	Injury and Illness Record
Saturday 16	AM	In transit								
	PM	Training								
Sunday 17	AM	Training								
	PM	Training								
Monday 18	AM	Training								
	PM	Training								
Tuesday 19	AM	Rest								
	PM	Training								
Wednesday 20	AM	Rest								
	PM	Ireland								
Thursday 21	AM	Rest/Rehab								
	PM	Video								
Friday 22	AM	Training								
	PM	Rest								
Saturday 23	AM	Rest								
	PM	New Zealand								
Sunday 24	AM	Rest/Rehab								
	PM									
Monday 25	AM	Training								
	PM	Training								
Tuesday 26	AM	Rest								
	PM	Training								
Wednesday 27	AM	Rest								
	PM	Argentina								
Thursday 28	AM	Rest/Rehab								
	PM									
Friday 29	AM	Video								
	PM	Training								
Saturday 30	AM	Rest								
	PM	Final Game								

b

Player name: _____

ENGLAND U21 – Player Diary
RICOH Southern Hemisphere U21 Championship, Sydney - Australia

Date June 2001	Meals (Tick all appropriate boxes for each day) B/fast	Snack	Lunch	Snack	Dinner	Rating of Perceived Recovery (Tick the most appropriate box) VP	Poor	Aver'	Good	VG	General Comments Relating to Perceived Wellbeing
Saturday 16											
Sunday 17											
Monday 18											
Tuesday 19											
Wednesday 20											
Thursday 21											
Friday 22											
Saturday 23											
Sunday 24											
Monday 25											
Tuesday 26											
Wednesday 27											
Thursday 28											
Friday 29											
Saturday 30											

Figure. **Sample travel diary as used by the 2001 England Rugby Union Team during the RICOH Southern Hemisphere U21 Championship in Sydney, Australia, June 2001.**

will be much easier to achieve if your athletes adopt the following strategies.

1. Avoid alcohol. A glass of wine or a small beer with appropriate meals (e.g., dinner) may be okay, but excessive alcohol will increase the rate of dehydration through a diuretic effect. Caffeine in beverages (e.g., coffee, tea, cola drinks) is likely to produce minimal dehydration, but avoid the temptation to drink more than usual just for something to do particularly within a few hours of sleeping. Soft drinks may induce a bloated feeling.

2. Drink plenty of water. The pressurized cabin of the plane will accelerate dehydration. Athletes should keep water containers with them and should take frequent sips throughout the flight. Dehydration is a major contributing factor in the symptoms of jet lag, including feeling disorientated and light headed. Maintaining hydration will minimize these effects and will help maintain normal blood viscosity.

3. During the flight the body will effectively be in rest mode and therefore will not require the same amount of food it normally does. Avoid the temptation to eat more because the food is available. Eating less is better for you. Eat only when hungry. It is okay to select only part of the meal or to refuse it completely. Avoid foods that you would not normally eat. Whenever you get the chance, eat fruit with your selected meal.

Arriving in the New Time Zone

After a long flight, it is normal to feel tired, even after following all the guidelines. However, quick adaptation to the local time is essential for the body to reset its biological clock and get back into training and competition mode. To this end, athletes should avoid sleeping if they arrive during the day. Make every effort to stay awake until that evening, preferably until at least 9:30 pm. Sleeping through the day will reduce tiredness but will delay the re-entrainment of the body's circadian system.

Sleep disturbances are common during the first few nights (depending on how many time zones have been crossed). Some individuals may wake at odd hours until the body adjusts to local time and the new sleep routine. If your athletes wake up at night, encourage them to avoid becoming frustrated and anxious because they cannot get back to sleep; these feelings will only make them tense, making it more difficult to relax back into sleep. If they cannot get back to sleep after about half an hour, reading or watching television and relaxing for half an hour should help. Beverages such as alcohol and coffee might make sleeping more difficult, so these substances should be avoided in the hours immediately prior to retiring. Similarly, a high-protein, low-carbohydrate meal late in the evening may make sleeping more difficult.

During the day, try to keep active. Once checked into the hotel, get a feel for the area. Getting out into the local environment and sunlight is particularly important for helping the body adjust. Tell your athletes to take a bottle of water with them and to consume water throughout the day in addition to several pieces of fruit. Bottled water is recommended over local tap water. Monitor fluid intake by checking weight daily along with other factors that might help monitor how athletes are adapting to the new time zone. The Figure illustrates a sample travel diary I developed that was used by an English Rugby Union International team competing in Australia. The diary was used to monitor a range of basic perceptions and physiological responses (e.g., body mass and resting heart rate) during a 15-day intensive tournament requiring travel across 10 time zones.

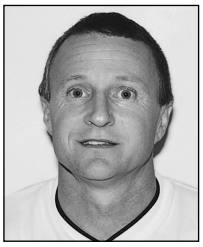
■ Conclusion

International travel is now common in competitive sports and is one of the many factors that strength and conditioning coaches must manage to get the most out of their athletes. Performance at training or in competition can be influenced by many factors. If the athlete is required to travel over multiple time zones to compete, the strength and conditioning coach will need to plan a strategy for minimizing the likely deleterious effects of jet lag. Much research has been done relating to the circadian system and its desynchronization that results from transmeridian air travel. The simple practical strategies presented here can help to limit the negative effects of this form of travel on sport performance. ▲

■ References

1. Arendt, J., M. Aldhous, J. English, J. Marks, J.H. Arendent, M. Marks, and S. Folkard. Some effects of jet lag and their alteration by melatonin. *Ergonomics.* 30(9):1379–1394. 1987.
2. Atkinson, G., and T. Reilly. Circadian variation in sports performance. *Sports Med.* 21(4):292–312. 1996.
3. Bassett, J.R., and R. Spillane.

Urinary cortisol excretion and mood rating in aircraft cabin crew during a tour of duty involving a disruption in circadian rhythm. *Pharmacol. Biochem. Behav.* 27:413–420. 1987.
4. Casper, R.C. Exercise and mood. *World Rev. Nutr. Diet.* 71:115–143. 1993.
5. Hill, D.W., C.M. Hill, K.L. Fields, and J.C. Smith. Effects of jet lag on factors related to sport performance. *Can. J. Appl. Physiol.* 18(1):91–103. 1993.
6. Jehue, R., D. Street, and R. Huizenga. Effect of time zone and game time changes on team performance: National Football League. *Med. Sci. Sports Exerc.* 25(1):127–131. 1993.
7. Lagarde, D., B. Chappuis, P.F. Billaud, R. Laurent, F. Chauffard, and J. French. Evaluation of pharmacological aids on physical performance after a transmeridian flight. *Med. Sci. Sports Exerc.* 33(4):628–634. 2001.
8. Manfredini, R., F. Manfredini, C. Fersini, and F. Conconi. Circadian rhythms, athletic performance, and jet lag. *Br. J. Sports Med.* 32(2):101–106. 1998.
9. O'Connor, P.J., and W.P. Morgan. Athletic performance following rapid traversal of multiple time zones: A review. *Sports Med.* 10(1):20–30. 1990.
10. Reilley, T. Travel and jet lag. First Australian Science in Football Congress. Melbourne, Australia, October 1994.
11. Reilly, T., G. Atkinson, and J. Waterhouse. Travel fatigue and jet lag. *J. Sport Sci.* 15(3):365–369. 1997.
12. Reilly, T., and T. Deykin. Effects of partial sleep loss on subjective states, psychomotor and physical performance tests. *J. Hum. Mov. Stud.* 9:157–170. 1983.
13. Waterhouse, J., T. Reilly, and G. Atkinson. Chronobiological consequences of long haul flights, travel fatigue, and jet lag. *Int. Sportmed. J.* 1(2). 2000. Retrieved November 23, 2001. http://www.espotmed.com/ismj/.
14. Winget, C.M., C.W. DeRoshia, and D.C. Holley. Circadian rhythms and athletic performance. *Med. Sci. Sports Exerc.* 17(5):498–516. 1985.
15. Worthen, J.B., and C.E. Wasde. Direction of travel and visiting team athletic performance: Support for a circadian dysrhythmia hypothesis. *J. Sport Beh.* 22(2):279–287. 1999.
16. Youngstedt, S.D., and P.J. O'Connor. The influence of air travel on athletic performance. *Sports Med.* 28(3):197–207. 1999.



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