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POSITION STATEMENT

Coping with jet-lag: A Position Statement for the European College of Sport Science

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Abstract

Elite athletes and their coaches are accustomed to international travel for purposes of training or sports competition. Recreational participants are similarly, if less frequently, exposed to travel stress. Transient negative effects that constitute travel fatigue are quickly overcome, whereas longer-lasting difficulties are associated with crossing multiple time-zones. Jet-lag is linked with desynchronization of circadian rhythms, and its impact depends on the duration and direction of flight, flight schedule, and individual differences. Athletes' performances are likely to be affected for some days until the body clock is readjusted in harmony with local time. Knowledge of the physiological characteristics of the body clock can be used to develop behavioural strategies that accelerate readjustment, in particular the timing of outdoor or bright light exposure, perhaps melatonin ingestion, meals, and exercise. Attempts to promote sleep by use of drugs that adjust the body clock, induce sleepiness or promote wakefulness are relevant but discouraged in travelling athletes. Support staff should develop appropriate education programmes for their athletes who can then make informed choices about their behaviour and minimize the transient effects of jet-lag on their well-being and performance.

Keywords: *Chronobiology, circadian rhythms, fatigue, sleep, travel*

Introduction

Contemporary elite athletes are frequent travellers across multiple time-zones. These journeys are undertaken to participate in club or international competition in single engagements or for more prolonged sojourns when tournaments are involved. In other instances, groups of athletes or members of sports teams take advantage of altitude or seasonal differences in weather conditions to attend training camps in other parts of the world where the climate is more conducive to strenuous exercise. Professional athletes based in Europe, such as soccer players, may incur a competitive schedule that includes international representation for their country on another continent (Asia, America or Australia) in between important domestic contests for the club. Such itineraries place a physiological and psychological burden on those athletes who have to adjust to a different time-zone and a different climate and then have to re-adjust back to their home time-zone after the return journey.

Irrespective of the mode of transport, travelling can cause discomfort and fatigue. The passenger may become stiff as a result of being in a cramped posture for too long during an air flight or a journey by car or omnibus. There may be stresses associated with the journey, delays, unplanned stops or detours. With flights there are also the problems caused by hypoxia. The fatigue and dehydration that result are transitory and can be remedied on arrival by rehydration, a rest or light exercise, and a shower or bath. This form of tiredness or "travel fatigue"

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ISSN 1746-1391 print/ISSN 1536-7290 online © 2007 European College of Sport Science
DOI: 10.1080/17461390701216823

(see Table I) is experienced when flying directly northwards or southwards, for example from mainland Europe to South Africa or from Canada to South America.

Travel fatigue accompanies any long journey, but a unique syndrome known as jet-lag is induced when long-haul flights entail crossing multiple meridians. Symptoms (see Table II) are due to a mismatch between "body clock time" and the new local time. The body clock gradually adapts to local time in the new environment and when this process is complete the symptoms of jet-lag disappear (Lemmer, Kern, Nold, & Lohrer, 2002; Reilly, Atkinson, & Waterhouse, 1997). Since jet-lag can have a negative influence on exercise performance (Waterhouse, Reilly, & Atkinson, 1997), and on the mood and performance of accompanying support personnel (Waterhouse et al., 2002a; Waterhouse, Minors, Waterhouse, Reilly, & Atkinson, 2002b), the provision of travel guidelines to sports participants is worthwhile.

In these guidelines, we first explain the nature of circadian rhythms that are controlled by the body clock. This outline is necessary for an understanding of the behaviour of the body clock when rhythms are desynchronized, which occurs in nocturnal shift-work as well as time-zone transitions. Methods commonly promoted for alleviating jet-lag and hastening adjustment to the new time-zone are considered and evaluated. Strategies designed to help deal with itineraries depend on the direction of flight, times of departure and arrival, and mission objectives. Advice can also be given regarding sleep loss. These strategies need to be translated into compact recommendations to be of practical benefit to athletes and their medical and scientific mentors.

Table I. Checklist for travel fatigue (based on Waterhouse et al., 2002b).

Symptoms
Fatigue
Disorientation
Headaches
"Travel weariness"

Causes
Disruption of normal routine
Hassles associated with travel (checking in, baggage claim, customs clearance)
Dehydration due to dry cabin air

Advice
Before the journey
Plan the journey well in advance
Try to arrange for any stopover to be comfortable
Be clear about documentation, inoculations, visas, etc.
Make arrangements for activity at your destination

During the flight
Take some roughage (e.g. apples) to eat
Drink plenty of water or fruit juice; avoid tea, coffee, and alcohol

On reaching your destination
Relax with a non-alcoholic drink
Take a shower
Take a brief nap, if feeling exhausted

Table II. Symptoms of jet-lag (based on Waterhouse et al., 1997).

- Feeling tired in the new local daytime, and yet unable to sleep at night
- Waking in the new night, and unable to get back to sleep
- Feeling less able to concentrate or to motivate oneself
- Decreased mental and physical performance
- Increased incidence of headaches and irritability
- Loss of appetite and general bowel irregularities

The body clock

The body clock is located within the suprachiasmatic nuclei (SCN) of the hypothalamus. The retino-hypothalamic tract and the intergeniculate leaflet provide input pathways from the retina (photic signals) and other regions of the brain (non-photic) to the timekeeping cells of the SCN. These act as "Zeitgebers" or synchronizing agents for the endogenous rhythmicity that is usually somewhat longer than 24 h. A multi-synaptic pathway from the SCN leads to the pineal gland, where melatonin is secreted at night and suppressed by light.

Natural light is the predominant Zeitgeber for the body clock, though less bright, artificial light also exerts an effect. This means that light in the morning can advance circadian rhythms to earlier, and light in the evening can delay circadian rhythms to later. This concept, that of a "phase-response curve", provides the practical basis for timing light exposure to attain more rapid shifts across time zones going east (advance) or west (delay). Melatonin receptors are found on the SCN, which means that exogenous melatonin can also act as a Zeitgeber to shift the biological clock. The phase-response curve to melatonin is opposite to that for light: melatonin in the evening can advance circadian rhythms to earlier, whereas melatonin in the morning can delay circadian rhythms to later (Cajochen, Kräuchi, & Wirz-Justice, 2003). Additionally, melatonin has direct effects on thermoregulation, which may be the mechanism by which it induces sleepiness (Atkinson et al., 2003; Kräuchi, Cajochen, & Wirz-Justice, 2005). Vasodilation in the hands and feet occurs rapidly after melatonin ingestion during the day, or at the natural time of melatonin secretion onset in the evening, and warm hands and feet are the physiological "gate" promoting sleep onset. Conversely, the direct effects of light to inhibit melatonin secretion also lead to distal vasonconstriction, with a concomitant increase in alertness (Kräuchi et al., 2005). Light also promotes wakeful-

Table III. Recommendations for the use of bright light to adjust the body clock after time-zone transitions (from Reilly et al., 2005).

	Bad local times for exposure to light	Good local times for exposure to light
	Local time	Local time
Time zones to the west (h)		
3	02:00–08:00[a]	18:00–24:00[b]
4	01:00–07:00[a]	17:00–23:00[b]
5	24:00–06:00[a]	16:00–22:00[b]
6	23:00–05:00[a]	15:00–21:00[b]
7	22:00–04:00[a]	14:00–20:00[b]
8	21:00–03:00[a]	13:00–19:00[b]
9	20:00–02:00[a]	12:00–18:00[b]
10	19:00–01:00[a]	11:00–17:00[b]
11	18:00–00:00[a]	10:00–16:00[b]
12	17:00–23:00[a]	09:00–15:00[b]
13	16:00–22:00[a]	08:00–14:00[b]
14	15:00–21:00[a]	07:00–13:00[b]
15	14:00–20:00[a]	06:00–12:00[b]
16	13:00–19:00[a]	05:00–11:00[b]
Time zones to the east (h)		
3	24:00–06:00[b]	08:00–14:00[a]
4	01:00–07:00[b]	09:00–15:00[a]
5	02:00–08:00[b]	10:00–16:00[a]
6	03:00–09:00[b]	11:00–17:00[a]
7	04:00–10:00[b]	12:00–18:00[a]
8	05:00–11:00[b]	13:00–19:00[a]
9	06:00–12:00[b]	14:00–20:00[a]
10	Can be treated as 14 h to the west[c]	
11	Can be treated as 13 h to the west[c]	
12	Can be treated as 12 h to the west[c]	

[a]Denotes promotion of a phase advance.
[b]Denotes a delay of the body clock.
[c]Reflects that the body clock adjusts to large delays more easily than to large advances.

ness, not only through this mechanism but also directly through the sympathetic nervous system.

Circadian rhythms and the sleep–wake cycle

While the rhythm of core body temperature is regarded as a good marker of the circadian system, many other physiological functions exhibit such 24-h cycles. However, in addition to the body clock, many measures are also affected by the duration of prior time awake. This phenomenon is called the "sleep homeostat", and it is the interactions between the two processes that are important for behaviour. Performance measures tend to follow closely the rhythm in core body temperature.

Drust and colleagues (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005) pointed out that many indices of sports performance had both a 24-h component (which would be parallel to the rhythm in core temperature) in addition to a component synchronous with the sleep–wake cycle. These two components are desynchronized after travelling across multiple time-zones, so that a deterioration in exercise and any other performance is likely to accompany this disruption of the body clock with respect to sleep timing. Besides, the symptoms of jet-lag (particularly those due to loss of sleep) are likely to have a de-motivating effect that will in turn impair performance.

Factors affecting jet-lag

The severity of jet-lag depends on the number of time-zones crossed and on the direction of travel. Symptoms are felt more acutely after travelling eastwards than after travelling westwards due to the greater ease of effecting a phase delay (i.e. to follow the longer-than-24-h endogenous rhythmicity of the body clock by drifting later). Allowing one day for each time-zone crossed for travellers to adjust seems to accommodate most people irrespective of the direction of travel (Waterhouse, Reilly, & Edwards, 2004), in particular where strategies to accelerate the readjustment are respected.

Although there are differences between individuals in their sensitivity to jet-lag, these differences appear to be small. Physical fitness may be beneficial, due either to its sleep-promoting effects or its association with mental toughness to cope with subjective discomfort. Younger individuals (notably athletes) may have a capability to cope better with circadian desynchronization, while older travellers (notably support personnel) derive benefit from experience of previous trips. Surprisingly, the young experience greater sleepiness and performance deficits with sleep deprivation than the old – who are already slower during the day (Blatter et al., 2006). Habitual female travellers may experience secondary amenorrhoea but the lifestyle of female athletes entails frequent but not habitual travelling. Morning-type individuals would have a theoretical advantage in adjusting to eastward travel, and evening-types to a westward flight, but the majority of athletes are intermediate in chronotype (Waterhouse et al., 2004).

For time-zone transitions approaching 12 h (towards the antipodes), there is some evidence that splitting the journey into 2 days with an overnight stopover can lessen the subjective symptoms experienced (Reilly & Waterhouse, 2005). Such stopovers may not be feasible in the case of sports groups for logistic and financial reasons, or because of losing training opportunities. While travel strategies can be designed to deal with itineraries that are imposed on the athletes concerned, it is preferable to have a choice of departure and arrival times, and alternative carriers. Coping strategies are easier to implement when arrival times at destination are in the late afternoon or evening (Waterhouse et al., 2002a). In these cases, individuals have the opportunity to take a full sleep at night in the new time-zone sooner after arrival. Cultural differences in the country of destination do not affect jet-lag but the climate encountered may do so. A high environmental temperature can accentuate the dehydration following a long-haul flight due to the dry cabin air, and hypoxia at altitude could compound subjective discomfort for athletes travelling across time-zones to training venues at altitude.

Dealing with jet-lag

The trip should be planned so as to arrive a number of days before the competition. This period will vary in accordance with the number of time-zone transitions experienced. Strategies for minimizing the effects of jet-lag embrace activities pre-flight, while on board the aircraft, and following arrival in the new destination. Pre-flight factors include planning details of the journey and adjustment of the sleep–wake cycle in accordance with the direction of flight. Adjustment of more than 2 h in retiring to bed is counterproductive since this change is liable to cause rhythm disturbance and impair the quality of training undertaken before departure (Reilly & Maskell, 1989). Planning the trip can include the times during flight when sleep is attempted (see below) and what meals are taken and/or missed.

It has been suggested that once the aircraft is boarded, the travellers should set their watches and begin to live (eat and sleep) in agreement with the local time at destination (Waterhouse et al., 2004). The dry air on board the aircraft can cause a gradual dehydration that is not perceived by the body. Passengers are therefore advised to drink more than expected to counteract this added fluid loss. Water and fruit juices are recommended, and diuretics such as alcohol and caffeine discouraged. Periodically getting up to walk in the aisles, or do light stretching exercises, will alleviate joint stiffness and safeguard against deep vein thrombosis (House of Lords Select Committee, 2000). Compression stockings also have a protective effect against deep vein thrombosis. Sleep and naps during the journey should be attempted only if it is night at the final destination; if this is not the case, then conversation or investigating the in-flight entertainment is advised. Sleep may be assisted by wearing eye-shades and ear plugs and wearing loose-fitting clothing.

The more appropriate behaviour on arrival at destination will depend on the direction of flight, the number of time-zones crossed, and the time of arrival. Separate strategies can be devised for eastward and westward travel. Generic therapies such as massage may have transient value in reversing the effects of having been sitting in a cramped position but have no direct impact on the body clock. Similarly, there is little evidence for feeding programmes that promote protein intake in the morning and mainly carbohydrate in the evening to hasten adjustment to the new time; the timing of the meal to fit in with habitual routines in the new environment is more likely to help readjustment of the body clock than is the macronutrient content (Reilly & Waterhouse, 2005). However, carbohydrates in the morning appear to advance circadian rhythms compared with carbohydrates in the evening meal (Kräuchi, Cajochen, Werth, & Wirz-Justica 2002), so more research on this theme of food as Zeitgeber is required. Adequate fluid ingestion is recommended and caffeine can help in combating sleepiness when experienced during the day. Although this arousal effect of caffeine is beneficial during the day while the body clock is being readjusted, there can be unwanted effects of evening ingestion on recovery sleep (Beaumont et al., 2004). Exercise, especially outdoors if it is a sunny day, can also have a positive effect on arousal, but morning exercise should be avoided for a few days after an eastward flight when it could induce a counter-productive phase-delay response (Edwards, Waterhouse, Atkinson, & Reilly, 2002). In any case, exercise training should be taken at the time of day of the future competition, the sooner after the flight the better. During the first training sessions, maximal exercise and risky manoeuvres should be avoided to prevent injuries. Exercising outdoors also helps the body to adjust to the new environment (especially when temperature and humidity are high).

Although benzodiazepines and non-benzodiazepine soporifics have been advocated for inducing sleep, and some benzodiazepines may act as chronobiotics (change the phase of the body clock), their benefits are not universally confirmed. Jet-lag reported by British Olympic athletes after a 5-h time-zone transition westward was unaffected by ingestion of temazepam (Reilly, Atkinson, & Budgett, 2001). A similar ineffective treatment using zopiclone was reported for a French group making a westward trip of the same phase-shift to Martinique (Daurat, Benoit, & Buguet, 2000). Moreover, these drugs have myorelaxant effects that can last longer than the hypnotic effects and might be dangerous when exercising.

Melatonin is a special case. Its vasodilatory effects do promote sleep without having any marked effects on the sleep EEG (in contrast to benzodiazepines) (Cajochen et al., 2003). However, the purity of melatonin bought "off-the-shelf" and without prescription (where available) cannot be guaranteed. It can also have unwanted side-effects in some individuals (Reilly, Maughan, & Budgett, 1998). The position is complicated in so far as melatonin, and possibly some benzodiazepines, can act as chronobiotics. While such an adjustment using melatonin could be beneficial, it must be in the required direction (a phase advance or delay following a flight to the east or west, respectively).

For any chronobiotic drug, the direction in which the body clock is shifted depends on the time of ingestion. In practice, ingestion is normally in the evening in the new time-zone (to promote sleep), so this is appropriate for adjusting the body clock only after some flights. Experimental data as to a phase-shifting role in field conditions are lacking. In other words, the chronobiotic – as opposed to the soporific – value of these substances is unclear.

Athletes must be protected against the ingestion of drugs on the banned list of the International Olympic Committee and sports governing bodies. Hence, drugs such as modafinil, methylphenidate, and pemoline that are viable antidotes to fatigue in a civilian or military context have no place in treating the effects of sleep loss due to jet-lag.

Bright light also can adjust the body clock and it opposes the action of melatonin. Therefore, seeking exposure to natural daylight and avoiding bright light at the appropriate times is important in determining the rate of readjustment to the new time-zone. Again the timing of such behaviours is crucial and the phase-response curve to light should therefore be taken into consideration. Guidelines for the best and worst time for exposure to light are shown in Table II according to the direction of travel and the number of time-zones crossed. The availability of artificial indoor lighting should also be considered where these guidelines are being implemented; sitting near a window amounts to exposure to bright light, whereas sitting in a dimly lit room away from windows amounts to avoiding bright light.

Recommendations

The following recommendations are based on observations on elite athletes and other travellers (Reilly, Waterhouse, & Edwards, 2005; Waterhouse et al., 1997, 2002a). While travel strategies are best designed for specific journeys and activity schedules, general principles can be applied based on the direction of flight and the number of meridians crossed. A checklist for planning purposes was presented by Waterhouse et al. (2004) and is updated in Table I. Adherence to such forward planning should ensure that the individual arrives in good time at the point of departure, rested, and free of anxieties about the trip.

During the flight

Travellers are encouraged to prepare for their own comfort, as far as possible, in advance of boarding the flight. Tall persons flying economy class might enquire at check-in on the most suitable seats available for them. For all passengers, wearing appropriate loose-fitting clothing should contribute to comfort on board. Relaxation can be planned for the hours between meals and, depending on the timing of the flight, some meals can be missed. Emphasis needs to be placed on fluid intake, avoiding diuretics such as coffee and alcohol.

"Travellers' thrombosis" is now recognized as a risk when individuals are in a cramped position without activity for a prolonged period. Periodic activity, approximately every 2 h, can include isometric exercises, walks along the aisles or stretching exercises. Compression stockings have been advocated for preventive purposes. Drugs such as aspirin have anti-thrombotic properties but are not universally prescribed due to the possibility of side-effects in some individuals.

After travelling westwards

On long-haul flights westward, a short nap may be of benefit. The theoretical value of this short sleep is that it reduces the homeostatic drive towards sleepiness that initially occurs with an extended first day of travel.

A flight westwards requires a phase delay of the body clock. It is important to remain active during the daytime and avoid long naps. Napping can contrive to anchor the body clock to the time-zone departed and have a counterproductive effect (Minors & Waterhouse, 1981). Light exercise can have a positive benefit, help to maintain arousal, and offer transient relief of jet-lag symptoms (Edwards et al., 2002). Social activity and fitting in with local time can facilitate exposure to Zeitgebers, particularly the light–dark cycle, supporting the readjustment of the body clock and the restoration of normal circadian rhythms.

It is acceptable to retire to bed 1–2 h earlier than normal according to local time. Conversely, waking up may occur earlier than normal in the new time-zone. The changes in sleep–wake cycles are transient and normal sleeping patterns tend to be restored before the rhythm in internal body temperature returns to its normal circadian phase (Reilly et al., 2001).

After travelling eastwards

When travelling through the night, a period of quiet is scheduled by airlines to allow possibilities for sleep. Typically, flights eastwards from Europe to Asia and Australia are overnight. The most likely times for sleep coincide with night in the time-zone just left, but the most appropriate time is during darkness in the time-zone at destination. On long-haul flights eastward that total 20–22 h, travelling athletes tend to obtain about 4 h sleep in total (Waterhouse et al., 2004). Although the duration of sleep during flight is not correlated with jet-lag symptoms subsequently experienced, it does have a recuperative value (the homeostatic component) and possibly begins the process of adjustment to the new time-zone.

Adherence to the phase-response curve to light is a key to resynchronizing circadian rhythms after flying eastwards. In this instance, a phase-advance of the body clock is required. The strategy therefore is to exploit the positive effects of natural light, but only after the trough of the body temperature is reached. The problem arising after crossing many time-zones (e.g. 6–9 h) to the east is that a morning arrival may coincide with body clock time that precedes this trough. In such instances, use of light shades in the plane and dark glasses en route to the immediate accommodation can minimize light exposure and allow the traveller to retire to bed until late morning if necessary after arriving, having hurried to the new accommodation to do so. As Table II indicates, light exposure in the new afternoon is beneficial.

Based on the same chronobiological principle, morning training should be avoided for the first few days under these circumstances. In contrast, exercise in the late afternoon would be beneficial.

In flights eastwards over nine or more time-zones, it is possible that the body clock adjusts by means of a phase delay rather than a phase advance (Waterhouse et al., 2002a). This is more likely if there is exposure to bright light in the morning and/or the traveller is ingesting melatonin in the evenings before bedtime. For such eventualities, a behavioural and concerted light exposure/avoidance strategy can be implemented (see Table II). It must be realized that, on the day of arrival, minimum temperature and performance will be in the late afternoon (about 05:00 h by time in the departure zone). Adjusting the body clock by phase advance will cause this nadir to advance through the afternoon and morning. In contrast, if the body clock adjusts by delaying, then the nadir soon moves to the later afternoon and evening. These differences due to the direction of adjustment have implications for training and preparation for matches. They should be borne in mind when considering the timing of the scheduled competitive engagements.

Overview

These guidelines are designed to help travelling athletes and any accompanying support staff to adjust quickly to new locations after long-haul flights. They are based on chronobiological principles and an understanding of how the body clock operates. Knowledge of the underlying physiology provides an insight into the impact of travel on circadian rhythms, well-being, and exercise performance. To ensure quality of performance, travel strategies must be actively managed and sports organizations should recognize the likely negative effects of jet-lag on the performance of athletes. An effective education programme would enable travelling athletes to make informed choices about their travel plans and adopt appropriate behaviours to minimize discomfort. Modification of behaviour to suit the progressive adjustment to the new time-zone is preferred to using chronobiotic or soporific drugs. Since there is no physiological adaptation on repetitive time-zone transitions, each long-haul journey is unique and requires its own specific travel strategy, based on direction of travel, duration, and times of embarkation and disembarkation. Most important of all for competitive sport, is to allow a sufficient number of days in the new time zone to attain re-entrainment and thus facilitate peak performance.

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