

[Primary Care]

Jet Lag in Athletes

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Context: Prolonged transmeridian air travel can impart a physical and emotional burden on athletes in jet lag and travel fatigue. Jet lag may negatively affect the performance of athletes.

Study Type: Descriptive review.

Evidence Acquisition: A Medline search for articles relating to jet lag was performed (1990-present), as was a search relating to jet lag and athletes (1983-January, 2012). The results were reviewed for relevance. Eighty-nine sources were included in this descriptive review.

Results: Behavioral strategies are recommended over pharmacological strategies when traveling with athletes; pharmacological aides may be used on an individual basis. Strategic sleeping, timed exposure to bright light, and the use of melatonin are encouraged.

Conclusions: There is strong evidence that mood and cognition are adversely affected by jet lag. Some measures of individual and team performance are adversely affected as well.

Keywords: jet lag; athletes; travel; fatigue; circadian rhythms

International tournaments are an integral aspect of an elite athlete's career. Travel across time zones is regularly required of professional and collegiate athletes. Prolonged travel places a physical and emotional burden on athletes.⁵⁸

JET LAG AND TRAVEL FATIGUE

Jet lag is a recognized sleep disorder⁴ that is experienced after rapid travel across multiple time zones (transmeridian travel). It affects a large proportion of travelers who cross multiple time zones.⁶² The American Academy of Sleep Medicine defines jet lag as a syndrome involving insomnia or excessive daytime sleepiness following travel across at least 2 time zones.¹ It is associated with impaired daytime function and general malaise and may include other somatic complaints, such as gastrointestinal disruption in the days immediately following travel.¹ It is the result of the body's circadian rhythms being out of phase with the new local time zone.⁵⁸ Jet lag symptoms usually persist 1 day for each time zone crossed until the body realigns its circadian clock, regardless of direction traveled.⁶² Prolonged travel within a single time zone will not result in jet lag but can be associated with travel fatigue, which usually resolves in 1 to 2 days.⁶²

CIRCADIAN RHYTHMS

Circadian rhythms are endogenous cycles that last about 24 hours (the "body clock") but may last between 20 and 28

hours.¹⁶ Circadian control occurs in the suprachiasmatic nucleus of the hypothalamus. Many circadian rhythms have been identified, including core body temperature and behavioral rhythms, such as the sleep-wake cycle.⁷⁸ These cycles are synchronized (entrained) by the earth's 24-hour light-dark cycle⁷⁸ but persist in the absence of light and dark cues.¹⁶

The sleep schedule is primarily modulated by exposure to light and secretion of melatonin, which have opposite effects on circadian rhythm entrainment.^{16,63} Melatonin is derived from serotonin and is secreted by the pineal gland for 10 to 12 hours in the evening and helps to induce sleep.^{4,9,30,63} Light inhibits secretion of melatonin and stimulates arousal.^{4,63} In jet lag, the internal sleep-wake cycle is out of phase with the local light-dark cycle, causing drowsiness or arousal at "inappropriate" local times. The sleep-wake cycle recovers quicker (2-3 days) than do physiological cycles such as core body temperature, which may take 8 to 10 days to resynchronize.¹⁶ Management approaches for jet lag typically target the sleep-wake cycle but also seek reentrainment of key circadian systems for trips of greater length.

RISK FACTORS

There is little doubt that jet lag will affect some individuals more than others; however, the evidence defining which groups are at highest risk is lacking. Data specifically discussing risk factors in athletes are even more limited.

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Sleeping Habits

Flower et al found that travelers with more rigid sleeping habits had more jet lag symptoms than did those with less rigid sleeping habits.²⁶

Chronotype

Chronotypes influence how individuals are affected by jet lag.^{8,34} “Morning-type people,” who prefer to wake up early, have less difficulty flying eastward, while “evening-type people,” who prefer to wake up late, have less difficulty flying westward.^{8,34}

Physical Fitness

Higher levels of physical fitness allow people to adjust more quickly to changes in the sleep-wake cycle.^{29,64}

Sex

Jet lag tends to be similar in women and men with few exceptions. Men go to sleep earlier and experience less fatigue after traveling 10 time zones in an eastward direction.⁷¹ Male and female collegiate swimmers responded similarly to travel across 4 time zones (higher systolic blood pressure in men).⁴⁹ Frequent transmeridian travel can disrupt the menstrual cycle of female flight attendants,⁶⁷ though this effect has not been noted in athletes.

Travel Direction

The direction of travel affects the severity of jet lag symptoms. Travel across time zones, especially eastward, disrupts the diurnal rhythm.⁶³ As a result, symptoms of jet lag and sleep disturbances are worse after eastward flights than after westward flights.^{61,68} When one travels in an eastward direction, the length of the day is shortened, and the circadian system must shorten to reestablish a normal rhythm. The body demonstrates a natural tendency toward periods longer than 24 hours; therefore, eastward travel is more difficult because these periods are shorter.⁷⁴

The effects of eastward travel persist longer for athletes.⁴⁰ When travel is westward, symptoms peak in the first 3 days, while for eastward travel, the symptoms are more severe and persist for as long as 7 days.⁴⁰

Number of Time Zones

For athletes traveling westward—specifically, from United Kingdom to Florida—the rate of adjustment to the new time zone was equal to 1 day for each time zone crossed.⁵¹ This is consistent with findings for nonathletes traveling across multiple time zones in either direction.⁶² Australian netball players showed small but significant differences in score when traveling across as little as 2 time zones.¹⁰

Age

Age may influence the effect of travel.^{21,31,45-47,69,71} Older individuals may be less prone to symptoms of jet lag.^{69,71} However, middle-age men reported more fragmented sleep and less alertness than did the group of 18- to 25-year-olds after travel.⁴⁵ Those over 60 years have less regular circadian rhythms, lower body temperatures and melatonin rhythms,^{21,31,46} and greater difficulty coping with jet lag, especially traveling eastward.⁴⁵⁻⁴⁷

Time of Destination

Data suggest that local time of destination can play a role in jet lag symptoms. In a case series of 85 participants traveling eastward across 10 time zones, midday arrivals experienced fewer jet lag symptoms than did morning arrivals.⁷¹

Other Factors

A study of elite athletes traveling eastward across 10 time zones demonstrated that jet lag symptoms were less in those who had experienced the journey before. The symptoms were also less for those who had a shorter interval between their last full nocturnal sleep in the departure city and their first full nocturnal sleep in the destination city.⁷⁰

EFFECTS ON PERFORMANCE

Cognitive Performance

Disruptions of sleep and circadian rhythms can alter cognitive function in individuals.^{27,42,72} Mood and complex mental performance tasks deteriorate faster than do simpler mental performance tasks.⁵⁹ Mental performance is affected by sleep loss, which is directly associated with jet lag and time zone transitions.⁷³ Inattention and an increase in errors and injuries in the workplace are common.²² Athletes in international competitions immediately after time zone transitions demonstrated a decline in performance involving complex mental activities, with a feeling of lethargy and a general loss of motivation.⁵³

Physical Performance

There are methodological difficulties in demonstrating that jet lag impairs sports performance,⁵⁴ and as a result, the evidence is inconsistent. Physiologic parameters, such as heart rate, ventilation, and blood lactate, are associated with circadian rhythms.²⁴ Direct measures of physical performance, such as peak muscle force, anaerobic power output, and vertical jump, are also associated with circadian rhythms.⁵⁸ Despite this influence on performance tasks, no clear jet lag influence on individual athletic performance in competition has been shown.⁷⁷

Table 1. Medications used in the management of jet lag.

Drug	Typical Dose, mg	Notes	Banned by World Anti-Doping Agency ⁷⁵
Melatonin	0.5-5	Minimal “hangover” effect, quality uncertain	No
Caffeine	200-1000	Palpitations, hypertension, restlessness possible	No
Zolpidem	10	Minimal effect on cognitive performance, some daytime somnolence possible	No
Modafinil	200-400	May decrease psychomotor performance, anxiety possible	Yes

Swimmers demonstrate decreases in arm and elbow flexion strength as well as sprint times after prolonged eastward travel.⁷⁶ British Olympic athletes showed a decrease in leg and back strength as well as choice reaction time when traveling westward across 5 time zones.⁵¹ Collegiate swimmers traveling across 4 time zones did not demonstrate negative physiologic, perceptual, or affective changes during heavy training.⁴⁹ Furthermore, skeleton athletes traveling from Australia showed no change in performance, despite alterations in saliva cortisol concentrations before and after air travel.¹²

Despite these contradictory findings, jet lag appears to have a significant effect on performance in most situations. The longer an athlete is engaged in an activity, the more likely the performance will be influenced by sleep loss.⁷³ An athlete’s circadian rhythms are optimal for performance in the early evening, when reaction time to light and sound is the fastest; the evening is the time of day when the majority of world records have been broken.^{5,6,33,53} Interestingly, activities that require fine motor control and accuracy, such as hand steadiness and balance, are best in the morning.⁷

Team Performance

National Football League data suggest that circadian rhythms and travel across time zones may affect overall team performance. West Coast teams consistently beat East Coast teams in evening games. This effect seems to be amplified in the later stages of the game.⁶⁵ Conversely, a retrospective study showed that eastward travel adversely affects National Football League teams.³³ However, successful teams and highly motivated athletes are less affected by physical and psychological factors of “home field advantage” and jet lag symptoms.³³

TREATMENT

Pharmacological (Table 1) and nonpharmacological treatment options minimize symptoms of jet lag and travel fatigue. Full adaptation to the new time zone is not always recommended, especially in the case of short trips (1-2 days). Individuals are unlikely to fully adapt to the new time zone over a day or

two.² When travel across time zones is for longer than 3 days, circadian adaptation is typically recommended.²

Pharmacological

Melatonin. Melatonin is intimately involved in the body’s circadian regulation of sleep.[‡] A recent Cochrane review³⁰ concluded that exogenous melatonin use is effective in preventing and treating jet lag and that short-term use appears to be safe. The review recommended melatonin for adults traveling across 5 or more time zones; it may also be of use in travel across 2 to 4 time zones as well. Doses of 0.5 to 5 mg were similarly effective; higher doses were more effective at inducing sleep. There are minimal “hangover” effects on physical performance the day after administration.³ Melatonin also acts as a chronobiotic⁴ and may shorten the time needed for reentrainment after travel.^{9,50} It contributes to phase advancement when taken in the evening (eastward travel) and phase delay when taken in the very late evening or morning (westward travel).⁴¹

Athletes should seek medical advice before taking melatonin for jet lag; melatonin product quality may be a concern.^{16,56} It should be avoided by high-risk populations, such as children and pregnant and lactating mothers.⁵⁶

Sleep aids. Hypnotic sleep aids reliably reduce insomnia secondary to jet lag.^{19,23,32,38,51} Their effectiveness has been questioned in at least one study.⁵¹ Benzodiazepines improve sleep quality³⁸ but may impair performance well into the following day.²⁸ Shorter-acting medications, such as zolpidem and zopiclone, may be effective while limiting the hangover effects the day after administration.^{32,66} Zolpidem may be more effective than melatonin and placebo at counteracting jet lag symptoms; the use of both medications together was not more effective than zolpidem alone but did increase daytime somnolence.⁶⁶ Selective usage of shorter-acting sleep aides has been recommended for athletes who previously tolerated the medication well and have persistent insomnia.⁵⁶

[‡]References 3, 4, 9, 16, 41, 50, 56, 63.

Stimulants. There is a potential benefit for these medications in the management of jet lag;⁶² however, routine use in athletes is not recommended, because most stimulants are banned substances in competition.⁷⁵ In nonathlete populations, modafinil is a potential off-label short-term treatment for jet lag.³⁶ It has been approved for excessive sleepiness associated with narcolepsy.³⁵ It is a banned substance for athletes⁷⁵ but could be considered for daytime sleepiness of coaches or support staff traveling with the team.

Caffeine increases daytime alertness in jet lag⁹ and may accelerate entrainment in new time zones when consumed in the morning.⁵⁰ Late-afternoon ingestion of caffeine may interfere with sleep induction.⁹ Caffeine maintained performance in hand grip strength, squat, and multiple jump when compared with placebo after an eastward flight of 7 time zones.³⁷ While not banned by World Anti-Doping Agency, caffeine is a monitored substance,⁷⁵ so athletes should be advised to use caution and moderation.

Nonpharmacological

Behavioral strategies before, during, and after the flight may advance or delay the sleep-wake cycle.^{15,55}

Preadaptation and bright light therapy. Light exposure is the primary cue for circadian rhythms. Exposure to bright light of adequate intensity and duration can advance or delay circadian rhythms, depending on the timing of exposure.¹⁷ Bright light exposure in the morning will advance the body clock, while exposure in the late evening will delay it.^{18,44} Attempts to shift the circadian rhythms with preflight exposure to bright light prior to departure have been successful in both eastward and westward travel.^{13,20} Exposure to natural bright light promotes circadian shifts.^{11,73}

Advancing or delaying sleep schedules with bright light is usually not practical or effective when trying to advance several hours, traveling westward, or arriving late.^{33,54} These techniques require careful compliance by avoiding unwanted light exposure, evening social nightlife preflight, and last-minute packing.² Bright light in the morning after eastward travel and in the evening after westward travel may be beneficial after crossing up to 8 time zones.⁶²

Diet. Manipulating diet may have a role in shifting circadian rhythms; ingesting a high-protein breakfast will promote arousal and wakefulness in the morning, and a high-carbohydrate dinner will promote sleepiness in the evening.^{39,77} Military personnel utilized the Argonne diet and alternating fasting and feeding periods to successfully mitigate symptoms of jet lag across 9 time zones.⁶⁰ The Argonne diet is largely impractical for athletes. The timing of the meal in a new environment appears to be more important than the type of meal.⁵⁷ Limiting ingestion of diuretics such as caffeine and alcohol in flight and drinking plenty of fluids may decrease the severity of jet lag and travel fatigue as well.^{52,62,71}

Sleep. Sleep can be used to prehabituatate the circadian rhythm before travel or decrease symptoms of sleepiness upon arrival. Shifting the sleep schedule 1 to 2 hours toward the destination time zone in the days preceding departure may shorten the duration of jet lag.^{52,62}

Strategic napping has also been discussed as a potential method to mitigate the symptoms of jet lag. Long naps in the new time zone when the athlete would have been asleep in the departure time zone may slow the adjustment to the new local time and may anchor the athlete to one's home time zone.⁴³ The best time to nap (in flight or postflight) is nighttime in the destination time zone.⁵⁹ "Power naps" (20 minutes) do not result in sleep inertia and may decrease daytime sleepiness in those with jet lag.^{16,62}

Exercise. Exercise affects the circadian rhythms of core temperature and heart rate and may ameliorate jet lag.¹⁴ A timed exercise to resynchronize the sleep cycles of marathon runners did not support this theory.⁴⁸ A review concluded that exercise cannot reliably shift the circadian rhythms but may maintain arousal level after travel.²⁵

CONCLUSION

Prolonged travel imparts a physical and cognitive toll on traveling athletes and may adversely affect performance in competition. Mood, cognition, and some measures of performance are adversely affected by jet lag and circadian disruption.



Clinical Recommendations

SORT: Strength of Recommendation Taxonomy

A: consistent, good-quality patient-oriented evidence

B: inconsistent or limited-quality patient-oriented evidence

C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
Behavioral approaches for jet lag are favored when traveling with athletes. ⁵²	C
Pharmacological aides should be used judiciously and on an individual basis when treating the symptoms of jet lag and travel fatigue in athletes. ⁵²	C
Before Arrival:	
Shift bedtime 1 to 2 hours closer to the destination time zone in the days prior to departure to shorten the duration of jet lag. ^{52,62}	B
Drink plenty of water and limit intake of diuretics such as alcohol and caffeine on the plane. ^{52,62,71}	C
Consider napping during the flight if it is late evening (time for sleep) in the destination time zone. ⁵⁹	B
After Arrival:	
Consider a short strategic nap (20-30 minutes) to decrease sleepiness, particularly when traveling westward. Prolonged napping may interfere with accommodation to the new time zone. ^{16,62}	B
Increase exposure to bright light in the arrival time zone to shorten the duration of symptoms. ^{11,17,44} When traveling westward, seek bright light in the evening. When traveling eastward, seek bright light in the morning. ^{18,44,62}	B
Melatonin in the evening will help induce sleep. ³⁰	A
For trips longer than 3 days, melatonin the first few days after travel will facilitate adaptation to the new time zone. When traveling westward, take melatonin in the morning; when traveling eastward, take it at local bedtime. ^{9,30,41,50}	B
Shorter-acting sleep aids (zolpidem) may be used for refractory sleeplessness in athletes who have previously tolerated the medication. ^{32,56,66}	A
Caffeine during local morning will increase alertness and decrease sleepiness. ^{9,50} Late-afternoon or evening caffeine may interfere with nighttime sleep. ⁹	A
Limit the difficulty and complexity of training for the first 1 to 2 days after arrival to limit the risk of injuries. ²²	C

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