Optimal Prevention/Recovery Plan to Increase Physical Performance for Individuals Experiencing Jet Lag

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Abstract

Airline travel is a key global industry that has advanced tremendously since the growth of the mass long-haul jet airlines in the 1960s (Dodge & Kitchin, 2003). Since then, it has become the most common means of transportation and has made traveling to far-away destinations accessible. According to Boeing, there were 50.9 million logged hours for commercial jets and 2.8 billion passengers recorded worldwide in 2011 (Generates, 2007). Commercial airline travel offers people a chance to explore new destinations, while experiencing several hours of shifts in time zones. Physiological adjustments occur during time-zone changes, causing adverse effects on the body due to the disruption of the circadian rhythm. Jet lag causes physiological damage on many levels, leaving passengers with little recourse to combat the elements that travel exposes to the body. This article attempts to clarify details of jet lag, including the disruption of the biological clock and the symptoms experienced by passengers, and offer preventive strategies to eliminate the threat of jet lag to those who expect to maintain their unique performance levels. With the numbers rising into the billions, travelers deserve more research on how to maintain proper function and quality of life while on the road.

Jet Lag

Jet lag is a circadian phase disruption that occurs when an individual experiences an adjustment to the external cues that synchronize the body clock and drive biological circadian rhythmicity due to rapid air travel across one or multiple time zones (Dragoo & Leatherwood, 2012). Medically referred to as desynchronosis, jet lag affects mental attention and physical performance. Symptoms affecting the mental-attention aspect of the brain include a twisted sense of space, distance, or time. There are a number of general physical symptoms that are associated with jet lag, including:

- Fatigue
- Anxiety
- Disruption of sleep
- Loss of appetite, concentration, and motivation
- Dehydration
- Headaches
- Nausea

Physical symptoms of jet lag that pose more danger include:

- Discomfort in the back, legs, and feet—deep venous thrombosis due to reduced blood flow
- Pulmonary emboli, which may increase the risk of hypoxia
- Gastrointestinal distress
- Susceptibility to illness
- Metabolic changes
- Impaired mental and physical performance
- General sadness and depression or other psychiatric disorders

The latter symptoms do not occur for every individual, and will affect each individual in a particular way depending on how well or how poorly their body adjusts to a change in time zone. Jet-lag symptoms occur in a time change of as little as one hour, but are most prevalent with a time zone shift of three hours or more (Dragoo & Leatherwood, 2012).

When an individual experiences jet lag, his or her biological clock, or circadian rhythm, is affected. Circadian rhythm is defined as daily biological rhythms that have maximum or minimum function at certain times of the day (Dragoo & Leatherwood, 2012). They are synchronized to the 24-hour light-dark cycle. Oscillators, or regulators, that are located in most human cells are controlled by a central oscillator, or "body clock" that dwells in the hypothalamus (Dragoo & Leatherwood, 2012). The hypothalamus acts as an "alarm clock" that indicates body functions such as hunger, thirst, and sleep. Environmental cues trigger the hypothalamus to send out these alarms, in the form of cortisol, to the body. The hypothalamus also controls certain rhythms at a steady state without the need for environmental cues, such as regulating body temperature, blood pressure, and levels of hormones and glucose in the bloodstream. When the body is determining the time of day, the fibers in the optic nerve of the eye transmit perceptions of light and darkness to a "timekeeping center" within the hypothalamus. Thus, when the eye of an air traveler perceives dawn or dusk at a much earlier or later time than that to which the body is adjusted, the hypothalamus may trigger certain actions in the body that it is not anticipating; this is when jet lag occurs (Cunha, 2014).

How the Internal Circadian Clock Works

As stated earlier, people are affected differently when shifting time zones, and the severity of the effect depends on their individual biology. In an article in the educational journal *Genes and Development*, scientists discussed the role genes play in relation to one's circadian clock. They found four proteins— Cryptochrome, Period, CLOCK, and BMAL1—that are coded by four genes. These genes that work together to control the cyclical changes in an individual's physiology, such as blood pressure, body temperature, and rest-sleep cycles by a feedback-loop mechanism that keeps cells in proper physiological rhythm. The CLOCK and BMAL1 bind to a pair of genes called Period and Cryptochrome, turning them into express proteins. These express proteins are degraded, which allows the circadian clock to begin due to the two proteins suppressing CLOCK and BMAL1 activity. By targeting these proteins, scientists are able to therapeutically address the way genes generate daily rhythmicity (Dutta, Nayak, Agrawal, Subramanian, & Bhas, 2014).

Research Studies on Jet Lag

Studies have proven jet lag's deterioration on overall performance of activity of any kind, and the entire body in general. In a study of 12 national-team athletes (Dragoo & Leatherwood, 2012), their jumping performance was assessed the day they had arrived post-travel and then again two days following their arrival at a location with a three-hour time zone difference. The researchers concluded that their jumping peak and mean velocities improved remarkably for their second test (two days after arrival). In another study, data of team performance from Major League Baseball players over 10 years were assessed, and researchers found that for every time zone that is crossed, a 24-hour recovery period is required to obtain optimal performance. Those traveling over fewer time-zones performed significantly better than those traveling over more time-zones, with a winning percentage of 60.6 percent in comparison to 30.2 percent (Dragoo & Leatherwood, 2012). This data is a great example of a positive correlation between the effect of jet lag and its detriment on performance.

In addition to the number of time zones crossed affecting the body's physiology and overall performance, the direction of air travel has been proven to have an effect on level of performance

(Pelotonen, Rusko, & Tikkanen, 2004). Some have shown that traveling eastbound is associated with higher-intensity symptoms, which causes a longer required recovery time; therefore, the athlete's peak performance is delayed much longer than "normal." On the other hand, other studies have shown that traveling westward is more detrimental to physical performance due to the gaining of additional hours, resulting in performing at a time that is typically much later than that to which the body is accustomed (Pelotonen, Rusko, & Tikkanen, 2004). With this being said, it may be beneficial to attempt to adjust the body's clock a few days prior to any type of physical performance in a different time zone. By slightly changing normal sleep patterns prior to plane travel, passengers, depending on the direction of travel, can adjust their bedtime schedule. If traveling westward, one can go to bed later and wake up later than their normal sleep schedule in order to prepare their body for the time-zone shift. If traveling eastward, one can go to bed earlier and wake up earlier than their normal sleep schedule in order to prepare their body for the time-zone shift.

Jet Lag and Athletic Performance

Jet lag and its effect on athletic performance need to be examined more diligently on individuals who are required to use air travel as a means to participate in sporting events. Various physiological techniques can provide the athlete with a way to combat jet lag. Athletes have a sensitivity to the disruption of their circadian clock due to the fact that they are more in-tune with their bodies in comparison to a person who does not participate in regular physical activity. There is also a need for optimal performance in areas such as neuromuscular function and maximal oxygen uptake while competing away from home (Dudley, Vadgama, Cook, & Drawer, 2012).

Clearly, the hassles of travel must be accommodated for in the preparations for a trip. Environmental factors such as acclimation and temperature differences may be a concern for individuals if combined with jet-lag symptoms. Athletes' primary focus is on their physical performance, but there is a need to consider the implications of acclimation planning (Fuard & Milne, 2007).

Experiential Jet Lag Case Study

In the interest of "real world" experience, one of the authors of this peer-reviewed article traveled with a group of eight individuals to Cambodia, which is 13 time zones away. After researching and comparing results of several peer-reviewed articles on the subject of jet lag, evidence points to the lack of oxygen saturation as being the strongest physiological change that affects travelers. This was apparent while traveling and monitoring five of the eight passengers to Cambodia, due to the fact that there was a significant loss in oxygen saturation during the longer flights, which were 13-hours, as opposed to the two- to three-hour flights.

The second physiological response the body experiences during travel over different time zones is disruption of the circadian rhythm. Statistically, the significant reduction in oxygen saturation is the culprit in passengers experiencing dizziness, headaches, or fatigue due to cabin pressures acclimated at or above 8,000 feet. Cabin pressure at 8,000 feet is also known to cause the body to dehydrate; within one hour, a typical loss of water in the body can be measured to about a half a cup (Kravitz, 2008). By diligently gathering information from the actual experience, the author found that the use of a thermometer, blood pressure gauge, and a pulse oximeter showed results similar to those seen in research articles. After exposure to long-haul flights, the five individuals monitored by the author experienced a drop in core temperature and at least a 4 percent drop in oxygen saturation due to the variables of air travel. Oxygen saturation was by far the most notable area that had a significant decrease.

Cabin pressure correlates with certain symptoms of jet lag, such as dehydration, headaches, nausea, anxiety, and discomfort (Humphreys, Deyermond, Bali, Stevenson, & Fee, 2005). Although speculation surrounds eastbound travel as having more physiological consequences, travel in any direction exposes commuters to symptoms similar to jet lag. This is due to sheer exhaustion from the basic necessities of catching flights, dietary issues causing lack of required nutrients, and other anxiety-provoking details that may be encountered as travelers make their way on their journeys. Situational stress accumulates and begins to resemble symptoms of jet lag.

Decline in O_2 Saturation

To apply the variables discussed in the research, we began experimenting with temperature, blood pressure, heart rate, oxygen saturation, and psychological questionnaires prior to, and following, air travel to Cambodia. These results showed that high altitudes affect a person's body considerably. The percentage of saturation of hemoglobin with oxygen determines the content of oxygen in the blood. At sea level, most oxygen-saturation levels are between 97 and 100 percent. After the human body reaches around 7,000 feet above sea level, the saturation of oxy-hemoglobin begins to plummet. The saturation can decreased to as low as 49 percent, as seen on Mt. Everest, for example. However, the human body has both short-term and long-term adaptations to altitude that allow it to partially compensate for the lack of oxygen (Humphreys, Deyermond, Bali, Stevenson, & Fee, 2005). Athletes are able to use these adaptations to aid their performance.

There is a risk of hypoxia at greater flying altitudes of 10,000 feet or higher, resulting in the possibility of increased detrimental effects on the body's system. Jet lag stimulates the sympathetic nervous system due to an increase in the breathing rate; it elevates the heart rate and reduces the stroke volume, possibly predisposing coronary patients to angina and arrhythmia (Heyward, 2010). Those who experience deep vein thrombosis and pulmonary embolisms are often individuals with existing heart or lung conditions. Those who suffer from these types of health problems are encouraged not to fly, especially at higher cabin pressures.

Blood pressure, heart rate, and oxygen saturation were measured on all participants during the case study before and after flights to assess any physiological effects placing stress on body functions. Between low body temperatures and low oxygen-saturation scores, all five participants exhibited significant signs of jet lag. The test was structured to measure vital signs that would help identify symptoms and show to what degree each participant's body would respond. This project provided a hands-on experience of the real impact of jet lag on an athlete's body. Tools used during these tests were a pulse oximeter, thermometer, and a blood-pressure device. Several questionnaires explored the psychological aspects of the symptoms, offering estimated accounts of each individual's experience. These experiences included tracking physiological and behavioral responses that supported the need for preventive strategies for individuals who travel by air.

Sleep Disturbance and Dehydration

During transcontinental flights, individuals experience difficulty in their sleeping patterns. These disturbances can develop into anxiety, depression, sleep apnea, and digestive dysfunction. Short naps are essential for the recovery of sleep deprivation. Long naps exacerbate jet lag because the circadian clock becomes tricked into thinking it is bedtime when in fact it is daytime. These flights are also known to have cabin pressures at about 10,000 feet that cause the body to lose an enormous amount of respiratory fluids from the mucous membrane, which can be replenished by drinking more than 200 mL of water every hour and a half. After acquiring and assessing the physiological data collected prior to, during, and after all flights, it was expected that jet lag would occur on the return flight eastbound. This assumption was correct, as three out of five participants experienced severe jet-lag symptoms that lasted for more than seven days. The remaining two participants experienced jet-lag symptoms but the symptoms were much less severe in comparison.

Ways to Survive Jet Lag

Jet-lag symptoms are the downside to air travel, as most travelers will experience a significant loss of energy. Research is dedicated to providing an intervention guide to remedy the symptoms that millions of commuters typically endure. Not all travelers experience symptoms of desynchronosis, but those who are affected are at risk of loss of work days, loss of vacation days, and a propensity of decline in athletic performance depending on the person, the situation, and his or her body's response to jet lag (Reilly, 2009). Scientific studies have come to an understanding that exposure to cabin pressure causes lack of oxygen to varying levels through several time zones. Data from a study in the UK informs the public of the danger of high cabin pressures and the drop of oxygen that has an effect on the body, especially for individuals with heart and lung conditions. Potential hazards and medical concerns of jet lag and its severity are increased for passengers who have heart or lung conditions. Further readings suggest that not all individuals experience symptoms of physiological distress and, for some unknown reason, these individuals maintain a hardy disposition. Knowing that the hypothalamus is influenced by the optic nerve, science has the opportunity to delve deeper into preventive strategies to assist globetrotters around the world (Dutta, Nayak, Agrawal, Subramanian, & Bhas, 2014).

Melatonin and the Effects on the Biological Clock

Melatonin has been widely studied as a jet-lag remedy and sleep aid, and is a commonly accepted part of effective jet-lag treatment. The latest research shows that melatonin aids sleep during times when a person would not normally be resting, making it of particular interest for people with jet lag. The body treats melatonin as a darkness signal, so it generally has the opposite effect of bright light. The time at which an individual takes melatonin is important. If the person is trying to reset the body clock to an earlier time, such as after flying east, he or she should take melatonin in the evening. If the person trying to reset the body clock to a later time, such as after flying west, melatonin should be taken in the morning. Doses as small as 0.5 mg seem just as effective as doses of 5 mg or higher, although higher doses have been shown in some studies to be more sleep promoting. If a traveler is going to use melatonin, it should be taken 30 minutes before he or she plans to sleep. It may also be a good idea to ask a doctor about the proper timing (Bauer, 2013).

Preventive Techniques Suggested for Jet Lag

- Exercise and conditioning – a fit individual experiences less fatigue
- Brief naps prior to, during, and after a trip – builds the immune system
- Shift the sleep cycle – tricks the biological clock
- Avoid dehydration from air travel – a pressurized cabin is a dry environment, depleting the body of half a cup of water hourly
- Limit stress – by performing diaphragmatic or basal breathing exercises

- Maintain good nutrition – by eating healthy, balanced nutritional meals that include protein, carbohydrates, and iron
- Move around during flights – this will help with circulation issues that result from immobility

An Optimal Recovery Plan for Preventing Jet Lag—For Eastbound Travelers

- *Before leaving:* Two days prior to flying, try to change sleeping tactics by getting in bed one to two hours later than usual, and then getting out of bed one to two hours later than usual (Lemmer, Lohrer, Kern, & Nold, 2002). Take time to nourish your body appropriately, keeping up your intake of fluids. For the most optimal traveling experience, your fitness regimen is an important indicator to how your body perceives stress. A workout will facilitate a less traumatic physiological response from flying long hauls.
- *On the plane:* Try to sleep once the first meal is delivered and removed. Drink plenty of water. Resist caffeine and alcohol. Move about whenever possible, stretching the legs, feet, and arms. When you board your flight, bring along a few healthy snacks to rely on if you find yourself hungry and needing fuel. The use of an eye pillow and ear plugs will allow an individual peace and quiet. Hydration is of the utmost importance due to the fact that, as stated before, passengers lose a half a cup of water each hour while flying. With cabin pressures above 8,000 feet, this leads to extremely dry air.
- *After arrival:* Depending on arrival times, you will need to adjust your cognitive appraisal and appropriately join in on what time of day it is where you are located. Stay awake if it is daytime, and go to bed at dark. Avoid afternoon naps. Light exercises are recommended for quicker adjustment strategies (Dodge & Kitchin, 2003).

For Westbound Travelers:

- *Before leaving:* Two days prior to flying, try to change sleeping tactics by getting in bed one to two hours earlier than usual, and then getting out of bed one to two hours earlier than usual (Lemmer, Lohrer, Kern, & Nold, 2002). Take time to nourish your body appropriately, keeping up your intake of fluids. For the most optimal traveling experience, your fitness regimen is an important indicator to how your body perceives stress. A workout will facilitate a less traumatic physiological response from flying long hauls.
- *On the plane:* Try to sleep once the first meal is delivered and removed. Drink plenty of water. Resist caffeine and alcohol. Move about whenever possible, stretching the legs, feet, and arms. When you board your flight, bring along a few healthy snacks to rely on if you find yourself hungry and needing fuel. The use of an eye pillow and ear plugs will allow an individual peace and quiet. Hydration is of the utmost importance due to the fact that, as stated before, passengers lose a half a cup of water each hour while flying. With cabin pressures above 8,000 feet, this leads to extremely dry air.
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