

# Module 4. Return to training sessions and competitions. Strategies for planning the team's trips.

## Unit 4.1 Return to play: decisions to return athletes to competition.

Dr. Ricard Pruna

### Introduction

Injury management is an essential aspect in sports medicine. The process's final stage, where decisions are made about the moment players should return to training and, what is more important, the moment they can return to play, is a key stage in the process called return to play or return to competition (RTP). It is stated that players return as soon as possible, so they can contribute to the team's performance without losing competitive attributes. At the same time, it is important that the return is not premature, since it can cause setbacks in the recovery process, injury relapses and a probability for additional injuries.

The return to play decision is complex and multifactorial; the challenge is to play under the science standards, while finding a balance between the player's interests and the team's interests.

Besides, the relationship among the coach, the athlete and the medical staff should be based on trust for making decisions altogether.

**RTP in practice** implies **a constant learning**; it is a process that is improved by the experience and the consideration on how to combine the best quality, the research and the clinical evidence (McCall et al., 2016).

What does the current philosophy for the decision-making process consider?

Taking the last scientific publications into account, the RTP specific study has had a limited advance. That is stated in the following article: "Return-To-Play Criteria after Hamstring Injury: Actual Medicine Practice in Professional Soccer Teams "(2014), by Delvaux, Rochcongar, Bruyère, among others, in which they give details about criteria that are usually used by doctors for determining the player's ability for returning to the sports practice.



At present, only a few studies appropriately deal with the situation and are focused on the sports reality. In relation to that, the following article is quoted: "Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention "(2010) by Heiderscheit, Sherry, Silder, among others.

This leads us to two key questions:

- a) How do we assess RTP nowadays?
- b) How shall we understand the RTP process? Is RTP studied simply as a static process with a series of parameters that should be followed and met when the injured athlete has gotten to the final stage or is it a decision making process that is constantly dynamic, adaptable, modifiable and creative?

Each decision from the beginning of the injury process affects the final RTP criteria. The first decision leads to the next one and the process becomes a decisions' network that implies a feedback where the different variables interact. But, which are those variables?

- 1) A correct and precise diagnosis based on the biological properties of the damaged tissue.
- 2) A strict control of the physical load during the recovery process.
- 3) A well planned management of factors that are modifiers of the sports risks and modifiers of each decision.

In order to fully understand and deeply explain these variables, it is important to emphasize that RTP must be understood as a dynamic and personalized process.

The main aim is to reduce the risk of new injuries and not to understand the RTP exactly in time terms. During a dynamic process, there are a lot of different factors that interact and modify the final result.

### **1) A correct and precise diagnosis based on the biological properties of the damaged tissue**

A common and serious mistake in RTP is the incorrect diagnosis. This is related to incorrectly and poorly planned decisions about the injury, which influences the final results (Orchard et al., 2005). As a consequence, it is important to understand that the RTP decision-making process is influenced from the beginning of the recovery process. A correct diagnosis is the most relevant step in the RTP; in fact, is the process's cornerstone. We cannot base decisions only on a magnetic resonance or on data obtained by GPS (technology applied to football, global positioning system that analyzes the athlete's strength and speed parameters), but we should consider all the parts together with the clinical symptoms and understand that they are all important components in the decision-making process. More and more, internal load's components as sleep's quality and quantity, stress, mind-set and nutrition are in interaction in the RTP process.

Regarding the diagnosis, many variables should be taken into account when dealing with professional athletes: the anatomic variation and the different healing ability in connective tissues, such as the tendon, the muscles and the fascias. This is stated by W. E. Garrett Jr., in his article "Muscle strain injuries "(1996), and by Voleti, Buckley, and



Soslowsky, in “Tendon healing: repair and regeneration ”(2012). Such variables are important for defining how the recovery process and the return to competition after a muscle injury are dealt with and planned (Miller et al., 2009).

As a consequence, we should take into account that tendon healing is very different from a muscle repairing. It is also important to make a difference between a first time injury and the relapsed one, which can trigger a chronic problem in the player.

It is essential to make a difference between the recovery process in relation to the exact injured player’s needs and to carefully control the rehabilitation progress, and the impact that an injury could have had on the physical condition, the cognitive qualities and the special and specific mobility for its sports activity; anyway, it is also relevant to provide advice on nutrition and on lifestyles that can improve the recovery process. Likewise, it is the medical staff’s responsibility that players do not take harmful or forbidden substances when they want to facilitate the RTP.

Even though the RTP range of definitions is wide, the most appropriate concept for its definition is the total availability for training and playing matches (Müller et al., 2014). Besides, the training stage should be understood as part of the recovery process, where the player can receive the medical permission or discharge, but not the competitive one. There are several aims to consider before making the decision of playing again. These aims include the following:

- To achieve a preinjury physical-competitive level.
- To complete a rehabilitation program.
- To achieve a complete activity and availability for intense training sessions.

What does achieving a preinjury level mean? Is it a point where the player is always 100% healthy? What can be shown when the player in the preinjury level was healthy and free of injuries? (Askling et al., 2006)

Taking into account the preinjury level, it is important to understand if this situation was a possible injury risk factor. Often, the preinjury level is part of a poor adaptation process to training and competition, which could indicate that the player was already at risk.

Would it have been less likely that the player suffer any injury if his/her preinjury condition had been better? Was there an indication that the player was at risk for suffering a specific injury? Was the injury related to a loss of strength? And if the player had deficits in muscle strength, which was the cause?

**There are several possible factors that could cause players to end up having a higher risk of injury. The type of injury, their biology, the reason behind the strength deficits and the loss of cognitive agility are the key factors for determining the recovery process and the RTP (Askling et al., 2006)**

## **2) The personalization in the training loads is the second key component in the RTP.**

The sports area has become more scientific and it requires that players and coaches adapt quickly to the “new sports”. Some training strategies and methods are obsolete. Most



exercises, included as secondary prevention, have no preventive effect and, on most occasions, they only overload muscles. As a consequence, it is essential to discuss the change in the concept of prevention. The goal should not be seen as prevention per se, but the adaptation concept should be introduced. The muscle overload injury should not be understood as the healthy tissue's mechanic alteration, but as a series of aberrant adaptive responses which, in time, will not allow the tissue to adapt to the load increase and stress.

There have been several advances in understanding the human body's functions. This has led to the development of new methods and ideologies in relation to training structure, type and intensity, with the goal of maximizing sports performance, but, at the same time, of keeping the player's health. Medical staffs should do everything they can to improve their multidisciplinary functioning and understand decisions made by players. Educating all the ones interested and related to a specific player's rehabilitation development highlights the practical implications and a benefit for them.

A static assessment on a player's skill, regardless the specific sports environment, is a current mistake and a new challenge that sports doctors should face. The important information no longer derives only from the doctor's office. Besides the clinical exam and the magnetic resonance, many medical and technical staffs consider it is important to use a GPS when they personalize the injury progress and they get a solid framework for validating RTP and load management for soft tissues. As it is stated by Hallén y Ekstrand in "Return to play following muscle injuries in professional footballers "(2014), and by Järvinen, Kääriäinen, Järvinen, and Kalimo, in "Muscle strain injuries. *Current Opinion in Rheumatology*"(2000).

Technology for controlling working loads provides a big amount of data and doctors should assess on what could be useful for determining the personalized profile, which is the profile obtained after collecting data of each training and the one that reflects the moment where the player is really healthy and in an optimal physical state. There are different profiles inside a team: a profile with predominance in acceleration, with deceleration or with a combination of both. This implies that there will be different RTPs that depend on the player's specific skills. Variables collected daily on training sessions and matches will help to give shape to the player's state, where the most important ones are acceleration, deceleration, high-speed running (HSR), HML, sprints and step balance. This way, we will be able to know which are the characteristics in each individual player and then to improve the individually adjusted profile. Monitoring these variables in the long term creates a complete profile for each player, in relation to their individual characteristics and it can help to identify the state in which they are more vulnerable to injuries, to their tolerance and to trainings and it helps to better understand the recovery progress. During this process, the adapted circuits are focused on the goal you need to achieve. Circuits are different, depending on whether the goal is speed (HSR or high-speed running, the maximum speed an athlete reaches in a certain action) or the strength (acceleration/deceleration; for being able to accelerate and stop, considerable strength levels are required). The adjuster will design circuits where athletes will be able to work different physical characteristics that are necessary for advancing in the injury rehabilitation process.

### **3) Intelligent management of modifiers**



The different sport rules greatly affect the return to play; in football, you need to fully recover from an injury, while in handball or in basketball, you can start playing before, because these sports allow players' frequent changes during competition. Returning to play does not necessarily mean that players should begin and finish their first match right after coming back. Football regulations allow using substitutions, which gives teams the opportunity to gradually reintroduce a player in the game and to guarantee that tension and load are not too high, too soon. Doctors should get involved in sports and deeply know the environment for wisely managing decisions made together with the player, the technical staff and coaches, so the experience acquired by doctors will depend more and more on this knowledge.

There are different determinants linked to players themselves (personal or sports), to their environment (family, manager, sports teammates with their own experiences), to the coach and to the technical staff that influence in the decision-making process. . The competition calendar and reaching a final or a contract renovation can accelerate or slow down a situation and, as a consequence, modify a decision that should be wisely managed.

### **Ethical aspects related to RTP**

Medical staffs are part of club's employees and they should meet its requirements and needs, but they are also required to fulfill their obligations and to act in the player's interest. These interests are sometimes not exactly the same. This means guaranteeing the player's wellbeing not only in the short term, but also in the long term in which there is a constant pressure by all the parts for ensuring that the most important players are always available and as soon as possible.

This can cause conflict of interests when the medical staff gets emotionally involved and has the same wish to win championships, which could be harmful for players' health in the long term, due to the wish of returning to competition too soon. This is stated by Danna et al. (2014) in "Therapeutic approaches to skeletal muscle repair and healing", Matheson et al. (2011) in "Return-to-play decisions: are they the team physician's responsibility?", Tol et al. (2014) in "At return to play following hamstring injury the majority of professional football players have residual isokinetic deficits" and Hamilton et al. (2010) in "Return-to-play in sport: a decision-based model".

Medical staffs should find the best balance and a way to guarantee success and health inside the team's structure.

Players' autonomy as patients give them rights on their bodies and it's up to them when to play, even if they are still injured, which can generate this conflict situation. Autonomy should be linked to informed consent and guarantee that players are also part of the discussion when they decide if they are ready to play.

Nevertheless, players often make decisions not only from the medical point of view, but also due to internal and external pressure, caused by the importance of competition, the opportunity of keeping a place in the initial lineup, financial benefits, matches that lead to international calls, etc. This shows that, regardless the consequences, medical staffs



should always act in the player's interest, using their experience and knowledge for making the best medical decision. This is stated by Danna et al., 2014; Matheson et al., 2011; Tol et al., 2014; and Creighton et al., 2010.

Another key ethical problem in RTP is confidentiality. It is important that details about players' medical conditions are known only by the ones that need the information (as the technical staff) and the player's permission is respected. Given football's popularity, there will always be a discussion about the relationship with the media and fans, but it is important that the player's needs and rights be respected and they are in the first place (Danna et al., 2014; Matheson et al., 2011; Tol et al., 2014; and Creighton et al., 2010).



**Table 1. Return to play: decision model**

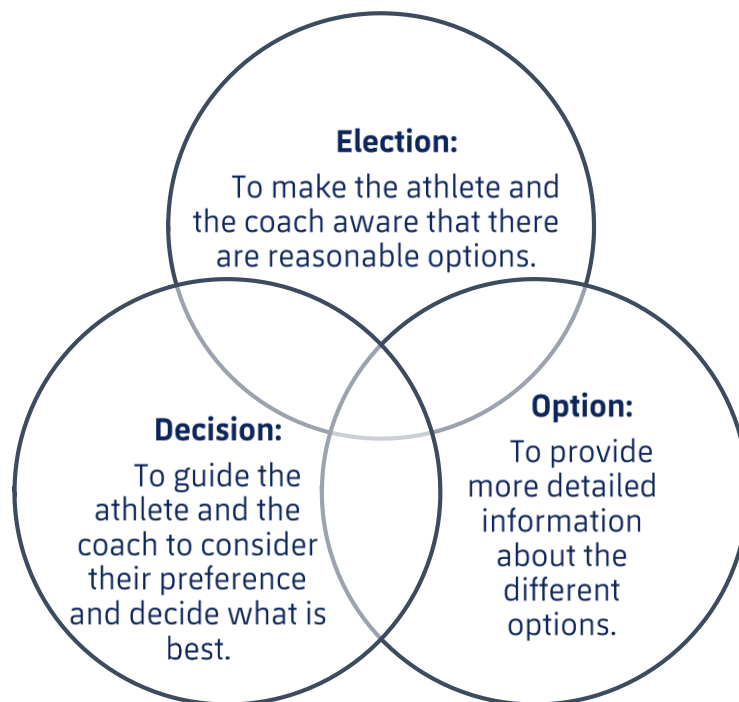
<b>RETURN TO PLAY: DECISION MODEL</b>		
<b>RISKS ASSESSMENT</b>		<b>STEP 3</b>
<b>STEP 1</b>	<b>STEP 2</b>	
<b>ASSESSMENT ON HEALTH STATUS</b>	<b>ASSESSMENT ON PARTICIPATION RISK</b>	<b>DECISION MODIFIERS</b>
<b>MEDICAL FACTORS</b>	<b>RISK FACTORS TYPICAL IN SPORTS</b>	
Patient’s demographic data (sex, age)	Type of sports	Moment in the season
Symptoms (pain)	Game position	Athlete’s pressure to compete
Personal background (recurrent injuries)	Lateralizing values (dominance)	External pressure
Signs (edema, weakness)	Competitive level	Use of analgesia to hide injury
Complementary examinations (Lab tests, MRI, X Rays)	Used protection	Conflict of interests
Functional tests		Fear of dispute
Psychological status		
Injury severity		

Source: Own creation based on Creighton, D. W., Shrier, I., Shultz, R., Meeuwisse, W. H., and Gordon, O. M. (2010). Return-to-play in sport: a decision-based model. *Clinical Journal of Sport Medicine*, 20(5), 379–385.

It is important to add that the return to competition decision should be a shared process; to this end, there is a shared decision-making process (SDM: Shared decision-making) in which we can find 3 key stages. They are detailed in the figure below.



**Figure 1. Shared decision-making**



Source: Dijkstra, H. P., Pollock, N., Chakraverty, R., and Ardern, C. L. (2016). Return to play in elite sport: a shared decision-making process. *British Journal of Sports Medicine*, 51(5), 419–420. <https://doi.org/10.1136/bjsports-2016-096209>

Finally, knowing if our athletes are psychologically ready for returning to competition can help us to make the best decision for them. Proximity during the readaptation and rehabilitation process will allow us to subjectively assess on, through different resources, our athletes' psychological status; besides, if possible, we should have more inputs like their family, friends, coaches and the rest of the medical team.

Athletes that are ready to return to competition should follow the following basic characteristics:

**Figure 2. Basic characteristics of an athlete that is ready to return to competition**



Source: Own creation based on Forsdyke, D., Gledhill, A., and Ardern, C. (2017) Psychological readiness to return to sport: three key elements to help the practitioner decide whether the athlete is REALLY ready? *British Journal of Sports Medicine*, 51(7), 555 –556.



## **Calls from national teams: interferences**

Players that represent their countries at the international level might be exposed to different medical staffs that can have different ways of working. This means that health care might not coincide. International players should often stay with their international teams during 10 days (excluding international championships like the World Cup, European championships, the Copa América, the AFCON-Africa Cup of Nations-). This can mean that international federations might be more willing to put pressure on players to return to play, making sure that the national team could get benefits and take their injury or their recovery relapse as something of the club's concern. It is important that national teams manage their players appropriately, not only in training loads, but also on injuries management. They should be constantly in contact with the club's staff and keep them informed about the incidences and about their risks, regardless they are under age or older, for guaranteeing that they would manage each individual in relation to their requirements.

The same as the other football aspects, the RTP concept and principles will continue evolving. Research and information exchange will, in the future, play a key role in the RTP knowledge development at all levels in football. The big data concept will help in the future, because doctors will be able to share the medical experience in different environments and countries and use it for improving knowledge.

## **Conclusions**

- The RTP decision-making process should be understood as dynamic, focusing on avoiding injuries and not in predicting the exact RTP moment.
- Technology in the court could be very useful, since it can personalize the decision-making process and it will do it even more in the future, but the valuable clinical experience and the football environment knowledge are also important.
- The RTP decisions should be ethical and protect the involved individual's rights and wellbeing.
- It is important to consider possible new rules in sports that could influence the RTP decision-making process, in the same way that special modifier factors are considered.



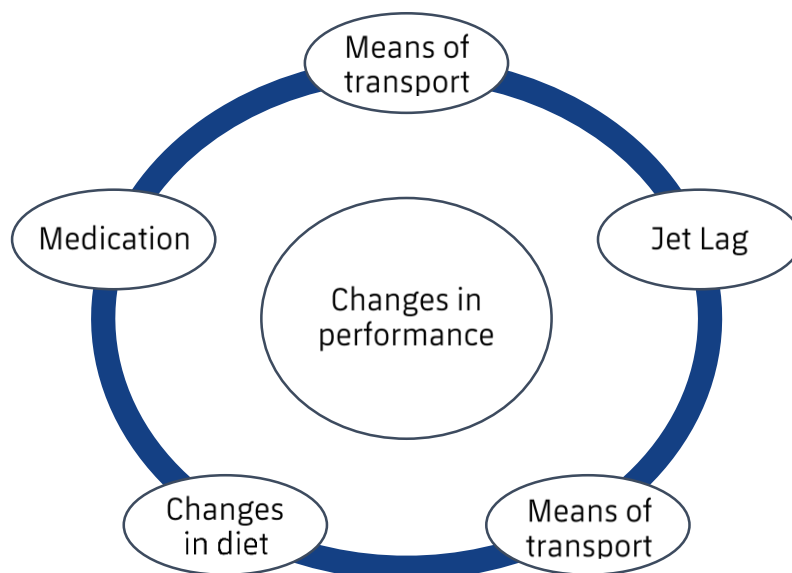
## Unit 4.2 Strategies for planning the team's trips.

Ramón Olive, Hospital Terrassa-CAR in Sant Cugat, Universitat Internacional de Catalunya, Universitat Ramon Llul.

Team physicians should adapt their knowledge to the new demands that professional sports' globalization claim. One of the demands this globalization faces is our players' long distance trips planning, in which there are long hours of flights and they move through different time zones. This can bring different health problems, so we will have to adopt enough preventive measures, so that the athlete's performance skill is not affected.

Triggers for these changes in the athlete's performance after a long movement have a double origin. On the one hand, the ones generated by means of transport themselves, in this case the plane. In the plane, the hypoxia conditions inside the cabin, the possibility of infectious diseases transmission, the fear and/or anxiety that is generated by some of the team's members, together with the possibility of Thromboembolic events (VTE) are happenings that must be controlled for mitigating their effects as much as possible. The other point we should consider is the jet lag that is caused by moving through several time zones, which transforms our internal clocks and modifies some of our body's rhythms like sleep/sleeplessness, which has a great implication in sports performance.

**Figure 3. Change factors in an athlete's performance after a long trip**



Source: Own creation

Given the text space limit we have, we are going to focus on two essential aspects:

- Physiological changes that are produced by the jet lag

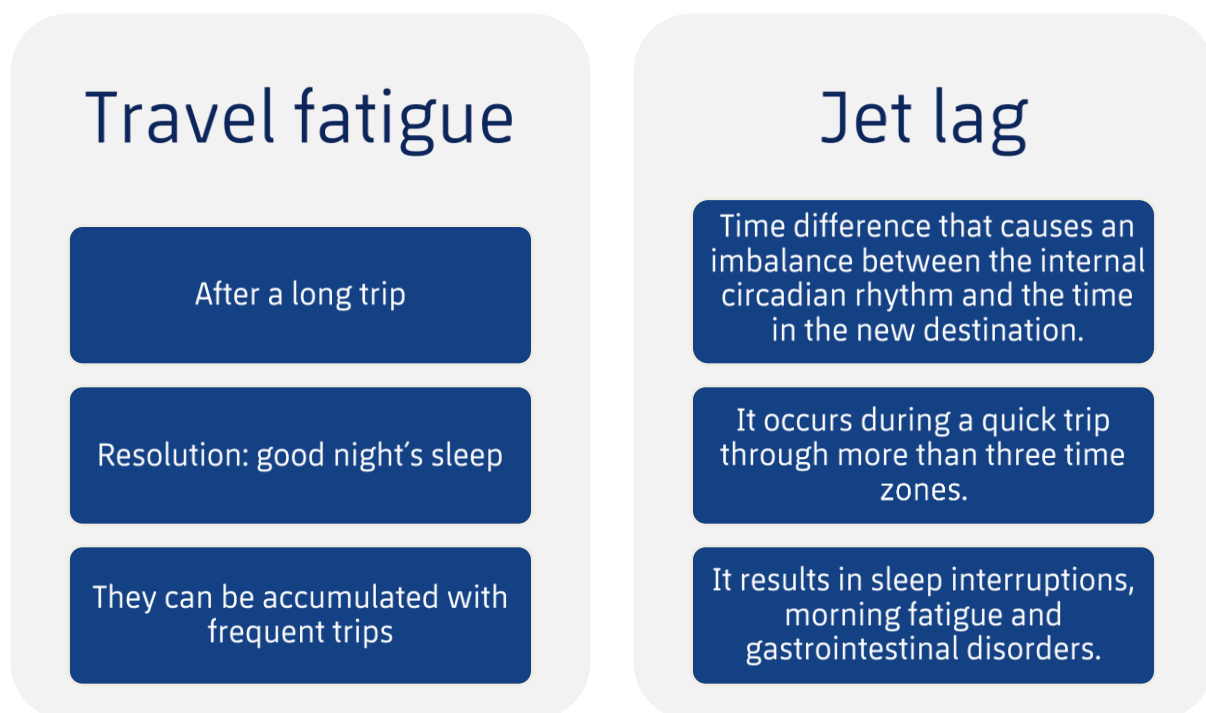
- Preventive measures for avoiding thromboembolic events due to long trips that are usually described colloquially as the “economy class syndrome”.

## Jet lag

Globalization in the world of sports has boosted the creation of supranational leagues, which has forced teams to make long movements that cross different time zones in a short period of time. An example of this are the basketball or football leagues, where some Russian teams that participate are 6-8 hours distance from the competition place. This can cause changes in our athletes’ body internal rhythms, which, in occasions, will affect their physical and mental performance skill.

*The disturbance on the body homeostasis that is created when we make a trip that moves through different time zones is what we call Jet Lag (Waterhouse, Reilly, and Atjinson, 1997).*

**Figure 4. Travel fatigue and Jet Lag**



Source: Janse van Rensburg, D. C., Fowler, P., and Racinais, S. (2020). Practical tips to manage travel fatigue and jet lag in athletes. *British Journal of Sports Medicine*. <https://doi.org/10.1136/bjsports-2020-103163>

This desynchronization among our endogenous and exogenous rhythms of the new time zone (for example, the light/darkness cycle) causes a series of disorders like the following:

- Difficulty for sleeping and sleep interruption (60-70 %)
- Lack of concentration
- Irritability

- Fatigue
- Time-space-distance disorientation
- Dizziness
- Loss of appetite
- Lack of motivation
- Gastrointestinal disorders

The bigger preponderance of each of these symptoms will depend on each individual's sensitivity, on the type of activities they have to do and on the moment of the day when we make the athlete the question, since in the morning there will more sleep problems, while at midday it will more difficult to concentrate (Waterhouse et al., 2003).

Besides these organic symptoms, there are also consequences on the sports performance, not only on performance's effectiveness, but also on performance during competition. It is difficult to know exactly the real effect this desynchronization has on the sports performance skill and it is also difficult to assess on the influence of the physical exercise on biological clocks (Edwards et al. 2005).

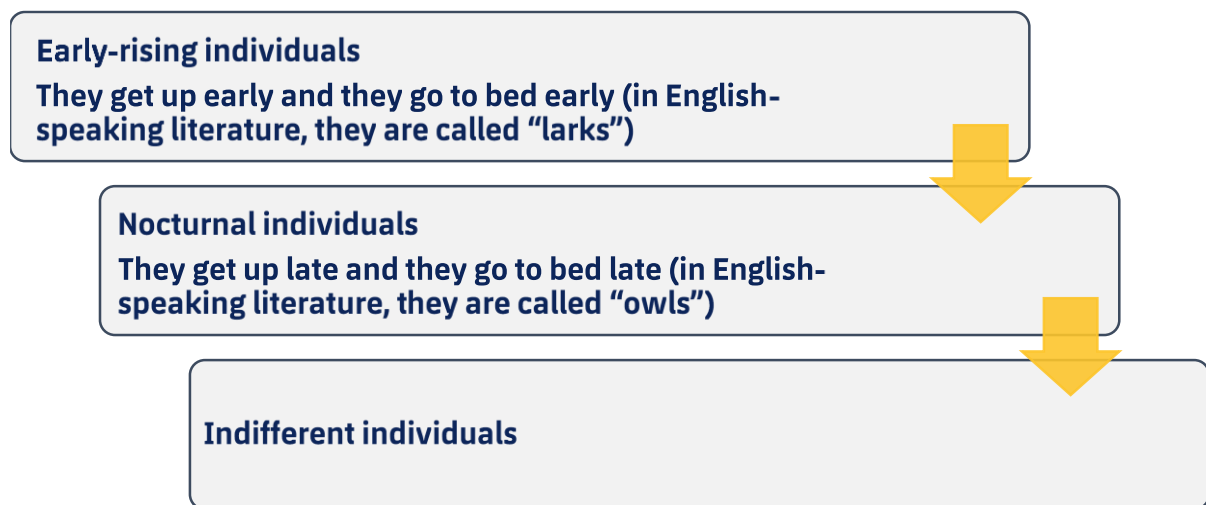
Another aspect that is added to the internal clock desynchronization is tiredness that is produced by the travel itself because of different factors: the conditions in the cabin where the athlete travels (seat in a reduced space or economy class syndrome, immobility, stress on the central seats), the cabin's environmental conditions (dry air that tends to cause a certain level of dehydration, a certain degree of hypoxia in the air breathed, too cold or too hot temperature, etc.), bureaucratic paperwork at customs, material and luggage control, etc. (Gorostiaga Ayestarán, and Olivé Vilás, 2007).

The science that studies the biological cycles structuring and their manifestations about life is **chronobiology**. The key founder of clinic chronobiology and human biorhythmicity J. Aschoff, who in 1959 published several works after exposing different individuals to cosmoclimatic isolation. He was the one who introduced the *zeitgeber* term for describing those environmental elements that human beings use for limiting and periodizing their biological rhythms. Biological rhythms are not imposed by the environment, but indeed they are adjusted by it; it is what is known as exogenous synchronization (light/darkness, food presence, etc.) (Gorostiaga Ayestarán and Olivé Vilás, 2007).

Chronobiology divides population into three big groups of schedule personalities or chronotypes:



Figure 5. Groups of personality schedules



Source: Own creation based on Gorostiaga Ayestarán, E., and Olivé Vilás, R. (2007). *Adaptaciones al clima y al horario de Pekín'08*. Comité Olímpico Español. <https://www.navarra.es/NR/rdonlyres/4E1F3179-C69F-4EC7-BBF3-006B3BC5EA09/189147/folletopekinokfindefi6.pdf>

Among the two first groups or chronotypes there is a difference of approximately 65 minutes in when the body temperature rhythm peak presents. Early-rising individuals segregate a bigger amount of adrenaline in the morning than nocturnal ones. Besides, the activity frequency, manner and rhythm differ in a period of several hours among both groups.

Older than 50 years old athletes tend to be more early-rising individuals than younger athletes. This is important when designing training programs and working loads. Circadian rhythms have bigger amplitude on trained individuals than on sedentary ones. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 49)

There is not enough information about exogenous factors that can influence human beings' internal clock, but one of the most important ones is light/darkness and it can affect all the others. Light stimulates the retinohypothalamic axis, acting directly on the central nervous system (CNS) and especially on the pineal gland, inhibiting melatonin production. In order for light to be a regulator factor, it should have an important intensity (shine) and its stimulus should be long-lasting. (Gorostiaga Ayestarán and Olivé Vilás, 2007)

Another factor would be the intake of a certain food group:

Consumption of high doses of proteins in the morning would increase the concentration of thyroxine, which would promote the norepinephrine (neurotransmitter) and dopamine's synthesis and release, which would activate the CNS. On the contrary, foods with a high concentration of carbohydrates facilitate the increase of tryptophan in plasma and, with it, the serotonin's synthesis and release, a neurotransmitter that has an important role in sleep

regulation and is a melatonin's precursor. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 49)

## Biological rhythms

What do we understand as biological rhythm? It is the biological change that is produced in relation to time, which is presented in form of a periodic wave and it is reproducible. These biological rhythms are closely related to environmental factors.

In the human body a series of rhythms develop; they are called endogenous and they have a variable periodicity. According to their duration:

**Figure 6. Biological rhythms**

Circadian	Infradian	Ultradian
20 – 28 hours	<20 hours	>28 hours

Source: Own creation

Physiological parameters inside a circadian rhythm are influenced by changes in the human behavior and in the environment in which athletes live. An example could be the human society behavior, which has its maximum activity period during daytime, when temperature and light are higher.

These exogenous factors can interrelate with physiological rhythms and modulate them, but they cannot fully condition them, while endogenous factors, colloquially called biologic clock, can indeed modify them. So, we see that biologic rhythms remain during the first days when an individual is put on an isolation chamber, with sleep deprivation, at the initial stage of changes of time zones; they can also remain on people that start working on night shifts. They are precise for several days, so that the individual's complete adaptation to the new environment occur (Minors and Waterhouse, 1981).

Where do we locate the human beings' endogenous clock?

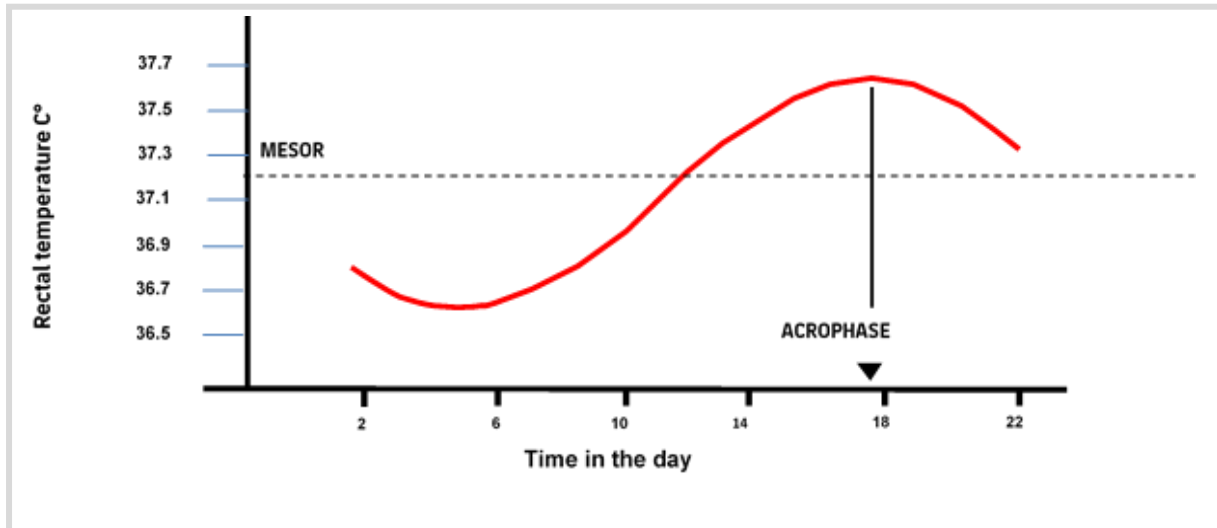
Human beings' endogenous clock is found at the level of **the hypothalamus' suprachiasmatic nucleus (CNS)**, close to the optic chiasm. Its periodicity would be higher after 24 hours, if it were not for the constant adjustment on the part of a series of factors that we generally call modulators (zeitgebers) and which are directly or indirectly influenced by environmental factors (Minors and Waterhouse, 1981). An example of this in mammals could be the cycles light/darkness, food availability/unavailability, activity/inactivity and social influences, single or combined; all of them could regulate the biological clock.

We are going to see how different circadian rhythms in our body behave:



## Central temperature

Figure 7. Rectal temperature's circadian rhythm with the terms used for describing biological rhythms



Source: Reilly, 1995.

Body temperature varies during the day, it rises before waking up and it reaches its maximum level around 6 in the afternoon, and it falls until 4 in the early morning, where the minimum body temperature is registered (Figure 7). Apparently, these changes are related to variations on the daily noradrenaline secretion.

Factors that have a bigger influence on the temperature rhythm are sleep and exercise.

Body's central temperature (rectal temperature) and superficial temperature (skin) do not show rhythmical changes with exercise (Reilly and Brooks, 1986).

## Heart rate, blood pressure and ventilatory frequency

Heart rate at rest often varies throughout the day, presenting a maximum value at 3 in the afternoon, with a daily variation range of 5 and 15 %. The same happens with other heart function parameters, such as the following: the ejection volume, the cardiac work, the blood pressure and the blood flow.

The ejection fraction and the blood pressure are influenced by external factors like the following:

- posture
- sleep
- diet
- physical activity

It is shown that blood pressure has a neuroendocrine regulation associated to sleep. There is a fall in blood pressure after the midday meal, followed by a peak in the afternoon. This phenomena is more evident on patients that take a nap and on those in which blood pressure fall after eating is bigger (elderly people) (Zulch and Hossmann, 1967).

Blood pressure and heart rate present a rhythmical variation throughout the day, but it is difficult to identify these variations when they are subject to the influence of the physical exercise. This is stated by Callard et al. (2001) in “Nycthemeral variations in core temperature and heart rate: continuous cycling exercise versus continuous rest”, and Deschenes et al. (1998) in “Biorhythmic influences on functional capacity of human muscle and physiological responses”

Two indicators of airways’ resistance, such as the forced expiratory volume and the maximum respiratory flow, vary throughout the day and they reach a maximum between 3 and 8 in the morning.

### **Gastric and urinary function**

Speed in food gastric emptying is a 50 % quicker in breakfast than in dinner (8 pm). But it is not known if isotonic drinks’ emptying is bigger in the morning than in the afternoon during exercise.

Urinary function presents a peak of electrolyte elimination in the afternoon (4 in the afternoon) (Robertson et al. 1977).

### **Hormone secretion and subjective mood state**

The cortisol as well as the growth hormone (GH) show secretion peaks in the night sleep. Both hormones are influenced by the sleep quality and this, in turn, by the physical exercise.

Peaks on catecholamines’ levels appear at midday (at 12). These rhythm’s variations can be observed with changes on individuals’ level of excitement. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 52)

Melatonin shows a circadian rhythm, being its maximum peak around 9 in the evening and it falls after until 8 in the morning. Darkness favors melatonin secretion and one of its effects is vasodilatation, which would induce heat loss, as well as delay in other functions that would prepare us for sleep.

Melatonin is an internal “modulator” with effects that are similar to light, but inverted. Light stimuli tend to stop melatonin secretion.

We know that melatonin secretion is influenced by exercise, but there is discussion on whether it produces a stimulant or inhibiting effect. Barger, Wright, Hughes, and Czeisler, in their article “Daily exercise facilitates phase delays of circadian melatonin rhythm in



very dim light "(2004), showed that the physical exercise (45 minutes ergocycle), practiced in darkness for avoiding light effects, delays melatonin secretion.

Most studies seem to show that the wake cycle and the good mood state happen after waking up. This good mood and excitement state is important for sports performance, for predisposition to physical work and for group work and for the group's cohesion (Atkinson et al., 1995).

## **Sports performance**

It is believed that circadian rhythm can be related to physical performance, because many parameters that define sports performance present a synchronism with the circadian rhythm of our body's internal temperature. Among them, we can highlight the following: the maximum force peak in the back muscles, in the legs and arms, the anaerobic power, the long and the high jump, the endurance capacity (maximum peak at 6 pm). The same happens with flexibility.

[...]

If we analyze in which moment in the day the maximum performance is given in different competitions, we can see that most sports scores have been achieved in the first afternoon hours, when body temperature reaches its maximum level [...]. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 54)

We should be wise when we claim that all that is due to circadian rhythms, because we should also take into account other factors, such as environmental ones (wind speed, temperature, altitude, etc.), which can have an important influence (Drust et al., 2005).

## **Psychomotor performance**

Reaction time shows its maximum peak in the afternoon, coinciding with the maximum body temperature. This would be explained because the rise in body temperature would facilitate nervous transmission (Winget et al. 1985).

In exercises in which balance is a key factor, as with balance boards and with balance beam, the best results are obtained in the morning (Atkinson et al. 2005).

"There is an inverse relation between speed and execution precision. That is why athletes that practice great precision sports (shooting, golf, etc.) should deliver a worse performance in the first hours in the afternoon" (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 55).

When we value recent memory and mental calculations, better performances are delivered very early in the morning than in the afternoon. Nevertheless, such aspects depend a lot on the characteristics of the task to perform (Winget et al. 1985). Short-term memory, "retention memory" (data that should be retained for a period of 1 week or more) is an 8% bigger when data is studied or presented in the time slot that goes from 3 pm to 9 pm.



We should take into account that there is an important individual variability in the daily rhythms of the previously analyzed variables (different chronotypes). Besides, with age, daily rhythms width and length get reduced. There is no information on whether this observed difference with age is due to the internal clock aging or because of the change that is produced in the sleep rhythm with age.

### **Effects of time change in sports performance**

There is a series of factors that can help to predict the bigger or smaller impact this time change can have on sports performance:

- ***Flight direction:*** the time necessary for adapting the physical condition to the time change is, approximately, one day for each hour of difference (Reilly, 1982). In general, we can say that when the trip is made towards the east, the difficulty for getting to sleep at the local time is bigger, while in flights to the west the problem is focused on individuals that wake up early.
- ***Individual variability:*** in one same individual, the adaptation to time change of the different endogenous cycles is variable and its regulation does not happen at the same time. For example, it seems that the first thing that is adapted is the sleep-wake cycle, followed by the body temperature (Lemmer et al. 2002). Women and elderly people find it more difficult to adapt than men and young people (Moline et al., 1992). Nocturnal individuals adapt better to trips towards the west than the early-rising individuals towards the east (Baehr et al., 2000). Individuals that are in better shape and are not so excited adapt better than the ones who are in worse physical conditions and are more excited (Van Someren et al. 1997).

Other aspects that can have an influence are having previous experience or the season of the year. So, when the trip is in summer, it is easier to adapt to time change.

Keeping circadian rhythms in mind can benefit us when planning tasks that need abilities like endurance, mental agility and physical strength. This benefit can get to the 10% in sports performance. We will have to bear in mind that a 10% decrease in sports performance is produced after a sleep of less than 3 hours, after consuming alcohol up to the legal limit or after taking barbiturates (Folkard y Monk, 1983).

### **Measures for reducing time change's negative effects**

- **Before leaving**
  - It is important to know about weather and epidemiological conditions in destination.
  - Define a space for medical consultations and for physiotherapy treatments in the place of accommodation.
  - Check that all delegation members follow the necessary immunization for making the movement.



- Prepare the emergency bag and the necessary materials for taking care of the delegation during the trip.
- Athletes should be informed about the possibility of the appearance of symptoms and the way they can prevent it.

Strategies:



It is important to have a good night's sleep before leaving, 8 hours minimum, for getting into the flight as rested as possible.

- **During the flight**

Soon after boarding, the most advisable thing is to change time in the clock and set it with destination's time.

*Drinks with coffee or tea (which favor dehydration) will be avoided.*

In order to alleviate or avoid problems associated with the fact of being seated the whole time, it would be convenient to perform exercises for stretching arms, trunk and legs which can be done on the seat itself. It would also be convenient to make frequent walks through the plane's aisles that would keep athletes awake. These stretching and mobility exercises should be performed every 2 hours. It is also advisable to use progressive compression socks which avoid the excessive accumulation of blood on legs.

It is advisable to drink liquids frequently, especially water, and to avoid drinking alcohol, coke or coffee, given their diuretic effect (dehydration) and the exciting effect on the Central Nervous System (avoid if the intention is to get to sleep). The plane cabin's air is very dry which will foster dehydration.

Meals and dinners will have to be light, as we will not move too much. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 65).

- **As soon as arriving**

- Verify the space devoted to medical and physiotherapy attention.
- Learn the number of rooms for the delegation.
- It is essential that the staff as well as players know where the medical staff's room is in case of emergency.

“In flights to the east, athletes should avoid exposure to sun in the morning and they should instead be exposed to sun in the afternoon. By doing that, they will adapt more easily to time change”(Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 65).

Even though advice is strictly followed, in general, the adaptation lasts approximately 1 day, for each time zone we have passed. So, if for example in destination there is a time difference of 5 hours in relation to the origin's one, it will take us at least 5 days to regulate our internal clocks.

Training loads programming for this period will have to be adjusted more to the adaptation moment the athlete is on, which may not coincide with the theoretical time of the competition.

During this adaptation stage, a diet with a big amount of carbohydrates for dinner will be fostered, avoiding alcohol and drinks with caffeine and theine for favoring sleep. Drinking a lot of liquids should also be fostered. Breakfast should contain a big portion of proteins for favoring a wake state.

It is important to avoid sleeping outside regular hours (for example, at mid-morning or at mid-afternoon), but in case it is necessary (excessive fatigue, load recovery) short periods of sleep could be allowed (no longer than 2 hours). (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 65).

### **How can we relieve symptoms produced by time change?**

Besides the measures previously described for trying to reduce symptoms associated with time changes, diet's appropriate composition and sleeping hours programming, there are other methods that we are going to expose (Gorostiaga Ayestarán and Olivé Vilás, 2007).

### **Phototherapy**

“Phototherapy consists in exposing an individual to an intense luminous light, during a certain period of time, for trying to delay or advance an individual's circadian rhythm and adapt him/her, this way, quicker to the time change”(Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 65).

Works done about therapy so far are not conclusive. As stated in *Concensus Report for Light Treatment*, more studies should be made in order to determine the appropriate parameters of light intensity, time of exposition and flight situations that are efficient for accelerating the adaptation to time changes (Boulos et al., 1995).

In general, we can say that in trips towards the east, there is a need to expose athletes to intense light in the afternoons and avoid their exposure in the mornings.

### **Substances that promote the wake cycle**



In relation to Gorostiaga Ayestarán and Olivé Vilás (2007), the substances that are mostly used for promoting the wake cycle are the following:

- amphetamines
- promalin
- modafinil
- caffeine

*As the only one that is not included in the forbidden list of substances is caffeine, it is the only one that is recommended, if needed.*

“Caffeine facilitates the wake cycle and the development of mental tasks. Athletes could take it if they do not adapt well to the new time zone, in order to keep the wake cycle and prevent them from sleeping at moments in which they should be awake [...]. Nevertheless, we should take into account that taking caffeine in high doses can generate difficulty for sleeping or not sleep interruption at normal sleep hours (good night’s sleep), with which adaptation to time change could get worse”. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 66)

## **Chronobiotic**

They are drugs that apparently work on a biological element in the circadian rhythm structure and if they are taken at an adequate hour every day, they could favor a quicker adaptation to time change. The two most popular presumably chronobiotics are benzodiazepine and melatonin.

Benzodiazepines work on GABA receptors in the Central Nervous System favoring sleep. This has made some authors suspicious about them having effects on the biological clock and favoring a quicker adaptation to time change. (...). Mostly used benzodiazepines are Diazepam (not too recommended because its effects last from 24 to 48 hours), the Lorazepam (with effects lasting more than 10 hours), (...) and Zaleplon (with a shorter average life and less side effects). Besides, they have more side effects, like reducing the wake state and the psychomotor performance, which are not good for athletes.

The melatonin is a substance that has hypnotic properties and a vasodilatation effect that reduces body temperature. It also stimulates, as a side effect, the humoral immunological response through the interleukin-4 and other cytokines. Besides, it is a powerful free radicals destroyer. When it is taken before going to sleep (around 8 pm local time), it favors sleep, which might be used for favoring the adaptation to the time change. Finally, it does not bring about so many side effects on the physical fitness the next morning, like benzodiazepines, although it usually produces a sensation of fatigue. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 66)

There are different scientific studies -“Melatonin and jet lag: confirmatory result using a simplified protocol”(1992) de Claustrat at al., y “Evaluation of pharmacological aids on



physical performance after a transmeridian flight”(2001) de Lagarde et al. - which show that melatonin intake can favor this biological clocks’ resynchronization. If someone decides to follow a treatment with melatonin, he/she should test its purity and get it in certified centers, because its purity can be questioned. The best effect is achieved in two doses of 2-5 milligrams (doses superior to 5 milligrams do not lead to symptoms’ improvement), soon before the time to go to bed in destination. The treatment will be started on the day of the trip, coinciding with bed time in destination and it will be followed during the following two and four days of stay at the destination place. It should be indicated that melatonin intake is not recommended for people that take warfarin oral anticoagulants and people with epilepsy (Herxheimer and Petrie, 2002).

### **The physical exercise**

As we have previously stated, there is evidence that physical exercise can work as an internal clock regulator. We know that individuals that perform physical exercises regularly show more easiness to adapt to time changes. Athletes also adapt better when they start training from the day of arrival to the destination place.

In case of trips to the east (Beijing), the best thing is to start training from the first day in the early afternoon, instead of doing it in the morning, since apparently if we start training in the afternoon after body temperatures fall, we get an advance in the biological clock, which is our goal for adapting to time changes when we travel to the east. (Gorostiaga Ayestarán and Olivé Vilás, 2007, p. 68).

### **Thrombosis syndrome in long-haul flights**

Venous thromboembolism events (VTE) are directly related to the flight duration (more than 8 hours) (Chandra et al., 2009).

The risk of suffering from a pulmonary embolism (PE) the day of landing after a long-haul flight is calculated between  $0.5-1 \times 10^6$  and it rises to  $27-1 \times 10^6$  of suffering from a deep vein thrombosis (DVT) or a PE during the first 14 days after landing (Lapostolle et al., 2001). The estimation is of 1.1 Pulmonary Thromboembolism by a million people each day, a number that is very close to the incidence of this pathology in the healthy population that is 1.9 - 5.2 people per million every day. If we are very strict and we make an echographic study to long-haul flight passengers, the DTV diagnosis increases to 3 - 12 % (Huges et al., 2003). This discrepancy among figures is because asymptomatic DTV is 5-20 times more frequent than symptomatic events.

- **Risk factors**

The risk of suffering from a thromboembolic event is 18% higher for each increase of 2 hours in the trip’s duration, and is even 26% higher (for 2 hours) when the trip is exclusively by plane (Chandra et al., 2009). The real risk of a symptomatic event is of 1/600



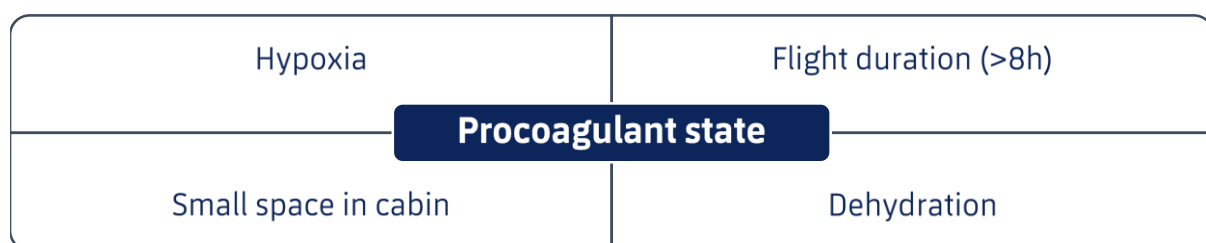
for flights of more than 4 hours and 1/500 for flights of more than 12 hours in travelers that are older than 50 years old (Geerts et al. 2008).

Seven risk factors have been identified for VTE related to flights (in the economy class as well as first class) or trips by car, train or bus:

- 1) The duration in long-haul flights (more than 6 h): the risk increases 2-3 times in comparison with shorter flights (Chandra et al. 2009).
- 2) Individuals that are older than 40 years old (45 % of 126 DTV cases) (Philbrick et al., 2007).
- 3) Female sex (three times higher than men) (Lapostolle et al., 2009).
- 4) Women that take contraceptive pills or receive the hormonal replacement therapy (HRT).
- 5) Varicose vein on lower limb (Philbrick et al. 2007).
- 6) Obesity with a Body Mass Index (BMI) > 30 (Philbrick et al. 2007).
- 7) Genetic thrombophilia (Philbrick et al. 2007).
- 8) High levels of coagulation (II and VIII) factors (Kuipers et al. 2009).
- 9) Other risk factors, for example, tall people, short people, etc.

## Etiology

**Figure 8. Procoagulant state**



Source: Own creation.

In most commercial flights, there is a high level of hypoxia in the cabin, compared to living in heights of 1800-2400 m. It is like this, because keeping the ideal air pressure between the internal and external compartments would demand a huge amount of fuel, which



would add weight to the plane. These hypoxia conditions are dangerous, especially for patients with chronic cardiovascular and pulmonary diseases (Silverman y Gendreau, 2009), which probably play a role in the coagulation system during the flight (Mohr, 2008).

A flight of more than 8 hours significantly increases procoagulant activity in a 17% in healthy people and, in particular, on those who can suffer from thrombophilia or in women that take contraceptive pills or receive the hormonal replacement therapy.

If we can also add that the space we have for moving in economy class is very limited, we find an increase in the venous stasis and the procoagulant activity. This immobility during the flight is related to almost a 75% of DTV cases.

Another point that favors this procoagulant activity is the level of dehydration during the flight, due to the low humidity in the cabin (8-12%), to lower intake of liquids and to the intake of coffee or alcoholic drinks that induce diuresis, which causes hemoconcentration and blood hyperviscosity.

## **Preventive measures**

We can divide them in two big individual groups and in improvements of flight conditions:

- **Individuals:**

- The first condition is to detect people with risks inside the team, taking into consideration the previously exposed factors, which will deserve special attention.
- The general measures we should avoid are the long periods of sedestation.
  - We will indicate exercises for moving the gastrocnemius while sitting.
  - Do small walks along the plane every 2-3 hours.
  - Drink water frequently.
  - Avoid drinking alcohol, coffee or tea.
- We can prevent venous stasis by using graduated elastic stockings, which have proven that they reduce the incidence of VTE in almost a 90% in patients with standard risk.
- Pharmacological prophylaxis is reserved for high risk patients. It has not been proved that anti-aggregating agents (aspirin, clopidogrel) reduce the incidence of VTE on high risk patients. The enoxaparin, in one dose of 1 mg / kg 2-4 h before long-haul flights significantly decreases the incidence of VTE from 4,8 to 0 %. This is stated by Brenner in "Prophylaxis of travel-related thrombosis in women"(2009) and Cesarone et al. in "Venous thrombosis from air travel: the LONFLIT3 study- prevention with aspirin vs low-molecular-weight heparin (LMWH) in high-risk subjects: a randomized trial"(2002).

- **Improvements in the environmental conditions in the plane's cabin:**



- Keep pressure in the cabin in hypobaric conditions (1.8-2.5 km height).
- Keep a relative humidity adequate for mitigating, as much as possible, dehydration of the units of air conditioner.
- Also, encourage passengers to drink liquids without alcohol, coffee or tea.
- Another aspect is to enlarge the space among the passengers' seats so they are allowed to stretch legs and to make contraction movements of the muscles in calf.
- Finally, provide optimal oxygen levels in the cabin.

- **Flight timetables:**

If there is a possibility to choose timetables in which the flights will be made, the following is recommended:

- If the trip is towards the **east**: choose an arrival time in the afternoon; this will allow athletes to have a complete rest night at the local time.
- If the trip is towards the **west**: it is better to travel during daytime and synchronize the time with the destination time immediately after landing.

## EMERGENCY PLAN

Besides all the previously explained measures to consider during a trip like the team physician, it is essential to have an emergency plan, which includes the knowledge and acknowledgment of certain important destination data, as well as the definition of roles in case of emergency.

### Essentials in the emergency plan:

- Contact information about the whole technical and medical staff.
- Address and contact information about all of the sports facilities and accommodation places.
- Distance and means of transport from the sports facilities and accommodation to the closest or the reference emergency room.
- Acknowledgment about access of emergency services in the sports facilities.
- All the members in the medical staff should be trained in basic life support and perform frequent practices.
- Define roles in case of emergency.
  - Define who will lead the team in case of emergency.
  - Define who will be in charge of calling the ambulance.
  - Check the first-aid kit and the defibrillator's location.
  - Check which is the emergency hospital.

## CHECKLIST FOR TRAVELLING

On the next table, we are doing a summary of the list of considerations to bear in mind before beginning and planning a trip.



**Table 2. Considerations before beginning and planning a trip**

**Confirm destination's unique characteristics and challenges:**

- Vaccination needs
- Insects infestation risks (For example: zika virus, malaria)
- Environmental characteristics (height, heat, humidity, cold)
- Catering arrangements
- Food provision and local food habits
- Hygiene standards and food and water security standards
- Quarantine regulations and epidemiological status (For example:

**Learn about athletes, coaches and support staff's special needs:**

- Medical affections
- Food intolerances (for example: celiac disease)
- Allergies (EpiPen need and allergen notifications in food arrangements)
- Special food requirements (for example, vegetarian meals)
- Catering organization (airlines, hotels) in advance

**Take into account nutrition needs during the trip's itinerary:**

- Consider the means of transport, the scheduled rests, the time zones changes, canceled flights
- Draw a plan with provided foods, responsible food, snacks and drinks

**Consider the destination's food culture and availability:**

- Basic food and key sources of nutrition (for example, proteins and carbohydrates, fruits, vegetables)
- Special food needs (for example, gluten free)
- Cooking styles (adding of fat or spices)
- Language problems (provide a translation list of ordinary elements)
- Consider the risk of substances/polluting elements in food and manufactured products (for example, clenbuterol in meat)



### Identify the destination's catering styles:

Take into account the accommodation style and the food service (for example, shared rooms, fridge in the room, apartments, student accommodations, hotels or external restaurants, buffet food or à la carte food, specialized cafeterias- for example, the Olympic village)

Identify food availability in training and competition locations

Make notes of the food service schedule and the food availability, including the access

Formulate an action plan in extended training hours or other commitments (for example, drugs tests after the event)

Locate supermarkets and fresh food stores for complementing provision

Take additional food provision (key food or missing items) with the team if possible / practical

Share food plans and challenges with the team before leaving, if possible

### Establish team/group protocols in relation to hygiene and food behavior:

Use of hand sanitizers

Behavior in relation to auto service food or to snack areas (for example, food processors, woks, kitchen utensils)

Policies on food in rooms

Alcohol consumption

Protocols for cleaning liquid bottles

### Make an exploration at arrival for implementing the plan:

Make a visual exploration of recovery areas, in relation to the risk perceived (kitchens, food servers and cleaning areas, storage areas and food handling areas, food security certificates, including products' authenticity)

Update the team's hygiene plan, if necessary

Source: Own creation based on Halson, S. L., Burke, L. M., y Pearce, J. (2019). Nutrition for Travel: From Jet lag To Catering. *International Journal of Sport Nutrition and Exercise Metabolism*, 29(2), 228-235.



## References

- Askling, C., Saartok, T., and Thorstensson, A.** (2006). Type of acute hamstring strain affects flexibility, strength, and time to return to pre-injury level. *British Journal of Sports Medicine*, 40 (1), 40–44.
- Atkinson, G., Buckley, P., Edwards, B., Reilly, T., and Waterhouse, J.** (2001). Are there hangover-effects on physical performance when melatonin is ingested by athletes before nocturnal sleep? *International Journal of Sports Medicine*, 22(3), 232-234.
- Atkinson, G., Todd, C., Reilly, T., and Waterhouse, J.** (2005). Diurnal variation in cycling performance: influence of warm-up. *Journal of Sports Sciences*, 23(3), 321-329.
- Baehr, E. K., Revelle, W., and Eastman, C.I.** (2000). Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *Journal of Sleep Research*, 9(2), 117-127.
- Barger, L. K., Wright Jr., K. P., Hughes, R. J., and Czeisler C. A.** (2004). Daily exercise facilitates phase delays of circadian melatonin rhythm in very dim light. *American Journal of Physiology. Regulatory, Integrative and Comparative Physiology*, 286, R1077-R1084.
- Boulos, Z., Campbell, S. S., Lewy, A. J., Terman, M., Dijk, D. J., and Eastman, C. I.** (1995). Light treatment for sleep disorders: consensus report. VII. Jet lag. *Journal of Biological Rhythms*, 10(2), 167-176.
- Brenner, B.** (2009). Prophylaxis of travel-related thrombosis in women. *Thrombosis Research*, 123(Suppl. 3), S26-S29.
- Callard, D., Davenne, D., Lagarde, D., Meney, I., Gentil, C., and Van Hoecke, J.** (2001). Nycthemeral variations in core temperature and heart rate: continuous cycling exercise versus continuous rest. *International Journal of Sports Medicine*, 22(8), 553-557.
- Cesarone, M. R., Belcaro, G., Nicolaidis, A. N., Incandela, L., De Sanctis, M. T., Geroulakos, G., Lennox, A., Myers, K. A., Moia, M., Ippolito, E., and Winford, M.** (2002). Venous thrombosis from air travel: the LONFLIT3 study—prevention with aspirin vs low-molecular-weight heparin (LMWH) in high-risk subjects: a randomized trial. *Angiology*, 53 (1), 1-6.
- Chandra, D., Parisini, E., and Mozaffarian, D.** (2009). Meta-analysis: travel and risk for venous thromboembolism. *Annals of Internal Medicine*, 151 (3), 180-190.
- Claustrat, B., Brun, J., David, M., Sassolas, G., & Chazot, G.** (1992). Melatonin and jet lag: confirmatory result using a simplified protocol. *Biological Psychiatry*, 32(8), 705-711.
- Creighton, D. W., Shrier, I., Shultz, R., Meeuwisse, W. H., and Gordon, O. M.** (2010). Return-to-play in sport: a decision-based model. *Clinical Journal of Sport Medicine*, 20(5), 379–385.
- Danna, N. R., Beutel, B. G., Campbell, K. A., and Bosco, J. A.** (2014). Therapeutic approaches



to skeletal muscle repair and healing. *Sport Health*, 6(4), 348–355.

**Daurat, A., Benoit, O., and Buguet, A.** (2000). Effects of zopiclone on the rest/activity rhythm after a westward flight across five time zones. *Psychopharmacology*, 149(3), 241–245.

**Delvaux, F., Rochcongar, P., Bruyère, O., Bourlet, G., Daniel, C., Diverse, P., Reginster, J. and, Croisier, J. L.** (2014). Return-To-Play Criteria after Hamstring Injury: Actual Medicine Practice in Professional Soccer Teams. *Journal of Sports Science and Medicine*, 13(3), 721–723.

**Deschenes, M. R., Kraemer, W. J., Bush, J. A., Doughty, T. A., Kim, D., Mullen, K. M., and Ramsey, K.** (1998). Biorhythmic influences on functional capacity of human muscle and physiological responses. *Medicine & Science in Sports & Exercise*, 30(9), 1399–1407.

**Dijkstra, H. P., Pollock, N., Chakraverty, R., and Ardern, C. L.** (2016). Return to play in elite sport: a shared decision-making process. *British Journal of Sports Medicine*, 51(5), 419–420. <https://doi.org/10.1136/bjsports-2016-096209>

**Drust, B., Waterhouse, J., Atkinson, G., Edwards, B., and Reilly, T.** (2005). Circadian rhythms in sports performance—an update. *Chronobiology International*, 22(1), 21–44.

**Edwards, B. J., Lindsay, K., and Waterhouse, J.** (2005). Effect of time of day on the accuracy and consistency of the badminton serve. *Ergonomics*, 48(11–14), 1488–1498.

**Folkard, S., and Monk, T. H.** (1983). Chronopsychology: circadian rhythms and human performance. In A. Gale, and J. A. Edwards (Eds.), *Attention and performance* (pp. 55–78). New York: Academic Press.

**Forsdyke, D., Gledhill, A., and Ardern, C.** (2016). Psychological readiness to return to sport: three key elements to help the practitioner decide whether the athlete is REALLY ready? *British Journal of Sports Medicine*, 51(7), 555–556. <https://doi.org/10.1136/bjsports-2016-096770>

**Garrett, W. E. Jr.** (1996). Muscle strain injuries. *The American Journal of Sports Medicine*, 24(6 Suppl.), S2–S8.

**Geerts, W. H., Bergqvist, D., Pineo, G. F., Heit, J. A., Samama, C. M., Lassen, M.R., and Colwell, C. W.** (2008). Prevention of venous thromboembolism: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8.<sup>a</sup> Ed.). *Chest Journal*, 133(Suppl. 6), 381S–453S.

**Gorostiaga Ayestarán, E., and Olivé Vilás, R.** (2007). *Adaptaciones al clima y al horario de Pekín'08*. Comité Olímpico Español. <https://www.navarra.es/NR/rdonlyres/4E1F3179-C69F-4EC7-BBF3-006B3BC5EA09/189147/folletopekinokfindefi6.pdf>



**Grobler, L. A., Schweltnus, M. P., Trichard, C., Calder, S., Noakes, T. D., and Derman, W. E.** (2000). Comparative effects of zopiclone and lorazepam on psychomotor and physical performance in active individuals. *Clinical Journal of Sport Medicine*, 10(2), 123-8.

**Hallén, A., and Ekstrand, J.** (2014). Return to play following muscle injuries in professional footballers. *Journal of Sports Sciences*, 32(13), 1229-1236.

**Halson, S. L., Burke, L. M., and Pearce, J.** (2019). Nutrition for Travel: From Jet lag To Catering. *International Journal of Sport Nutrition and Exercise Metabolism*, 29(2), 228-235.

**Harma, M.** (1993). Individual differences in tolerance to shiftwork: a review. *Ergonomics*, 36(1-3), 101-109.

**Heiderscheit, B. C., Sherry, M. A., Silder, A., Chumanov, E. S., and Thelen, D. G.** (2010). Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. *Journal of Orthopaedic & Sports Physical Therapy*, 40(2), 67-81.

**Herxheimer, A., and Petrie, K. J.** (2002). Melatonin for the prevention and treatment of jet lag. *Cochrane Database of Systematic Reviews*, (2): CD001520. <https://doi.org/10.1002/14651858.CD001520>

**Hughes, R. J., Hopkins, R. J., Hill, S., Weatherall, M., Van de Water, N., Nowitz, M., Milne, D., Ayling, J. and Beasley, R.** (2003). Frequency of venous thromboembolism in low to moderate risk long distance air travellers: the New Zealand Air Traveller's Thrombosis (NZATT) study. *Lancet*, 362(9401), 2039-2044.

**Janse van Rensburg, D. C., Fowler, P., and Racinais, S.** (2020). Practical tips to manage travel fatigue and jet lag in athletes. *British Journal of Sports Medicine*. <https://doi.org/10.1136/bjsports-2020-103163>

**Järvinen, T. A., Kääriäinen, M., Järvinen, M., and Kalimo, H.** (2000). Muscle strain injuries. *Current Opinion in Rheumatology*, 12(2), 155-161.

**Kuipers, S., Cannegieter, S. C., Doggen, C. J. M., and Rosendaal, F. R.** (2009). Effect of elevated levels of coagulation factors on risk of venous thrombosis in long-distance travelers. *Blood*, 113(9), 2064-2069.

**Lagarde, D., Chappuis, B., Billaud, P. F., Ramont, L., Chauffard, F., & French, J.** (2001). Evaluation of pharmacological aids on physical performance after a transmeridian flight. *Medicine & Science in Sports & Exercise*, 33(4), 628-634.

**Lapostolle, F., Surget, V., Borron, S. W., Desmaizières, M., Sordelet, D., Lapandry, C., Cupa, M., and Adnet, F.** (2001). Severe pulmonary embolism associated with air travel. *The New England Journal of Medicine*, 345, 779-783.

**Lapostolle, F., Le Toumellin, P., Chassery, C., Galinski, M., Ameer, L., Jabre, P., Lapandry, C., and Adnet, F.** (2009). Gender as a risk factor for pulmonary embolism after air travel. *Thrombosis and Haemostasis*, 102(6), 1165-1168.



**Lemmer, B., Kern, R. I., Nold, G., and Lohrer, H.** (2002). Jet lag in athletes after eastward and westward time-zone transition. *Chronobiology International*, 19(4), 743-764.

**Matheson, G. O., Shultz, R., Bido, J., Mitten, M. J., Meeuwisse, W. H., and Shrier, I.** (2011). Return-to-play decisions: are they the team physician's responsibility? *Clinical Journal of Sport Medicine*, 21(1), 25-30.

**McCall, A., Lewin, C., O'Driscoll, G., Witvrouw, E., and Ardern, C.** (2016). Return to play: the challenge of balancing research and practice. *British Journal of Sports Medicine*, 51(9), 702-703. <https://doi.org/10.1136/bjsports-2016-096752>

**Miller, M. D., Arciero, R. A., Cooper, D. E., Johnson, D. L., and Best, T. M.** (2009). Doc, when can he go back in the game? *Instructional Course Lectures*, 58, 437-443.

**Minors, D. S., and Waterhouse, J. M.** (1981). *Circadian Rhythms and the Human*. Wright PSG.

**Mohr, L. C.** (2008). Hypoxia during air travel in adults with pulmonary disease. *The American Journal of the Medical Sciences*, 335(1), 71-79.

**Moline, M. L., Pollak, C. P., Monk, T. H., Lester, L. S., Wagner, D. R., Zendell, S. M., Graeber, R. C., Salter, C. A. and Hirsch, E.** (1992). Age-related differences in recovery from simulated jet lag. *Sleep*, 15(1), 28-40.

**Müller, U., Krüger-Franke, M., Schmidt, M., and Rosemeyer, B.** (2014). Predictive parameters to return to pre-injury level of sport 6 months following anterior cruciate ligament reconstruction surgery. *Knee Surgery, Sports Traumatology, Arthroscopy*, 23(12), 3623-3631.

**Olivé, R.** (2002). Jet lag, adaptación del equipo olímpico español en su viaje a Sydney. *Selección*, 11, 160-165

**Orchard, J., Best, T. M., and Verrall, G. M.** (2005). Return to play following muscle strains. *Clinical Journal of Sport Medicine*, 15(6), 436-441.

**Philbrick, J. T., Shumate, R., Siadaty, M. S., and Becker, D. M.** (2007). Air travel and venous thromboembolism: a systematic review. *Journal of General Internal Medicine*, 22, 107-114.

**Reilly, T.** (1982). Circadian variations in ventilatory and metabolic adaptations to submaximal exercise. *British Journal of Sports Medicine*, 16, 115-116.

**Reilly, T., and Brooks, G. A.** (1986). Exercise and the circadian variation in body temperature measures. *International Journal of Sports Medicine*, 7(6), 358-362.

**Reilly, T., and Piercy, M.** (1994). The effect of partial sleep deprivation on weight-lifting performance. *Ergonomics*, 37(1), 107-115.

**Reilly, T., and Waterhouse, J.** (2005). *Sport, exercise and environmental physiology*. Elsevier.



**Robertson, W. G., Hodgkinson, A., and Marshall, D. H.** (1977). Seasonal variations in the composition of urine from normal subjects: a longitudinal study. *Clinica Chimica Acta*, 80(2), 347-353.

**Silder, A., Heiderscheit, B. C., Thelen, D. G., Enright, T., and Tuite, M. J.**(2008). MRI observations of long-term musculotendon remodeling following a hamstring strain injury. *Skeletal Radiology*, 37(12), 1101–1109.

**Silverman, D., and Gendreau, M.** (2009). Medical issues associated with commercial flights. *Lancet*, 373(9680), 2067-2077.

**Tol, J. L., Hamilton, B., Eirale, C., Muxart, P., Jacobsen, P., and Whiteley, R.** (2014). At return to play following hamstring injury the majority of professional football players have residual isokinetic deficits. *British Journal of Sports Medicine*, 48(18), 1364-1369.

**Van Someren, E. J., Lijzenga, C., Mirmiran, M., and Swaab, D. F.** (1997). Long-term fitness training improves the circadian rest-activity rhythm in healthy elderly males. *Journal of Biological Rhythms*, 12(2), 146-156.

**Voleti, P. B., Buckley, M. R., and Soslowky, L. J.** (2012). Tendon healing: repair and regeneration. *Annual Review of Biomedical Engineering*, 14, 47–71.

**Waterhouse, J., Reilly, T., and Atkinson, G.** (1997). Jet lag. *Lancet*, 350 (9091), 1611-1616.

**Waterhouse, J., Nevill, A., Edwards, B., Godfrey, R., and Reilly, T.** (2003). The relationship between assessments of jet lag and some of its symptoms. *Chronobiology International*, 20(6), 1061-1073.

**Winget, C. M., De Roshia, C. M., and Holley, D. C.** (1985). Circadian Rhythms and athletic performance. *Medicine & Science in Sports & Exercise*, 17, 498-516.

**Wurtman, R. J.** (1982). Nutrients that modify brain function. *Scientific American*, 246(4), 50-59.

**Zulch, K. J., and Hossmann, V.** (1967). 24-hour rhythm of human blood pressure. *German medical monthly*, 12(11), 513-518.

