Module 1. Prevention and Readaptation from Injuries

Unit 1.1 Definition of Injury and Its Influence on Team Sports

In team sports, it is difficult to prevent injuries from happening, especially because of their unpredictability. That is why, for decades, countless injury prevention programs have been studied and implemented in an effort to at least reduce the number and severity of injuries.

Therefore, there is a need to classify them and, at the same time, to determine the reasons for their genesis (or to try to do so). But first, we must make something clear: the athlete will tend to suffer injuries every time he is exposed to situations for which he is not prepared and this includes his physical and psychological condition, nutritional status, among other factors. For example: if there is a collision between two players in an attempt to head a ball in a "second play", the ability to land in that situation will be essential to prevent a sprained knee or ankle, as well as muscle injuries in the eccentric contraction that occurs at the time of contact with the field of play.

Another case that can also be contemplated by the previous statement is that the levels of strength that an athlete is prepared to withstand in a tibial internal rotation with the body weight loaded on the foot of that same leg and resting on the ground will be inversely proportional to the severity of the anterior cruciate ligament (ACL) injury that may be suffered during this mechanism or gesture, since this represents the highest percentage of ACL injuries. To be more precise, 70% of the injuries of this ligament are the result of situations without contact with the opponent (Arendt, Dick, 1995).

> As regards handball in Scandinavian countries, ACL injuries occur in 4 to 8% of players per year, with a frequency 3 to 5 times higher in women. (Engebretsen, Bahr, en Bahr & Maehlum, 2007).

> In their study on ACL injuries in female athletes, Gray et al. explain that the most common mechanisms of injury are foot landing in pivot action

> followed by a change of direction (29% of cases), jump landing with the knee in extension (28% of cases), sudden landing of the jump in monopodal landing with the knee in hyperextension (26% of cases). Another study that follows this line of injury mechanisms details that ACL injuries in basketball and football occur in most cases without contact, mostly through decelerations or landing from a jump. (Romero Rodríguez, en Romero & Tous, 2011).

Returning to the need to classify the possible causes of injury, the factors to be taken into account when considering this classification will be: whether there was contact or not, the chronic, acute or immediate (at the exact moment of injury) training load, the joint movement mechanisms in which it occurs (flexion, extension, adduction, rotation), the types of muscle contraction (concentric, eccentric, isometric), among other factors. And, of course, the combination of these.

Romero (2011) classifies injuries in team sports into two main groups:

- Traumatic injuries: sprain, strain, contusion, fracture, dislocation, etcetera.
- Overuse injuries: they can be defined as any pain syndrome of the musculoskeletal system that appears without previous trauma or disease.

This is why in order to talk about prevention, we have to know about injuries and their incidence in sport. Van Mechelen (1992) proposes that in order to establish the incidence of injuries in sports, we must parameterize the number of injuries as regards the time of exposure to a given sport or discipline. However, this will only make sense if we first define what we mean by sports injuries.

- Ekstrand (2009) refers to injury, particularly in football, as the injury resulting from sports practice, which leads to the player not being available to participate fully in future training sessions and competitions.
- According to Bahr and Maehlum (2007) the definition of sports injury is tissue damage that occurs as a result of participation in sports or physical exercise.
- Bahr and Trosshaug (2005) state that the injury is the result of a specific transfer of energy to the tissue from a biomechanical point of view, which takes into account both the properties of the tissue and the characteristics of the load.
- On the other hand, an injury may be recorded as such if it forces the player to miss the entirety of the following game or training session. All actions that result in medical care during competition or training sessions should also be considered as such (Soomro et al., 2016).
- Gabbett (2004) defined an injury as any pain or disability suffered by a player during a training session or competition, which results in medical attention during or

immediately after the end of the session. At the same time, this author classified the injuries, according to their severity, into: transitory injuries (without loss of training sessions), mild injuries (up to one week of loss of training), moderate injuries (between two and four weeks of absence from training), important injuries (5 weeks of absence from training or more).

- Van Mechelen (1992) proposes to define sports injuries as all types of damage that occur in relation to the practice of sports activities.
- Fuller (2006) provides a deeper analysis, characterizing sports injuries in terms of their consequences. Injuries for which the athlete must receive medical attention are called “medical attention injuries”. If the player, as a result of an injury, is temporarily sidelined from competition, this is called a "time loss injury".

Therefore, we see how the definitions of injury refer to damages. From a physiological point of view, these damages are reflected in tissue ruptures. From a sports perspective, what is produced is the loss of performance and what is contemplated is the impossibility of participation in training sessions and competitions. This indicator shows us where the paradigms linked to injury prevention programs are heading.

Incidences and Characteristics of the Injury

When we talk about incidence, we must begin by making reference to the frequency with which injuries occur according to the discipline and level of competition. We also need to mention what is the level of exposure that an athlete has by practicing a sport in a systematic way. Thus, the number of injuries sustained in a certain number of hours of sport practice (of a particular sport) will be considered when analyzing the likelihood of players to get injured. This is an extremely important exercise not only to set objectives to guide injury prevention programs, but also to be able to magnify the damage caused by injuries in both economic and sporting terms.

According to Romero (2001), the calculation of hours of exposure to the risk of injury during a given period, such as a season, must take into account the following:

- Duration of the game (1.5 hours)
- The number of players that participate in a game (in football it would be 22: 11 on each side)
- The number of games played on each matchweek of the tournament (10 games if the league has 20 teams).
- The number of matchweeks of the tournament (38 matchweeks if the tournament has two rounds like the Spanish league).

This will result in the number of hours of exposure to the risk of injury in a given league or tournament. (1.5 x 22 x 10 x 38 = 12,540 horas).

Now, if we want to transform that number into a rate (generally injury rates are calculated every 1000 hours of exposure), we must use a simple rule of three considering the number of injuries of a particular type, such as hamstring tears:

1000 x number of tears / 12,540 = hamstring tear exposure rate per 1000 hours of competition in Spanish league football.

Table 1 shows an example of how to consider the injury exposure rate (without discriminating the type of injury) according to the discipline considered, taking national teams as a sample, both in competitions and in training sessions.

Table 1: Incidence of acute injuries in national teams

Sport	During competition	During training sessions
Basketball	2-3	5-6
Football	11-35	2-8
Futsal	14	1-2
Ice Hockey	29-79	1-3
Volleyball	3-6	1-4

Number of injuries per 1,000 hours of participation.
Source: Bahr, en Bahr & Maelhum, 2007.

> To get an idea of the magnitude of the problem in high-level football, we know that approximately 9 injuries occur for every 1,000 hours of play (between training sessions and competitions). (Cos F., Cos M., Buenaventura, Pruna, Ekstrand, 2010).

Hours of exposure rates will be critical when thinking about the objectives of our prevention program. However, we do not have to forget to consider the severity of injuries, that is, the injuries we really do not want our players to suffer. We have to keep in mind that each type of injury will cause a loss of performance that will be qualitatively and quantitatively different. We also have to consider the costs of the healing and readaptation process of an injury. Moreover, we do not have to forget about the recovery times that stem from them. Therefore, even though the rate of exposure to muscle injuries is higher than that of ACL rupture, this does not mean that the prevention program will be focused only on the injury with the highest incidence, but also on those that can cause the greatest damage, taking into account the variables previously mentioned.

> Not all injuries are equally severe in all sports, but some team sports such as basketball, football and handball have been documented to have a disturbingly high incidence of more serious injuries, particularly anterior cruciate ligament injuries. (Bahr, en Bahr & Maelhum, 2007).

Another valuable way of contemplating the incidence of injuries in order to make decisions for prevention purposes is that shown by Bahr (2007) (Table 2), which refers to the percentage that each sport or discipline may represent for a given population or age group.

Table 2: Incidence and severity of sports injuries

	13 to 17 years old	18 to 24 years old	25 to 64 years old	Over 64 years old
Football	30	36	33	3
Futsal	13	12	11	2
Volleyball	2	3	3	-
Basketball	8	5	1	2
Ball sports (not specified)	7	6	6	4
Slalom/Alpine skiing	5	6	5	1
Cross-country skiing	2	3	20	40
Ski jumping	2	2	4	-
Backcountry skiing	3	2	2	1
Other sports with skis, including snowboarding	2	1	-	-
Skating	1	1	1	-
Ice Hockey	2	2	1	-
Gymnastics/martial arts	8	9	4	9
Track and field running	3	4	6	11
Rowing and water sports	2	1	2	3
Equitation	3	1	1	1
Others	3	3	6	16
Not specified	2	2	3	7
Total in %	100	100	100	100

Source: Bahr, en Bahr & Maelhum, (2007).

Distribution of injuries in outpatients expressed as a percentage (%) according to sport and age (n=244 thousand). The sum of the percentages in the table will not necessarily result in 100%, due to rounding of decimal numbers.

Risk Factors Adapted to Team Sports

When thinking about injury prevention, that is trying to prevent our players from suffering certain injuries, or at least reducing the possibility of this happening, we have to contemplate the characteristics of both the sport and each of our athletes.

Risk factors are divided into extrinsic and intrinsic. The staff in charge of the health and performance of the team will surely have more influence on those who depend on the player and not on what happens outside the player or what the environment imposes on him. Therefore, extrinsic risk factors must be contemplated and taken into account, but

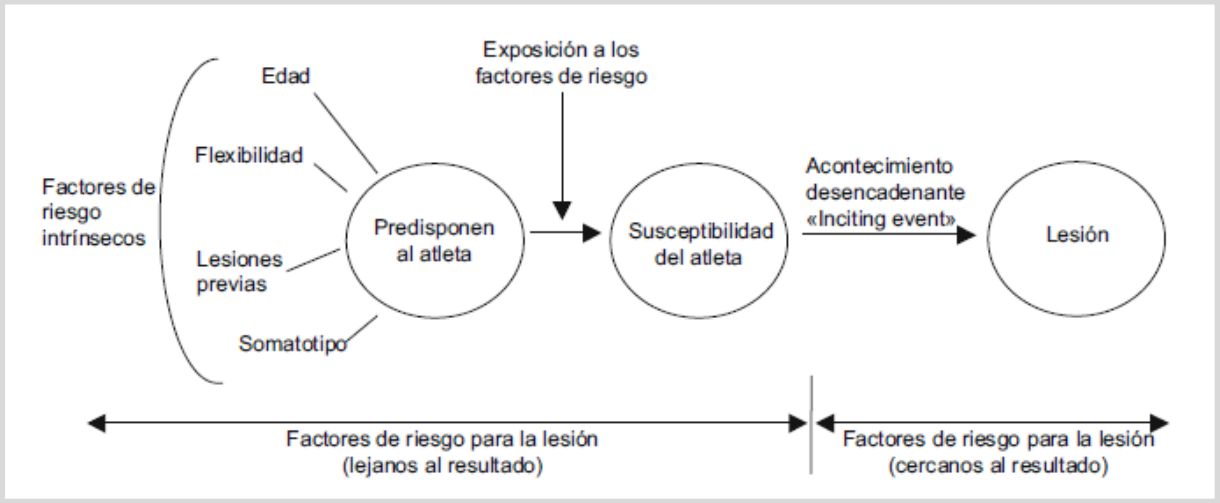
the prevention program will be developed based on the intrinsic risk factors, that are those over which the staff can have greater influence.

If we take the example of overuse injuries, we must understand that what is occurring is an imbalance between a subject's ability to withstand a given training load and the load imposed on him. This indicates that, in addition to modifying the training load, our prevention program should also aim to increase the capacity of our athletes to resist the most frequent contacts that occur in the discipline they practice, in order to reduce the incidence and severity of this type of injuries.

As it can be seen, the risk factors for injury are determined, on the one hand, by the forces or stimuli applied to the player and, on the other, by his capacity to respond to them. In the same way, training sessions cause adaptations, both positive and negative, in the medium and long term through the individual's biological reactions (internal load) to an external stimulus proposed by the trainer or simply by the game situation (external load). This is why injury prevention should be approached as a training process whose objective is to adapt the athlete's responses to the game actions to which he will be subjected during sports practice and which pose a risk of injury.

Without going any further, the two main objectives of the training load control in team sports are, on the one hand, to optimize performance and, on the other hand, to prevent injuries by predicting them through the recording of both acute and chronic loads of the team and the individual.
Risk factors should be understood as variables that interact with each other to cause an injury, especially in team sports where the predictability of game situations is low. Cos et al. (2010) show a diagram of the multifactorial origin of injuries in team sports proposed by Meeuwisse in 1994. He tests a combination of risk factors that predispose the athlete to suffer an injury and that will be expressed during the event that triggers the injury.

Figure 1: Multifactorial etiology model in sports injuries



Source: Cos et al., 2010.

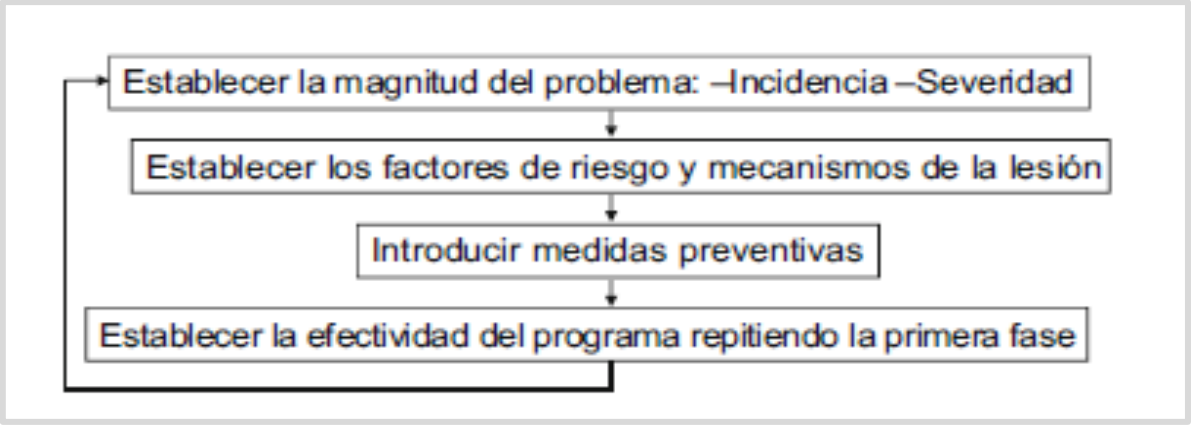
The English translation of this image is below.

Factores de riesgo intrínsecos	Intrinsic risk factors
Edad	Age
Flexibilidad	Flexibility
Lesiones previas	Previous injuries
Somatotipo	Somatotype
Predisponen al atleta	Predispose the athlete
Exposición a los factores de riesgo	Exposure to risk factors
Susceptibilidad del atleta	Susceptibility of the athlete
Acontecimiento desencadenante «inciting event »	Inciting event
Lesión	Injury
Factores de riesgo para la lesión (lejanos al resultado)	Risk factors for injury (remote from the outcome)
Factores de riesgo para la lesión (cercanos al resultado)	Risk factors for injury (close to the outcome)

Historical Models of Prevention

The measures taken for injury prevention do not stand on their own. On the contrary, they are part of a cycle that is determined by a sequence. First, we need to establish the magnitude of the problem by comparing the incidence of injuries and their severity. Secondly, we have to establish the origin and mechanisms of an injury. Based on the two previous points, preventive measures are proposed and implemented. Finally, we have to study the effectiveness of the proposed measures, thus restarting this cycle by applying the first step based on the results obtained (Van Mechelen, 1992).

Figure 2: The "sequence of prevention" of sports injuries



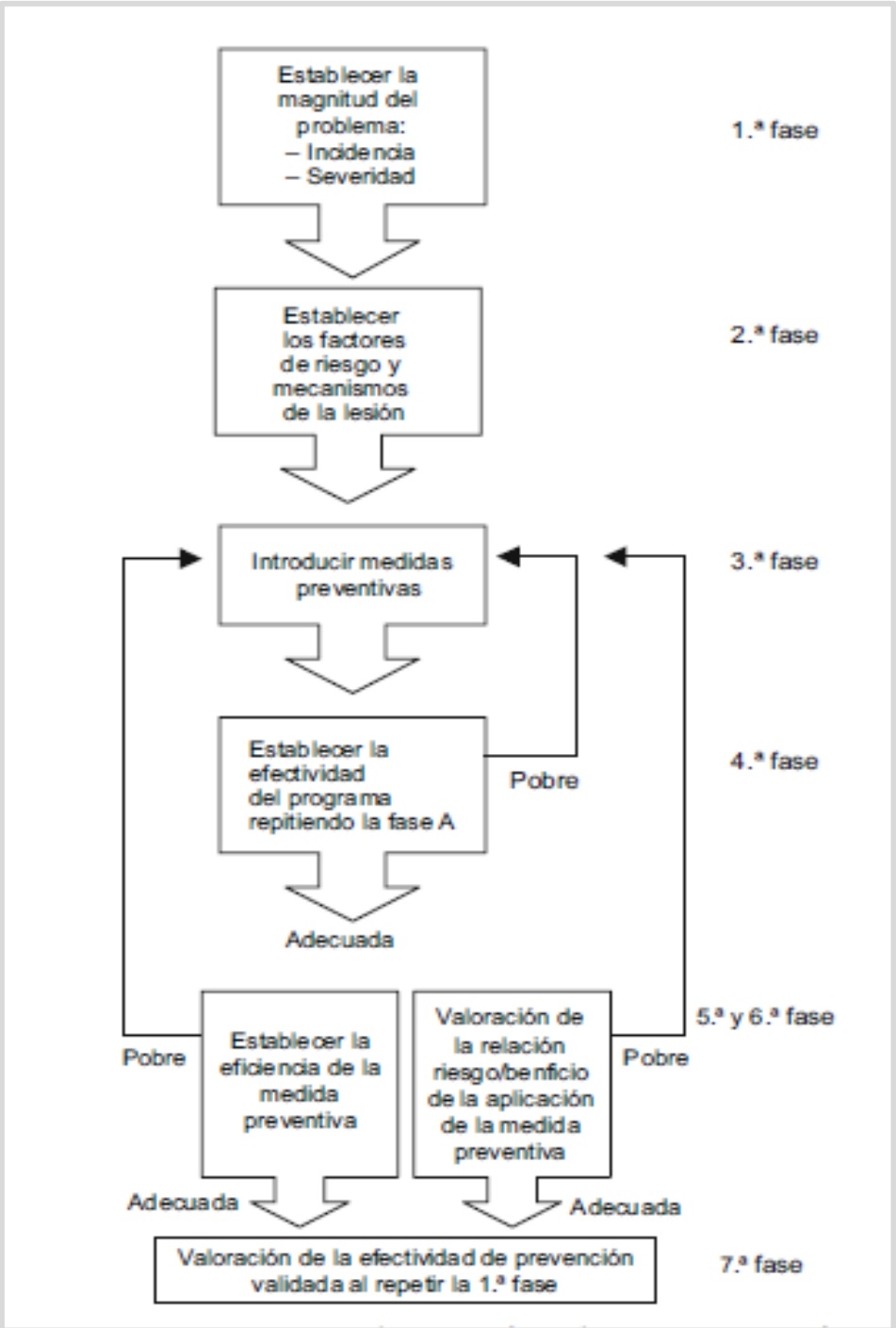
Source: Cos et al., 2010.

The English translation of this image is below.

Establecer la magnitud del problema: -Incidencia - Severidad	Establish the magnitude of the problem: -Incidence - Severity
Establecer los factores de riesgo y mecanismos de la lesión	Establish the risk factors and mechanisms of injury
Introducir medidas preventivas	Introduce preventive measures
Establecer la efectividad del programa repitiendo la primera fase	Establish the effectiveness of the program by repeating the first phase

This sequence has been globally used and is still a reference model in relation to injury prevention in sports. However, Van Tiggelen (2008) elaborates on this model by adding some steps. Here, the efficiency of the proposed preventive measure is considered, as well as its benefit-cost ratio. This can be seen in Figure 3.

Figure 3: Van Tiggelen's model of the prevention sequence of the recurrent sports injuries



Source: Cos et al., 2010.

The English translation of this image is below.

1ª fase	1st phase
Establecer la magnitud del problema: -Incidencia	Establish the magnitude of the problem: -Incidence

-Severidad	- Severity
2ª fase	2nd phase
Establecer los factores de riesgo y mecanismos de la lesión	Establish the risk factors and mechanisms of injury
3ª fase	3rd phase
Introducir medidas preventivas	Introduce preventive measures
4ª fase	4th phase
Establecer la efectividad del programa repitiendo la fase A	Establish the effectiveness of the program by repeating the phase A
Pobre	Poor
Adecuada	Adequate
5ª y 6ª fase	5th and 6th phase
Establecer la eficiencia de la medida preventiva	Establish the efficiency of the preventive measure
Valoración de la relación riesgo/beneficio de la aplicación de la medida preventiva	Evaluation of the benefit/cost ratio of the application of the preventive measure
7ª fase	7th phase
Valoración de la efectividad de la prevención validada al repetir la 1ª fase	Evaluation of the effectiveness of the validated prevention by repeating the 1st phase

Prevention Program

The use of a systematic injury prevention program can reduce the injury rate in young athletes by up to 40%. The exact reasons why this is happening have yet to be clarified. However, it could be assured that this is due to an increase in the levels of strength, proprioceptive balance and flexibility, generally increasing the athlete's physical readiness at the time of sports practice (Soomro, 2016).

This shows how important preventive intervention is when seeking to mitigate the prevalence of injuries in sports. However, as we have developed above, we should not forget that these interventions have to be part of a program adapted to the needs of the sport in general and the athlete in particular. Therefore, some characteristics that should be taken into account for its design are shown below (Romero, in Romero, Tous, 2011):

- Principles of injury prevention planning:
  - Multilaterality and polyvalence of the load: it is necessary to identify the most important physical qualities that should be worked on in order to reduce the risk of

injury. We also need to take into account the technical-tactical skills of the sport in question.

- Specialization: the loads designed in a prevention plan must be specifically oriented to each sport specialty. We should design exercises that work in similar conditions to competition.
- Individualization: prevention must be specifically adapted to the athlete, his most frequent technopathies, his poorer gestures, the improvement of his less developed physical qualities and the necessary metabolic demands, among others.
- Cyclic alternation or periodization: loads must be distributed multilaterally over time. It is also necessary to systematically repeat these loads and their variations at intervals of varying duration. When talking about prevention, it is necessary to study the adaptability of the prevention to the athlete's own training focused on sports performance.

- Neuromuscular pillars on which the prevention plan is based:

  - Perceptual-visual-vestibular system.
  - Strength understood as a neuromuscular quality.
  - Neuromuscular coordination.

Therefore, it is essential to emphasize the emergence of the cognitive component in prevention programs. This is due to the levels of permanent uncertainty which the athlete goes through in each game situation, in interactive sports in a shared space, such as football or basketball.

Based on the previous premise, let us see how, in the case of muscle injuries, the prevention program should consider the most frequent injury mechanisms due to the characteristics of each discipline. Here is a clear example of this:

> The most common mechanism of muscle injury is eccentric contraction, i.e. muscle contraction with muscle lengthening. As with fatigue or flexibility, the ability to tolerate eccentric contraction is trainable. If we take as an example the prevention of hamstring injuries in football players, we observe that teams that use a specific pattern of eccentric training of the hamstring muscles, such as the Nordic Hamstring Powers, have up to 65% fewer hamstring injuries than teams that do not use this type of pattern. (Pedret Carballido, Rodas Font, in Balius & Pedret, 2013).

FC Barcelona Model

The club has two levels of injury prevention: primary prevention and secondary prevention. Primary prevention consists of all those interventions that are carried out to prevent injuries from occurring for the first time. Secondary prevention, on the other hand, is used to prevent or avoid the recurrence of an injury that has already occurred. One of the most important risk factors for injury is the previous occurrence of injuries of this type.

These processes do not necessarily have to be similar. In the case of primary prevention, most of the training is done with the team, during warm-ups, or also as part of gym training. Our interventions are not only designed to achieve a certain objective, but also based on the week and time of the competition of the team. In addition to these, individualized preventive training is carried out, which arises from the detection of intrinsic risk factors that should be included in the primary prevention program (Pruna, Rodas, Til, 2015).

The preventive model considered relevant within FC Barcelona is based on the premise that the best prevention is just good training. It is well known that sports in which the interaction of physical space is shared pose great complexity when it comes to intervening on the so-called "preventive methodologies"(Romero, in Seirul-lo, 2017). That is why it is fundamental to build training exercises with an optimizing objective. They should allow the human-athlete to have a high rate of participation throughout the competition calendar. In other words, to make the human-athlete available to the technical staff and teammates for as long as possible.

According to what has been exposed so far, each of the scientific studies associated with injury prevention is presented as tools to provide an approach to the needs of team sports (in general) and athletes (in particular). However, in many cases they lack real proposals, that is to say, they are not applied to real-life practices. This does not mean that these studies are not valuable when it comes to considering them as guidelines for a better process of support and optimization.

One of the issues raised by Romero (in Seirul-lo, 2017) when thinking (or rethinking) of prevention in team sports is how can we develop preventive action in this sporting situation (referring to football as a sport of shared physical space, where the ball is disputed and changing situations occur at maximum speeds).

Here, an integrative approach is proposed, in which the structures of each athlete (conditional, coordinative, cognitive, emotional-volitional, and socio-affective) must be addressed with an end in itself: "to extend the sports life of the player".

In other words, what is the point of having a "strong" athlete if he does not know how to display his strength in those situations when the game demands it? What is the point of having a "fast" athlete if his decision making is never correct? Do we need "resistant"

athletes if the actions in which they are mostly involved (one player in particular) do not represent significant levels of aerobic capacity? All these actions in which the player is trapped are of great importance in sports. This is why the development of training exercises must preserve and respect a high degree of specificity so that strength, speed and velocity, among others, do not become potentially harmful actions.

Moreover, the pressure felt before an important game (a final) as well as a bad relationship between teammates may trigger an injury episode in a player at a specific moment of the game. Also, the lack of tactical synchronization within a team can lead the athlete to make decisions that compromise his health on the field. In turn, unexpected changes of direction present a high degree of injury in sport (both in the absence and presence of fatigue), so it is essential to work (build favourable environments) on exercises in which the athlete manages to self-organize for better decision making that allows him to economize their effort and increase their motor quality.

During the 1980s, Paco Seirul-lo proposed the need for an integrated approach to injury prevention and its inclusion in the training process:

Coadjuvant training, suppression training

The objectives of this systems are the following:

- - To constantly increase the basic coordination capacities of the different parts of the body areas that are specially involved in the execution of the specific techniques of that sport specialty.
- - To achieve the required muscle balance in the most important groups—protagonists and antagonists of the athlete's preferred techniques.

Some years later, FC Barcelona has consolidated a new perspective based on the needs of the player as regards the changing complexity of the game, redefined as optimize-preventive training.

Unit 1.2 Injury Readaptation. Readaptation Chapter (RDP) Readaptation (RDP) Chapter

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Index

- RDP contextualization
- RDP Concept
- Scientific evidence on RDP
- FCB Model and Rehabilitation Specialist
- Technology in RDP
- RDP contextualization

In the elite sporting environment, in terms of the athletes' health, or the lack of it, we usually talk about injury processes, estimated recovery times, the evolution of the healing process, the progressive reintroduction to new contents, among others. More and more, we all discuss the concept of sports readaptation. Most of us wonder when the injured athlete is going to return to training. The answer to this question provides invaluable information for both the player—as he would be the most concerned—the coaching staff and, increasingly, the media.

The evolution of the sport has in itself implied a greater physical demand on the athlete (training with greater volume and intensity and less time for recovery), as well as a higher level of emotional stress and other factors of different kinds which, together, lead to a higher incidence of injury.

The evolution of the sport has in itself implied a greater physical demand on the athlete (training with greater volume and intensity and less time for recovery), as well as a higher level of emotional stress and other factors of different kinds which, together, lead to a higher incidence of injury.

Athletes get injured the same or more, but the recovery process is becoming more and more specific from the point of view of sports medicine and physiotherapy. But above all, is becoming more and more specific from the point of view of the work of readaptation to training during the recovery process itself. So that at the end of the process, when the injury is resolved, the player is able (or very close to being able) to participate in training at the same level he was before the injury occurred.

RDP Concept

The concept of return to play is still not well defined, either nationally or internationally. International meetings have been held so as to integrate concepts on the definition, the criteria for decision making, the principles to be followed in the different injuries, the different aspects to be considered in the athlete's injury, etc. However, it is difficult to close concepts in this environment since it is very recent and very open. For example, we cannot compare the decision-making process in the medical area and the criteria that can be used for a pathology diagnosis with the decision-making process in the evolution of the field training to be performed by an injured athlete, nor the criteria to be taken into account for the approach of these contents. The symptom does not have to be linked to the image.

At the international level, Clare Anders published in 2016 the *Consensus assessment in return on play* at the First World Congress of Sports Physical Therapy (Anders et al., 2017).

On the other hand, at the national level, the literature also shows variations in the concept of readaptation and there does not seem to be a consensus on the definition (Lalín, 2006; Seirul-lo, Vargas, 1986; Tarragó Costa, Cos Morera, Gordillo Molina, Lizárraga, & Martín Urrialde, 2004). These variants or the lack of consensus in the definition are also shown in the definition of the process, which ranges from the already globally accepted return to play or readaptation to other terms such as *specific phase of the sport* to define such period of recovery. It is true that the figure of the rehabilitation specialist is still poorly defined even though the trend, which is becoming clearer and clearer, is for him to be a professional who can combine knowledge of the pathology and its treatment with knowledge of training and the dynamics of the loads. Therefore, a physiotherapist who is proficient in the world of training can be considered dual-qualified.

Return to play (RTP) is generally referred to as the part of recovery in which field training is introduced, including specific sport gestures and the physical and cognitive demands of the sport itself. This part of the recovery training starts in combination with the physiotherapy treatment and, at the beginning, has a secondary role. Then, it changes its prominence and becomes the main part of the treatment. In addition, it is combined with physiotherapy treatment and it will last until the athlete returns to normal sports practice. Readaptation is therefore proposed as a continuous process in which training begins by developing basic skills through individual training and progressively increases the level of demand of these individual demands until it becomes necessary to participate in group training in order to work on decisional aspects of the game that are difficult to simulate individually. In order to end the process, the player must spend some time training naturally with his training group before he is ready to return to normal competition.

One of the main objectives that we must achieve during this process is to work on all those aptitudes, skills and abilities necessary for the practice of sports, individually and adapted to each athlete.

The concept of rehabilitation as a continuum is adapted to the different populations that practice physical activity. The contextualization of the athlete's return to play is of utmost importance, given the fact that the concept of return to sport is very broad. When we talk about the amateur athlete or the professional athlete, we talk about a process of reintroduction and return to previous demands, but we must be aware that these demands—physical and cognitive—are different according to the level of the athlete and, therefore, must be addressed differently during this process.

Scientific Evidence on RDP

For years, scientific application has been introduced in sports medicine and it is increasingly being introduced in elite sport physiotherapy. The application of scientific evidence requires the objectification of physiological characteristics, such as pain, flexibility, strength, etcetera. Methodologies such as the ERA rating scale, pendulum inclinometers or dynamometers, isokinetic exercises or accelerometers allow us to accurately measure these variables, and the resulting data provide us with very useful complementary information for the whole process.

Nevertheless, this data is not only helpful as a criterion to increase the level of difficulty of the proposed exercises or to continue with the progression of the process. It is not a "phase change"; the "phases" overlap in a continuum of training, they are not separated by stages in which one content or another is not introduced because it is in one phase or another. The contents will be introduced progressively.

The data will support a process in which the observational role of the rehabilitation specialist, together with the sensations described by the player based on the proposed training, are very important, but they *do not indicate a phase change*. The collected data inform us about the specific situation of the athlete and it can possibly give us an overview of how the athlete is doing compared to how he was doing before injury or compared to how the group is doing. Collecting data of interest is as important as knowing how to interpret it, since it is not useful to have data on a player who plays in a certain position and compare it with a series of players with whom there is no similarity in physical demands or who play in different positions.

> *"Sports injuries are not treated, they are managed." (J. Brau)*

It seems that scientific evidence and its practical application through physical tests, musculoskeletal system evaluations or load monitoring can help to identify possible injury risk factors. For example, it is known that a weakness of the adductor musculature and a decreased range of motion of the coxofemoral joint may increase the risk of groin pain injury (Engebretsen et al., 2010).

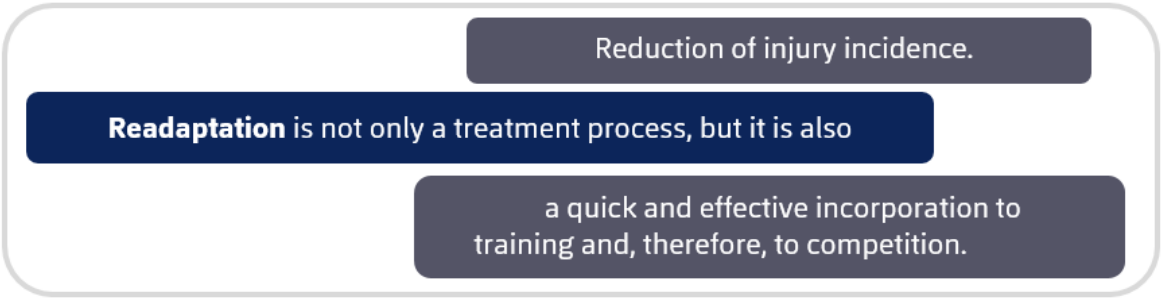
Evidence has also validated functional tests such as Symmetry Limb Index, T-Test, single leg jump or drop test. The use of normative data allows the use of functional tests, strength ratios in different injuries and even algorithm proposals, especially in hamstring injury (Mendigutxia, 2017; Fournier-Farley, 2017; Van der Horst, 2016; Van Dick, 2017), which allow us to have orientative information of the optimal state. From the physiotherapy department and in the readaptation, other factors are mainly taken into account such as the integration of health components, the healing state of the injured structure, the load that the structures receive, the tolerance of the structure to the introduction of new contents and kinematic mechanisms and the sports performance. These factors are difficult to objectify, but are relevant in readaptation.

FCB Model and Rehabilitation Specialist

FC Barcelona assumes its own character and methodology in the concept of return to play. Through innovation, evidence, experience and results, a unique retraining system has been developed that is characterized by working on physical and cognitive qualities in an integrated way

The main objective of the readaptation department is to allow the player to participate in group training again, maintaining a maximum level of demand, and to allow him to return to competition. Equally important, it must be ensured that the player does not suffer a recurring or relapsing injury during the process or after returning to the training group.

Figure 4: Concept of the sports injury treatment process



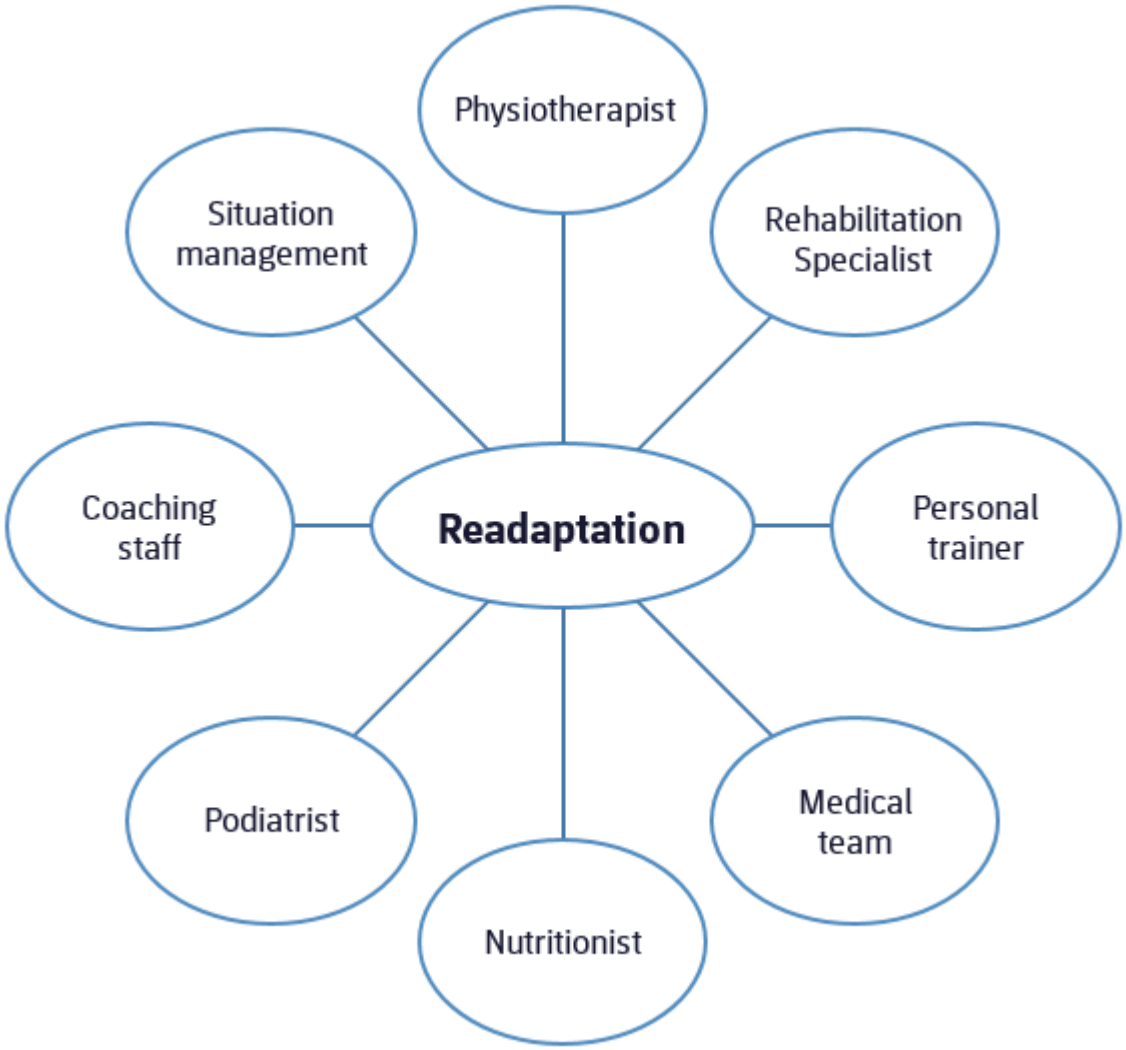
Source: Own elaboration.

Readaptation is based on a work system directed by physiotherapists in a multidisciplinary environment in which they work daily with the medical team, physical trainers, nutritionist and podiatrist, mainly. The technical team is also added.

We must consider the readaptation of a professional football player as a process not only of treating a pathology and planning an adequate exercise on the field, but also as the management of a complex situation. Therefore, we must take into account a series of elements that occur at the same time of the injury and that can affect the way in which the whole procedure is carried out: from the time of the season when an injury occurs (is

there a relevant competitive date nearby or, on the contrary, is there time to manoeuvre?) to the player's previous injury history, considering also the player's culture or religion and their effect on the day to day. Determining the player's media influence, the influence of his environment and that a player tolerates, in some degree, certain types of exercises, among others, are just some of the aspects that can alter the process and that we need to know how to manage.

Figure 5: Multidisciplinary team in the RDP



Source: Own elaboration.

During the readaptation process of an athlete's injury, there is an evolution in terms of the typology of the efforts made, which will increase in terms of difficulty, demand, intensity and mainly load. However, readaptation is a complex process that is not regulated in terms of "phases" or closed elements, in each of which we must introduce certain exercises or control tests that show us how to progress. The progress within a readaptation process is evaluated every day, based on the exercises that the athlete is able to perform and under the observation of the rehabilitation specialist so as to

determine whether or not it is correctly executed and the achievement of the objectives that have been set. Throughout the process, the player will work on elements of mobility, strength, motor control, balance, agility, coordination, among others, which will be structured within his training sessions with a predominance of one or other elements depending on the moment.

As a general rule, the rehabilitation specialist proposes exercises to the player. These exercises should always be consistent with the time of the injury and the state of the physiological repair process. These exercises make up a structure that is the training session that has been scheduled. Let's take for example a training that is developed in the gym: a series of exercises are prepared and proposed to the player and, if the player does not feel confident or has a strange feeling in the execution of any of them, they are eliminated or changed for others in which this feeling is improved. In an example of training on the field, the rehabilitation specialist prepares a training session on the field, explains to the player what exercises he has to carry out, and he does so always working under a sense of security and with a good feeling; the intensity will be incremental in order to progressively reach an execution as expected.

It is a very difficult aspect to combine the maintenance or restoration of the physical condition as such with the training adapted to the needs of the injury.

The rehabilitation specialist is a professional with knowledge in the area of physical activity and sport sciences, who facilitates the management and monitoring of the training loads applied to the injured player, protecting and stimulating his health while giving him sufficient stimulus to maintain or improve his physical condition. When the player rejoins the training group, he must be at least in the same physical condition as the rest of his teammates.

It is understood that for the readaptation it is essential to have an excellent knowledge of the behaviour of sports injuries and the management of the injury during the entire recovery period. Management is also necessary to try to avoid relapse in a recovery process, which is one of the main objectives of the entire readaptation process.

> *"There is no prevention but risk reduction" (J. Brau)*

As is already the case with treatment at the physiotherapy or medical level, adverse physiological responses may occur during readaptation training, either during the application of the training *per se* or *a posteriori*. The professional must have the necessary knowledge for the early identification of that response and must be able to analyze whether the response is related to the injury, the type of training performed, the load applied or the mechanisms introduced. He should also be able to manage if the adverse

response modifies the planned training and, if so, he should come up with an adapted plan.

The physiotherapist profile is specialized, with knowledge in sports pathology, anatomy, physiology and pathological biomechanics of sports. The FCB rehabilitation specialist, in addition to pathological and physiotherapeutic knowledge, must have applied knowledge in movement analysis, planning and application of therapeutic and functional exercises, sport gestures, and sport-specific physical and cognitive demands. Therefore, knowledge and understanding of the sport are necessary skills for a good rehabilitation specialist, who must be able to reproduce actions, intensities and sport contexts as similar as possible to a real situation.

Figure 6: Knowledge and skills in the RDP of the injured player

Source: Own elaboration.

FCB's proposal regarding the start of readaptation is linked to the concept of *early functionalization*: that the athlete will recover better from the injury by moving. Therefore, it is about getting the athlete to start moving early (this starting time will be different depending on the type of injury suffered by the player) always under the criterion of safety at the medical level that allows the start of the activity. This early activation of the player is linked in time with the physiotherapy treatment and, in fact, it can be considered part of the treatment itself. Consequently, when we start the readaptation, the player will probably not have fully recovered his pre-injury strength values or his active/passive joint ROM or his neuromotor patterns or his ability to perform complex exercises, among others, because these are aspects that will be worked on in the readaptation process.

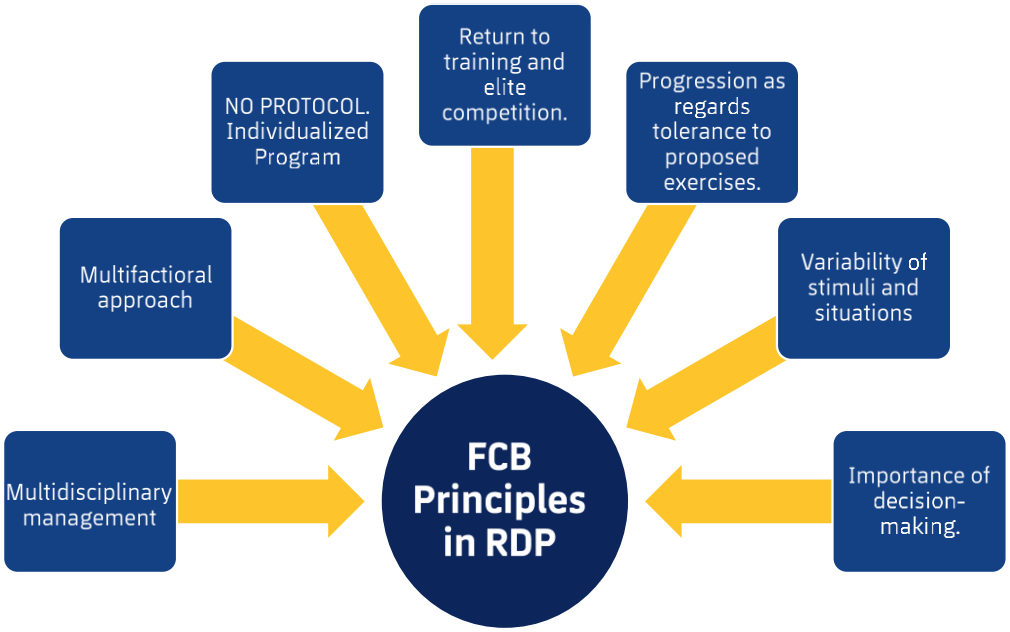
The readaptation system considers that the progression criteria are based on a multifactorial evaluation, in which the physical-sporting capacities of the competition are only a part of the factors to be considered. The rehabilitation specialist prioritizes cognitive and technical skills as well as physical skills. Likewise, Shrier (2015) raised a risk and tolerance evaluation in the RTP decision (StARRT). The FCB rehabilitation specialist, following Juanjo Brau's method for more than 15 years, considers a multifactorial evaluation as a daily process in the planning of each training session.

The variability of the stimuli is a key aspect in the readaptation process, whether it is at the level of strength recovery exercises in the gym, such as functional training, field training, etcetera. The aim is to enrich the cinematic possibilities of the recovering player as much as possible. Team sports, especially football, are unpredictable. Therefore, during the readaptation process, we must look for stimuli that are not repetitive in order to avoid an adaptation to a specific movement or performance pattern. Performing the same exercise with different resistances, varying ranges of motion, random repetitions per exercise, stable or unstable surfaces, etc., will help us not to adapt the movement or contraction to a specific situation.

In terms of field training in a readaptation session, this non-adaptation can be explained by the different surfaces on which we work: treadmill (even with a reduced surface), sand, artificial grass, natural grass and tartan surface (ramp running). Variability in all aspects in which we can produce it.

Another of the principles of the FCB's rehabilitation specialist is the individualization of the recovery programs. Taking into account that FCB's playing system determines a specific player profile, factors such as player position, decision-making and execution, player characteristics and his personality on the field are considered when planning a readaptation program. The use of prescribed exercise programs or protocols is not part of the FCB readaptation system. Each injury is a particular case that must be approached individually, not only in treatment, but also in readaptation.

Figure 7: FCB Principles in the RDP



Source: Own elaboration.

As we have mentioned, scientific evidence proposes functional tests to objectify player information, but, when it comes to practical application, their use has been limited due to lack of individuality and limitation on specificity in sports. The rehabilitation specialist will constantly develop exercises and functional tests specific to the club, which are related and oriented to assimilate with the type of demands that the game system generates.

Technology in RDP

The use of functional tests, specific circuits and the introduction of technology such as GPS have provided very relevant information in the readaptation phase, since it is possible to make comparisons through reliable data of the physical demands achieved in a group training and in a readaptation training. Being able to have and analyze the data generated by a player during a session, together with the critical nature of the rehabilitation specialist, is very valuable information in the evolution of the process.

The technological evolution in which we are immersed enables us to have more and more non-laboratory technology, which in turn allows us to obtain data during the application of a particular training. This is an element to be explored in the coming years.

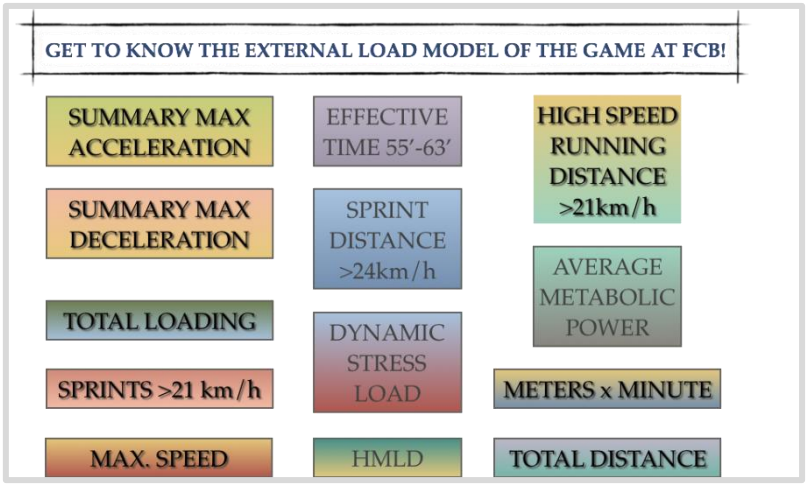
Currently, other systems such as motion analysis by satellite or 3D, reaction speed and decision making training circuits, or analysis through wearable surface electromyography are integrated into the data collection and analyzed by the rehabilitation specialists, thus creating their own individualized RTP criteria for each player.

In recent years, the use of GPS has been widely used in professional football to monitor training loads and it has been accepted to the point that we can see many teams using the device even in league games. We can consider its use in readaptation as a fundamental tool, since it allows us to analyze the results of the session carried out and to objectively assess whether the expected results have been achieved or not.

The ultimate objective of the readaptation is to ensure that the player is in optimum conditions when he returns to training with the group. Through GPS, we can analyze whether the data obtained individually is similar to the data obtained by the players of the group playing in the same position or the data previously collected from the player himself.

GPS is a very powerful tool that records thousands of data per second, while recording a number of different variables that are interesting. However, you need to know how to analyze and interpret them. We could talk about variables such as maximum accelerations or decelerations, maximum peak speed, maximum impacts generated, load indicators such as HMLD, the number of meters travelled at high intensity, among others. There are more than 180 variables that must be properly and carefully analyzed.

Figure 8: External load model of the game



Source: taken from Pons. Document for internal use of FC Barcelona.

Once the player is discharged and back to group training and competition, preventing relapse is a fundamental objective of recovery. The readaptation department understands prevention as the reduction of the risk of injury, since there are so many factors that can influence the incidence of injury, as it is not possible to control them all, and, therefore, it is not possible to prevent all injuries.

In order to try to reduce the risk, it is necessary to ensure that the player has an optimal physical condition, as well as knowledge of injuries, their risk factors, the monitoring of musculoskeletal characteristics of players and internal and external loads that help us to

identify indicators of possible risk of injury. The use of RPE (Rating of Perceived Effort) questionnaires is useful to control the internal load. These questionnaires provide information on the state of motivation, fatigue and perception of the player's effort. They are applied prior to the realization of each readaptation session.

In professional football, the figure of the rehabilitation specialist is one more in the management of the injury, in which he provides fundamental information for decision-making in the return to play. At FC Barcelona, the experience of the last 15 years has led the rehabilitation specialist playing a major role in the process and decision making for the return to play due to his transcendence in the knowledge of the player, the experience in the management of the injury and the success in the reduced number of re-injuries.

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