Introductory module

Concept of training load

Both in this course and in previous ones, we define the concept of training load because it is an essential component in sports science. The training load refers to the stress or stimulus to which the athlete is subjected during the training process. These activities or stress stimuli have two major components–volume and intensity–the product of which is the load value. In addition, two types of load can be studied–the external load and the internal load. The external load refers to the nature of the activity undertaken by the athlete, while the concept of internal load refers to the stress generated in the body due to this activity. In this way, the internal load is directly conditioned by the external load. In this sense, a 5 km running activity completed at a speed of 10 km/h will represent the external load, which will cause an internal load for the individual, determined for example in an average heart rate value of 140 beats per minute representing 70% of the individual maximum heart rate, average levels of lactate concentration of 5 Mmol/L and an increase in basal glycemia to 110 mg/dl. Meanwhile in individual B the internal load caused by the same external load (5 km at 10 km/h) could be 180 beats per minute representing 85% of the individual maximum heart rate, 8 Mmol/L of lactate and 150 mg/dl of blood glucose. Knowledge of this relationship leads us to conclude that the state of adaption or performance of the athlete must be measured two-fold, taking into account all activities that are performed during the training process but also the biological impact that they have on the athlete (González Badillo and Ribas Serna, 2002).

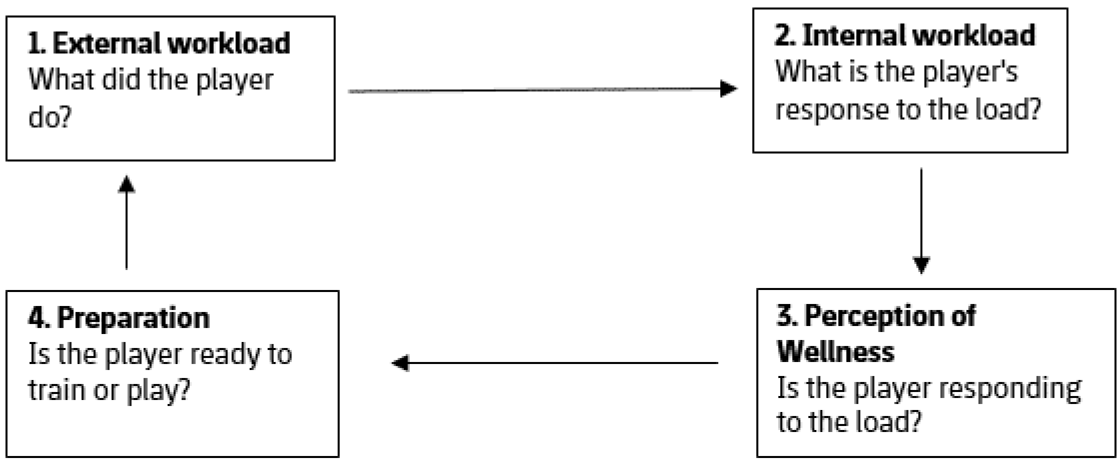
Control and objective and subjective assessment of fatigue

Within the tools used to monitor an athlete's performance, those that are used to monitor fatigue are of great importance. From there we can obtain data from mostly objective indicators, such as heart rate, lactate concentration and other biochemical markers, as well as mostly subjective indicators, including an extensive group of scales and questionnaires (Hooper's Index, Wellness Questionnaire, Total Quality Recovery or TQR, among others).

The athlete monitoring cycle

Given the importance of controlling the workload over a day, a week or a month of training, Gabbett et al. (2017) have proposed a methodological model or process to achieve optimal control over this training-competition process. Four stages are presented: The first step describes the workload undertaken by the athlete (external load). Next, the biological response to the workload (internal load) is established. The third step of the cycle consists in studying the extent to which the player tolerates the workload. Finally, whether the athlete is ready to train or play is confirmed (Figure 1). This matrix, which will be presented in more detail in a different course, is utilized to help the technical and physical trainers to make decisions during the training process.

Figure 1: The athlete monitoring cycle



Source: Prepared by the author based on Gabbett et al. (2017).

Tools for monitoring the athletes' internal load

There is a large number of tools and methods to monitor internal load in athletes. These include the analysis of muscle temperature, brain function and the analysis of saliva, blood, sweat and muscle activity, although there are many other alternatives. The importance of monitoring in this sense lies in finding methods that support decision-making, taking into account economic costs and their practicality, where the reliability, validity and sensitivity of the measures are determining factors. Furthermore, each trainer should establish the monitoring and evaluation system that is most suitable to the context in which it will be applied. In other words, as well as selecting tools that the club can consider given its economic circumstances, trainers should evaluate their applicability.

The most common methods detailed in this course include monitoring heart rate, expressed in both absolute values and relative to the athlete's different individual characteristics, such as the maximum heart rate and resting heart rate. Thus, some of the most used variables are peak or average heart rate, or establishing different heart rate intensity ranges or zones. We will also review the rate of perceived exertion (RPE) which is a widely used measure and allows us to obtain the RPE-session load indicator. Finally, we will review lactate concentration as an indicator of internal workload, considering its uses, but also its limitations when working with elite athletes.

Tools for monitoring the athletes' external load

Movement or external load analysis includes the quantification of displacements by the athletes supplying information related to the actions, speeds, durations and distances during training or competition (Casamichana, 2011). This information can be classified into three levels or types (Buchheit and Simpson, 2017):

- Level or type 1: Total distances covered and distances covered in different displacement velocity ranges (absolute or relative).
- Level or type 2: events related to changes in speed (accelerations, decelerations, metabolic power, equivalent average distance, equivalent distance index, distance covered to high metabolic power or HMLD, etc.)
- Level or type 3: Data derived from inertia sensors or accelerometers (player load, force load, contact and flight times, vertical stiffness, collisions, etc.)

In this way, it is important to understand that a wide variety of systems can be used to record an athlete's movement and GPS technology stands out today as the most used technology.

Introduction

Studying the relationship between variables and/or indicators can help us determine which ones we must pay more attention to when assessing the training and competition process, thus avoiding repeating information through the selection of complementary variables. So it is very important to analyze the possible relationships between variables in order to make the appropriate decisions in the context of a training session or task.

Today, the demands of training tasks are the subject of widespread study. These analyses are being published in scientific research and books (Casamichana, San Román, Calleja, and Castellano, 2016).

The methodological process is of paramount importance in order to make decisions in the training process seeking to maximize performance through the optimization of the conditional system, always with the implicit minimization of injuries.

Over the years the incorporation of GPS technology and its subsequent developments and evolutions has proved very useful. They have provided in depth information on the activities the athletes perform during each task (and in each of the repetitions) assigned during the training session.

We are going to provide an example of this process. The task begins with a 1 vs. 1 scenario, where the attacking player has positional superiority, and has to try to score a goal in the opposite goal. Once the goal is scored, the defending player together with a new teammate begin to play as 2 vs. 1 in the opposing goal, finishing up with the defense from the 2 vs. 1 by attacking the opposing goal with a new teammate and against a new opposition.

Based on this task, we will go on to detail the absolute load values involved in the performance of this task in training, taking different variables into account. We provide, as an example, the average value of different load variables for the whole team, and the detailed values of two of the players participating in the task. This information describes the activity carried out by the athletes and we consider it as one of the initial steps in the process of monitoring/evaluating the training load. We need to understand that training load management requires a methodological process that allows us to make decisions in training load management.

Table 1: Values of different load variables during the assigned task for the team's average and for two players participating in the task

	Distance (m)	Distance at high-speed (m)	Number of sprints (n)	High intensity accelerations (n)	High intensity decelerations (n)
Team	1107	207	12	13	8
Player 1	1094	185	10	13	8
Player 2	913	237	12	12	5

Source: prepared by the author.

We can also observe the intra-subject comparison, which will allow us to compare the developed activity or the requirement of a training task for one particular player at different times. This process can be applied both to a comparison of different repetitions within the same training session and to a comparison between tasks (or repetitions of the task) in different training sessions.

If the goal of conditional training is to optimize the player's physical behavior during competition, the demands of competition should thus serve as a guide in the training process. This is why we must make replicate (or get as close as possible to replicating) the demands the players are submitted to during the competition to the demands of the training tasks, thus respecting their characterization.

Following the analysis of the training load, and its intensity during the performance of a task, it is possible to express the results either in absolute terms (for example, distance covered in m as a measure of load and m*min-1 as a measure of intensity), or in relative terms, i.e. in comparison with the demands of competition. That is, the demand of a variable could be represented with respect to the % that a match or some other reference value represents (season average, average of the last 5 games or average of the more active matches, for example). Thus, in the evaluation we would integrate the training needs of each of the athletes, bearing in mind that individual references are most often used instead of demarcation references, since there is some variability between the demands imposed on the players occupying the same demarcation (Castellano and Blanco-Villaseñor, 2015).

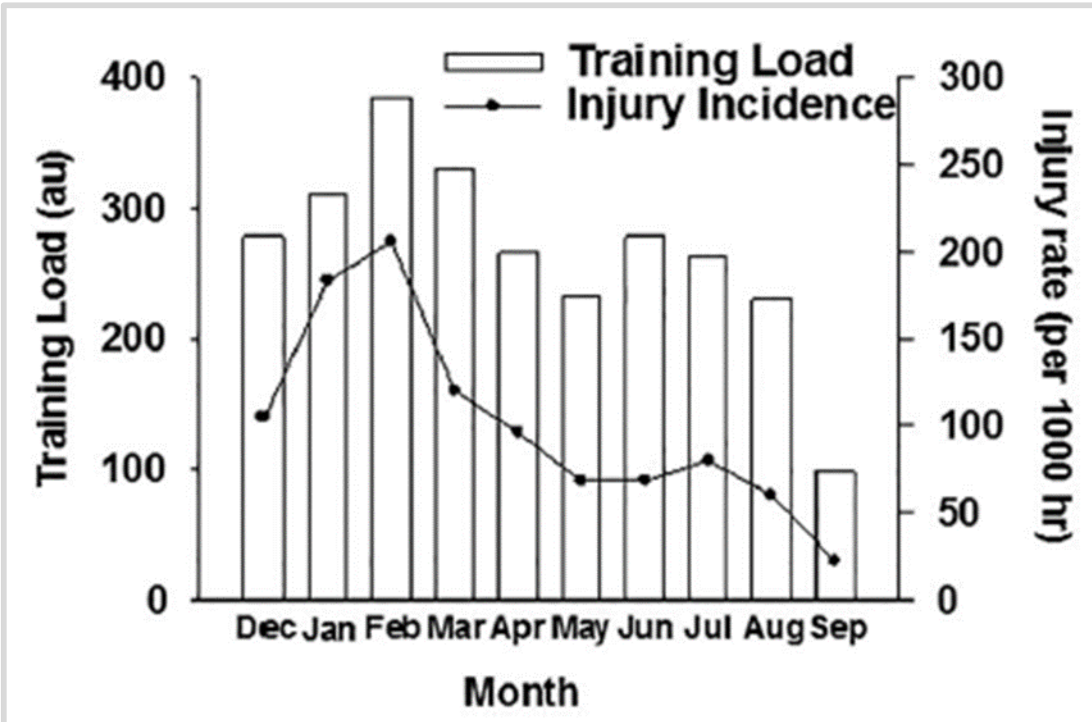
Let's now focus on the training session, the second temporal unit that we usually monitor, quantify and manage in the training process. There is plenty of descriptive information in the literature regarding load, volume and intensity for professional soccer players, but little information on non-professional players, young players or female soccer players.

The description of the load experienced by players according to the day of the week and other variables has been published by different authors in recent years. Authors have described the demands imposed on the players in the different training sessions in absolute values, according to the player's position on the playing field. So for example, Owen, Dkaouis, Newton, Malone & Mendes (2017) demonstrate that there are significant differences, in function of player position, in the variables of total distance covered, RPE and average speed, while they do not observe significant differences in the variables associated with actions carried out at high speed (distance covered at high speed and sprint).

Another important aspect is the training week or microcycle, often known in team sports as the operational planning unit; therefore the right distribution and management of the training load (training and match) acquires a great importance. This analysis will be fundamental in order to optimize athletes' physical fitness, to detect possible states of over- or under-stimulation, and to be able to reduce athletes' incidence of injuries.

During the load control process and the appropriate application to training (and to the athlete), the analysis of the monthly internal load and injury risk arises; here is the most classic figure, which reveals the association between training load and injury, where we can observe a clear relationship between load level and injury incidence. This figure shows how, when the training load increases, not only does the number of injuries increase, but also the injury incidence (injuries per 1000 hours of exposure). Therefore, based on these results, we see that not only do they get more injured because they spend more exposed to injuries, but the fatigue caused by the greater amount of work also increases the likelihood of injuries.

Figure 2



Source: Gabbett, 3. 2016.

Other studies, by monitoring the training load, through the session-rating of perceived exertion method during a season, of two professional soccer teams, conclude that, with loads accumulated in two and three weeks during the pre-season above 5980 and 9154 AU there appeared significantly higher probabilities of injury (x5) than the reference group (<3250 AU over a period of 2 weeks and <7260 over a period of 3 weeks). However, these load levels during the competitive season have a protective effect, so they reduce the chances of injury with respect to the reference group.

Finally, another aspect that for many years has been a matter of endless debate (without taking into account advances in science, and much less the contextual needs of the sport and the athletes) is that of the pre-season period. This preparatory phase of the season is one of the phases in which major training load management "mistakes" are often committed.

The pre-season is the ideal time for the coaching staff to instill into the team their philosophy, style or game model. But is this really the philosopher's stone of the competition cycle?

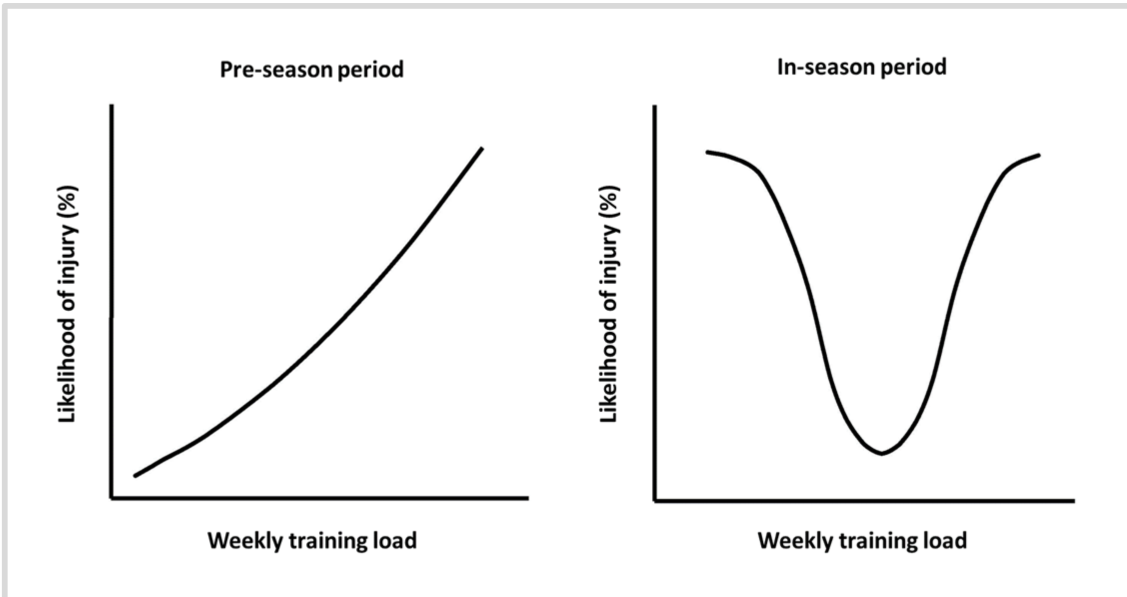
The majority of studies indicate that the pre-season period is the period in which the frequency of injury is significantly higher as compared to other moments of the season (Gabbett, 2004). So it seems like there is something that we are not doing right. Temporal structures where the athlete must train with loads of volume and intensity much higher than the annual average (up to three times higher) put the player's freshness at risk and will expose him to sports injuries.

So, the pre-season, which has traditionally been conceived as the right time to pump up the training loads, is now more and more being viewed as a period of gradual preparation, in which the athlete reconnects with the sporting activity. Some authors propose more gradual progress. Verheijen (2014) presents the dilemma between build-up and quick build-up, and opts for the first one: gradual acquisition of physical fitness. But we should not mistake gradual preparation for non-specific preparation. It should be as specific as possible, but gradually increase.

Contextualization

In team sports, specifically soccer, we should take into consideration some of the research conducted on training loads when establishing a methodology for training and competition load management. For example, according to Malone et al. (2017), in their study carried out with two top tier European teams, they found a significant increase in the probability of injury as the level of load increased during pre-season, meaning that the probability of injury was tripled when the weekly load exceeded a value of 3,200 arbitrary units (AU, obtained using the session-rating of perceived exertion method) in comparison to when the weekly load is less than 1,500 AU. Notwithstanding, during the competitive season, the relationship between load and probability of injury is U-shaped, with less probability when loads are moderately high (between 2,120-3,200 AU), increasing significantly when the load is greater than 3,200 AU. However, in the case of high loads (>3,200 AU) the probability of injury increases during pre-season in relation to competitive season.

Figure 3



Source: Malone et al., 2017.

While very little research has been conducted on the relationship between weekly load and performance, some studies have focused on the relationship between weekly training load and player activity during the game. Although the analysis should be performed taking into account not only the activity performed during the previous week, but also the activity performed during all previous weeks. With regards to this, in the study by Fessi et al. (2016) the authors find that in match activity during week 4 in which *tapering* is used (a decrease in training load) is 15% higher than match activity in other weeks.

For these reasons, future research needs to take a more in-depth look at the relationship between weekly load and performance, perhaps using the athlete's state of readiness for competition, measured using subjective questionnaires or an objective measure of performance or fatigue prior to competition (Thorpe et al., 2017).

Another important factor to note is what is known as monthly external load and the injury risk that arises in team sports.

Upon reviewing the literature in question, we come across all types of trends in the relationship between total distance covered by athletes and injury incidence:

- Tasks and measurement variables in studies where there is no relationship between the monthly or chronic workload and the probability of injury (Hulin, Gabbett, Lawson, Caputi, & Sampson, 2015).
- Studies in which a direct relationship is discovered (i.e., the greater load, the greater probability of injury).

- There are also studies that find an inverse relation, such as in the case of Colby et al. (2017) in Australian rules football, where they found that the probability of injury was significantly higher when the monthly load for distance covered was low (<71.0 km), meaning that the probability of injury is reduced as the monthly distance covered increases.

At the same time, distance covered at high speed or sprint and injury risk are part of the analysis of what is known as external load. As part of this analysis, Duhig et al. (2016), in research carried out among Australian rules football players, find that the distance covered at high speed is not a differentiating factor between those who incurred hamstring injuries and those who did not. Despite this, the probability of injury in the hamstring musculature increases when subjects exceed the average monthly distance covered at high speed.

In conclusion, we can study the pre-season more in-depth, when decisions that must be made regarding the demand levels used depend on different factors, such as, whether or not the players or the trainer and coaching staff are new to the club and, therefore, to the style and system of play that they want to instill, as well as players' backgrounds (age, injuries, level of activity during the previous season, familiarity with the type of training to be engaged in, etc.), the players' profiles (trial assessments, usual playing position, particularities, etc.) and on the downtime or loss of fitness in the players since the previous season.

As such, it would appear that the traditional view of the pre-season as the time for "fueling up" is falling by the wayside; the view now is that the pre-season is a time for gradual training, where the athlete comes back into contact with the activity.

Constant long runs and non-specific endurance-oriented tasks that, in many cases, reduce physical fitness rather than improve it, need to become a thing of the past. As such, we must not lose sight of the aim of training: to play a lot of soccer and to play it well. The aim is not to improve physical fitness; which is merely a means to the end. Furthermore, in addition to being the means, training is only effective when it is specific.

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