1

Who is the Sport Scientist?

In recent years, the sports industry has evolved at a dizzying pace (Ratten & Ratten, 2019). This has led to an increase in the availability of resources, as well as a growing interest in athlete monitoring (Rojas-Valverde, Gómez-Carmona, Gutiérrez-Vargas, & Pino-Ortega, 2019). We know more and more about the athlete, partly due to the emergence of the *Sport Scientist* as another member of the coaching staff.

It could be said that the *Sport Scientist* is the "cool" or professionalized name for the Exercise and Sport Sciences graduate. In short, it is a specialist role within the coaching staff who is perhaps more distant from the athlete than the fitness coach. In this context, they are necessary specialists supporting the field fitness coach who may be unable to get everything they need due to lack of time. Indeed, suppose the field fitness coach wants to analyze physical performance parameters or poses questions requiring a literature review as well as analysis and interpretation of the information. In that case, the *Sport Scientist* is responsible for providing a justified response to these questions.

In Australia and the United Kingdom, the role of the *Sport Scientist* within the coaching staff is more firmly established, as are others, such as the physiotherapist or fitness coach (Meur & Torres-Ronda, 2019). These countries have been pioneers in Exercise and Sport Sciences for many years, primarily due to work developed by the *English Institute of Sport*, the *Australian Institute of Sport* and professional clubs within the *Premier League*, *Rugby League* or *Australian Football League (AFL)* (Meur & Torres-Ronda, 2019). However, although economic resources are a determining factor in the development of science, it is surprising that in countries such as the United States, the prestigious *National Basketball Association (NBA)* only has full-time *Sport Scientists* in one-third of the teams (Meur & Torres-Ronda, 2019). Likewise, in countries like Spain, it is rare to find a *Sport Scientist* within the coaching staff (Meur & Torres-Ronda, 2019).

1.1. Educational profile and competencies of the Sport Scientist

University undergraduate degrees, as is the case of the Degree in Physical Activity and Sports Sciences in Spain, aim to develop academic curricula so that graduates acquire a series of basic and specific knowledge of this science, as well as the competencies necessary to practice the profession (i.e., not only to know about Sport Sciences but also to know how to apply that knowledge) (National Agency for Quality Assessment and Accreditation, 2004). In this sense, learning basic knowledge consists mainly of knowing and coming to understand:

- The purpose of studying Exercise and Sport Sciences.
- The biomechanical, physiological, social and behavioral determinants of each physical activity, exercise or sport.
- The fundamentals of human motor skills.
- The effects of physical activity on the structure and function of the human body and the psychological and social aspects of the human being.

For example, using the Spanish legal framework as a reference, the *Sport Scientist* profile is commonly a graduate or postgraduate in Physical Activity and Sport Sciences, which has the following areas of competence in Spain at present (Ministry of Science, Innovation and Universities, 2018):

1. Intervention in education.
2. Prevention, adaptation and improvement of athletic performance and health through physical fitness and exercise.
3. Promotion of healthy and autonomous habits through physical activity and sports.
4. Intervention through the manifestations of human movement.
5. Planning, evaluation and management-organization of resources, physical activity and sport.
6. Methodology and scientific evidence in practice.
7. Performance, deontology and professional practice in the context of interventions.

However, areas 2 and 6 are the most relevant in high-performance sports. Specifically, area 2 describes the following competencies:

2.1. To know how to guide, design, apply and technically-scientifically evaluate physical exercise and physical condition at an advanced level, based on scientific evidence, in different environments, contexts and types of activities for the entire population and with emphasis on special populations such as older adults (senior citizens), children, people with disabilities and people with pathologies, health problems or assimilated (diagnosed and/or prescribed by a physician), attending to gender and diversity.

2.2. Identify, communicate and apply scientific anatomical-physiological and biomechanical criteria at an advanced skill level in the design, development and technical-scientific evaluation of procedures, strategies, actions, activities, and appropriate orientation to prevent, minimize and/or avoid a health risk in the practice of physical activity and sports in all types of population.

2.3. To design and apply with fluency, naturalness, consciously and continuously, adequate, efficient, systematic, varied physical exercise and physical condition, based on scientific evidence, for the development of the processes of adaptation and improvement or re-adaptation of specific capacities of each person concerning human movement and its optimization; to be able to solve unstructured, increasingly complex and unpredictable problems, with emphasis on special populations.

2.4. Articulate and deploy an advanced level of skill in analyzing, designing and evaluating tests for assessing and controlling physical condition and sports performance.

2.5. Know how to re-adapt, re-train and/or re-educate individuals, groups or teams with injuries and pathologies (diagnosed and/or prescribed by a doctor), whether they compete or not, through physical-sports activities and physical exercises appropriate to their characteristics and needs.

2.6. Deploy an advanced level in planning, implementing, controlling and evaluating physical and sports training processes.

In addition, Area 6 outlines the following competencies:

6.1. To know and understand the basis of the methodology of scientific work.

6.2. Analyze, review and select the effect and effectiveness of the practice of methods, techniques and resources of research and scientific work methodology in solving problems that require creative and innovative ideas.

6.3. Articulate and deploy with rigor and scientific attitude the justifications on which to elaborate, support, substantiate and justify constantly and professionally all acts, decisions, processes, procedures, actions, activities, tasks, conclusions, reports and professional performance.

6.4. Articulate and deploy procedures, processes, protocols, and own analysis, with rigor and scientific attitude on issues of social, legal, economic, scientific or ethical nature, when necessary and relevant in any professional sector of physical activity and sport (formal and informal physical and sports education; physical and sports training; physical exercise for health; physical activity and sport management).

Therefore, to practice the profession, any training/education plan should try to facilitate the acquisition of these competencies as well as the acquisition of other instrumental competencies (National Agency for Quality Assessment and Accreditation, 2004) related to:

- The application of information and communication technologies.
- Understanding scientific literature in English (the universal language established by the scientific community).
- Developing teamwork, leadership and communication skills.
- Developing work habits within the principles of ethics and quality for the correct professional practice.
- Autonomous learning and development of problem-solving skills and adaptation to new environments.

This formal education is usually complemented with a Master's degree in Research in Physical Activity and Sport Sciences, High Performance, or Big Data applied to Sports, among other types of degrees, which facilitate the acquisition of other skills such as:

- The application of the scientific method to optimize the athlete's performance.
- The management, organization and control of the workload according to training principles.
- Data interpretation using specific analysis tools: Excel (Microsoft Corporation, Redmon, Washington, United States), PowerBi (Microsoft Corporation, Redmon, Washington, United States), Tableau (Tableau Software LLC, Mountain View, California, United States), Python (Python Software Foundation, Wilmington, Delaware, United States), or R (The R Foundation for Statistical Computing, Vienna, Austria).

Studies related to Exercise and Sport Sciences are booming, and proof of this is the number of university enrollments in these studies in recent years (Robertson, 2020), meaning that the number of *Sport Scientists* with formal training is also increasing. In addition, new technologies, which most sports clubs are beginning to acquire to improve their performance, can generate a vast quantity of data (Robertson, 2020). This has resulted in faster and cheaper access to this data, meaning that the way the information is treated and decisions are made has changed (Robertson, 2020). It has led to new professional profiles (e.g., computer engineers or mathematicians), characterized by their training in analysis, management, processing and interpretation of information, which are becoming increasingly important in the role of *Sport Scientist*.

1.2. Key criteria for incorporating a Sport Scientist into the coaching staff

The demand for Sport Scientists in the labor market has increased in recent years. Likewise, it is important to remember that the training of each *Sport Scientist* varies, fundamentally, depending on the country in which the training takes place (*Agencia Nacional de Evaluación de la Calidad y Acreditación*, 2004). For example, educational training in Europe, in terms of duration, number of credits, degree orientation (generalist or specialist) and training content, differs from country to country. Thus, even if a *Sport Scientist* has received a basic education and training, it is advisable to take into account a set of key criteria when hiring someone for this position:

1. Academic qualifications in sports are through university degrees (bachelor's, master's, doctorate) and scientific-technical training courses. Bachelor's degrees cover the acquisition of essential competencies, master's degrees facilitate the broadening of knowledge, and a doctorate enables students to carry out scientific research tasks and leads to the mastery of a specific line of research. If this academic training is supported by scientific publications (especially those of high impact) related to developing the tasks to be carried out by the coaching staff, then it can be said that the *Sport Scientist* has a certain level of specialization.
2. Previous professional experience as a head, assistant, strength and conditioning or rehab coach (particularly in the same sport).
3. High level of familiarity with ICT (Information and Communication Technologies) to develop tools for information search, interpretation and data analysis.
4. Data analysis and interpretation skills: it is necessary to understand the statistics and data analysis needed to answer specific questions. In other words, knowing how to apply the appropriate statistical analysis to interpret the data correctly is crucial. However, it should be noted that this is a rather delicate criterion because the *Sport Scientist* is "forced" (sometimes) to probe an area of knowledge where their academic training may not be sufficient.
5. Continuing education involves staying current regarding the knowledge of a specific field by attending congresses, continuing education courses and daily reading of recent publications. Today, social networks are another element of constant training.
6. Proficiency in foreign languages: it helps with internal communication as well as learning and training opportunities. Nowadays, professional teams can comprise members from different countries. In addition, most of the specialized documents are in English, which is considered the scientific community's universal language. Publications in this language have a more significant impact at the international level; therefore, the publications with the greatest impact are in this language.
7. Cultural exchange experiences: especially in team sports, there are often situations where athletes from different countries, social classes, religions or lifestyles end up living together in a multicultural environment. It is essential to know how to deal with everyone as equals and learn to respect any differences within the group. Unconscious bias training is also recommended in this regard.
8. Motivation and willingness to learn: no matter how much you train, no matter how many experiences you have, you should never stop learning. The more we know, the more we understand how much we do not know. The moment you think you know enough, you are at the point where you stop learning.
9. Responsibility and trust: a person who is responsible and complies with their work in terms of format, time and place can facilitate the pace of work. In addition, it is essential to earn the trust of the whole group. If a person generates distrust, this may impact the rest of the team's performance.
10. Social interaction and communication skills: while developing good relationships are essential to daily work life, the ability to interact and communicate what you want to convey in the appropriate language for the receiver is also crucial. A common request from the coaching staff is that they want to be spoken to in their "language." For example, a *Sport Scientist* states in his report to the coach: "The difference in acceleration and deceleration values are above 3 m/s^2 today, which are too high for this player". This message could confuse the coach, who would perhaps have un-

derstood it better if it was stated as: "The difference in the values of high intensity accelerations and decelerations is too high for this player." Therefore, one of the *Sport Scientist's* tasks is to express themselves clearly, adapting each message to their audience.

11. Respect, professionalism and empathy: the primary concern should be that the relationships between all athletes and members of the coaching staff flourish. Communication must be based on respect and is essential for creating a pleasant day-to-day work experience. This includes putting yourself in another's shoes, compliance with the rules and acceptance of others. In short, besides being a good professional, you should also be a good colleague.
12. Growth mindset: believe in yourself and please, do understand that in sports, you do not always win. In fact, you may lose more often than you win. We often consider defeat as something negative that impacts the group's mood, but the *Sport Scientist* needs to understand that these negative experiences can be an opportunity to grow. With dedication and development of skills, the *Sport Scientist* will experience a positive growth.
13. Flexibility: the ability to be prudent, open and sensitive to change is essential for this role. Things do not always happen the way we would like them to happen. You should be prepared for change in sports, particularly high performance sports. Something always comes up that is unforeseeable.

2

The importance of load monitoring in team sports

Load monitoring is another task that *Sport Scientists* perform. Its importance lies in knowing each athlete's response to the training stimulus, both internally (internal load) and externally (external load). The relationship between load, sports performance and injury prevention is very close. Hence, in recent years, different monitoring tools have evolved, and within the coaching staff, load monitoring has been one of the main functions of the *Sport Scientist* since sports training aims to improve performance by optimizing all resources. In addition, information about the athlete's daily condition is also valuable for physiotherapists, doctors and coaches. In short, athlete monitoring is necessary to improve performance while simultaneously reducing the risk of injury. This process is also known as "performance optimization."

This process has led to doubts about the acceptance of some traditional clichés, such as "the greater the workload, the greater the likelihood of injury." The main reason for these changes in perception are studies that report that training can act as a vaccine against injuries and are based on the idea that for athletes to develop the necessary capabilities to protect themselves from injury, they must first be prepared to train hard (Gabbett, 2016). That is, reducing workload with the goal of avoiding injury is not always the best mechanism.

Why are major international sports organizations such as the Union of European Football Associations (UEFA) conducting scientific studies on injuries?

In recent decades, sport has assumed an increasingly important role in the economy and the globalization of business and public events (Zhang, Kim, Mastromartino, Qian, & Nauright, 2018). Sporting events such as the International Football Federation (FIFA) World Cup or the Olympic Games attract worldwide attention through the performance of athletes (lately seen as a spectacle) (Zhang et al., 2018). Therefore, one of the main challenges for sports organizations is ensuring the best possible performance of athletes, who are the main constituent of the sports industry.

Concerning the question posed in this section about why sports organizations are starting to develop scientific studies on injuries, a recent study (D'Hooghe, 2016) contemplates four main reasons:

- Sports performance: the availability or not of an athlete on competition day and the condition in which they arrive are vital for the team.
- Medical: athletes' health must be protected. An injury can affect an athlete's performance, career, and personal life (emotional, psychological, and physical problems).
- Legal: sports federations have a responsibility to establish measures to protect the health of athletes, as well as to study the impact that the management of labor contracts, the competition calendar, or schedules have on an athlete's physical, psychological and emotional state.
- Costs: for example, it is estimated that an injury to a starting player in the *UEFA Champions League* can cost approximately €500,000/month.

Given the reasons stated above, there are several investigations derived from the *Elite Club Injury Study*, one of UEFA's benchmark projects, which for more than 15 years has been collecting data related to various performance parameters as a source of information for clubs, federations and other sports organizations.

Just as these agencies have found it necessary to implement these types of projects, the technology sector has discovered a market with great potential (Cardinale & Varley, 2017). It could be said that, lately, the development of tools that monitor athletes has been immense, particularly with regards to microtechnology applied to sport (i.e., through microscopic devices such as accelerometers or gyroscopes), which is the most common in day-to-day fieldwork monitoring (Buchheit & Simpson, 2017; Cardinale & Varley, 2017). Virtually all teams use these tools in sports such as soccer, grid-iron football or elite basketball (Chambers, Gabbett, Cole, & Beard, 2015). This type of technology includes GPS-enabled devices and heart rate monitors (Cummins, Orr, O'Connor, & West, 2013) and the accompanying software that aids real-time monitoring of each session (Rojas-Valverde et al., 2019). They facilitate instantaneous decision-making on an individualized basis since multiple reports are available on the individual's performance in the session compared to their peers or other sessions. In this context, *Sport Scientists* are specialized professionals who try to keep control of certain variables concerning the load, level of physical condition, fatigue, etc.

2.1. Internal load

Traditionally, internal loading has been the most commonly used method of load monitoring in team sports. We refer to internal load as the internal response or effect caused in the organism by a given effort (Gabbett et al., 2017).

How can the internal load be quantified?

- Subjective perception of exertion: The simplest but least objective method has always been the *rating of perceived exertion* (RPE) (Borg, 1998). It is a practical, non-invasive method with no financial investment required (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004; Wallace, Slattery, Impellizzeri, & Coutts, 2014). There are different scales, among which we can find the well-known "Borg Scale" (Borg, 1998). This scale relates each athlete's perception of effort to values between 6 and 20, with 6 being no exertion at all and 20 being maximal exertion (Figure 1).

RATINGS	DESCRIPTION
6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Figure 1. "Borg Scale". Adapted from Borg (1998).

However, it is sometimes somewhat complex for the athlete to accurately determine each of the thresholds and therefore, other simpler scales, such as the "Modified Borg Scale," were developed (Wilson & Jones, 1989). This scale ranges from 0 to 10, with 0 being nothing at all and 10 maximal effort. In this regard, a study conducted with professional soccer players highlighted that the second ventilatory threshold (i.e., anaerobic threshold) was found at values of 6 and above (Algrøy, Hetlelid, Seiler, & Pedersen, 2011).

One of the main drawbacks of RPE as a method of quantifying internal loading is that it is subjective since it measures an individual's perception of their own exertion (Chen, Fan, & Moe, 2002). There is also a lack of consensus on how to formulate the question of perceived exertion to the athlete, when to ask it or which words to assign to each exertion category (ordered in Figure 2). Moreover, it is a discontinuous scale that, technically, does not quantify the perception of effort but rather classifies it (which is why other methods have been proposed, such as the visual analog scale or the centiMax scale, also known as CR100) (E. Borg & Borg, 2002; Rebelo et al., 2012). It should also be noted that at any level, but especially at the professional level (where the athlete relies on their performance to maintain their professional status), there is a risk that the value reported by the athlete may be false. For instance, if an athlete encounters a level of fatigue that prevents them from successfully completing a task that they were previously able to perform without a problem because they feel they are not in good shape and their perception is that the task required a very high level of exertion, the athlete may hide their feelings. This is not to say that the athlete wants to deceive us, but rather, they know that it may arouse suspicions that they are not in good shape or that another athlete is in a better condition to replace them on match day.

RATINGS	DESCRIPTION
0	Nothing at all
1	Very very slight
2	Very slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very very severe
10	Maximal

Figure 2. "Modified Borg Scale". Adapted from Wilson & Jones (1989).

Since this data is subjective, it is also necessary to look for other objective load monitoring tools even though RPE may be considered as a psychophysiological scale (i.e., the athlete classifies their perception of exertion as a physiological response) (Abbiss, Peiffer, Meeusen, & Skorski, 2015) which can even be measured 48 hours after a session (Fanchini et al., 2017). However, some studies have shown that RPE is a method with high validity and reliability for measuring perceived exertion intensity in high-level athletes (Alexiou & Coutts, 2008; Scott, Lockie, Knight, Clark, & Janse de Jonge, 2013; Scott, Black, Quinn, & Coutts, 2013). Studies also observe that variables such as fitness level or the nature of the activity being performed can influence RPE (Alexiou & Coutts, 2008; Scott et al., 2013). For example, Alexiou and Coutts (2008) demonstrated that the correlation between RPE and heart rate-based variables was higher in continuous aerobic training sessions than in sessions with greater intermittency.

- Heart rate monitoring: this is the most direct method of measuring exertion, but it is somewhat uncomfortable since the athlete must wear a monitor (usually with a chest band or chest strap).

Heart rate monitoring is very beneficial, especially when expressed as a percentage of maximum heart rate, given its correlation with maximal oxygen consumption (VO_2 max) during exercise (Achten & Jeukendrup, 2003). There are various technologies for heart rate monitoring in sports, such as wrist monitors or monitors connected to chest straps (Pino-Ortega, Bastida-Castillo et al., 2019) (Figure 3). Wrist monitors are some of the best examples of wearable biosensors that have recently experienced a breakthrough in the sports industry. Reflective photoplethysmography has enabled heart rate monitoring from a single smartwatch, but the accuracy depends on the activity's intensity and the device itself (Jo, Lewis, Directo, Kim, & Dolezal, 2016).

Figure 3. Heart rate monitor with chest strap (Garmin Ltd., Olathe, Kansas, U.S.A.)

Similarly, to reduce invasiveness, T-shirts have been developed that contain electrodes to collect data that connect to a heart rate monitor (Pino-Ortega, Bastida-Castillo et al., 2019). This novel measurement technique has been scientifically validated and can replace the usual chest band (Pino-Ortega, Bastida-Castillo et al., 2019). In this sense, sports technology manufacturers, such as RealTrack Systems, have, in collaboration with the textile industry, developed a "smart" vest that directly connects the heart rate data collected by the sensors incorporated in the vest itself with other inertial or positioning parameters (distances, speeds, accelerations), which are then collected through the EPTS. However, one of the current challenges for the sports industry is not only to develop a vest that can integrate such technology and connect with other devices but also to ensure that the vest is practical. For example, is it comfortable for the athlete to wear on the skin? Would some athletes prefer to wear it over their T-shirts for better comfort? Can it be washed like any other garment without damaging the sensors, or is its useful life determined by an estimated number of washes?

- Finally, other methods used to monitor athletes' internal load, which are less frequent but still interesting, are those related to muscle oxygen saturation, muscle activation or body temperature analysis.

2.2. External load

External load refers to the response or work derived from the movement that the athlete provides independent of their internal response (Gabbett et al., 2017). The external load is quantified in the form of accumulated minutes, total distance covered, number of accelerations, decelerations and any movement specific to each sport (high-speed actions, collisions, jumps, etc.).

Devices with inertial measurement units (IMUs) and GPS (Figure 4) have been game changers in load monitoring processes (Cummins et al., 2013). These devices provide a multitude of variables for assessing each athlete's performance and thus can prescribe the training load more objectively. Therefore, the specialist's level of understanding of the validity and reliability of the data provided by these systems is critical. Another advantage of this type of data is that it can be individualized by, for example, setting individual speed (Rago, Brito, Figueiredo, Krustrup, & Rebelo, 2020) and acceleration (Abbott, Brickley, Smeeton, & Mills, 2018) thresholds. In addition, it considers each athlete's individual profile (medical history, age, sporting experience, level, playing position).

The same external load can generate very different internal responses, not only among athletes but also in the same athlete over time. For example, if three athletes of the same age, height and weight but with different fitness levels run a 1500-meter race at maximum speed and all make exactly the same time, this does not mean that their internal response is the same. Therefore, the same amount of external load could be inappropriate for some of the athletes, and in team sports, this is very important since the team usually trains as a group.

Another advantage of having external load data is that it allows us to study the evolution of performance throughout each season (Figure 4). Each athlete's evolution can be analyzed individually and as part of a group (e.g., by position, by team) over a given time period based on the load variables selected.

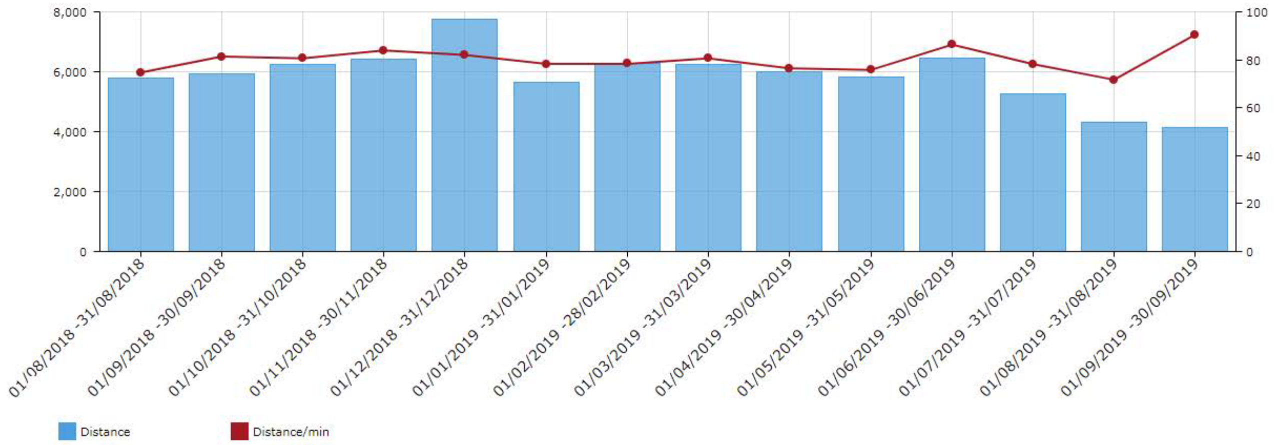

Figure 4. Evolution of the distance covered (total and per minute) by a player during a season.

The external load profile of each competition microcycle is also available from the day each athlete begins post-match training until the next match day (Figure 5), as has been proposed in previous studies related to daily load quantification (Clemente et al., 2019; Malone et al., 2015):

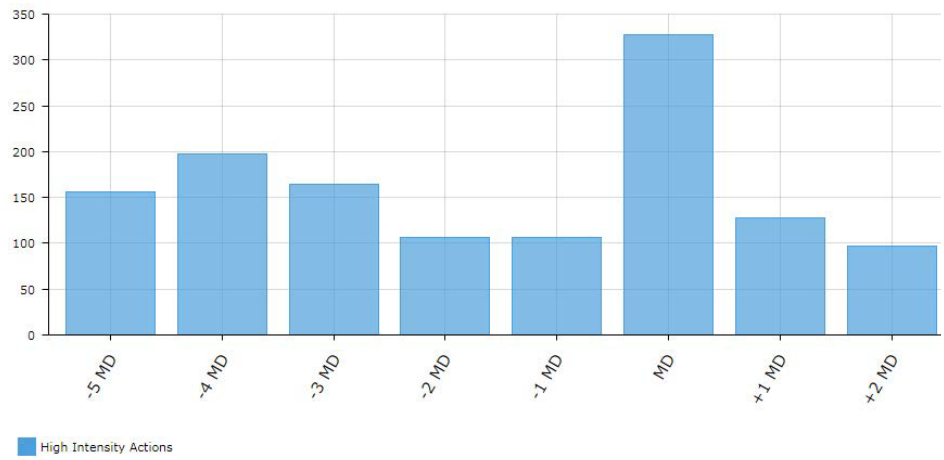

Figure 5. Example of external load profile for each day of the microcycle

We can also analyze the volume of external load accumulated throughout the mesocycle. Figure 6 shows that the yield for the week of February 1 to 7, 2019, was higher in the variables shown in a dark green color. The color scale is a tool frequently used by *Sport Scientists* and will be explained in detail in future chapters.

Field	MAX	AVG	01/02/2019 07/02/2019	08/02/2019 14/02/2019	15/02/2019 21/02/2019	22/03/2019 28/02/2019
Duration (min)	86,53	80,93	86.53	82.15	70.54	80.29
Distance (m)	8034,23	6504,30	8034	6351	5079	6468
Distance/min (m/min)	91,96	80,01	92.0	76.5	73.4	80.1
HSR Rel (m)	134,87	84,52	135	65	23	72
HSR Rel/min (m/min)	1,58	0,98	1.58	0.72	0.30	0.87

Figure 6. Accumulated volume throughout the competition mesocycle

It is not only interesting to know the evolution of performance during each week but also to determine the accumulated performance during the entire mesocycle for each athlete. This can help determine who are the athletes with the highest and lowest values recorded for certain variables (Figure 7):

Rank	HSR (m)
1	WIMU 1 - 9.167,92
2	WIMU 2 - 8.710,43
3	WIMU 3 - 7.242,49
4	WIMU 4 - 5 678,07
5	WIMU 5 - 5.668,37

Figure 7. Cumulative volume ranking over the competition mesocycle

It is also helpful to know each athlete's training and competition performance profile compared to their specific playing position and performance in previous sessions (Figure 8). In this case, the figure shows the average performance for each variable within the analyzed session, the percentage difference with prior training sessions (% session) and the percentage difference with competition sessions (% MD; *match day*).

		Duration (min)	Distance (m)	Distance/min (m/min)	HSR (m)	HSR Rel (count)	Sprints (count)	MAX Speed (km/h)	Acc +3/m/s²	Dec +3/m/s²	HMLD/min (m/min)	HMLD (m)	HIA (count)	Player Load (u.a.)	RPE
MF	SESSION	80,61	6327,55	78,47	277,38	24,00	34,00	28,85	45,50	66,50	15,20	1224,79	183,50	93,61	8,00
	% SESSION	5 %	2 %	-3 %	-45 %	-77 %	-20 %	-5 %	-1 %	23 %	-11 %	-7 %	7 %	9 %	67 %
	% MD	-14 %	-39 %	-29 %	-70 %	-90 %	-57 %	-11 %	-27 %	-23 %	-40 %	-48 %	-42 %	-31 %	-20 %
WIMU 1	SESSION	79,94	5912,73	73,97	280,92	9,51	34,00	27,22	39,00	60,00	15,59	1246,61	149,00	83,50	8,00
	% SESSION	8 %	6 %	-2 %	-31 %	-82 %	1 %	-8 %	8 %	36 %	1 %	9 %	-4 %	5 %	82 %
	% MD	-15 %	-41 %	-31 %	-68 %	-94 %	-56 %	-15 %	-35 %	-30 %	-36 %	-46 %	-52 %	-34 %	-20 %
WIMU 2	SESSION	81,27	6742,37	82,96	273,85	38,48	34,00	30,48	52,00	73,00	14,80	1202,96	218,00	103,73	8,00
	% SESSION	2 %	-1 %	-4 %	-54 %	-76 %	-34 %	-2 %	-6 %	14 %	-21 %	-20 %	16 %	13 %	54 %
	% MD	-13 %	-38 %	-29 %	-74 %	-90 %	-59 %	-9 %	-20 %	-16 %	-44 %	-51 %	-33 %	-32 %	-20 %

Figure 8. Performance profile during competition of each athlete compared to his specific position (e.g., midfielder, MF), performance in the last five training sessions and matches.

An analysis of the number of minutes of work by tasks performed in the session can be seen below (Figure 9). Each color represents a task, and its length on the timeline indicates its duration:

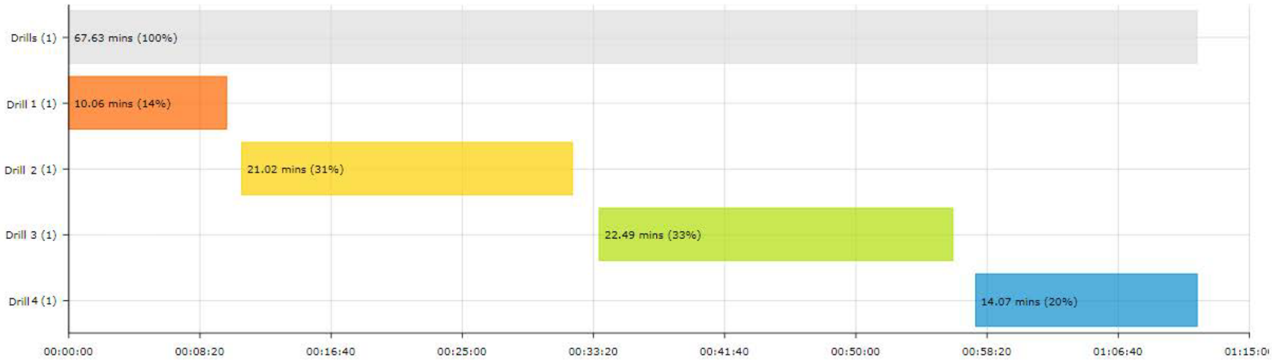

Figure 9. Distribution of the workload by tasks in the session

These devices also provide specific reports for injury prevention and performance optimization, such as the recognized Acute:Chronic ratio (Gabbett, 2016) (Figure 10).

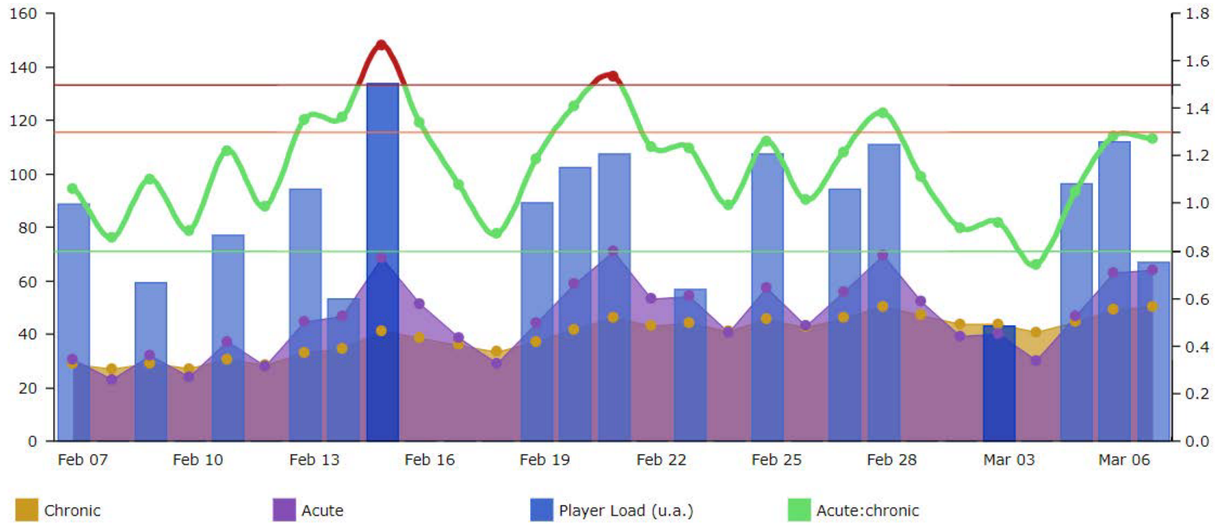

Figure 10. *Acute:Chronic ratio* during one month of competition

Or the devices can simply summarize the data of the activities carried out during a session (Figure 11).

Name	Duration	Dis	HSR	HMLD	HSR + Sprints	MaxSp	Acc+3	Dec+3	HIA
FIELD PLAYER Tactical-technical	61	3087,22	32,99	349,20	4,42	22,19	18,89	22,11	76,26
CENTRAL	53	2697,64	12,92	218,02	1,67	20,77	13,67	11,00	32,00
WIMU 1	80	4336	9	476	2	21.4	38	30	84.00
WIMU 2	40	1941	29	106	3	24.2	0	2	3.00
WIMU 3	40	1816	0	72	0	16.6	3	1	9.00

Figure 11. Summary data of activities in a session

However, although this type of information is vital for athlete monitoring, the reality is that it is not always possible to monitor the load. An example of a common scenario is when athletes may be temporarily on national team duty. In this scenario, a question arises: is it sufficient for teams to monitor the load during training camps? Is incorporating data into an athlete's profile correct if the national team's data has been processed with other devices, with different sampling frequencies or differences in calculating the different variables than what we handle? Another possible scenario, which occurs daily, is if the athlete has not worn one of the devices used by their local team to monitor the load or the system experiences errors during data collection, resulting in missing data.

These are some of the situations you could face as a *Sport Scientist.* You need to know how to handle them: understand the technology and the variables you are analyzing and make decisions according to your experience and knowledge. In the last example (session without data), a possible solution could be the simulation of a previous session with similar characteristics of the same athlete (example: day -3 before the competition). Thus, when faced with all these scenarios and issues, the *Sport Scientist* must know which tools not only provide external load data but also the features that solve these types of situations.

2.3. Athlete monitoring cycle

When referring to the importance of load monitoring in team sports, it is also advisable to know what the monitoring cycle itself is and, of course, to cite the great contribution of the Gabbett et al. cycle. (2017):

1. The athlete's workload (external load) must be described.
2. Then, the internal response to that load (internal load) must be described.
3. Check if the athlete is able to tolerate the load (perceptual well-being).
4. Assess the physical and mental condition to expose the athlete to more stimuli.

Thus, by combining each phase of the cycle, we obtain information and interpret it as follows (Gabbett et al., 2017):

> Examining the relationship between external load and internal load (combination of step 1 and 2): It is understood that when an athlete bears a lot of external load, it implies an increase in their internal load; therefore, the next decision may be that that load is reduced/modulated. However, if the external load was very high but the internal load was very low, an adaptation case may be identified. Maladaptive training responses could also be identified if the training load is low but internal load is high.
>
> Relationship between perceptual well-being and workload: the relationship between load variables and perceptual well-being informs how each athlete tolerates the stimuli. If the workload is high and perceptual well-being is high too, the athlete may continue training/playing. If the workload is low and perceptual well-being is high, we can increase the workload. However, if the workload is high, but the perceptual well-being is low, we might need to reduce the workload. Likewise, when an athlete is not adapting (e.g., low workload and poor perceptual well-being), it is essential to conduct a purely qualitative analysis: standard of living, adaptation to the group, socio-family situation, language difficulties, etc.
>
> Relationship between perceptual well-being and readiness (combination of step 3 and 4): additional variables are analyzed to assess the level of *readiness to train/compete* through submaximal effort tests and lower or upper body power tests, among others. If the well-being is good and level of readiness is high, the athlete is ready to train/complete. If the well-being is good, but the level of readiness is poor, we may need to increase physical preparation. Also, it is important to know that if perceptual well-being is poor and the level of readiness is low, the athlete may need extra recovery. However, if the well-being is poor and the level of readiness is good, mental preparation may need to be increased.