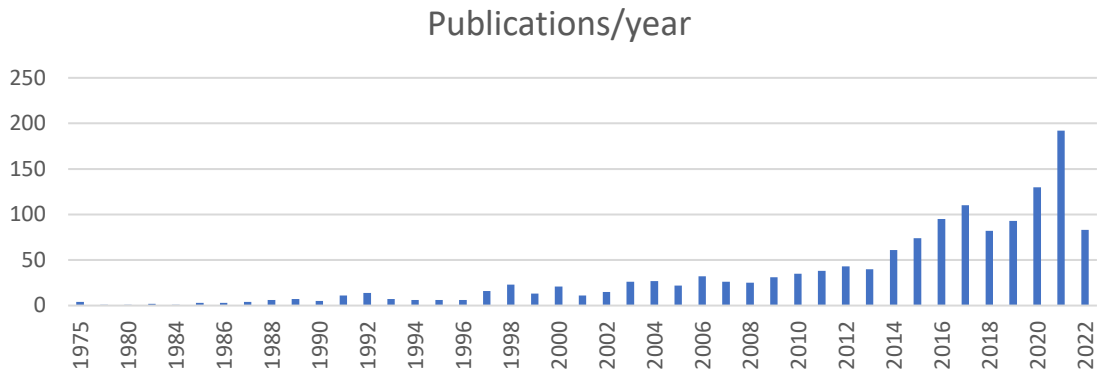
Module 1. Scientific Contextualisation

Introduction

In the 21st century, interest in training load has grown exponentially (see Image 1). The increase in scientific publications on the concept of training load is a small sample of how coaches, physical trainers, doctors, and physiotherapists are more concerned about optimising the training process.

Image 1: Interest in training load



Source: own creation

Publicaciones/año	Publications/year

Before getting into the subject matter, some of the main concepts will be defined. In the sports environment and with the vast bibliography around, there is not a single definition for concepts, and, according to the environment and context, some definitions are more useful than others. That is why, we will define these concepts in relation to team sports context, specifically, football.

Sports training:

"A complex process through which an athlete can, starting from their genetic potential, achieve a certain level of performance thanks to the complex processes of adaptation of the organism" (Solé, 2008). This definition refers to three very important points in the sports field.

1) Complex process: it suggests that understanding everything involved in the training process will be difficult to grasp, and often, the answers we find may not be as expected. This is due to the multitude of factors that surround sports, as not only what the athlete

does is important, but there are many other uncontrollable and, most likely, unknown factors that will affect this sports training process.

2) Genetic potential: each athlete will adapt differently to the same training stimulus. Some athletes will adapt faster, others will feel less fatigue, and vice versa. It should be noted that not all athletes in the same training session will perform exactly the same work, even if they perform the same tasks.

3) Complex adaptation processes: there is no defined cause-and-effect relationship between an athlete's training and their future adaptations. The relationship among external load, internal load, and their adaptations is different training after training, and multiple factors will affect how a similar external load can cause different internal loads and disparate adaptations. A future section will discuss the training cycle, which will be the key concept for the monitoring process.

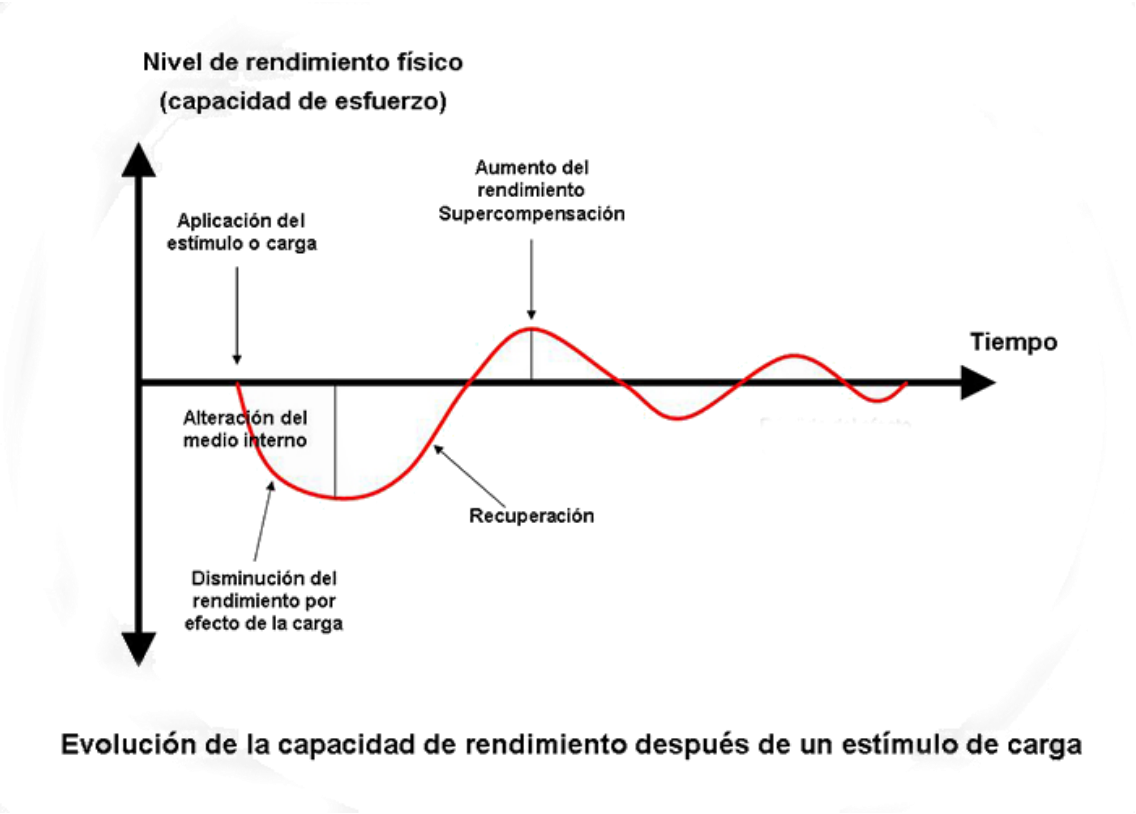
General Adaptation Syndrome

"Adaptive response of the organism to various stressors" (Seyle, 1946).

Any stimulus to which an organism is subjected is a stressor. A stimulus is anything that can alter the homeostasis of the athlete. Training is a stressor that affects the organism mainly physiologically and biomechanically. An important match in two days is a stressor that cognitively affects the athlete. This could lead to modifications in behaviour during and outside of training or hormonal system alteration depending on how the athlete manages this future event. In short, anything that can alter the athlete will alter their homeostasis and depending on the adaptation of the athlete to the different stimuli and their magnitude, their allostatic load will cause short-, medium- or long-term modifications.

The General Adaptation Syndrome (GAS) explains that after an initial stimulus, performance decreases due to the effect of load or fatigue. Later, the organism enters a recovery phase until it returns to its basal state again, and then, for a limited time, it will exceed the initial performance, known as supercompensation. Ideally, this is the time to apply another training load with higher performance (see Image 2). Achieving this in reality is not as easy as drawing it on paper. As we mentioned in the definition of sports training, the fact that it is a complex process means that truly understanding the mechanisms by which performance can be increased requires special attention to all the details that may be important to quantify.

Image 2: Evolution of performance capacity after a load stimulus



Evolución de la capacidad de rendimiento después de un estímulo de carga

Source: [image without heading of evolution of performance capacity after a load stimulus], s. f., https://bit.ly/3OfAQdR

Nivel de rendimiento físico (capacidad de esfuerzo)	Physical performance level (effort capacity)
Aplicación del estímulo o carga	Stimulus or load application
Aumento del rendimiento. Supercompensación	Performance increase Supercompensation
Tiempo	Time
Alteración del medio interno	Internal environment alteration
Recuperación	Recovery
Disminución del rendimiento por efecto de la carga	Performance decreases due to load
Evolución de la capacidad de rendimiento después de un estímulo de carga	Evolution of performance capacity after a load stimulus

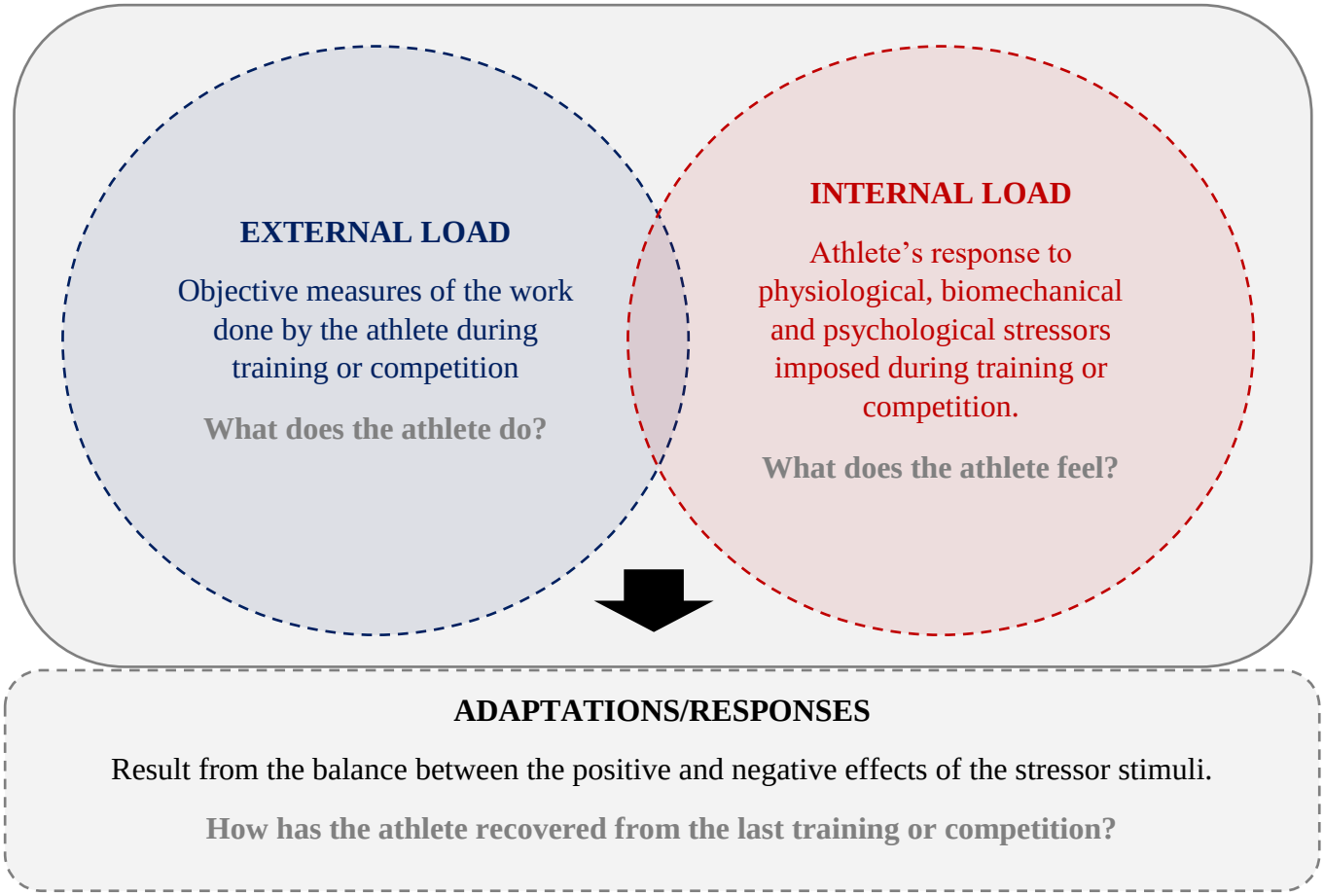
If we do not leverage the supercompensation period, the organism will return to its basal state, which is determined by the athlete's genetics.

Training load

Now, we will define training load, a concept that is widely discussed and justified in different sports and teams' environments. It is vital to understand it to know the possible buttons we can press to modify possible alterations of our athletes.

Training load is composed of the interrelation of three main pillars:

Image 3: Training Load



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Carga externa	External load

Medidas objetivas del trabajo realizado por el deportista durante el entrenamiento o la competición	Objective measures of the work done by the athlete during training or competition
¿qué hace el deportista?	what does the athlete do?
Carga externa	External load
Respuesta del deportista a los estresores fisiológicos, biomecánicos y psicológicos impuestos durante el entrenamiento o la competición	Athlete's response to physiological, biomechanical, and psychological stressors imposed during training or competition.
¿qué siente el deportista?	what does the athlete feel?
Adaptaciones/respuestas	Adaptations/Responses
Resultado del balance entre los efectos positivos y negativos de los estímulos estresores	Result from the balance between the positive and negative effects of the stressor stimuli
¿Cómo se ha recuperado el deportista del último entreno o competición?	How has the athlete recovered from the last training or competition?

External load

The external load are the objective measures of the work done by the athlete during training or competition (Bourdon *et al*., 2017.) In simpler terms, it is what the athlete does. More details about external load will be provided in the specific module.

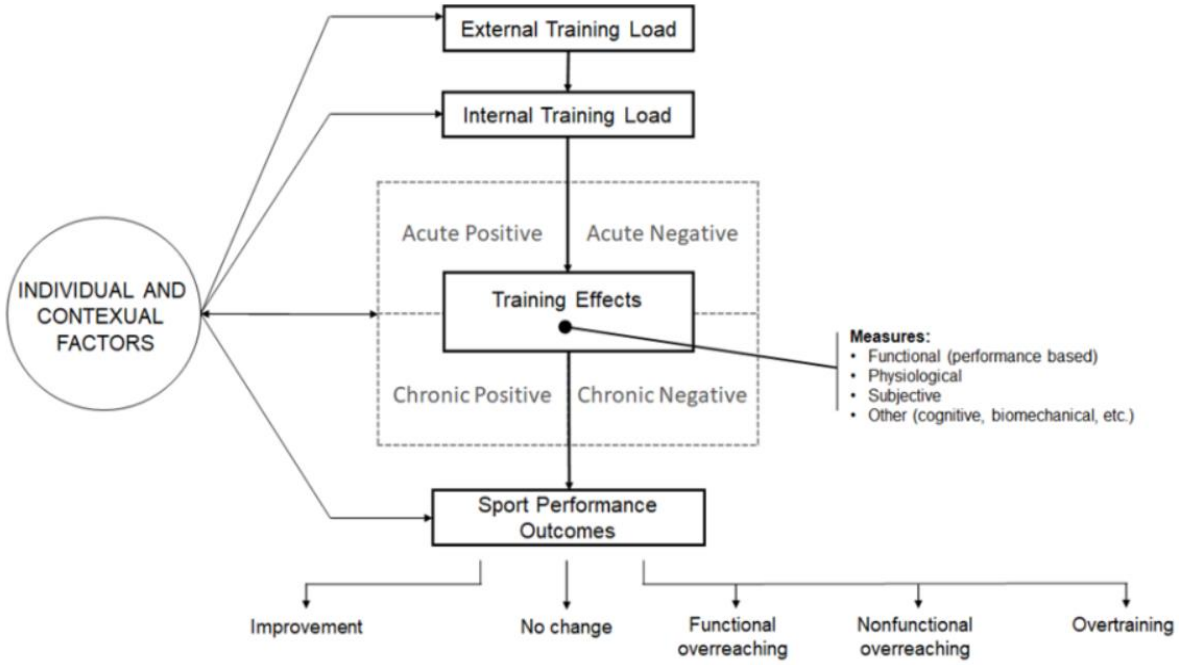
Internal Load

Internal load is the athlete's response to physiological, biomechanical, and psychological stressors imposed during training or competition (Impellizzeri, Marcora y Coutts, 2019). This is what the athlete feels or experiences internally. More details about internal load will be provided in the specific module.

Adaptations/Responses

Adaptations or responses, also known as performance outcomes, are the result from the balance between the positive and negative effects of the stressor stimuli (Jeffries, Marcora, Coutts, Wallace, Mccall e Impellizzeri, 2020.) It is very important to know how the athlete has recovered from the last or previous sessions of training to evaluate how they are adapting to the training loads. More details about adaptations and responses will be provided in the specific module.

Image 4: Individual and contextual



Source: Jeffries *et al*., 2020, p. 3

Everything that the athlete does will have acute training effects that could be positive or negative. Acute positive effects will immediately improve performance, such as warm up or the first day of competition, in which the objective is not to create fatigue but to prepare the organism to improve performance in a future stimulus. Acute negative effects are those that decrease immediate performance, but this does not mean that they should be avoided. Depending on the phase of the microcycle or time of the season, it will be a sought-after stimulus to trigger the supercompensation mechanism mentioned before. The training process would be based on the accumulation of different acute positive and negative effects to provoke long-term positive chronic effects. The problem arises when we do not know the impact our training is having. If we are training more than the athlete is currently able to tolerate, we will cause negative chronic effects, leading to non-functional overload or overtraining.

Training monitoring cycle

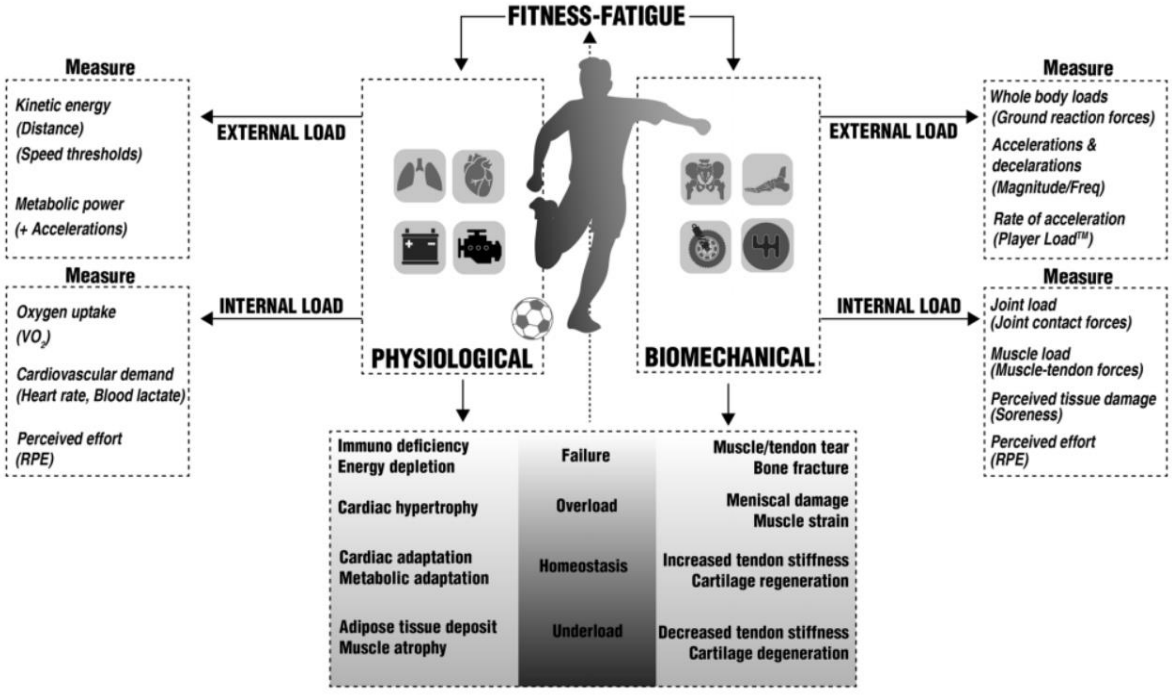
Having defined the main concepts of the module, let's see how to carry out this monitoring process in a practical and understandable way.

To do this, the first thing we have to clarify is that we are talking about a continuous cycle. An athlete is a person 24 hours a day, 7 days a week, and 52 weeks a year. We should not make the mistake of thinking that by monitoring only what the athlete does when they are in the sports facilities will be enough to have optimal control. If we settle for this, we are leaving aside one of the most important parts of the training process: knowing how the athlete responds to training loads.

The training cycle will be based on the three pillars of training load, establishing relationships among them.

Training and competition will provoke a load that will cause physiological and biomechanical adaptations. Physiological adaptations will be related to the transport of substances and nutrients via airway and bloodstream. Biomechanical adaptations will be related to the structures that allow the athlete to move (mainly the musculoskeletal system) (Vanrenterghem, Nedergaard, Robinson, & Drust, 2017).

Image 5: Pillars of training load



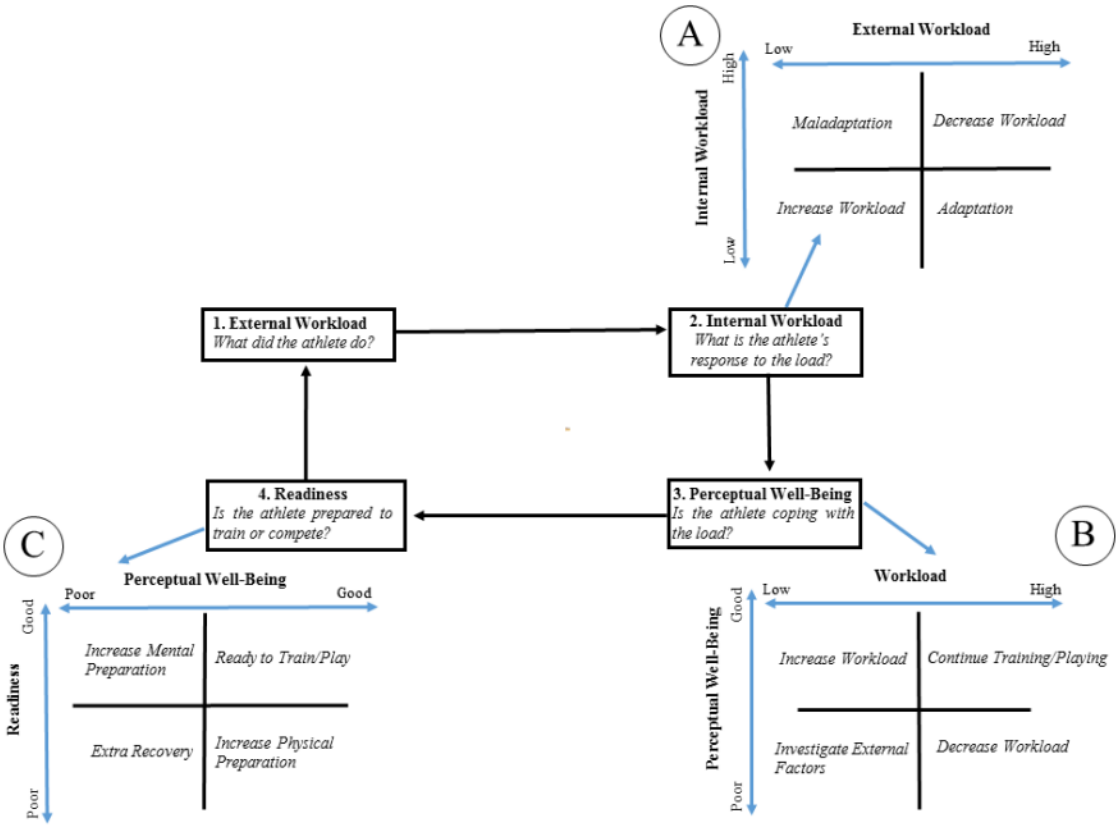
Source: Vanrenterghem *et al.*, 2017, p. 3

The nature of the load will depend on what the athlete does, so it is necessary to understand that the biomechanical and physiological systems do not have equal adaptation processes, and one type of stimulus may affect the biomechanical system more than the physiological system

and vice versa. Let's take an example to better understand this part, as it will help us better understand the entire monitoring cycle that will be explained later. Two athletes, A and B, perform a continuous running stimulus at the same speed, assuming a similar external load, but athlete A does it at 70% of his maximum heart rate and athlete B at 80%. In this case, they will have performed the same external load, but the physiological impact measured through the internal load will have been different.

The following diagram proposes four phases for this monitoring cycle.

Image 6: Monitoring cycle phases



Source: Gabbett *et al.*, 2017, p. 1452

1) What has the athlete done?
2) How has the athlete responded to the workload?
3) How is the athlete adapting to the workload?
4) Is the athlete ready to train or compete?

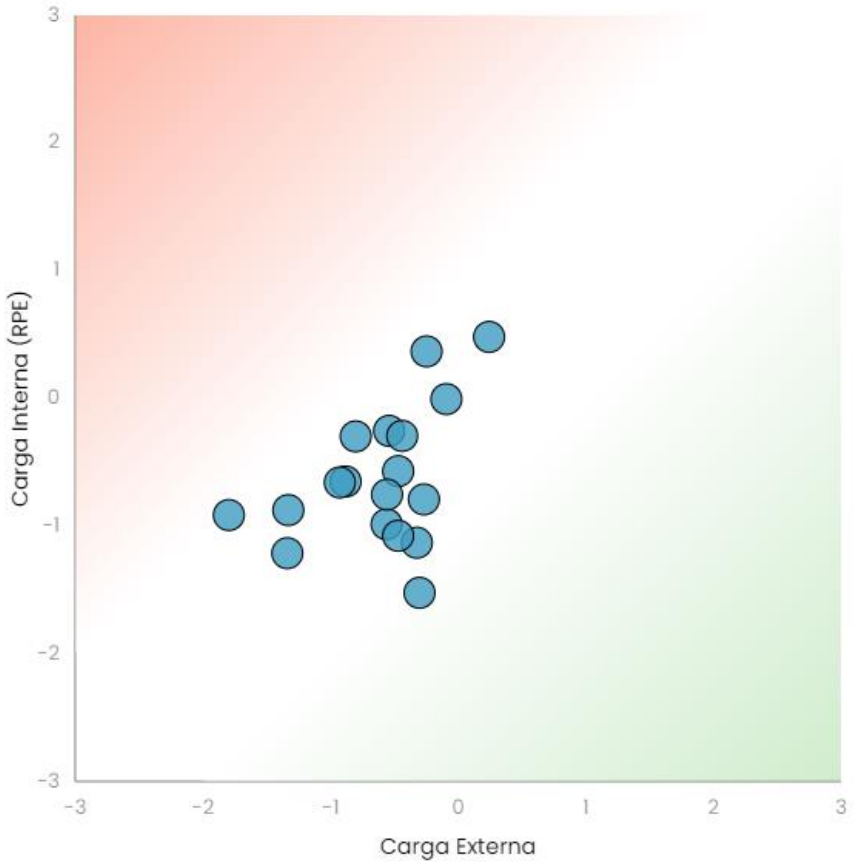
Table 1: Training monitoring

Name	Duration	Dist	Abs HSR	HMLD	Abs HSR + Abs Sprints	MaxSp	Acc+3	Dec+3	HIA
JUGADOR DE CAMPO Official game	68	7214,96	605,91	1140,26	32,29	27,22	29,43	37,93	80,71
CENTRAL	72	7465,50	731,97	1174,30	34,00	26,56	32,00	31,67	81,67
	24	2881	269	498	13	26.4	11	15	35.00
	95	9523	804	1342	37	28.2	44	33	107.00
	95	9992	1123	1682	52	25.1	41	47	103.00
EXTREMO	75	8016,98	731,29	1314,09	42,33	27,76	36,33	40,00	88,00
	58	6652	607	1054	28	29.0	32	31	71.00
	71	7013	725	1233	44	27.6	35	43	93.00
	95	10386	861	1655	55	26.7	42	46	100.00
INTERIOR	77	8231,60	501,68	1295,44	30,00	26,55	37,00	44,50	94,00
	95	9838	559	1465	32	25.1	49	45	111.00
	58	6625	444	1126	28	28.0	25	44	77.00
LATERAL	44	4583,73	488,32	851,52	23,33	27,57	16,00	32,33	64,00
	36	4020	394	815	24	27.0	17	37	71.00
	36	3945	412	684	18	28.6	16	27	54.00
	58	5787	659	1055	28	27.1	15	33	67.00
MEDIOCENTRO	66	7016,85	368,26	846,02	18,50	26,91	25,00	38,00	68,00
	36	4130	295	635	18	23.5	24	22	49.00
	95	9904	442	1057	19	30.3	26	54	87.00
PUNTA	95	10313,88	888,11	1661,06	56,00	28,47	35,00	54,00	105,00
	95	10314	888	1661	56	28.5	35	54	105.00

Source: own creation

The second question relates what the athlete has done with the internal load to understand the physiological and biomechanical impact that training or competition has had on the athlete. For example, in an athlete with a high external load, it is assumed that the internal load should also be high, but this is not always the case, depending on the degree of adaptation or whether the proposed load is suitable for the athlete's level.

Image 7: Internal and external loads in monitoring



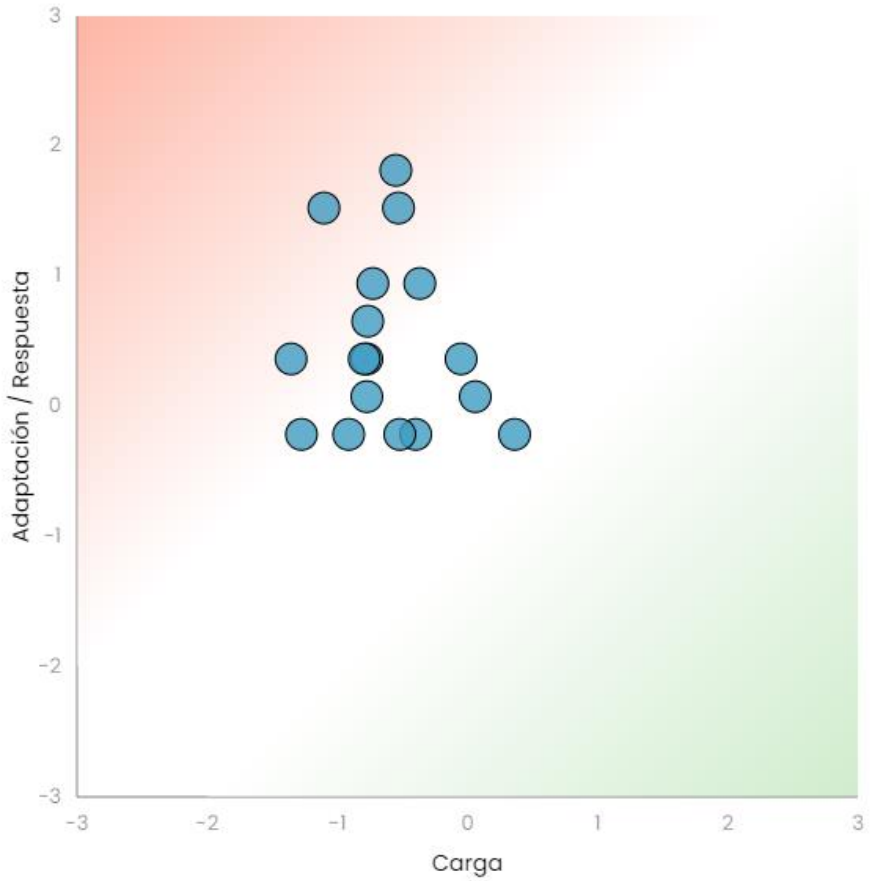
Source: own creation

Carga externa	External load
Carga interna (RPE)	Internal load (RPE)

Understanding the association between external and internal load during training or a match is complex. The relationship that may exist on a specific day will be determined by a multitude of factors, including those that affect the external and internal load on that day, as well as the degree of adaptation the athlete is experiencing.

The third question gives us clues about the athlete's perception of how they have recovered from the last training or competition. There can be cases of very different perceptions of the same training load. The ideal time to ask this question is before facing the next training session, a good time could be during the pre-training breakfast, the athlete has already got up, moved a bit and already has a perception of how they feel. As it will be seen in the internal load and adaptations module, the wellness questionnaire is a very practical tool for monitoring this perception.

Image 8: Monitoring of Recovery from Training or Competition



Source: own creation

Carga	Load
Adaptación /Respuesta	Adaptation/Response

This association between the perception of recovery and the load from the previous day gives us an indicator of how the athlete is tolerating the training loads.

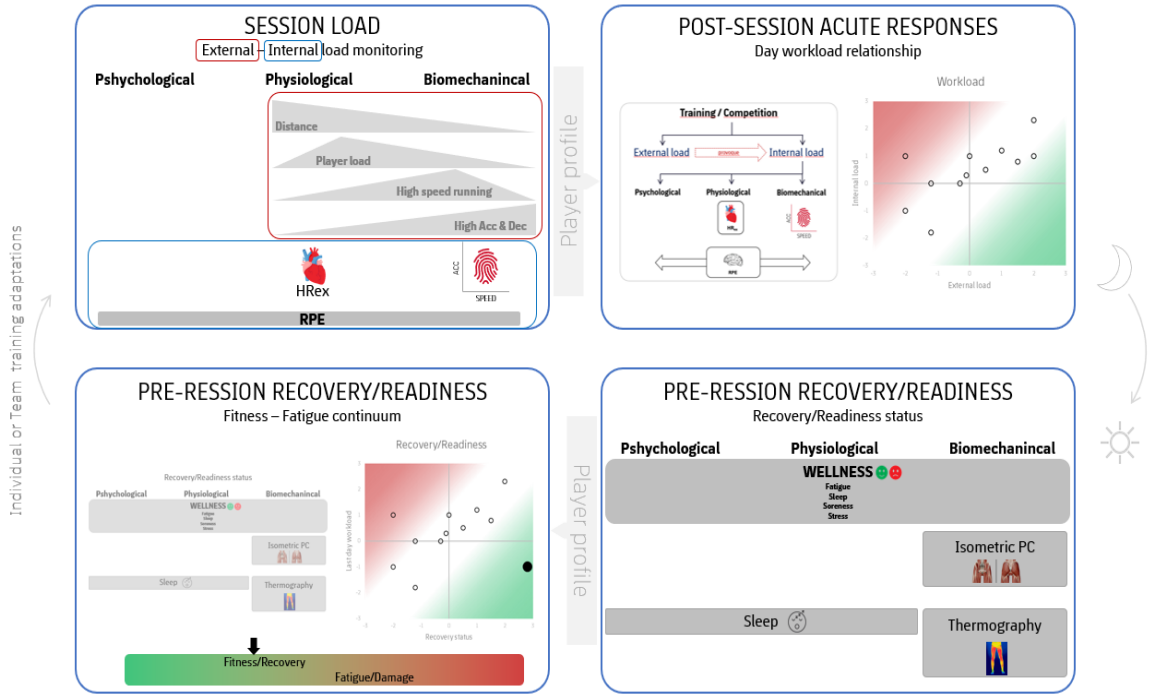
Another important aspect of subjective perception may be affected by multiple factors, not only physical ones from the previous day. It is important to be aware of this in order to avoid making mistakes when making decisions, modifying training loads based solely on the athlete's response without knowing why they have responded with a low score. One option is to have an alarm system that indicates when the athlete has responded with low scores, so that the

responsible person can investigate the reason behind this response, based on the dynamics of the team.

The fourth question aims to objectively assess the athlete's actual physical condition. The proposal here is to be able to make some kind of assessment where the athlete cannot influence the response subjectively. There are many examples that could be carried out in this section, from more purely conditional tests such as a short sprint or a jump, to a biochemical analysis of blood or saliva parameters. The handicap of this fourth part is that it is sometimes very invasive, and it takes time, which if added up over an entire season makes it a bit complicated to do it on a daily basis. For this reason, this fourth question usually does not enter a daily monitoring cycle, but rather into a medium or long-term cycle.

In Barcelona FC we have adapted this proposal making it more suitable to what the reality is for team sports.

Image 9: Real conditioning state objectification



Source: own creation

In this proposal, there are two moments of data collection and two moments of data analysis.

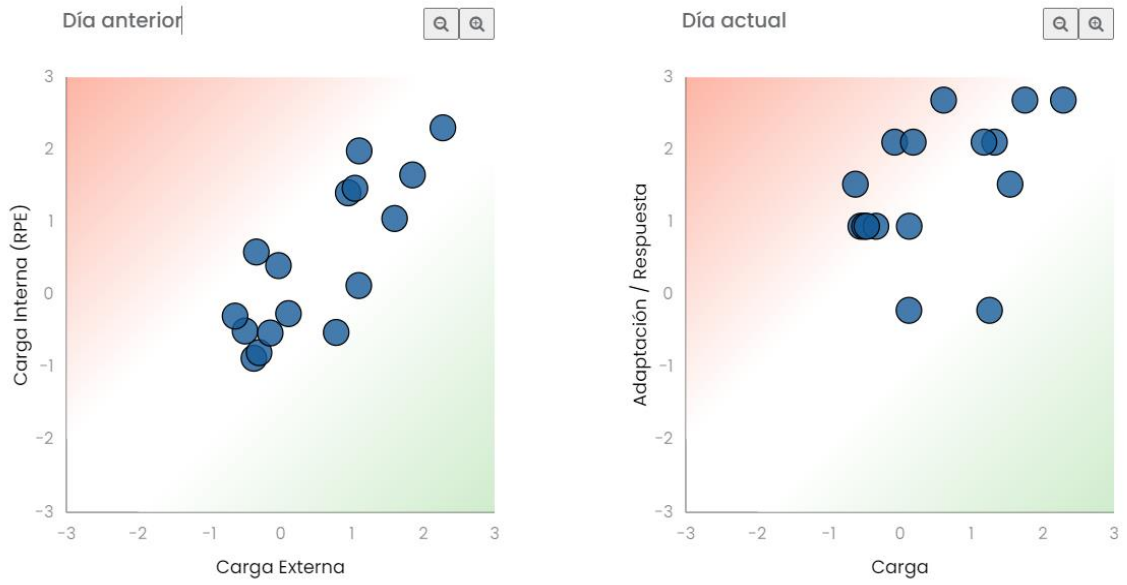
The first moment of data collection is during training, where all data related to external and internal load are collected. External load through tracking devices or through information on tasks and their contextual variables; internal load through heart rate or RPE. The first moment of data analysis is where the data are crossed with individual profiles. The calculation of these profiles is beyond the scope of the course, as it requires knowledge of data analytics. To calculate the profile, we must consider the individual values of the athlete. Once we have this

relationship between external and internal load, we already have a first snapshot of the impact that training has had on the athlete and the team.

The second moment of data collection is the day after, before training, where the objective is to gather information on how the athlete has recovered from the previous day's training/match or the accumulation of training. As mentioned earlier, the result of this assessment will not only be determined by the previous day but also by the accumulation of the last few days or weeks. At this stage, subjective data can be collected, such as the wellness test, or objective data, such as blood or saliva analysis, a jump test, or any other measurement.

Once the information is collected, it is crossed with the individual profile again to understand the impact of the previous day's training. This is an important point because the external-internal load relationship from the previous day is easier to follow logically, but adaptation to training load is where athletes differ the most. It should be considered that the athlete's state before training will not only take into account the previous day's training load but also the recovery methods used, nutritional intake, sleep quality, and other factors that can impact the recovery and adaptation processes of the athlete to the training loads. The internal load module delves into this topic to optimise the recovery processes.

Image 10: Previous day training impact



Source: own creation

Dia anterior	Previous day
Dia actual	Current day

In the previous example, we can observe how, for a training session, external and internal loads maintain a logical relationship, but in the graph on the right, which represents the relationship between the load from the previous day and the athlete's perception of recovery, there is much more dispersion, not all athletes have adapted equally to the training loads.

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