Module 1. Context and Evolution of Strength Training in Women

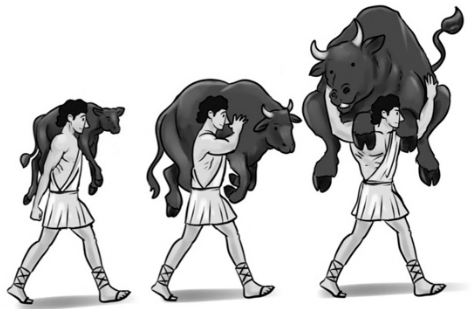
1.1. Historical Evolution of Strength Training in Women and Level of Participation in Sports

The inclusion of women in competitive sports and, in particular in strength training, has been slow throughout history. Women were ignored and excluded from participating in competitive sports in their early stages due to the mistaken assumption that sports were physically demanding for women to practise. However, over the past 50 years the interest and attention towards sports practised by women have grown exponentially, leading to greater opportunities for participation at all levels: local, regional, national, and international. It is important to know the context surrounding women's sports to understand the current needs of women football.

Strength training has progressed since its inception, from practicing for survival needs to evolving into an entertainment and spectacle-based approach, to finally becoming a scientific discipline that will help us create the most suitable training scenarios for football players.

The first texts related to strength training date back to 3600 BC in Chinese writings (Tous-Fajardo, 1999). Around 558 BC, there was a story about how an Italian wrestler named Milo of Croton (image 1), winner of 6 Olympic games, carried a calf on his shoulders every day until it was four years old. The calf weighed more every day, and the wrestler became stronger because of it. This story features the first references to strength training with progressive loads.

Image 1: Milo of Croton carrying a calf



Source: Valera, 2021, https://www.lionmode.es/sobrecarga-progresiva/.

Regarding books, in 1531 Sir Thomas Elyot published the first book about strength and power training (Stojiljković *et al.*, 2013; Tous-Fajardo, 1999). Later, in 1569, Hieronymous Mercurialis' De Art Gymnastica was written, and in 1573 the same book was illustrated with a wide variety of exercises with dumbbells and heavy material like iron plates (Kraemer *et al.*, 2017). From the 19th century, around 1800, strength training became popular among the population. It was closely linked to the world of entertainment, for example, in the circus. In other areas, there was competition to demonstrate who was the strongest, that is, who was the person capable of moving the most weight.

The discipline strongman emerged from there (Kraemer *et al.*, 2017; Tous-Fajardo, 1999).

'Training' began to approach the general population and was also seen as a factor that could improve performance in competitions and everyday life. In this way, in 1835, William Wood opened the first general gym in New York.

However, it was not until the early 20th century that a more scientific approach to strength training appeared, led by Ling, Amorós, and Ludwing Jahn, who developed training programs with different objectives. At this point, distinctions were already established between a structural strength training (hypertrophy) and a functional one. In 1860, MacLaren developed the first barbell and dumbbell training program for the British Navy, from which the framework of weightlifting and competitive bodybuilding was configured in parallel. In 1896, weightlifting became an Olympic sport at the Athens Olympic Games in Greece, which were the first of the modern era. Ancient Greeks banned women from participating in the ancient Olympic Games, even as spectators. No women participated in Athens. Until then, women did not have the access to sports that they currently have.

Four years later, in 1900, women were allowed to participate in the Olympic Games in Paris (image 2). There were 22 women out of a total of 997 athletes competing, which was equivalent to 2% of the total of all events.

Image 2: The first great tennis player, Charlotte Cooper (1870-1966)

Source: Ferrer Valero, 2014, https://www.mujeresenlahistoria.com/2014/06/la-primera-gran-tenista-charlotte.html.

Image 2 shows English tennis player Charlotte Cooper, who was a pioneer in winning an Olympic victory in individual competition. She defeated the French player Helène Prévost in the final with a score of 6-1 and 7-5.

At the same time, the interest of the population in strength training was increasing. This led to the emergence of the first publicly distributed magazines on the topic of ‘strength training’ during the 20th century. In 1914, Alan Calvert published the *Strength* magazine; in 1932 Bob Hoffman advertised the *Strength & Health magazine*. His message on athletic training was clear: strength training improves athletes’ performance (Kraemer *et al*., 2017).

As time went by, books became more specialised. In 1951, Dr. Delorme published *Progressive Resistance Exercise: Technic and Medical Application*; and in 1956 Karpovich and Murray published *Weight Training in Athletics*.

At the same time, due to the feminist movement in the 1950s and 1960s, individual sports like golf and tennis opened new possibilities for women in sports. The first federation was the “*Ladies Professional Golf Association*” (LPGA) and later the association “*Women's Tennis Association*” (WTA) opened its doors. These federations were considered pioneers in promoting and encouraging women's sports, and in motivating the practice of sports other than golf and tennis. This message was particularly for team sports to continue this shift towards a professional and feminist era, opening new possibilities for women's competition (Bae, 2012).

At that time, women's participation in sports had steadily increased since 1900 in Paris: in 1964 Tokyo Olympics there was a 20% increase in women's participation in various sports events compared to previous years.

At the same time, competitive bodybuilding became popular, and in 1965, the first Mr. Olympia was held. Strength training at that time was mainly associated with weightlifting and competitive bodybuilding, generating stereotypes of masculinity in strength training that still persist today.

In the late 1960s, there was a growing concern to generate knowledge about the different sports disciplines being practised. However, it was not until the 1970s when science began to focus on strength training to improve performance in different sports. In 1978, the *National Strength and Conditioning Association* magazine was founded. It promoted the production and dissemination of available information on the subject.

At the beginning of the 21st century, there was a social trend towards professionalising women's team sports worldwide (Taylor et al., 2019). In 2001, the first professional women's football league was founded in the United States. Currently, it could be said that it is the most popular sport for women around the world.

On the other hand, in the 2012 London Olympics, 46% of athletes were women. Those were the first Olympic Games in which women competed in all of the sports on the program. In addition, all participating countries had male and female representation for the first time in history. In 2014, at the Olympic Games held in Sochi, female participation was equal to male participation at 50%.

In the 1980s, in Spain, professionals involved in team sports training rejected the use of external overload training. At the same time, players and coaches criticised its use due to an alleged decrease in the ability to perform specific football movements efficiently, and because they felt a loss of speed in executing the movements. They were probably right, since the coaches' lack of knowledge of training systems meant that strength was trained using methods for bodybuilders for many years. In football, it was very common to hear comments like: 'The gym doesn't score goals' or 'Technique is what matters'. This way, with the evolution of this sport and knowledge about it, there are still comments like: "When there is contact against German and Italian teams, it is the Spanish teams that fall to the ground, and this is because they go to the gym more."

Since its beginning, the evolution of strength training has always been linked to the world of training for individual sports. But in recent decades, specific research on strength training applied to team sports has increased significantly. However, even today, most of us (coaches) are comfortable with what we know about strength training methodology and tend to avoid changes that are taking place at the scientific research level.

For some years now, we have had available information indicating that we should train a female football player differently from how we would train an athletic runner. The ultimate goal of our work as physical trainers should be that our players, after each training session, are better than they were before. This may seem obvious, but throughout history, we have used many different strategies for this same objective. One of the main mistakes we have made in sports sciences is atomising athletes, and this has led us to analyse players into parts, trying to explain the things that happen as a cause of an effect or intervention we have made. These resolution mechanisms led us to arrive at erroneous solutions to the complex problems that arise in the day-to-day of a female football player. We are used to analysing things by their parts and not as a whole and that is where we lose the meaning of the phenomenon we are observing. We study anatomy, neurophysiology, mathematics, chemistry, etc. This does not mean that separate or specialised study is not important; but we should not lose sight of the complete phenomenon. For example, the kick to a ball triggers a series of complex mechanisms; that movement emerges from the interaction of many subsystems that need to be studied separately but considering the causal relationships that exist between the different levels; and finally adding the variable of time, considering that changes in systems occur at different temporal scales. In that sense, we should think systemically, integrating the knowledge we have in an organised and coordinated manner.

We come from a training paradigm in which it was believed that the repetition of decontextualised actions would allow female football players to generate the ability to respond to complex problems that arise during the game. It is important to note that the behaviour of athletes must adapt to the situations that arise in the game, and these conditions are always uncertain, although not entirely so.

Another problem we encounter when advancing or modernising the systems with which we train our athletes is that much of the knowledge we have available is not always guided by scientific evidence, since, in many occasions, we do what was usually done that is, we continue practising based on previous experience: that is, we do what we always do or know how to do, what we know it works, or what other professionals do and tell us it has worked for them.

In the university course that prepares us to be trained in our profession, the name of the subject that aims at educating us in training is called ‘training theory’ Theories should be based on evidence, but the term ‘theory’ often indicates that the information is not only based on scientific knowledge, but another part of it is based on models. Whenever possible, theories are backed up by available scientific evidence and continue to reason from the perspective of evidence. But it is necessary to put this reasoning into practice: beyond scientific evidence, it is necessary to rely on concrete training practice because the theory of training must be applicable and usable in practice. In this sense, we have to accept that training is not only a science but also an art where experience and intuition play a role. Scientific support for training models is quite limited. This is because a large number of factors play an important role in training, and they all interrelate with each other in such complex ways that it is extremely difficult to eliminate confusion biases due to this interaction and to analyse what actually happens during the training process. Therefore, there is a need to understand which factors are important in a particular training environment and which are not. In summary, for a deep understanding of training, research needs not only facts but also thinking models based on practical experience that can provide a framework for collecting more evidence.

It is a common error (which I personally consider very dangerous) and a common practice in sports, particularly in women's football, to use scientific evidence that does not correspond to the population we train, and we use it as valid knowledge. As Lenskyj (2012) points out, women's experiences in elite sports are not homogenous and are shaped by many factors, such as discrimination and oppression, not only due to gender, but also race, sexuality, and social class. These differences make it even more difficult to standardise training, even within the same team. In practice, something as simple as reading a scientific study that categorises a women's team as elite based on their experience can lead to an error. For example, there are many cases of players who are currently in the elite of women's football who went from training 2 or 3 times a week and playing every 6 or 7 days just two years ago, to currently training 5 or 6 times a week and playing matches every 2 or 3 days. We cannot ignore this disparity in levels; therefore, we must be careful with the evidence we use.

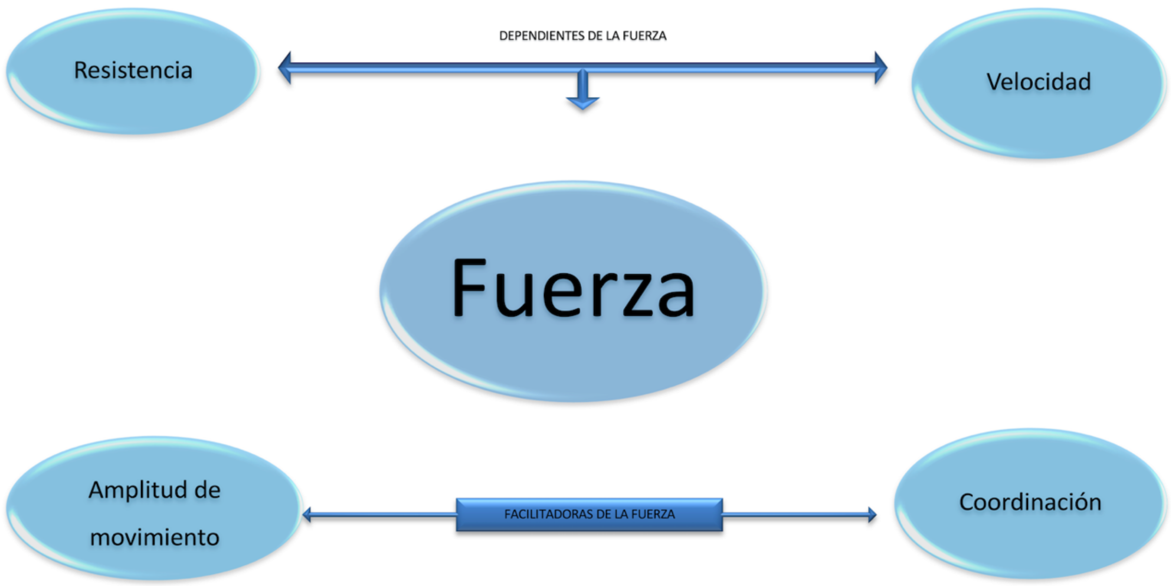
Strength training has evolved from its origins linked to spectacle, where strength was the physical quality that allowed us to maintain, overcome or oppose external resistance. Other authors, like Wilmore *et al.* (1999), define it as the maximum tension that a muscle or a group of muscles can generate. However, as we can observe in most actions in football, the tension required is often produced so quickly that it does not allow for the ‘maximum’ possible tension, and in many cases the task can be successfully completed without reaching those maximum levels of tension mentioned by the authors. Rarely will a player be able or have to apply maximum force, in some cases because they do not have the necessary time to reach it (around 300 ms) (Tous-Fajardo, 1999), and in others because it is not necessary to reach those levels to successfully complete the action. It has been established that the highest level of accuracy in kicking is achieved when the speed applied to the ball is around 80% of maximum speed (Tous-Fajardo, 1999.)

To understand the concept of strength applied to the needs of human movement, we must take into account the concept of applying different muscle tensions. When we talk about team sports such as football, we must also consider the importance of context and the moment in which this muscle tension is applied, understanding strength in football as the ability of a muscle or muscle group to generate muscle tension under specific conditions (Siff and Verkhoshansky, 1996). If we understand strength as the ability to generate movements adjusted to the specific needs of the competitive situation and interpret good levels of strength as those that will allow us to be competitive in our sports environment, we must assume that technique and strength are words that express the same thing.

This approach can help us question the fact that strength training has historically focused on the development of muscle contractile properties or muscle architecture through poorly integrated approaches, but very rarely it takes into account motor learning (Frank et al., 2008). Consequently, technique training is left to coaches, when the reality is that both fields have a common goal: the improvement of neuromuscular processes in movement generation.

In that framework, strength training should be based on movement under specific conditions. In that case, motor action will act as the target of strength training exercise proposals (Seirul·lo, 2017) and not muscle groups, as it used to be considered. Muscles will only be executors of sports movements. To have movement, it is necessary to generate muscle tension. Therefore, we can understand strength as the only basic physical quality from which the others are derived (Image 3.) In this way, some authors assert that strength is the basis of all conditional capacities (Cometti, 1998; Tous-Fajardo, 1999).

Image 3: Strength is the only physical quality, and from which the others derive.



Source: own creation based on Tous Fajardo, 2003, p. 20.

Original	Translation
Resistencia	Resistance
DEPENDIENTES DE LA FUERZA	STRENGTH DEPENDENTS
Velocidad	Speed
Fuerza	Strength
Amplitud de moviemiento	Range of motion
Coordinación	Coordination
FACILITADORAS DE FUERZAR	STRENGTH FACILITATING

Basic study on muscle contraction can be summarised in three parameters:

- Amount of applied force: quantification of newtons generated in a given action. This would be the measurement that has the closest relationship with what has traditionally been understood as strength. Typically, actions involving fighting or grappling, which have a relatively long duration, will be favoured by the application of maximum force.

- Time taken to reach different levels of strength: concept related to power, that is, the study of the relationship between force application and the time it takes to apply this force. This would be the way in which speed is expressed once movement has begun.

- Time that the athlete is able to hold an amount of strength: ability to maintain force application over time, whether maximum or sub-maximum. It would be related to resistance. The ultimate goal will be the same: to reload the energy reserves that provide energy to the muscle (ATP) so that it can continue to activate.

It is clear that we can use strength to move a body part very quickly (speed) or apply a more or less reduced force for a long time (resistance.) Whatever terminology we use, when we want to classify sports actions such as a detachment to receive the ball, which we can classify as maximum speed or anaerobic alactic resistance or explosive strength, what is clear is that we are referring to a complex relationship of systems that results in a movement, which in turn is a product of muscle strength application on certain bony levers. Therefore, it seems clear that the only physical quality is the ability to generate movement, so that a football player can relate to the competitive environment through movement.

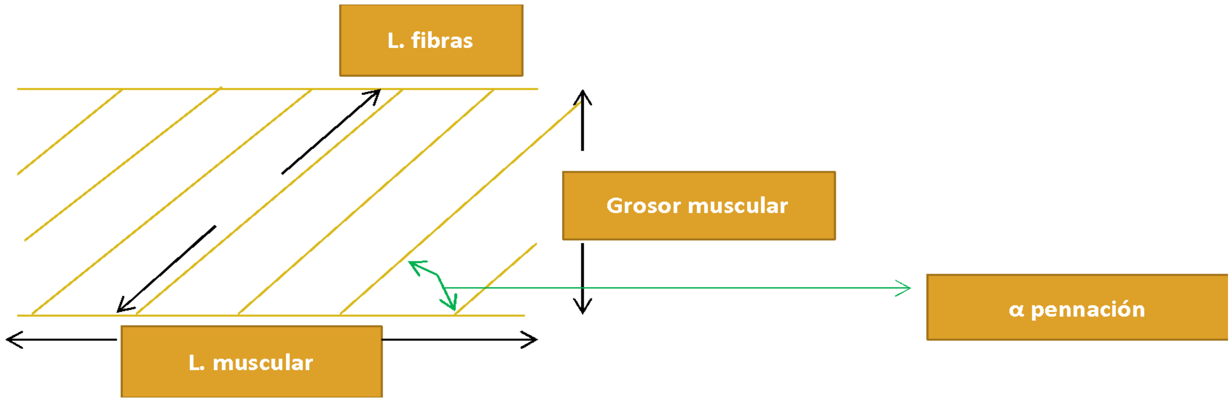
Therefore, the training process programming will be oriented according to the type of actions that preferably occur in the game, and the type of conditional and bioenergetic involvement they pose for the player, taking into account the interdependent relationship between perception and action cycles.

1.1.1 Level of Applied Force

As mentioned earlier, atomising, and separating body parts is useful for understanding how things work, but we must start from the integration of the parts to understand how they relate to each other. Traditionally, the same has been done with strength, that is, separating muscle architecture on the one hand and movement on the other. However, there is a relationship between the two, and a small modification in a parameter such as the diameter of the muscle in a segment can affect the production of movement.

For example: at the beginning of this module, we talked about the tendency to relate strength training to the strength training done by bodybuilders. The latter aims at generating the greatest amount of strength possible getting an increase in muscle mass. However, the increase in muscle mass that results from such training can have disastrous consequences on the movement of players. Hypertrophy usually generates modifications in the tissues responsible for proprioception, changes in weight, increased pennation angle (image 4), decreased specific tension, and changes in the centre of body gravity (Durán, 2004), which will modify the player's way of moving.

Image 4: Behaviour of Muscle Architecture



Source: own creation

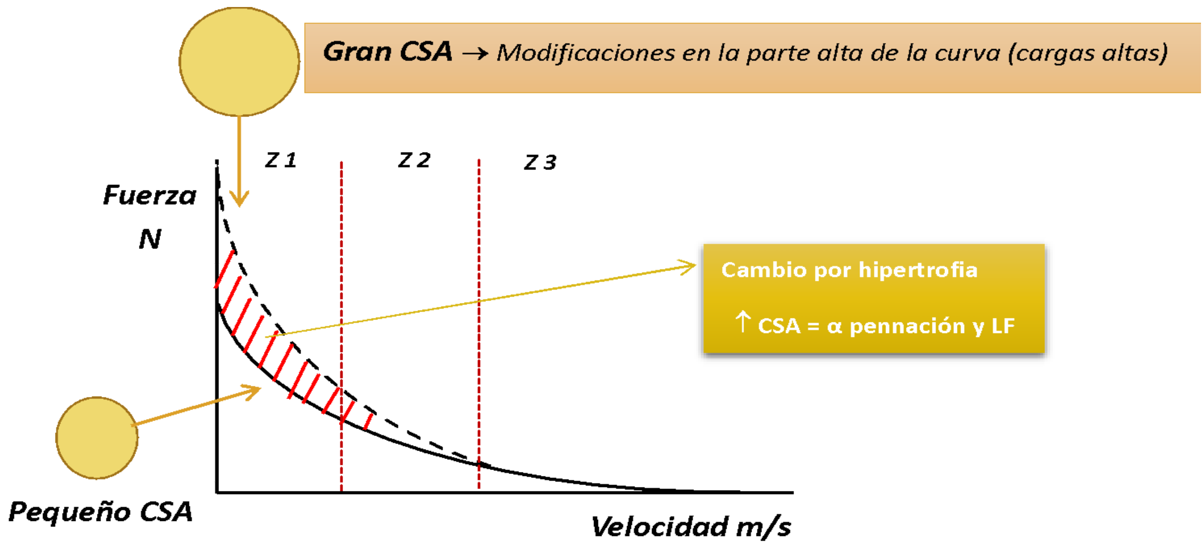
Original	Translation
L. fibras	Fibres length
Grosor muscular	Muscle thickness
L. muscular	Muscle length
α pennación	α pennation

When talking about muscle length, we are referring to muscle belly. Fascicle's length = Muscle thickness/sine of angle

- (Fibres length < Muscle length) when the ratio tends to 0, we will say the muscle is a strength muscle.
- (Fibre's length = Muscle length) when the ratio tends to 1, we will say the muscle is a speed muscle.

Hypertrophy leads to an increase in the pennation angle, which means that although strength is gained, the transmission of strength will be worse. Hypertrophy training increases levels of strength (image 5), but it makes us take more time than before to reach the peak at which maximum strength was transmitted (image 6), and it can alter the efficiency with which the athlete performs actions.

Image 5: Increase in the Strength Levels and Hypertrophy

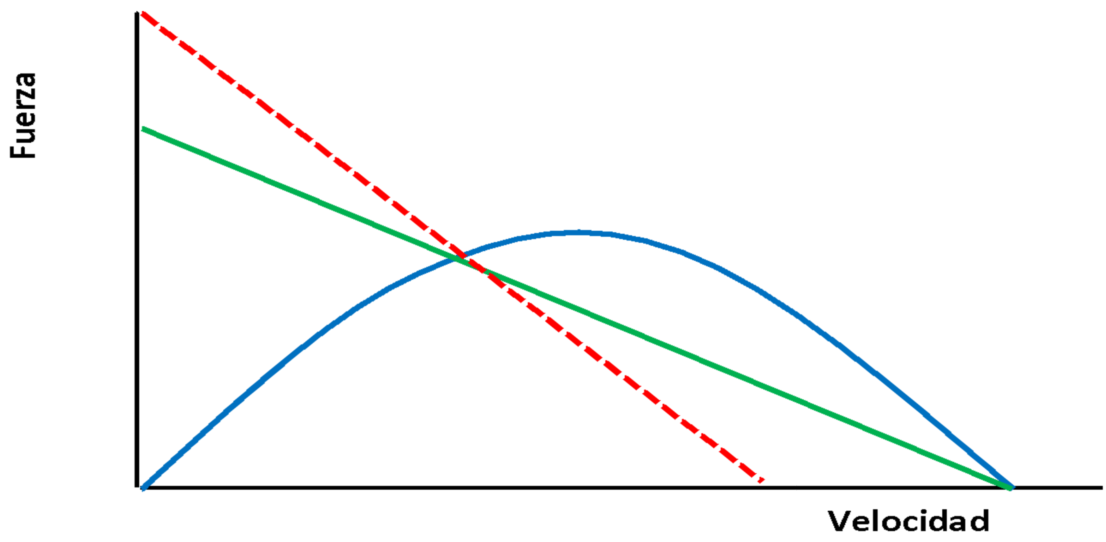


Source: own creation

Original	Translation
Gran CSA modificaciones en la parte alta de la curva (cargas altas)	Large CSA modifications in the upper part of the curve (high loads)
Fuerza N	N Strength
Cambio por hipertrofia	Changes due to hypertrophy
CSA = α pennación y LF	CSA = α pennation and FL
Pequño CSA	Small CSA
Velocidad m/s	Speed m/s

Description of image 5: Assuming an equal pennation angle and fibre length, with only CSA varying, which is actually impossible but theoretical. This is what should be attempted as much as possible, and this is a well-done hypertrophy. On the left side, when hypertrophying, this left side of the curve is modified, increasing the weight that can be lifted at low speeds.

Image 6: Relationship Strength - Speed



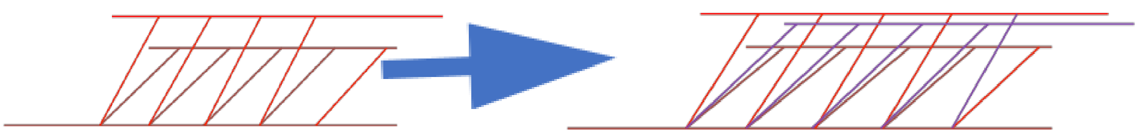
Source: own creation

Fuerza	Force
Velocidad	Velocity

Description of image 6: Increase in force and decrease in velocity for the same movement. The F-V ‘curve’ will always be modified with training, and we need to know if this modification improves or worsens performance.

A subsequent increase in fascicle length (image 6) could decrease the achieved pennation angles while maintaining the achieved hypertrophy. Through eccentric work, we can achieve these muscle adaptations of fascicle length increase, which would decrease pennation angles and increase power.

Image 7: Hypertrophy and Sarcomeres



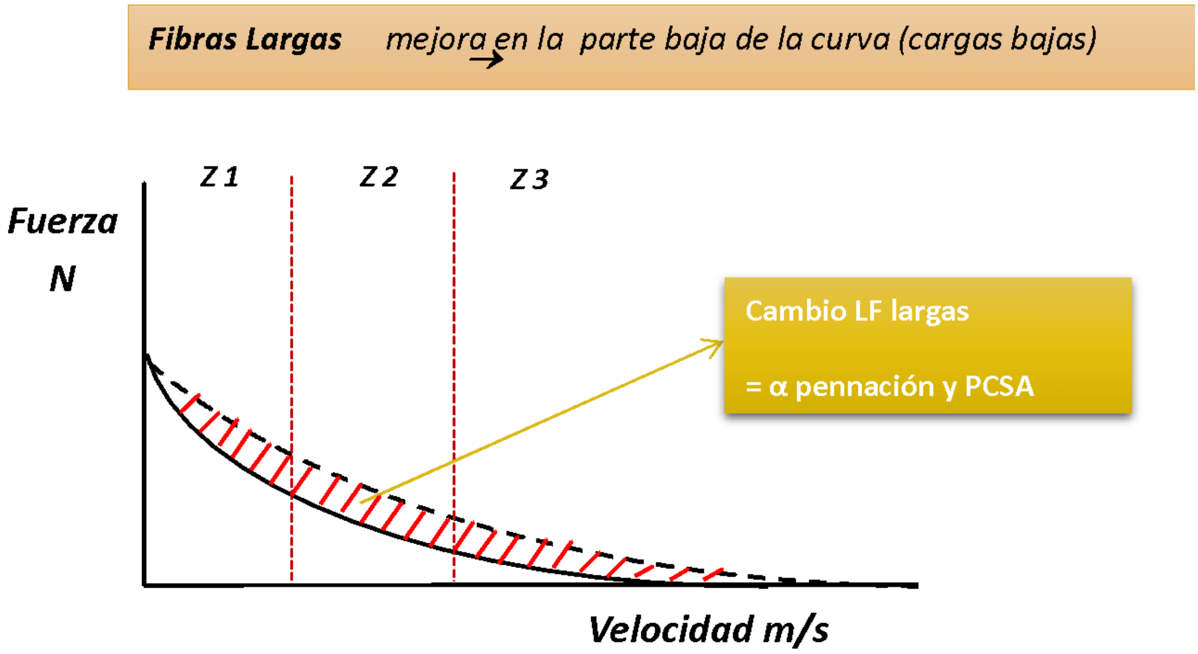
Source: own creation

Description of image 7: On the left, hypertrophy is shown from sarcomeres in parallel; on the right, the transition to hypertrophy from sarcomeres in series is shown in purple.

Ideally, we want to achieve an increase in fascicle length without increasing the pennation angle. To achieve this, it is important to consider the muscle architecture and try not to modify the player's ability to move. This is a process of gaining quality and not quantity, and it is more difficult to achieve.

Strength training performed quickly or explosively favours the generation of positive adaptations for greater performance in high-speed actions. Some of these adaptations include an increase in fascicle length and modification of the elastic properties of the muscle-tendon complex (Kubo *et al.*, 2007), favouring efficiency in actions that are dependent on the stretch-shortening cycle, which are predominant in football. All of these adaptations lead to improved speed for low loads, i.e., low loads are moved much faster. At the same time, the optimal length at which peak strength is produced is modified, but the strength that can be expressed is not modified as much; the length of the sarcomeres at which this peak strength is produced is changed (image 8), although the peak is quantitatively equal to the previous one. Speeds improves significantly, but no strength.

Image 8: Increase in Length of Muscle Fibres

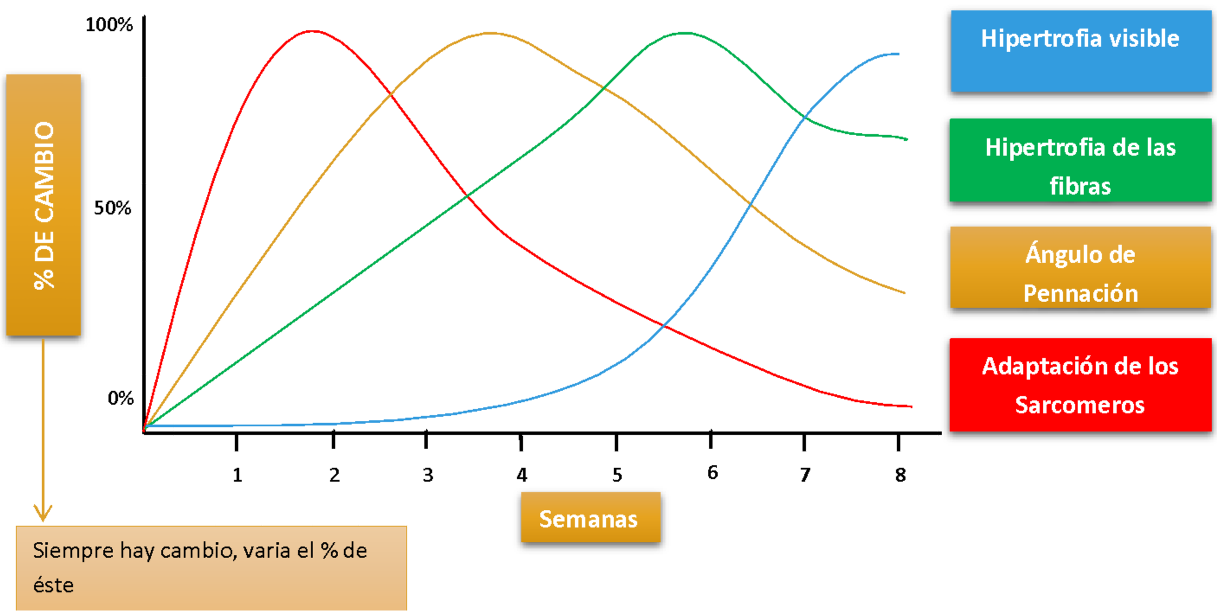


Source: own creation

Fibras Largas mejora en la parte baja de la curva (cargas bajas)	Long fibres: improvement in the lower part of the curve (low loads)
Fuerza N	N Strength
Velocidad m/s	Speed m/s
Cambio LF largas	Long FL change
= α pennación y PCSA	= α pennation and PCSA

Speed is directly proportional to the number of sarcomeres in series that we have. When we increase sarcomeres in series, speed is greatly modified but strength only a little. Structural adaptations can be achieved in three weeks, this is, visible changes in hypertrophy, pennation angles and fibre length, and sarcomere adaptation (image 9)

Image 9. Structural Adaptations to Training Percentage of Change



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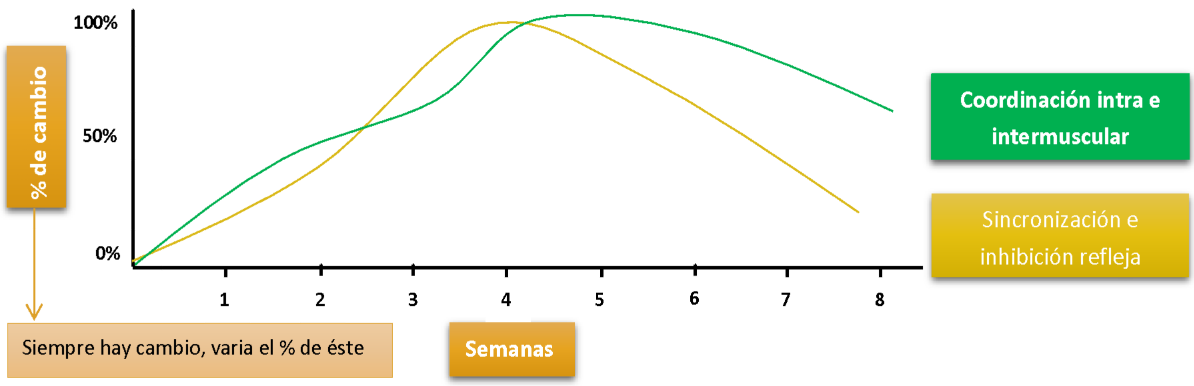
% DE CAMBIO	% OF CHANGE
Hipertrofia visible	Visible hypertrophy
Hipertrofia de las fibras	Fibre hypertrophy
Ángulo de Pennación	Pennation angle
Adaptación de los Sarcómeros	Sarcomere adaptation
Semanas	Weeks
Siempre hay un cambio, varía el % de éste	There is always a change, which % varies.

We must analyse motor action, and from there see how the muscle architecture has behaved, and not the other way around.

When we train for strength, our nervous system obtains adaptations such as intermuscular coordination (among different muscles) and intramuscular coordination (within the same muscle), such as increasing the frequency of nerve impulses and increasing the activation of motor units. Therefore, the more motor units recruited, the more muscle fibres we will use, and therefore, the more tension and strength we can exert. Intra and intermuscular coordination, synchronisation, and reflex inhibition take longer to make changes visible: from 4 to 5 weeks (image 10.)

Image 10. Adaptation to Strength Training Percentage of Change



Source: own creation

% de cambio	% of change
Siempre hay cambio, varia el % de éste	There is always a change, which % varies
Semanas	Weeks
Coordinación intra e intermuscular	Intra and intermuscular coordination
Sincronización e inhibición refleja	Synchronisation and reflex inhibition

The problem with the human body is that it has a finite amount of energy, so when trying to redirect the training process towards improvement, a lot of energy is expended. In this transformation from maximum strength to explosive strength, if too much energy has been expended, stagnation occurs and there is no improvement. Rest is important to get adaptive changes. When working on maximum strength, speed decreases with low loads, and the ideal is to improve maximum strength without losing speed, and then being able to improve speed, always keeping the coordinative aspects in mind.

Adaptation to training can occur through a sum of neutral responses, and optimal adaptations do not always occur in every training session, as otherwise, the improvement in training would be linear and constant, but this is not the case.

Hypertrophy can never be an end goal in itself. The goal is related to the athlete's motor skills, such as making her faster, jump higher, etc. We should follow the necessary steps to get it. It may happen that a structural change is necessary, but it will be a step towards our goal, not an end goal in itself.

As mentioned earlier, strength training performed quickly or explosively favours the modification of the elastic properties of the muscle-tendon complex. With hypertrophy in series, functionality improves in the muscle sides and stiffness increases in the tendons, which contributes to some positive effects on movement such as:

- Shorter time to apply force (higher RFD.)
- Greater capability to store and use elastic energy more efficiently (less loss due to heat.)
- Improved running economy, that is, the ability to maintain the same pace with lower effort and energy expenditure (due to a more efficient use of applied force, thanks to stored elastic energy).

Therefore, it is important to consider that even at a structural level, adaptations related to explosive actions are the most positive and closest to football training. Structural adaptations should not be separated from functional adaptations (movement), as this can lead to problems in the athlete's performance and possible future injuries. It should be noted that when a structure is modified, it has an impact on its function. It cannot be ignored that the mechanical properties and ability of tissues to withstand tension are different depending on the direction in which force is applied, as they are ‘specialised,’ and the ability to withstand tension will vary depending on the activity they perform.

It should be noted that the neuromuscular system that produces movements is constantly interacting and receiving feedback from the environment, and that all experiences lived will modify the interaction conditions. Therefore, generating decontextualised scenarios can create new coordination that may not be interesting for the player’s performance.

It seems clear that most actions in football require submaximal forces rather than maximal forces, since there is not enough time in the actions to reach that level of demand. The combination of power and precision seems to be the predominant manifestation of force in football. Explosive actions in football are favoured by stretch-shortening cycles that are related to elastic properties, which were previously mentioned.

1.1.2 Time Take to Reach Different Levels of Strength

The definitions of speed have always been linked solely to neuromuscular factors, to the conditional ability to perform movements in the shortest possible time. The evolution of the definitions of this manifestation of strength has progressively included the concept of efficiency in the shortest possible time. Based on the need of team sports, the concept of maximum speed was replaced by optimal speed, to meet the demands required to compete (Peñas and del Olmo, 2002). Thus, the player will explore what is the most efficient and necessary speed at the moment of action and will only act at the maximum possible speed when the competitive environment requires it to favour her interests and those of the team.

In football, more than being fast, it is more important to know when to be fast, depending on what the competition demands and the intentions we have to intervene in it. Players must be prepared to read what speed the action they are performing needs: it may be interesting to play with a first touch to favour a high pace or, on the contrary, it may be interesting to dribble and reduce speed to attract opponents and generate new spaces and positional advantages for teammates.

56% of actions in football last between 1 and 3 seconds, so maximum speed in movements will have little impact on such short actions. Actions of maximum speed of movement represent 2% of the actions in the game (Pol, 2014). It is clear that these actions of maximum speed occur in the game and should not be ignored in our training, but each player's ability to perceive the possibilities offered by the game and the correct adaptation to the environment will also be very important. The faster player not always wins the challenge. There is great complexity present in the game that makes it possible to resolve actions optimally.

Speed training should respect the complexity of stimuli and perceptions (external and internal) that affect the decisions the player makes. These experiences are important for the game experience and for being able to discern and perceive information by identifying relevant stimuli.

To be able to perform an action optimally during the game, footballers must be prepared to perform technical gestures effectively, quickly, and efficiently. As mentioned, speed is often understood as the capacity for linear movement in a short amount of time, but it has been explained, this rarely occurs in football. However, the ability to accelerate and decelerate occurs much more frequently and will be of great importance in the game.

Changes of direction, accelerations, decelerations, and movements at maximum speed are different actions, each conditioned by different parameters, so the correlation among them is not high, and adaptations to training programs for each of them do not affect the others (Little and Williams, 2003). This shows us, as we will point out in the specificity module, that improvements due to training are specific to the type of action being performed. In this sense, we must bear in mind that an exercise that we propose only simulates one of the many ways in which sports movement appears in competition, and adaptations will go towards improving this.

1.1.3 Time Athletes Are Able to Withstand an Amount of Strength

The ability to maintain an effort over time seems to have an important relationship with performance. Football is an intermittent team sport characterised by high-intensity actions such as accelerations, decelerations, sprints, changes of direction, jumps, impacts, and other specific technical skills that require force applied and oriented to resistance to keep performance in game actions, therefore, they must maintain high levels of skill. It is sought in the players that they can do each of the actions more and more times without modifying their performance, that is, without modifying their motor response. This motor action will be modified by the effect that fatigue can exert on it, causing the muscle to have less capacity to absorb energy. Some authors suggest that game actions where there is a failure due to fatigue are not solely linked to the fatigue of the protagonist muscle of the action, but that there is a loss of functional synergies among protagonist, antagonist, and stabilising muscles (Hristovski and Balagué, 2010). This can cause an injury, due to the alteration of neuromuscular coordination produced by the fatigue process.

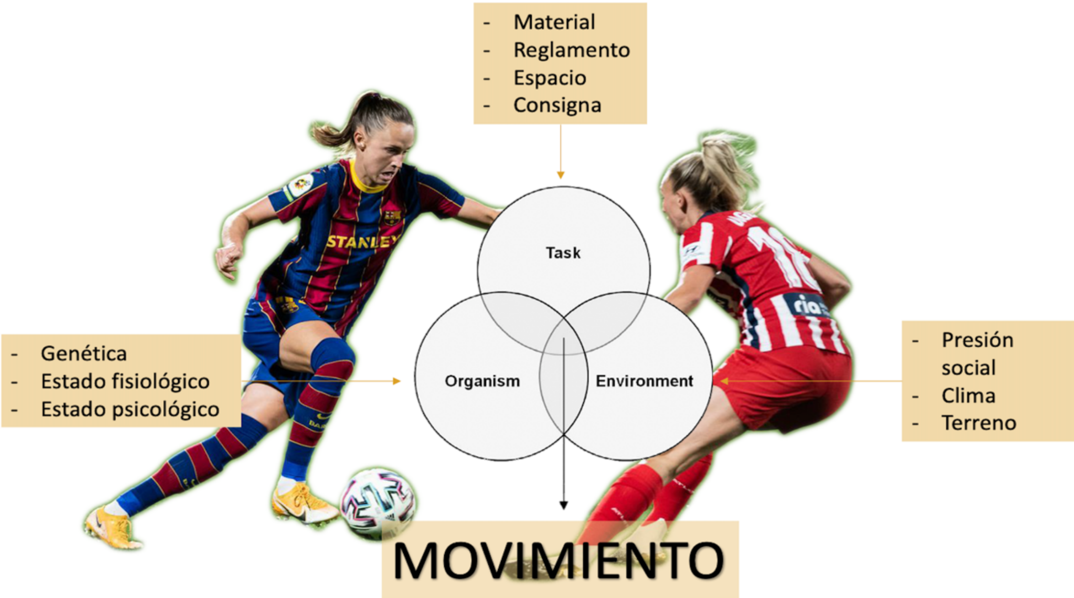
We can conclude that stability of the coordination systems of the players is sensitive to fatigue, so the ability to produce movement effectively and efficiently under specific fatigue conditions should be stimulated to improve neuromuscular processes and movement dynamics under these conditions. Therefore, the preseason, as it will be explained in the following module, will build the foundations of training oriented towards metabolic processes not in isolation, but to train coordination under the necessary conditions demanded in competition, with the objective of creating a stable functional state under fatigue conditions.

1.2. Perception-Action Cycle in Women's Football

Assuming the ability to generate movement through muscle contraction as the only basic physical ability through which different sports actions will be developed allows us to have a less reductionist approach to training that, rather than being based on speed, resistance, or strength, enables us to orient training towards sports functionality.

The adaptive movements of female football players during competition are the result of an emergent process arising from the complex interaction among the player's constraints, constraints of the environment, and the constraints of the action to be performed (Araujo et al., 2006; Davids et al., 2013) (Image 11). In complex biological systems, such as female athletes, factors that may seem small and apparently insignificant can, in interaction with other influences, have a significant impact on the adaptations that occur in training sessions.

Image 11: Interaction Organism - Environment - Organism



Source: own creation

Material	Equipment
Reglamento	Rules
Espacio	Space
Consigna	Instruction
Genética	Genetics
Estado fisiológico	Physiological state
Estado psicológico	Psychological state
Presión social	Social pressure
Clima	Weather
Terreno	Ground
MOVIMIENTO	MOVEMENT

The perception of the different sources of information of the environment allows athletes to perform the necessary movements to respond to the different scenarios and demands of the game. Therefore, the tasks and constraints proposed during training sessions should promote the coupling of the perception-action cycle, according to the information available in the game context.

Although the main objectives of the game are shared by the players of each team, the motor solutions represented by each player's actions during the competition are different and variable. These behaviours are influenced by the individual characteristics of each athlete and by the great variety and variability of contextual dynamics, allowing them to adapt, explore, and perceive the action opportunities that emerge in each specific situation of the game.

It is essential to determine which constraints contribute the most to the emergence of optimal behaviours during competition and, through their manipulation, generate situations that favour athletes to perceive sources of information for action, and to explore possibilities of action that allow achieving the defined objective (Araújo, 2006).

Before starting the analysis of each of these factors, it is important to emphasise that none of them can be understood as independent of the others, and therefore, cannot be improved to their maximum potential separately, since their interdependence makes them interact in the same period of time. For example, we cannot improve the tactical behaviour of a player without understanding that it is linked to the movement capacities that are within her reach. A player who makes a good decision to make a pass into space but does not have the necessary skill to perform it and, therefore, does not reach its target, will be giving an ineffective response given her individual coordinative capacity, which does not allow her to make that pass. We cannot say that a movement is effective only from the individual player's perspective, but it will be an optimal movement if it is coordinated with the rest of the team and the movements of the opponents.

Traditionally, it has been believed that a player's lived experiences are stored in the cortical and subcortical structures of different perceptual systems, with this stored information serving as a basis for creating all cognitive operations and movement generation (Memmert, 2009). However, the brain is an integrative and complex organ without a central governor (Fingelkurts and Fingelkurts, 2004). Each cortical area is conditioned by the interaction of other areas connected to them (Schöner and Kelso, 1988). Therefore, behaviour responds to a self-organising process that enables the coordination of cortical and subcortical activity to achieve a common functional state among areas, and to stabilise the parameters of this activity (Fingelkurts and Fingelkurts, 2004). In this way, the concept of meta-stability, understood as the explained tendency of areas to function autonomously, but at the same time to coordinate their activity (Kelso, 1991), is key for the interaction between neuronal systems to generate adaptive behaviours in complex and variable environments (Fingelkurts and Fingelkurts, 2004).

In that sense, cognitive theories have no place since there cannot be a stimulus/response relationship in brain processes because they do not follow linear dynamics. Instead, the direct perception of the environment will occur through the recognition of perceived information that will act as attractors of certain patterns of neuronal activation (Spencer and Schöner, 2003). In football, the process by which a player decides, and acts arises from the functional interaction between the footballer and the environment based on the player's perception of these activation patterns. It is necessary, then, that when we want to improve a footballer's decision-making process, we have to respect the competitive environment where it occurs (called the ecology of the environment).

We should also understand that the movements made by the footballer will modify the information present in the environment, and it is this information that will provide feedback for future decisions and actions in the game, forming a constant cycle of feedback between perceptual and action processes (known as the perception-action process). An action is an interaction between the player and her environment with an intention or objective, and a decision is limited by what the environment allows based on the player's abilities in space and time. The motor actions that players can perform in competition are also influenced by their ability to detect relevant information from the environment (Araujo et al., 2006; Gibson, 1979). Players with less experience will focus on more irrelevant aspects of the game than those with more experience (Fajen et al., 2008). It is important for players to learn to identify relevant stimuli to be effective in their relationship with the environment, and even to ignore information that has little importance in the game and focus on what is most relevant for the performance of their actions.

Gibson's concept of 'affordance' helps us understand this. Performance in the game is not only determined by the ability to perform an action effectively, but also by the ability to detect the possibilities for action based on whether the behaviour is possible in the context of the game. Good players are not necessarily the fastest or strongest, but those who know what they are capable of doing and when to do it; they rarely attempt something that they are not capable of doing. The possibilities for action that arise in the game are dynamic and will emerge and disappear depending on the constant evolution of the player-environment relationships. In other words, players adjust to the possibilities offered by the environment.

In summary, players perceive information that leads them to action, and this movement modifies the information that the athlete can perceive from the environment, conditioning the next action. We must be careful when separating perception and action processes in training tasks. Being able to perform a movement (a decontextualised motor action) is not the same as being able to perform that movement interacting with a dynamic environment, taking into account the necessary temporal and spatial adjustments for performance. Ignoring perceptual processes can harm the player's ability to perceive information and adapt to the coordination of sports movements. For example, excessive training in dribbling through cones without opposition can lead the player to look down at the ball to avoid collision, and when they play a game, they may not be able to lift their head to see the game due to the coordination pattern generated in that training task.

Here follows a practical example (image 12) in strength tasks of manipulating parameters so that these 'affordances' arise and facilitate the appearance of certain behaviours:

- We perform a lateral step (open stance) on an isoinertial machine. The first image (left) shows what happens when the player is only told to perform the movement, and the second image shows what happens when the intention of blocking the path to a defender is added.

Image 12: Practical Example of Affordance with a Perceptual Constraint

Mirada al suelo

Mirada al frente

Source: own creation

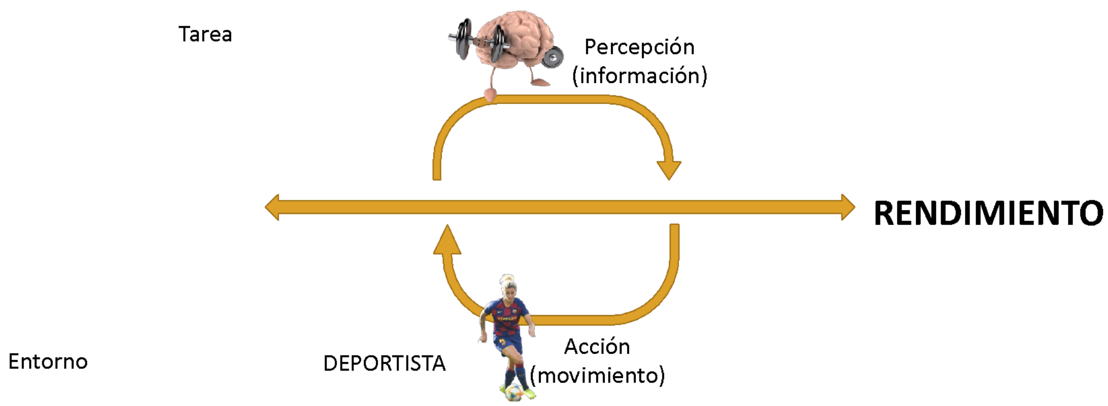
Mirada al suelo	Look at the ground
Mirada al frente	Look straight ahead

With the introduction of affordance, we try to generate in the player a perceptual behaviour of attention to the movements of rivals to perform the action.

Therefore, we must design training tasks that respect the interaction and interdependence relationships of perception and action processes. Thus, by modifying the constraints of the task, we can influence important variables in the regulation of adaptive behaviour, allowing us to reach a higher state of adaptation in the player (image 13).

Behaviours occur according to the contextual constraints imposed on the task (number of opponents, spaces, rules, among others). We will delve into task design in Module 3.

Image 13: Performance as a Phenomenon of Self-organisation of the Characteristics of an Organism and Its Possibilities in a Specific Environment



Source: own creation

Tarea	Task
Entorno	Environment
Percepción (información)	Perception (information)
DEPORTISTA	ATHLETE
Acción (movimiento)	Action (movement)
RENDIMIENTO	PERFORMANCE

Description of image 13: This image represents the complex process by which our players achieve performance. Sports performance is nothing more than a self-organisation phenomenon that arises from the continuous interaction of the characteristics of an organism, and the possibilities of action offered by a specific competitive environment. Therefore, behaviour evolves along the temporal scales of performance, learning, and development. Gibson proposed that information detection (perception) regulates action and vice versa. Performing tasks reinforces functional behaviours in dynamic performance environments.

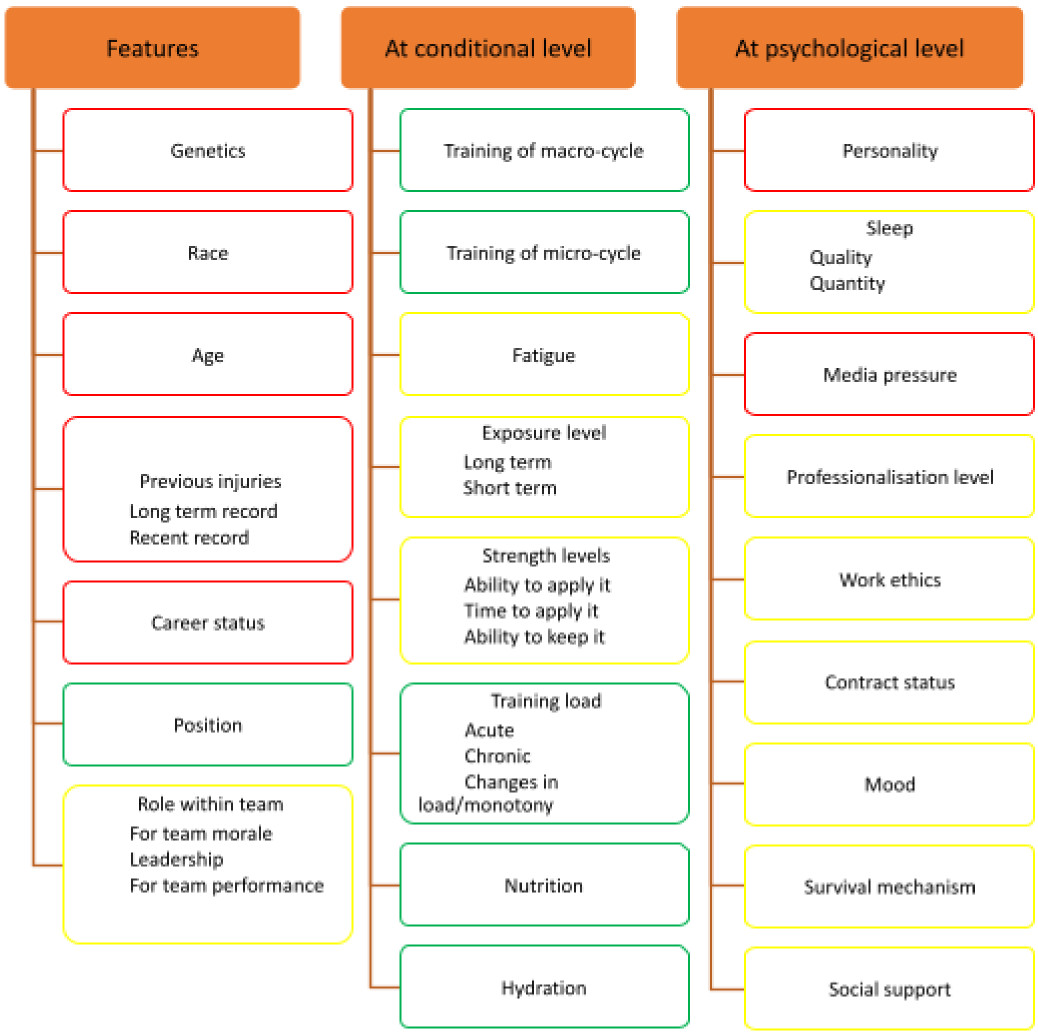
Dynamic systems in motion can explore the constraints that surround them and interacting with them in a way that allows the emergence of functional patterns in specific environments (Araujo et al., 2006). These functional patterns are the product of the preferred coordination of the players (Davids et al., 2013), expressed as an order parameter (Davids et al., 2013), which are the more or less stable preferred coordination that arises when certain constraints (control parameters) are present (Balagué et al., 2008). The constraints reduce the possibilities of action (degrees of freedom), so action emerges because of the pressure exerted by dynamic constraints. Therefore, players evolve through the coordination that emerge from the available degrees of freedom or by stabilising specific coordination.

We must know which constraints intervene in the execution of movements and influence the perception-action cycle in order to know how to orient training. We have mentioned that the constraints are the athlete, the environment, and the task; we will try to understand them more deeply to generate the ideal training scenario for our players.

1.2.1. Player's Constraints

The constraints of our players refer to intrinsic constraints. We cannot understand the performance of a football player as something independent of the environment in which it occurs, but that does not mean that it is not important to study individual characteristics of the players in isolation, and then relate them to their competitive environment.

Image 14: Constraints



Non-modifiable	Modifiable	Modifiable in the mid - long term

Source: own creation

Features	Características
At conditional level	Nivel condicional
At psychological level	A nivel psicológico
Genetics	Genética
Training of macro-cycle	Entrenamiento de microciclo

Personality	Personalidad
Race	Raza
Sleep	Sueño
Quality	Calidad
Quantity	Cantidad
Age	Edad
Fatigue	Fatiga
Media pressure	Presión mediática
Previous injuries	Lesiones previas
Long term record	Registro a largo plazo
Recent record	Registro reciente
Exposure level	Nivel de exposición
Long term	Largo plazo
Short term	Corto plazo
Professionalisation level	Nivel profesional
Career status	Estatus de la carrera
Strength levels	Niveles de fuerza
Ability to apply it	Habilidad para aplicarlos
Time to apply it	Tiempo para aplicarlos
Ability to keep it	Habilidad para mantenerlos
Work ethics	Ética de trabajo
Position	Demarcación
Training load	Carga de entrenamiento
Acute	Aguda
Chronic	Crónica

Changes in load/monotony	Cambios en la carga/monotonía
Contract status	Estado del contrato
Mood	Humor
Role within team	Rol en el equipo
For team morale	Para la moral del equipo
Leadership	Liderazgo
For team performance	Para el desempeño del equipo
Nutrition	Nutrición
Survival mechanism	Mecanismo de supervivencia
Hydration	Hidratación
Social support	Apoyo social
Non-modifiable	No modificable
Modifiable	Modificable
Modifiable in the mid - long term	Modificable en el mediano - largo plazo

In this course, we want to delve into the needs of women in the football context, and to do so, we must know where we start from. People seem to have an extreme sensitivity to initial conditions. The previous experiences that a person has lived through condition the rest of the constraints (environment and task), perceptions, and emotions created for each movement situation, so they have a great influence on the solutions that players give to each event they encounter in the game. In this section, which deals with the constraints that affect the player, we will briefly discuss where most of the players who play football today start from. Knowing the initial conditions at the social level can help us better understand their ways of acting during the game, and their relationship with the previous experiences they have had, which are integrally linked, as we have mentioned.

When we talk about intrinsic constraints, we refer to everything that surrounds the player, which can be modified (body composition, strength levels, etc.) and what we cannot change (genetic aspects such as gender or age). We start from the fact that women have been practicing professional football for a relatively short time. In the last 40 years, there has been an exponential increase in the participation of women and girls in recreational physical activities, as well as in competitive sports at the highest level. Women now train and compete in most sports, many of which historically only men participated in, so much of the available information is based on data from men.

Lough and Geurin (2019) state that the evolution and professionalisation of women's sports are growing and will continue to do so. Currently, their sports careers are short, insecure, and uncertain. Women are in a sports market that is valued as a spectacle. Elements such as aggression, strength, speed, among other characteristics, predominate in men. However, in recent years women's football has shown that with a large enough stage and the right setting, it can attract crowds to take an interest in it.

The social context of female footballers is strange. It is felt that, simply by being women and professionals, they should be grateful for the opportunity to be paid to play (despite the financial insecurity). Likewise, there is a feeling that women are second-class citizens in the sports field. Despite this, the business of women's sports continues to grow, and living off football is no longer seen as the exclusive domain of men (Williams, 2013). While limitations on women's possibility to participate in sports as professionals may be disappearing, this is not the same everywhere; it is easier for a white, middle, or upper-class, heteronormative female player.

When women enter semi-professional sports, they are expected to behave according to notions of professionalism (Allison, 2020). However, despite making professional commitments and meeting professional expectations, female athletes are often treated as amateurs, and therefore not provided with employment and job security to protect them in their occupation. This is often evident in terms of financial remuneration, contract length, protection against injury, and maternity rights. However, many athletes are reluctant to question the inadequate conditions of the workplace, as Taylor *et al.* (2020) pointed out, as there is often a narrative of being "grateful" that surrounds women in professional sports environments (Pavlidis, 2020). Attaining professional status offers legitimacy to female athletes. However, this results in increased pressure and expectations.

The increase in women's participation in sports has led to an increase in research activity related to sports science for women. This research has revealed the special needs that women have in terms of physical condition, nutrition, body composition, endocrinology, etc. As training science continues to evolve, future research will provide more advanced information so that we can go beyond the question science has recurrently asked: should we train women the same way as men? To move beyond this, more research and education focused on women and the issues/conditions they face are needed to help them optimise their performance.

It is clear that much of the existing scientific evidence is based on the needs of men to compete, and that it seems that the easiest thing to do is to compare the behaviour of men and women for the same task to differentiate them. However, even if we try to normalise variables that can influence the results so that the comparison is as predictive as possible, the little homogeneity that women present in elite sport has been demonstrated. As we mentioned earlier, in such complex systems, differentiated factors, which may be small and seemingly insignificant, can, in interaction with others, have an important impact on adaptations. In practice, the way in which training leads to adaptation differs greatly from one person to another, and even occasionally within the same player. Longitudinal studies of training in an "X" population can reveal a trend in how adaptations occur, but this will rarely produce 100% reliable information on the impact of training. Therefore, we must be careful in how we use the available information in current science.

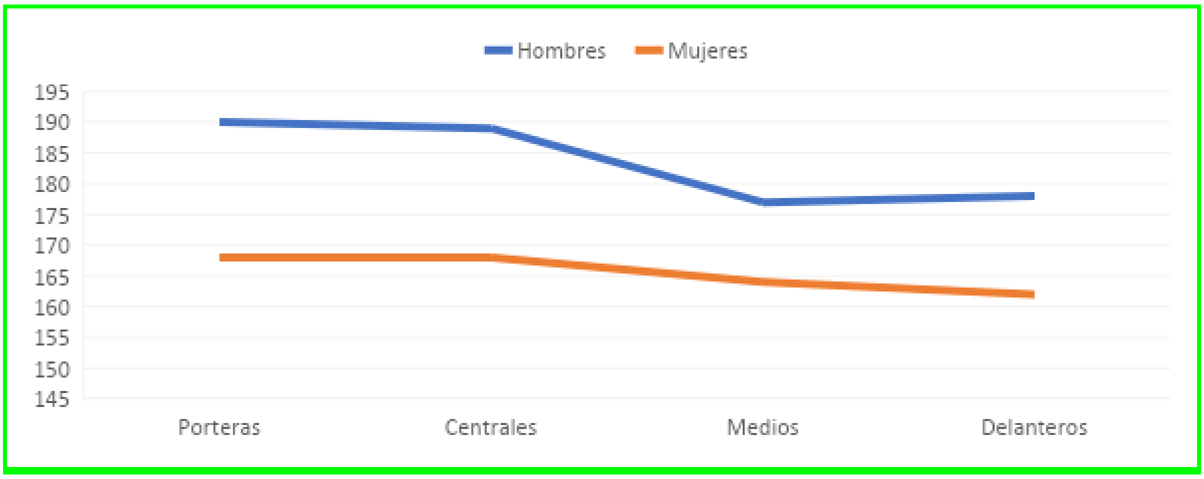
We have seen that there are a series of constraints in the player that, in interaction with the environment, will result in a movement. We also know that the professionalisation of women's football is very recent and responds to an increase in social pressure around equality, resulting in a shift from an amateur to a semi-professional model in a short time, which generates stress at various levels: psychological, physical, etc., some of which we can modify/control and others we cannot. But what do we currently know regarding the factors that condition the player?

- Anthropometric constraints:

Science tells us that men are, on average, about 13 cm taller than women, which supposedly gives them an advantage in sports practice. But there is a great overlap between the sexes, there are tall female players and short male players; the average height of Swedish men, for example, is 181 cm, but the 95% confidence limits are wide between 169-193 cm. Similarly, the variation around the average height of young women in Sweden is also 167 cm, and they range from 155 cm to 179 cm.

Regarding football, these differences between men and women are clear and support the argument that height is used as an advantage in some positions of the game (image 14); but a relevant data that supports this view, as we mentioned before, is related to the recent professionalisation that reveals that there is no clear specialisation in the positions that female players occupy on the field. Men who occupy the position of centre-backs and goalkeepers are the tallest players, and although in women's football the trend is to approach this, it still cannot be corroborated with data.

Image 14. Average Height of Male and Female Professional Footballers



Source: own creation

Hombres	Men
Mujeres	Women
Porteras	Goalkeepers
Centrales	Centre-backs
Medios	Midfielders
Delanteros	Forwards

In the case of the FC Barcelona women's team, champion of the 2021 Champions League, we can see a trend of signing increasingly taller players, with an average height of 176 cm (image 15).

Image 15: Height of Female Players in FC Barcelona

Source: adapted from internal FC Barcelona image.

Description of image 15: FC Barcelona's women's team signings in the season after winning the 2021 Champions League. From left to right: Fridolina Rolfo, Irene Paredes, and Ingrid Engen.

In addition, there are anatomical differences: pubertal and skeletal maturation is achieved at an earlier age in women (a matter that will be discussed in more depth in module 4). On average, men are not only taller but also have broader shoulders and a narrower pelvis than women. A wider pelvis in women contributes to a greater Q angle at the knees, which has traditionally been proposed as a significant risk factor in knee injuries in female footballers.

Women have shorter limbs and a lower centre of gravity, which may offer an advantage in having better balance.

The percentage of body fat is higher in women than in men, predominantly due to a higher proportion of essential fat, which consists of fat specific to being female, such as that found in breasts, around the buttocks, and thighs. However, storage fat is similar in both sexes.

- Endocrine constraints:

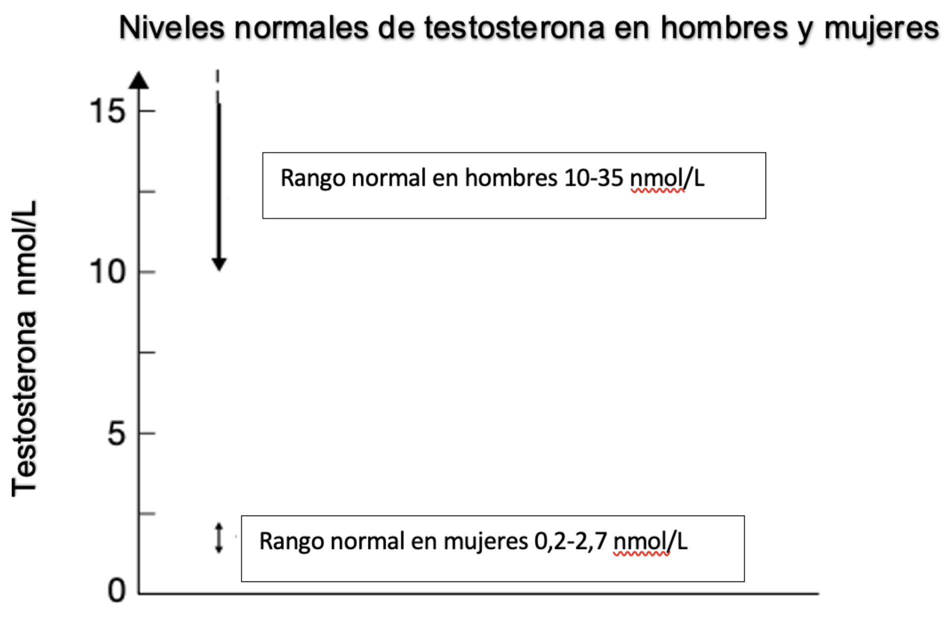
More than three-quarters of women who participate in sports report that their menstrual cycle has a negative impact on training and performance (Martin et al., 2018), underscoring the need to understand female physiology, and define the effects of cyclic variations in hormones in performance (Bruinvels et al., 2017).

Traditionally, sports have two categories to compete in: male and female. This is because there are differences between the sexes, mainly conditional differences such as strength. This is evidenced even at the highest levels of competition where elite athletes compete.

The fact that anabolic-androgenic hormones improve physical performance has been widely studied. Therefore, high levels of these hormones in the blood result in doping sanctions for athletes. During embryonic development, sexual differentiation takes place due to the presence of different perfectly synchronised events, which are determined by the XY sex chromosomes in males or the XX in females. These chromosomes will determine the development of the sex glands that will be responsible for the physical development as a male or female. The absence of androgens will cause the individual to develop as a female (whether XX or XY). In the case of an XY individual, physical development as a female would be the result of a resistance to the action of androgens in tissues, due to a mutation.

The natural difference in testosterone levels in men and women is the main determining factor in the development of muscle mass during and after adolescence, which means that an average man can develop more muscle mass than an average woman. In the case of testosterone, there is no overlap in the normal range's levels in blood between men and women (image 16), unlike what would happen with height where there is an overlap in the ranges. For this reason, testosterone is the only hormone with levels that can differentiate one sex and the other. However, the presence of sex hormones has physiologically important effects in both sexes, even though serum levels may be very different. Adequate levels of oestrogen in men are necessary for bone development, and their deficiency would lead to osteoporosis. On the other hand, low levels of androgens produced by the ovaries and adrenal glands are present in women and have some physiological effects.

Image 16: Average Testosterone Levels in Men and Women



Source: own creation

Niveles normales de testosterona en hombres y mujeres	Normal testosterone levels in men and women
Testosterona nmol/L	Testosterone nmol/L
Rango normal en hombres 10-35 nmol/L	Normal range in men 10-35 nmol/L
Rango normal en mujeres 2.2/2.7 nmol/l	Normal range in women 0.2-2.7 nmol/L

Excess androgens (hyperandrogenism) in women, due to a disease or intentional administration of androgens, causes virilization, increased muscle mass, and therefore an advantage in competitive sports against other women with normal androgen levels. There are different benign conditions that cause hyperandrogenism, most of which are truly rare. However, polycystic ovary syndrome can occur in up to 5-10% of women (Lee et al., 2006).

As explained earlier, it is not entirely easy to define sex in a person. Sex can be defined by taking into account different aspects: assigned sex, chromosomal sex, hormonal sex, and sexual identity There can be intersex states due to sexual development disorders or transexuals due to sex change in adulthood. Therefore, a clear definition of who should participate as men or women is demanded in most societies.

- Menstrual Cycle and Sport

Heavy menstrual bleeding is common in women who exercise and is one of the main causes of iron loss, an essential micronutrient vital for metabolic and physiological function (Bruinvels et al., 2015). Additionally, during the pre-ovulatory phase of the menstrual cycle, several authors have reported an increase in ligament laxity (Anderson et al., 2016), which could have implications for the health of female athletes. An increase in laxity in the knee and ankle ligaments would result in greater elasticity and affect balance, as it would be affected by increased joint moments that are more unstable. Strength training and "technical" movement stability training help to address this mechanical disadvantage.

In general, the normal 28-day menstrual cycle has been divided into 2 phases (follicular and luteal phase) (Girdler *et al.*, 1993), 3 phases (follicular, ovulatory, and luteal phase) (Stoney et al., 1990), and 5 phases (early follicular phase, late follicular phase, ovulatory phase, early luteal phase, and late luteal phase) (Broocks et al., 1990), but it is not clear which is the best classification. What has been demonstrated is that there is a hormonal fluctuation in both oestrogen and progesterone in all phases.

Oestrogen could influence postural stability, as previously mentioned, and this could affect muscle coordination since oestrogen can affect the neuromuscular system directly and indirectly (Rozzi et al., 1999). There are studies that suggest there is muscle relaxation during the ovulatory phase of the menstrual cycle (Sarwar et al., 1996). Also, the maximum concentration of oestradiol seems to induce ligament laxity during this same phase, for example in the ankle (Shultz et al., 2012). Oestrogens and androgens affect verbal fluency, spatial task performance, verbal memory tests, and fine motor skills (Hampson, 1990).

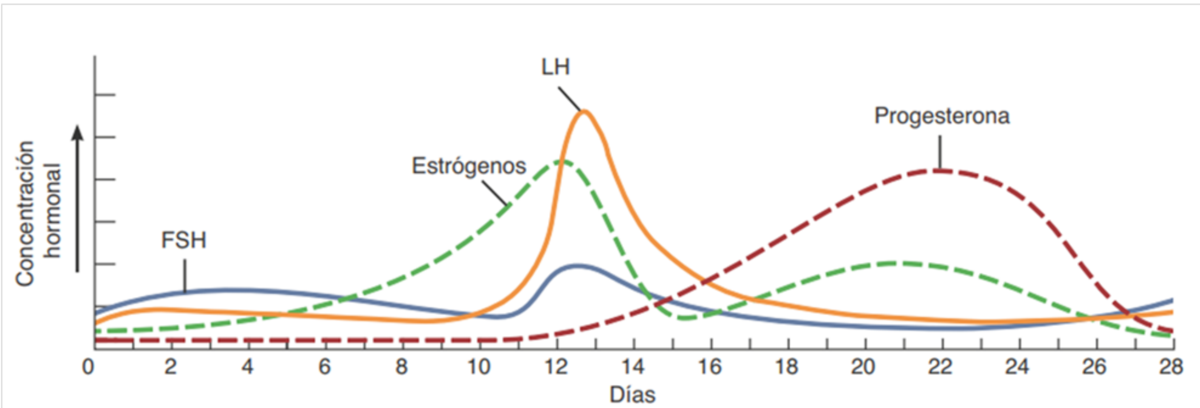
During the menstrual cycle, as oestrogen and progesterone levels in the body vary, the effects of these hormones on the central nervous system (CNS) will also change (Woolley, 1999). Oestrogen and progesterone induce the regulation of synaptic formation. The loss of oestrogen in women may involve the loss of synaptic connections in the hippocampus (Woolley and McEwen, 1994). Fluctuation in oestrogen or progesterone qualitatively or quantitatively influences muscle strength, hypertrophy of type 2 muscle fibre (Sung et al., 2014). In addition, hormonal level variation can contribute to muscle strength gain in adult women (McEwen, 1994).

Some studies on postural control have suggested greater control of posture in the luteal phase and early follicular phase compared to ovulation phase (Friden et al., 2003). However, others have disputed this (Hertel et al., 2006) by demonstrating that there are no differences in postural control during the menstrual cycle, nor are there changes in ligamentous laxity. These divergencies may be due to the training performed by the population analysed and the effect this has on the central nervous system, as well as greater values of muscular strength in the athlete group (Hertel et al., 2006) (Sung et al., 2010).

Oestrogen has an influence on the CNS and neurotransmitter systems (Friden et al., 2003). Hormonal fluctuations in oestrogen also have effects on motor control and muscle strength (Sarwar et al., 1996; Sung et al., 2014).

Summary

Image 17: Menstrual Cycle



Source: Moreno Gómez and Jáuregui-Lobera, 2021, https://revistas.proeditio.com/jonnpr/article/view/4429/5155.

Concentración hormonal	Hormone concentration
FSH	FSH
Estrógenos	Oestrogens
LH	LH
Progesterona	Progesterone

Días	Days

Table 1: Follicular phase, ovulation phase and luteal phase

Follicular phase	Ovulation phase	Luteal phase
Strength in dominant leg seems to decrease	Small peak of strength increase	Studies suggest that there could be greater risk in late luteal phase.
Reaction times decrease	Increased ligamentous laxity?	At the end of the cycle from day 25 to 28 (in a normal cycle) reaction times decrease and there could be muscle pain.
	Decreased postural control	It is suggested to specially differentiate player with pre-menstrual syndrome.
	Muscle relaxation.	Some women have changes in their weight and cravings.
	Player's body feels good.	Increased heart rate in response to aerobic exercise (alterations in thermoregulation).
	Muscle coordination affected.	Increased oxygen consumption.

	Increased metabolic ratio.
	Lower fat oxidation.
	Lactate productions seem to decrease.
	Increased postural control.

Source: own creation

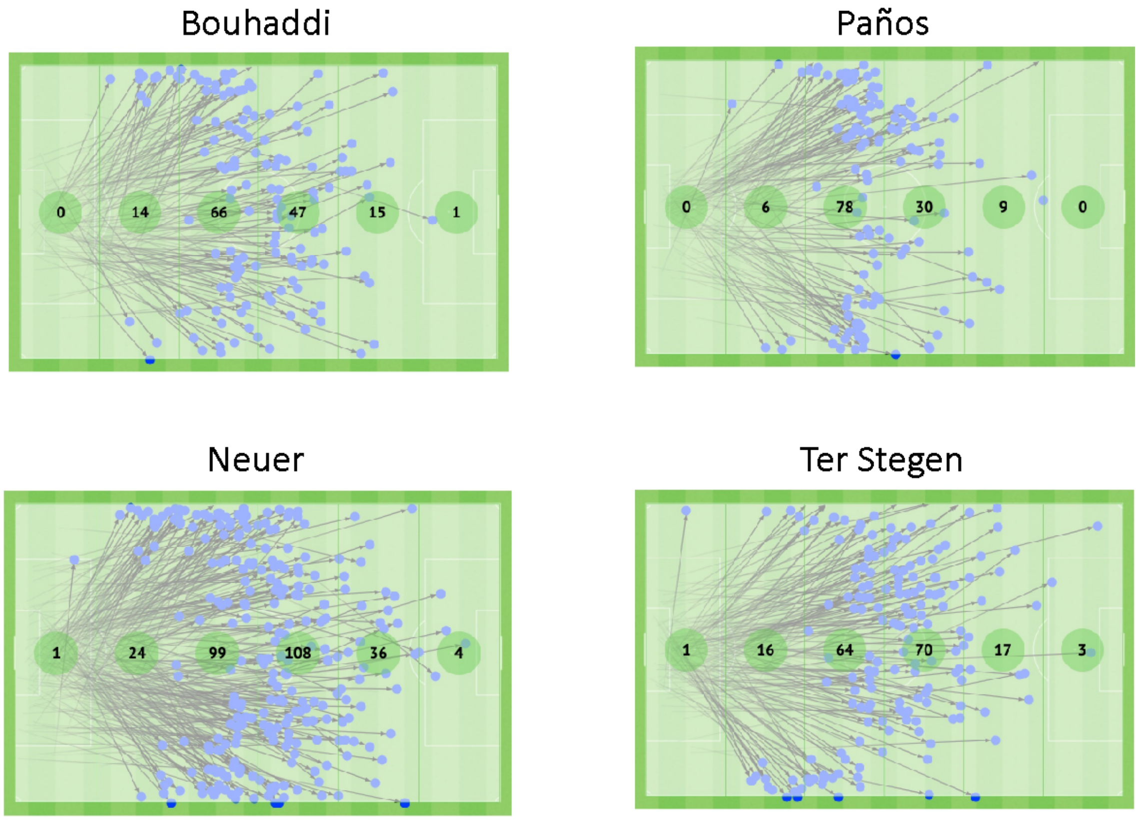
Numerous methodological issues and a great scarcity of studies with the appropriate population have prevented evidence-based conclusions from being drawn in almost all areas of research in this field, but in this section of the module, we have attempted to summarise the most relevant evidence regarding the menstrual cycle, and how to consider it as a factor that affects training. Additionally, there seems to be a great degree of interindividual and intraindividual variability in these hormonal responses. The challenge in the future will be to obtain a non-invasive and quick test to know which phase of the cycle one is in based on hormonal changes, as this has been one of the greatest problems in selecting evidence, since the methodologies used in studies are many and deficient. On the other hand, study subjects did not always meet the necessary requirements for sports practice to be considered elite athletes. Consequently, the references used come from active women or the general population, reducing the usefulness of the information and increasing the heterogeneity index of the samples.

- Conditional Constraints

Conditional constraints are related to and influenced by all the previously mentioned factors but can be modified within certain limits. Women's muscle mass is approximately 25% of body weight compared to 40% in men, and women have smaller muscle fibres. Women have a similar proportion of fast and slow-twitch muscle fibres as men and can achieve similar relative muscle strength gains with strength training. When body weight is controlled, women have less upper body strength and similar lower body strength compared to men. The effects of testosterone cause greater muscle hypertrophy in men when training strength.

These strength differences between men and women can be observed in the goalkeeper's kicking distance in football, perhaps the clearest action where footballers have to develop high levels of strength (although also precision). In image 18, it can be seen that female goalkeepers tend to make their kicks before the midfield line, while male goalkeepers tend to make them beyond that line and with longer distances. These differences do not seem to be significant for a team's performance but having a greater kicking distance from the goal generates greater uncertainty in the defence because there are more possibilities for action in attack.

Image 18: Goalkeepers' Kicking Distance



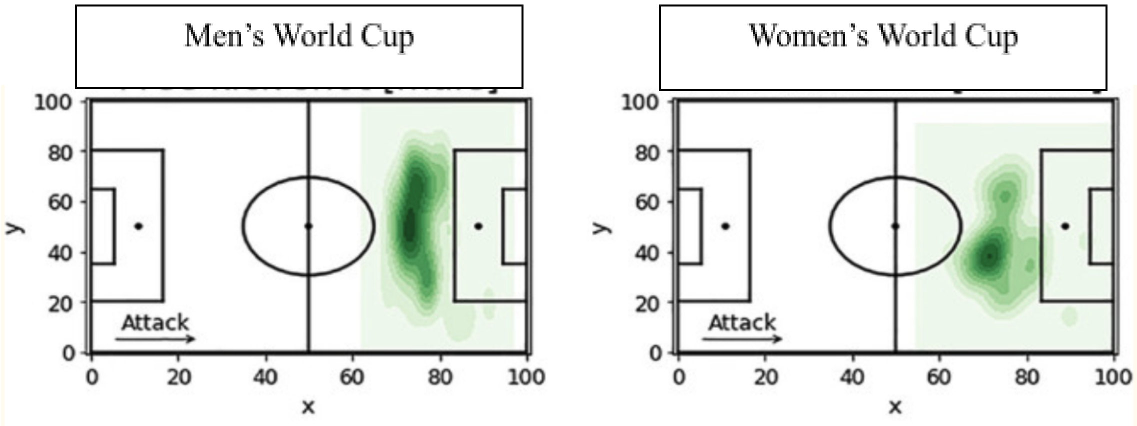
Source: https://objetivoanalista.com/el-analisis-del-portero-de-futbol/

Bouhaddi	Bouhaddi
Neuer	Neuer
Paños	Paños
Ter Stegen	Ter Stegen

Description of image 18: goalkeepers' kicking distance. Top: Bouhaddi (O. Lyon) and Paños (F.C. Barcelona) Last 2 starting line-up goalkeepers to win the Champions League. Bottom: Neuer (Bayern Munich) and Ter Stegen (F.C. Barcelona).

This can also be observed in the distance of free-kick shots to the goal in both genders (Pappalardo et al., 2021)

Image 19: Free kick shot distance in the 2019 Women's World Cup and the 2018 Men's World Cup in Russia.



Source: own creation based on Pappalardo, Rossi, Natilli, Cintia, 2021, p 5.

Men's World Cup	Men's World Cup
Women's World Cup	Women's World Cup

It has been observed that men and women have similar relative strength gains when exposed to the same training stimuli (Cureton et al., 1988; Huston and Wojtys, 1996). As the level of training of female athletes increases, training programs for men and women can become more similar in intensity, something that we should avoid with lower-level female players. As years of strength training experience increase, men and women equally approach their absolute potential, and realistic comparisons of true sex differences become possible. Until then, it is risky to make such comparisons as they arise from very different contexts, as explained before.

Maximum absolute oxygen consumption (L.min-1) is usually 40% greater in men than in women. This difference is reduced to approximately 20% when Vo2max is expressed per kilogram of body weight (Sparling, 1980). It further decreases to less than 10% when expressed per kilogram of lean body weight. Although women's excess fat does not seem to explain all sex differences in performance, some factors that favour lower aerobic capacity in women may include having a smaller heart and thoracic cavity with smaller lung volumes, less blood volume, fewer red blood cells, and less haemoglobin. The difference in performance records in female resistance events compared to male events is decreasing in competitions such as marathons but may never be equal due to inherent differences in body composition and aerobic capacity.

Regarding anaerobic performance, women have a lower maximum anaerobic threshold than men, which may be due to differences in muscle mass or differences in training received during their lifetime.

As mentioned earlier, all of these factors are interrelated and to a lesser or greater extent, affect performance. There are more specific studies that analyse the ways in which a player's position on the field affects adaptations in her, or even what is usually seen in players who occupy a particular position on the field:

- Attackers usually take less time in 20 m (3.05 s) and 30 m (4.38 s) tests (Griffin et al., 2021).
- Midfielders usually resist more sustained efforts (55.4 ml/kg) (Griffin et al., 2021).

The conditional abilities of international players analysed are higher: they have significantly higher speed and repeat sprint ability, power, and resistance (Pappalardo et al., 2021). This is something that does not happen in men's football, as the players with the most sports success are not the strongest, think for example of Messi, Iniesta, Cristiano Ronaldo, etc., and they are not among the top 100 in the ranking of fastest male footballers.

There have been periods in history where the ability to produce strength in a short period of time has been more determining for sports success, and we are currently experiencing this in women's football: players with lower coordinative and cognitive abilities are decisive due to their conditional abilities (Sommerfield et al., 2020). The evolution of women's football with the professionalisation, not only of the players but also of the coaching staff, over the years and with experience gained from a young age, will mean that players, to reach the elite level, will need minimum conditional levels that make this structure less decisive in achieving sports success. Instead, other structures such as coordinative or cognitive abilities will be more relevant in performance.

1.2.2. Constraints of the Environment

These constraints refer to the elements surrounding the football player with which she interacts and exchanges energy, such as the playing field. It is not the same to practice football stadium with turf with 90,000 spectators as in an artificial turf field with your family in the stands. In football, the movements in the space shared by your teammates and opponents that condition the player's performance should also be valued. Other very important constraints are the social or socio-affective ones, which interfere with footballer's perception of the environment. Perceptions of the environment clearly influence the player's actions in the game. They are formed by the direct grasp of action possibilities according to the meaning data of the environment have for the player (Guia, 2009).

1.2.3 Task Constraints

These are the constraints specific to the particular tasks that footballers perform. They are imposed by the rules of the game, such as offside, or not being able to play outside the field. Athletes are dissipative structures that need energy exchanges with the environment to self-organise the coordination of their substructures (Araújo, 2007). Therefore, it is necessary to respect the specificity of the environment in training tasks and generate tasks with similar conditions to those of the competition, creating the ideal scenario for the players to learn to direct their attention and sharpen their perception-action connection, allowing them to be increasingly selective in relation to the information to use (Pol, 2014). This way, we help the player to perceive more clearly the information that allows her to act and continue perceiving to achieve the behaviour they need for the proposed objective.

A lateral defender who is moving back to give space to the opposing forward will act based on the set of variables that she is able to perceive at that moment, for example: the speed at which the forward is coming, if it is a skilled forward, if she dribbles the ball near or far, etc. All these variables will make a behaviour emerge in the defender, for example, directing the body towards covering the inside since the forward is playing on the opposite foot; meanwhile, the forward could also modify her behaviour to alter the defender's movement in this perception-action cycle continuum. All these behaviours will occur on different scales in the two teams.

1.2.4 Interaction Among Constraints

A complex system could be the one we see in image 20. This is a system composed of interrelated parts that we must understand. We can see the complexity of football in a static image where we observe how multiple dynamic interactions at the micro scale (players) give rise to nonlinear macro patterns (team).

Image 20: Dynamic Interaction on Micro (players) and Macro (team) Scales

Source: own creation based on the game https://www.youtube.com/watch?v=-CZ9we2KnRI.

This strength training module will focus on the interrelations at lower scales (micro) that refer to the intervention space of the player in yellow in image 20.

Optimising motor actions could provide significant benefits in competition. Actions such as kicking, jumping, changing direction, and other motor skills are of utmost importance for success in football.

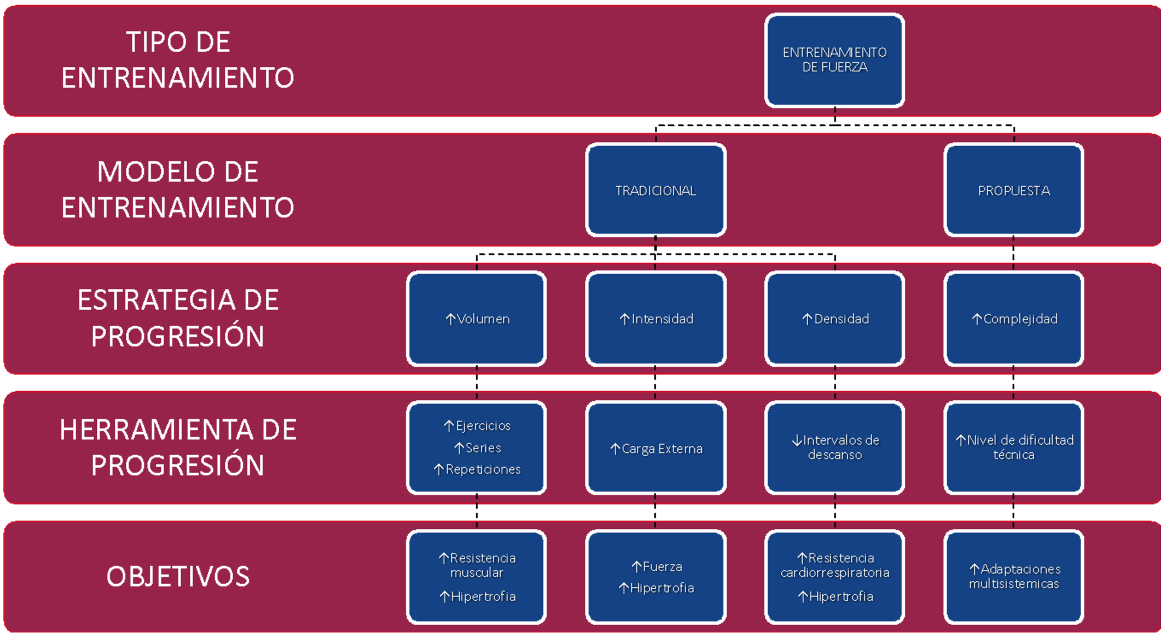
All of the indicated actions depend, at least to some extent, on strength, since any human movement is the result of joint torque or muscle force generated by muscle action (Oshita and Yano, 2012). Thus, supplementing regular football practice with other training methods, such as strength training, allows for optimising sports performance thanks to synergies created.

The need to achieve constant adaptations through strength training has traditionally required some principles proposed in the general theory of training, such as progressive overload, to produce internal responses that favour subsequent adaptations.

Most strength training-based research proposes increasing and varying the magnitude of stimuli of this type of training by modifying the volume, intensity, and density of the nature of the load. However, analytical training alone does not allow for optimising sports performance. Strength training can encompass a wide variety of tasks, from analytical and completely decontextualised exercises to more representative and complex tasks. In this sense, scientific studies proposing other intervention strategies to favour adaptations through training loads have recently appeared. In summary, it is about applying force training in a holistic, synergistic, integrated, and balanced way together with other physical capacities, player structures, and systems based on the complexity paradigm (image 21) (La Scala Teixeira et al., 2016).

From complexity, we aim to achieve multisystemic adaptations, modifying the level of stress that training imposes on the athlete without necessarily increasing the variables of the nature of the conventional loads mentioned. This stress is achieved by establishing constraints, as explained above.

Image 21: Strength Training Proposal



Source: own creation

TIPO DE ENTRENAMIENTO	TYPE OF TRAINING
ENTRENAMIENTO DE FUERZA	STRENGTH TRAINING

MODELO DE ENTRENAMIENTO	TRAINING MODEL
TRADICIONAL	TRADITIONAL
PROPUESTA	PROPOSAL
ESTRATEGIA DE PROGRESIÓN	PROGRESSION STRATEGY
Volumen	Volume
Intensidad	Intensity
Densidad	Density
Complejidad	Complexity
HERRAMIENTA DE PROGRESIÓN	PROGRESSION TOOL
Ejercicios	Exercises
Series	Sets
Repeticiones	Repetitions
Carga externa	External load
Intérvalos de descanso	Rest intervals
Nivel de dificultad técnica	Technical difficulty level
OBEJTIVOS	OBJECTIVES
Resistencia muscular	Muscle resistance

Hipertrofia	**Hypertrophy**
Fuerza	**Strength**
Resistencia cardiorrespiratoria	**Cardiorespiratory resistance**
Hipertrofia	**Hypertrophy**
Adaptaciones multisistémicas	**Multisystemic adaptations**

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