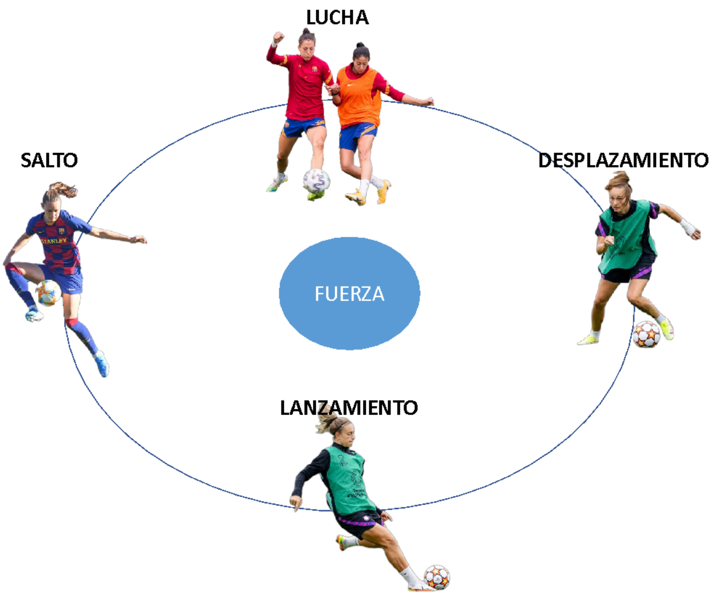
Module 3. Design of Simulating Situations, Variability and Specificity

As mentioned in Module 1:

> Strength training has evolved as regards its applied definition...And, when talking about [football], apart from [the importance of muscle tension], we have to add the importance of the context, and the moment in which muscle tension is applied. Strength is understood as the ability of a muscle or muscle group to generate muscle tension under specific conditions (Siff & Verkhoshansky, 1996). Julio Tous (Seirul·lo, 2017, Chapter The Conditional Structure) proposes a paradigm shift basing strength training on human movement. Thus, movements will act as the backbone of strength exercise proposals, rather than muscle groups, which will be mere executors. (Fernández-Valdés Villa, 2020, pp. 32-33).

Movement is inseparable from the human being: we express and communicate through it, but we also solve problems we encounter in the game with it. That is why "practise oriented towards specific football movements [will be fundamental for the player] to advance towards sports specialisation" (Fernández-Valdés Villa, 2020, p. 39). As described in Module 2, it is necessary to know what the specific movements are in football. Four basic motor skills linked to sports movements were described: throwing, jumping, moving, and fighting (Image 1):

Image 1: Groups of Movements



e
Source: prepared by the authors.

> These manifestations of strength form the groups of movements... linked to [football] sports movements... As we move towards more specific exercises, these groups of movements will interconnect with each other, and the proposed exercises will be composed of combinations of several or even all of the movement groups, just as they happen in the real game [where all of them occur]. (Fernández-Valdés Villa, 2020, p. 41).

To design the training exercises with which we intend to stimulate our football players, we must pay attention to the degree of similarity between the proposed exercise and the sports movement, known as specificity. If specificity is guaranteed, the exercise and sports movement feed back to each other, which is known as *transfer*. For this transfer to the sports movement to occur, the player must be stimulated to a greater degree than they are used to; this is known as *overload*. The adaptation process is highly individual, so it varies from player to player. This is known as *individuality*. To continue the adaptation process, the system must be progressively overloaded. Knowing that this effect is only temporary, if training is stopped, the effects disappear. This is known as *reversibility*.

We must analyse in detail the sports movement to identify the link between the simulating situation and the movement that occurs during competition. The difficulty of this in football lies in the fact that many movements do not follow fixed and repetitive patterns, which in turn hinders the task of establishing their link with strength training.

The unexpected nature of the motor skills that occur in football makes it difficult to analyse the sports movement because it changes depending on the situation observed. Thus, it is difficult to conclude which types of training are most effective. For example, in football, the ability to run is so linked to the game situation that the same strength training rules cannot be applied as in sports such as athletics, where running is done in a straight line and without the influence of opponents. Running in athletics cannot be transferred to football, where the demands of the environment require a constantly changing organisation of the running pattern. However, even skills in open environments appear to have a fixed structure. Having to improvise a movement and adapt it to the constantly changing demands of the environment does not mean that all components of the movement are unstable; some are, but others remain unchanged. Effectiveness in movement is related to the player's ability to change stable and unstable components of movement in response to environmental demands (we will see how throughout this module).

Unit 3.1 Degrees of Freedom

If we have to move; this is, going from one position to another, there are many different ways to make the movement. There are a great number of possibilities, which makes it difficult for the body to select the most efficient one.

When performing a movement that involves multiple joints, each with its own degrees of freedom, there are many possible combinations of ranges of motion that can produce the same result. This, along with the possible combinations of joint angles in various joints, causes these degrees of freedom to increase even more because movements can generally be performed by more than one muscle. This, in turn, increases the options available to choose which is the most efficient movement, making it almost impossible to choose one.

Of the thousand and one ways in which we can move, only a few are economic and effective, but which ones? It is evident that we cannot and should not compare all those alternatives just before performing the movement since it would take too long and fatigue the brain, so the movement would be extremely exhausting. Therefore, there must be a mechanism in the motor control system that eliminates inefficient alternatives and selects the correct one. According to Bernstein, Latash, and Turvey (1996), the essence of motor control is the more or less automatic elimination of superfluous alternatives or degrees of freedom.

In addition to degrees of freedom, Bernstein described a second important problem regarding movement control: *variability* depending on context (Fajen, Riley, and Turvey, 2008). In a changing environment, forces will be constantly different, so the same command from the central nervous system to the muscles will generate different movements in different environments. If the performance of a movement (the total joint angles) must be always the same regardless of the influences of the environment, muscles will have to be controlled differently in each situation. This means that if the predicted joint angle in a movement pattern must be always more or less the same, a different selection of muscles and muscle action may be necessary in each situation (the opponent's movements and resistance). This, in turn, means that a motor skill cannot be designed linearly not only by degrees of freedom but also by the influence of opposing forces, which are variable.

The musculoskeletal system eliminates inefficient and unstable movement patterns that are in the system. The movements we choose are interconnected. The fixed ones are the most valid for the system. The most frequently occurring ones are those that the body will normally resort to in order to solve game situations.

The body spends little energy learning movement principles that only work in a limited number of cases, that is, it wants to learn a technique applicable in most cases. Therefore, when we learn movements, we mainly learn to find and apply rules that filter out inefficient ways of performing the movement to avoid rigid use of the muscles and, therefore, rigid movement patterns (e.g., co-contractions). Since the system seeks to maximise the use of general application rules, movements, although they may seem different, become more similar (running and jumping, for example, differ in the speed of segment movement).

A football player performs many different movements and skills during the game. These movements and skills are complex, with many degrees of freedom (strength, speed, multiple joints and muscles) that need to be controlled (Fajen et al., 2008). If the brain had a motor pattern stored for each separate movement, the catalogue of motor patterns would be so large that it would be impossible to process, especially under the pressure of time available for action. Schmidt et al. claim (2018) in the generalised theory of motor patterns that various similar movements are grouped together. Some movement components are similar for various related movements, while other components are variable. Without the existence of generalised motor patterns, any new movement would require extensive practise or might even be impossible because there is no motor pattern.

This strategy of seeking efficiency to achieve control for many tasks is, therefore, the basis for the *specificity* and *transfer* of fixed training patterns.

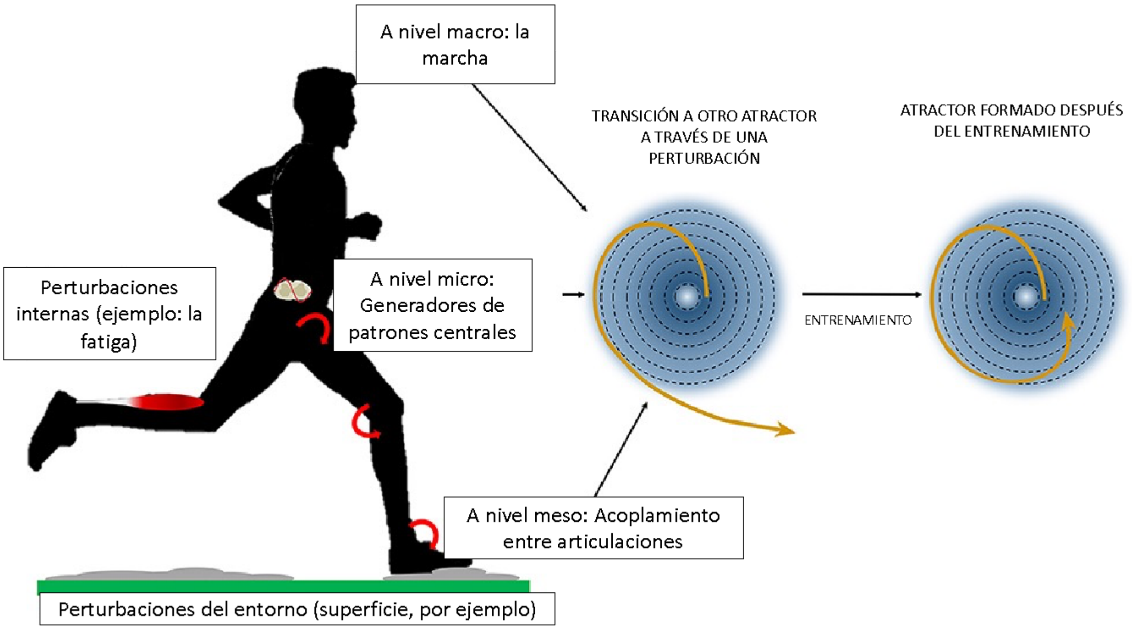
Unit 3.2 Attractors and Fluctuations

So far, we have seen how movements are designed by eliminating degrees of freedom until a robust and efficient movement is reached. Here, *robust* means stable and difficult to disturb, and *efficient* means that the movement can be performed with minimal energy west. A movement pattern always seeks to be stable, and in this search, it can change a different stability if this is lost with the previous strategy. Such a phase transition can sometimes occur even in response to a small perturbation, leading to sudden phase transitions between movements that include stable and unstable patterns, and in which the moving body tries to change from one stable pattern to the next, skipping unstable patterns whenever possible.

Stability and efficiency (economy) of movement not only play a role in choosing general movement patterns. Even within a single movement, the various components of the movement are arranged in stable (low-energy waste) and unstable (high-energy waste) components. The stable and economic components of movement are known in the literature as *attractors* (habitual pattern), and the unstable ones as *fluctuations* (also known in the theory of phase transition as *order parameters* and *control parameters* (Kelso, 1991). Fluctuations are necessary to adapt movement to the changing demands of the environment. If it were only composed of stable parts, movements would be performed rigidly, and the influence of the environment would constantly generate errors due to the lack of adaptability of the system.

Attractors represent coordination tendencies between the components of the system (Davids, Button, and Bennett, 2008) that can be identified at multiple levels and emerge from the self-organisation of lower and higher-level components through circular causality (Kelso, Schöner, Scholz, and Haken, 1987). This means that the behaviour of components at a higher level will be influenced (restricted) upwardly by the behaviour of components at the lower level, and vice versa (Image 2).

Image 2: Walking or Running



Source: prepared by the authors based on Van Hooren, Meijer and McCrum, 2019, p. 3.

A nivel macro: la marcha	At a macro level: the march
Perturbaciones internas (ejemplo: la fatiga)	Internal perturbations (example: fatigue)
A nivel macro: generadores de patrones centrales	At a macro level: central pattern generators
A nivel meso: acoplamiento entre articulaciones	At a meso level: coupling between joints
Perturbaciones del entorno (superficie, por ejemplo)	Perturbations of the environment (such as surface)
Transición a otro atractor a través de una perturbación	Transition to another attractor through perturbation
Entrenamiento	Training
Atractor formado después del entrenamiento	Attractor formed after training

About Image 2. Walking or running, the march, the joint coupling, and the central pattern generators (CPGs) may represent limit cycle attractors (repeating coordination patterns, simplified, represented on the right) at the macroscopic, mesoscopic, and microscopic levels. Internal and external perturbations, such as fatigue or an uneven surface, can lead to a phase transition to another potentially less effective or efficient attractor. Large perturbations can, for example, cause problems such as falls while walking or ankle sprains while running. Training can increase the stability of the attractors so that larger or perhaps more frequent or unpredictable perturbations can be adapted without loss of stability (van Hooren, Meijer, & McCrum, 2019).

Therefore, a movement consists of a mix of attractors and fluctuations that must meet two main criteria:

- The entire movement must be as stable (and therefore economic) as possible.

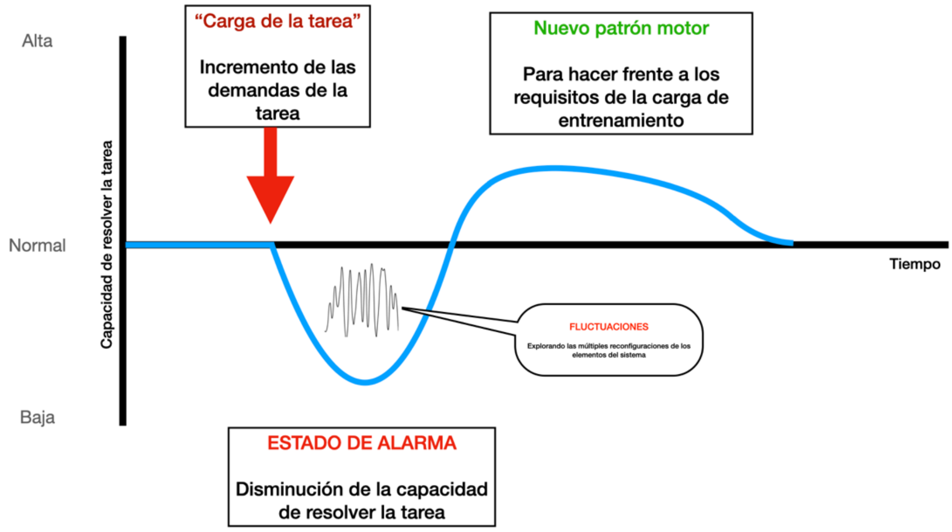
- Try to keep a low number of fluctuations (movement is only controllable if there is a limited number of variables to control) but enough to meet the changing demands of the environment.

The fewer variable ranges of motion, the easier it will be to control the movement; that is, learning to move is not just a matter of learning the various components of the movement but also of learning the relationship between stable and unstable components (Davids et al., 2008). Therefore, during the learning process, it is necessary to learn which components should be used stably and which variably.

The learning process consists, in part only, of learning to perform the various components of a movement. An important part of motor learning focuses on the proper division of movement components into attractors and fluctuations.

At some point of the initial learning process, especially in more complex movements, the attractors and fluctuations that develop may not meet all the criteria for optimal and efficient movement in the environment and therefore, they may not be desirable. The resulting attractors must be perturbed again to create a new and better coordination (Image 3).

Image 3: Increasing task demands (perturbation) to generate a new stable attractor



Source: prepared by the authors.

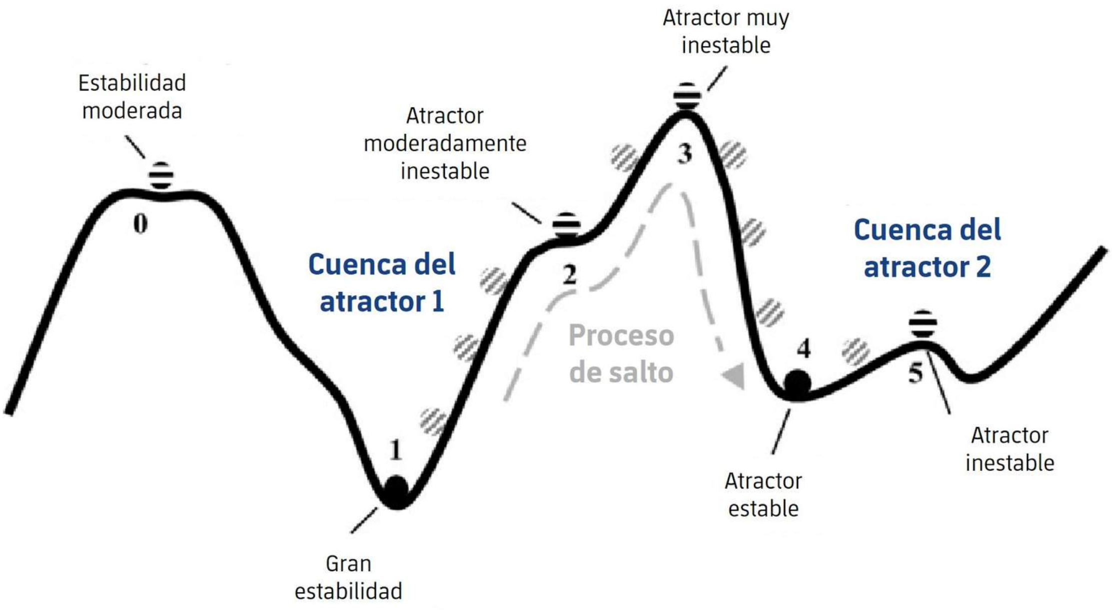
Alta	High
Normal	Normal
Baja	Low
Capacidad de resolver la tarea	Task-solving ability
'carga de la tarea'	'Task load'
Incremento de las demandas de la tarea	Increase in the task demands
Estado de alarma	State of alarm
Disminución de la capacidad de resolver la tarea	Decrease in the task-solving ability
Nuevo patrón motor	New motor pattern
Para hacer frente a los requisitos de la carga de entrenamiento	To cope with training load
Fluctuaciones	Fluctuations

Explorando las múltiples reconfiguraciones de los elementos del sistema	Exploring the multiple reconfigurations of the elements of the system
Tiempo	Time

Disturbing existing inadequate movement patterns is therefore a key step in learning new and better movements (more coordinated). Instead, the focus is on learning the new pattern, which is hindered by recurrent old patterns. In some situations, the real problem in the learning process may be the disturbance of old attractors. Through training, the player will find the correct relationship between the stable and variable parts of the movement, whereby the stable parts will become even more stable and low-energy. This is, less energy will be spent on performing certain movements.

> A very good example of this idea involves a ball moving on a landscape with wells. The wider the well, the more it will "attract" the ball, and the deeper the well, the more difficult it will be for the ball to escape [(Image 4)]. [A female player] will be “attracted” by many movement patterns depending on the imposition of certain constraints such as her body, the environment, and the tasks she intends to perform. Grupo Movement-Readaptación de lesiones & Entrenamiento, 2016, https://www.facebook.com/MovementRehabEntrenamiento/posts/diferencia-entre-movimientos-atractores-y-fluctuadores-un-atractor-es-un-estado-/1034456359975339/).

Image 4:



Source: prepared by the authors.

Estabilidad moderada	Moderate Stability
Atractor moderadamente inestable	Moderately unstable attractor
Cuenca del atractor 1	Attractor basin 1
Gran estabilidad	Great Stability
Atractor muy inestable	Very unstable attractor
Proceso de salto	Jump process
Cuenca del atractor 2	Attractor basin 2
Atractor estable	Stable attractor
Atractor inestable	Unstable attractor

When first performing a movement, attractor components of similar and already known movement patterns are used, limiting the number of degrees of freedom from the beginning to achieve control and even success in performing the movement.

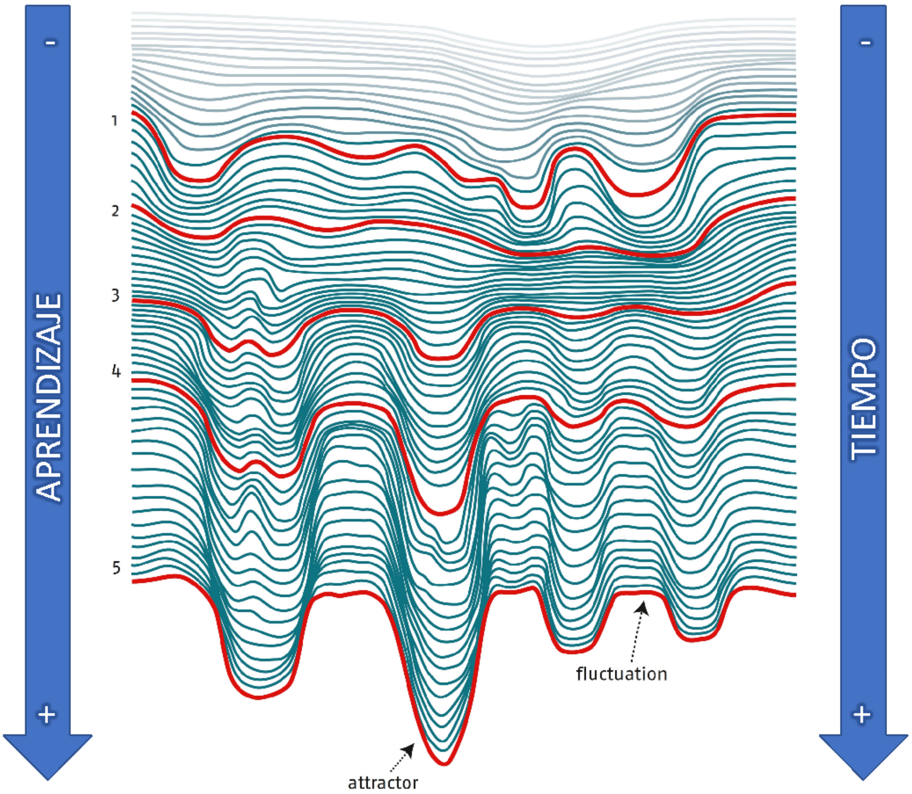
When the chosen attractors are not appropriate, the movement is difficult to control and performance is reduced. As an emergency measure, several joints are immobilised in the body so that the movement is controllable once again. This is known as *freezing degrees of freedom* and can happen to a girl when she hits a ball for the first time: she stiffens all the joints, keeps the knees extended and immobilises the trunk to make the attempt successful. This is a strategy of freezing degrees of freedom and keeping the complex throwing movement under control.

In physiotherapy, it is a common strategy to eliminate compensatory movements in exercises, for example, by prohibiting patients who are recovering from a shoulder injury from bending the trunk to the sides while isolating the arm during an exercise. Compensatory movements are a strategy of the body to achieve balance in the ranges of motion to make them healthy.

> According to Bosch, although humans can perform almost infinite movement tasks, there are relatively few basic movement patterns (running, jumping, squatting, and throwing). These basic movement patterns become the foundation for all movement. They are combined in varied and adjusted ways to generate a huge repertoire of complex movements. Attractors are the basic movements and [fluctuations] are the movements that make adaptation and contextual adjustment. Grupo Movement-Readaptación de lesiones & Entrenamiento, 2016, https://www.facebook.com/MovementRehabEntrenamiento/posts/diferencia-entre-movimientos-atractores-y-fluctuadores-un-atractor-es-un-estado-/1034456359975339/).

The attractor wells are deepened even further so that movement performance is more suitable for the body and efficient (Image 5). Strength training can play a key role here.

Image 5: Attractors and Fluctuations in the Learning Process



Source: prepared by the authors based on Bosch, 2020, p. 112.

Aprendizaje	Learning
Tiempo	Time
Attractor	Attractor
Fluctuation	Fluctuation

About Image 5: The attractor and fluctuation landscape changes from the start (top) to the end (bottom) of the learning process.

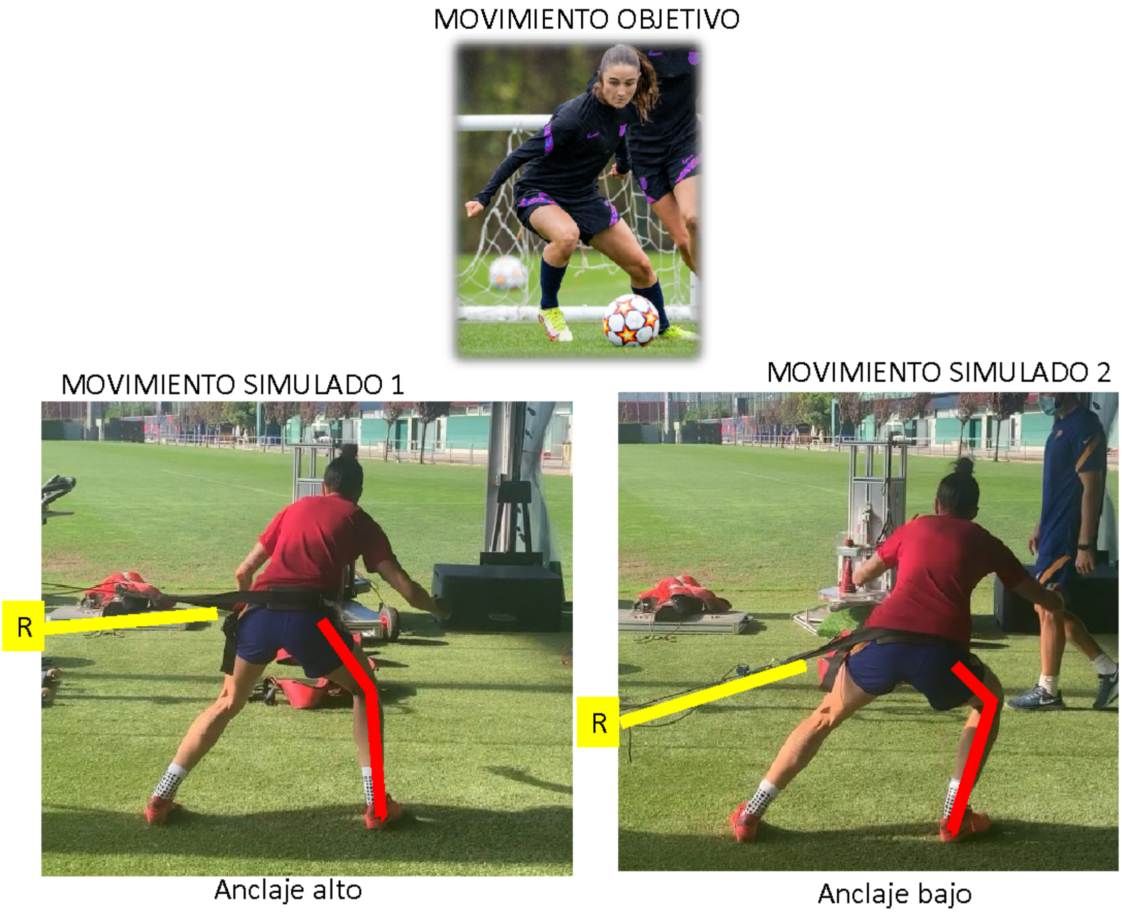
With training, the movement becomes more stable. There are very effective ways (fluctuations) to adapt the movement to the demands of the environment, and that the movement control can do automatically. When we master the movement, it can be combined with highly complex perceptual environments.

> And here is where the great benefits of strength training come into play, so that we can use it to "deepen" the attractor wells. That is, to develop the basic fundamental movements such as throwing, jumping, running [or fighting]. For example, the coordination of ankle-knee-hip triple

extension during jumping does not differ much from a power clean. Therefore, a power clean can teach the athlete something about how to optimise force production in this fundamental movement, and this will be transferable to many different areas in the [game]. Grupo Movement-Readaptación de lesiones & Entrenamiento, 2016, https://www.facebook.com/MovementRehabEntrenamiento/posts/diferencia-entre-movimientos-atractores-y-fluctuadores-un-atractor-es-un-estado-/1034456359975339/).

Movements should be part of a coherent matrix, and there should be relationships between the different categories of related movements (Bernstein et al., 1996). If two or more movements share the same intention, the system interprets them as related movements (Image 6).

Image 6: Related Movements



Source: prepared by the authors.

Movimiento objetivo	Objective Movement

Movimiento simulado	Simulated Movement
Anclaje alto	High anchor
Anclaje bajo	Low anchor

About Image 6: In the movement that we are trying to simulate (change of direction) with training task 2 (resistance from below), it is more likely that we will simulate the objective movement better because the resistance placed below forces the football player to lower their centre of gravity, just as the inertia with which changes of direction are made, where gravity pulls the player towards the ground to a greater or lesser extent depending on the speed prior to the movement.

The system is designed to execute movements with great variation in the muscles used, so we organise our movement solutions into groups of similar intentions, rather than groups of similar muscle activity. The system tries to reason from movement solutions to specific actions; therefore, when teaching a movement, we must ensure to add an intention in strength exercises.

The *intention* is a key component of the movement. There is likely to be a mechanism that supports movement control based on intention. Purpose driven movement is directed by attention. If attention is focused on movement-related features, motor learning and movement processes will be controlled more effectively. Controlling movements effectively is focusing attention on the outcome of the action using mechanisms such as vision effectively (making optimal use of central and peripheral vision). Generating attention on the external focus works better than the internal focus because the former is based on the result of the movement, while the latter is based on how a movement is executed.

3.2.1 Variability of Human Movement (fluctuations)

The variability of human movement can be defined as the variations present in motor execution and which can be observed through multiple repetitions of a task (Dias et al., 2014; Stergiou, Yu, & Kyvelidou, 2013). This variability is inherent in all biological systems and human actions. (Araújo, Davids, Bennet, Button, & Chapman, 2004; Stergiou, Harbourne, & Cavanaugh, 2006)… Applied to [football], this variability represents the complexity of a given movement or may simply represent an early stage of motor learning or the presence of difficulties in solving the task (Newell & Vaillancourt, 2001). The variability of [a] player must be understood and perceived during the execution of the task, within the process variables (angular positioning of the joints, acceleration or contraction of the muscles, etc.) (Couceiro et al., 2014). (Fernández-Valdés Villa, 2020, p. 47).

Many researchers interpret variability in sports science as a mechanism for athletes to adapt and stabilise their actions [(attractors)] in the face of task constraints (Couceiro, Dias, Mendes, & Araújo, 2013). By introducing variability in training situations, what is provoked is that the player losses control and the ability to predict in the new situation, which will generate a certain amount of stress and, consequently, a state of alert and excitement in having to find new rules of control and prediction (Sapolsky, 2008). (Fernández-Valdés Villa, 2020, p. 48).

As responding to different perturbations initiated through various unstable conditions increases the richness of the specific perceptual-motor experience of the task and, therefore, improves performance (Birklbauer, 2019; Wulf & Shea, 2002), we consider that understanding movement variability during the strength training process in [football] can be a key factor in optimising this training. Thus, from the perspective of structured training, it will be through the constraints in tasks with different levels of sports approximation where these perturbations in strength training will occur, seeking changes in movement variability, especially when we want to emphasise the coordinative structure.

One of the great challenges is to establish what is the optimal variability of movement for each task. A movement variability below the optimum in biological systems will represent that they are too rigid and immutable, while a variability above the optimum will represent that they are chaotic and unstable systems (Stergiou et al., 2006). Both situations characterise systems and tasks that are less adaptable to perturbations (Stergiou et al., 2006), and, therefore, they will have a lower level of trainability (Weineck, 2005). (Fernández-Valdés Villa, 2020, pp. 48-49).

Unit 3.3 Variation in Strength Training

To help players learn, we must generate appeal in strength training sessions: motivation is a powerful engine of the learning process. The unknown connections between sensory and motor patterns activate motivation, triggering the learning process when the movement is successfully executed. To achieve an optimal learning effect, movements should not be constantly repeated in the same way. Variation is the key to efficient training. When planning physiological adaptations during training, variation should be one of the main characteristics of training, along with individualisation.

Bernstein et al. (1996) described the need for variation in learning movements such as "repetition without repetition." We do not learn by constantly repeating the same solution to a movement problem but by constantly solving a new movement problem. Learning and motivation are stimulated by the appearance of unknown sensory and motor patterns that do not fit into existing and familiar sensorimotor relationships. We learn through the emergence of something new, rather than from something familiar.

In strength training, only a limited number of movements are usually performed compared to those in competition, and the traditionally generated movement patterns are not complex or diverse. Additionally, in strength training, sensory stimulation is low since the information of the environment is minimal and has little influence. In movements during the game, the visual system has to work hard to estimate and calibrate central and peripheral vision. For example, central vision is used to judge contact time, which almost plays no role in strength training. Peripheral vision is important if control information is released through optic flow when moving in space, whereas in strength training, the player generally does not move in space. That is why the learning system generally finds strength training monotonous and boring. Traditionally, the only difference between movements in strength training is the variation in load on the bar. This monotonous training leads to a decrease in corticospinal activity, which decreases the ability to learn new skills. This monotony hinders the transfer of coordination. Therefore, variation and avoiding monotony should be important parts of strength training design.

Variable training helps increase attractor wells, turning different movement variations into movements of general application. This can only happen when they are tested and executed in all circumstances that may arise. During these tests, the number of effective control mechanisms will have been greatly reduced, and only the remaining principles should be stored in long-term memory, eliminating or limiting the appearance of inefficient behaviours.

Under the paradigm that strength training has to be safe and that injuries cannot occur during its execution, it has been reasoned that this training must remain within strict technical and "ideal" limits. But what really makes training unsafe is the use of heavy loads. However, with low loads during strength training, safe and variable movements can be performed. Variation helps football players develop the basic components of movement control.

If strength training were seen as *coordination training against resistance*, variable resistance training would become a useful way to explore stable patterns and flexible patterns. Women often need more rest between strength training sessions because the processes can lead to more fatigability. Therefore, this type of coordinative and variable training generates less fatigue, making it useful for them, instead of basing it solely on intensity and volume.

Therefore, variable training can play an important role at every stage of athlete development: beginner football players can use it to find a meaningful distribution between attractors and fluctuations, and elite players, to further increase the difference between attractors and fluctuations in sport movement.

If there is little variation in exercises, it will be difficult to find generic principles, even if the exercises provide clear information about the results. If there are more variations, generic principles will be easier to find and can be linked to relevant result information still available. However, if there is too much variation, it will provide a lot of information that can be used to formulate generic principles, but the information about the outcome will be less relevant. With more variation in the direction of random movement, the anticipated and achieved results can no longer be compared, and the learning process will come to a halt.

From all of this, we can conclude that, for exercise design, a general and simple rule is to choose exercises with maximum variation, where the intention of the exercise remains close to the outcome of the sport movement that needs improvement.

Unit 3.4 Specificity

Supposedly, the various motor programs are not separated in the brain, but rather related and linked to each other. This is what we know as *specificity*. Transfer will be the way in which movement patterns influence each other, and will be facilitated by specificity, which can be divided into five categories that will be presented in the following sections.

3.4.1 Movement Similarity due to Similarities in the Internal Structure of the Movement

This category can, in turn, be divided into similarity in intramuscular coordination (similarity in coordination within a muscle) and similarity in intermuscular coordination (similarity in cooperation between different muscles).

Intramuscular Coordination

Muscles can work in more than one way. The various types of muscle action (concentric, eccentric, isometric, and elastic) differ considerably, and when a movement is executed correctly, there is no gradual transition between them. In practice, the specificity of an exercise at the intramuscular level depends largely on the type of muscle action that takes place.

Therefore, the first step to making strength training specific lies in the similarity in the type of muscle action. But this alone does not optimise specificity. Even when the type of muscle action is the same, the intramuscular pattern of cooperation can still be variable. If a muscle has to act concentrically while cycling, the system will organise the cooperation between muscle fibres differently than when the muscle acts concentrically in another activity, such as playing football.

Intermuscular Coordination

Strength training is also very suitable for optimising cooperation between muscles. Intermuscular coordination is so complex that at least two requirements must be met when performing sports movements:

- The movement must be executed in an efficient and economic way (with similarity to the sports movement). A good intermuscular cooperation must take into account the specialisation of muscles in sports movements.

- The movement must be controllable. This is only possible if movement patterns are built on fixed principles that are flexibly integrated into a complete pattern. Among other things, this requires co-contractions and synergies that make movement execution resistant to failures and control errors.

To meet the requirements of efficiency and flexibility, specific cooperation between muscles in a movement is based on fixed building blocks of intermuscular cooperation. In terms of contextual transfer to non-linear control of sports movement, strength training is particularly suitable for improving these building blocks.

3.4.2 Movement Similarity due to Similarities in the External Structure (Form) of the Movement

If the movement outcomes of various movement patterns are externally similar, there is a degree of specificity. Here we can consider similarities in joint angles, movement speed or angular velocity at joints, and the direction in which force is applied.

Similarities in the external structure of movement are an important starting point in the search for high specificity and efficient exercise transfer, among other reasons, because the form of the movement is important for the virtual representation of a movement pattern used in competition. The external structure facilitates the integration of intention, sensory patterns, and movement similarity.

3.4.3 Movement Similarity due to Similarities in Energy Production

The specificity feature that is least applicable to strength training is the similarity in energy production. Strength training rarely meets this criterion. Sometimes it could happen for training transfer. This is because energy production is rarely a limiting factor in performance; limitation lies much more in neural factors.

3.4.4 Movement Similarity due to Similarities in Sensory Response

In summary, we must distinguish between sensory organs that register information from the environment (eyes, ears, vestibular system, touch, etc.) and those that register the state of the body, i.e., proprioception (muscle spindles, tendon sensors, joint sensors).

Sensory patterns have a great influence on motor patterns. The brain not only designs a movement (motor programme) that is sent to the muscles and is carried out without changes, but the movement is constantly evaluated and adjusted based on sensory information. As a result, the actual movement is always carried out differently than the original design. This adjustment of motor patterns based on sensory information largely determines the quality of movement execution; therefore, it is safe to assume that similarity in sensory information has a significant impact on training transfer and specificity.

The sensory information of the environment perceived by sensory organs is rarely specific between strength exercise and sports movement, so the main specificity in terms of sensory information is proprioception. This plays a particularly important role in strength training regarding training transfer during complex movement patterns, where the moving resistance is low and the execution speed can be high as a result of this.

3.4.5 Movement Similarity due to Similarities in the Movement Intention

The learning system tries to reason from the intention of movement to the process (muscle action), and mainly uses the intrinsic knowledge of the results to do so. In this sense, it is clear that an exercise will primarily result in transfer to a sports movement if the intention is the same in both cases. Therefore, the similarity in movement intention is a feature of specificity.

The specificity between movement patterns is conditioned not only by the limits of similarity between movements but also by other factors such as the following:

- the need for overload to produce adaptations limits the margin of specificity.

- If a sports movement does not have a marked intramuscular structure, as in the case of slow sports movements, it can be better addressed on the basis of external structure. Fast sports movements, on the other hand, can be better addressed based on intramuscular and intermuscular structure, because the external structure of the fast movement is difficult to imitate with high resistance.

- The types of strength training can produce a positive transfer to an aspect of the movement to be improved but also a negative transfer to another movement.

The variables that we must observe to know if a movement is specific that relate to the conditional, bioenergetic, and coordinative structures of the structured microcycle are the following (Siff & Verkhoshansky, 1996):

Table 1: Variables to observe

CONCEPTO	VARIABLES A OBSERVAR
DIRECCIÓN DE LA FUERZA	¿Cual es el vector primario? ¿Donde es aplicada la fuerza?
MAGNITUD DE LA FUERZA	¿cuánta fuerza es aplicada?
RANGO DE MOVIMIENTO	¿qué recorrido tienen las articulaciones durante el movimiento?
REGIÓN DE MAYOR PRODUCCIÓN DE FUERZA	¿En qué momento dentro del rango de movimiento se produce la mayor cantidad de fuerza?
MÚSCULOS PRINCIPALES	¿cuáles son los principales músculos que favorecen de la producción de fuerza?
TIEMPO DE CONTACTO	¿cuánto tiempo se tarda en aplicar la fuerza?
VELOCIDAD DE MOVIMIENTO	¿a qué velocidad se mueven los segmentos a través de sus respectivos rangos de movimiento?
RÉGIMEN DEL TRABAJO MUSCULAR	¿cuál es el tipo de contracción dominante que ocurre durante el movimiento?

Source: prepared by the authors.

Concepto	Concept
Variables a observar	Variables to be observed
Dirección de la fuerza	Force direction
Magnitud de la fuerza	Force magnitude
Rango de movimiento	Range of motion
Región de mayor producción de fuerza	Area of greatest force production
Músculos principales	Main muscles
Tiempo de contacto	Time of contact
Velocidad de movimiento	Movement speed
Régimen del trabajo muscular	Muscle work regimen
¿cuál es el vector primario? ¿Dónde es aplicada la fuerza?	Which one is the primary vector? Where is the force applied?

¿Cuánta fuerza es aplicada?	How much force is applied?
¿qué recorrido tienen las articulaciones durante el movimiento?	What is the range of motion of the joints during movement?
¿en qué momento dentro del rango de movimiento se produce la mayor cantidad de fuerza?	At what point within the range of motion is the greatest amount of force produced?
¿cuáles son los principales músculos que favorecen de la producción de fuerza?	What are the main muscles that contribute to force production?
¿cuánto tiempo se tarda en aplicar la fuerza?	How long does it take to apply the force?
¿a qué velocidad se mueven los segmentos a través de sus respectivos rangos de movimiento?	What speed do the segments move at through their respective ranges of motion?
¿cuál es el tipo de contracción dominante que ocurre durante el movimiento?	What is the dominant type of contraction that occurs during movement?

In addition to the above parameters, the similarity in intention and sensory information should be considered.

3.4.6 Load versus Specificity

Overload is created by providing training stimuli that the body is not yet prepared for and requires specific adaptations. This has traditionally been associated with a quantitative measure (more weight, more sets, more repetitions, etc.). However, measuring overload in qualitative terms is more appropriate for addressing strength training in terms of coordination. Providing overload then becomes more of a matter of variation and creating sensorimotor stimulation exercises that the player is not yet familiar with. This is particularly important when seeking transfer to a more complex coordinated sports movement. Such transfer has its own dynamics and is isolated from the increase in force production in a simple strength exercise.

In the context of football, high specificity eliminates the possibility of a large overload, and vice versa (Image 7).

Image 7: Load versus Specificity

Source: prepared by the authors.

carga	load
Especificidad	Specificity

About Image 7: The higher the specificity, the less load we can impose. On the contrary, the more load, the less specificity the task can have.

Unit 3.5 Levels of Approximation

Based on the athlete's structures (Module 2) and groups of movements, Seirul·lo Vargas (1993b) and later Moras (2000) developed a proposal that presents training as a sequence of movement proposals with different orientations and levels of specificity (Seirul·lo Vargas, 1993b), where the importance of the participation of different athlete's structures is accentuated until the creation of tasks where all behave similarly to the competition and reach their highest level of complexity and representativeness.

To facilitate the classification and relationship of the structures with different tasks and levels, a base structure is proposed that is generally of a conditional (and bioenergetic), coordinative or cognitive nature. On the other hand, socio-affective, emotional-volitional and expressive-creative structures are considered auxiliary and supplement the structures considered fundamental or base (Seirul·lo Vargas, 1993a; Sole Forto, 2016). It is important to highlight that this does not mean that some structures are more important than others, but that those used as a basis will be more directly related to the nature of the load of the proposed simulating situation, while the auxiliary structures will take into account the nature of the human being playing football as a complex system.

Seirul·lo Vargas's proposal (in Fernández-Valdés Villa, 2020) is based on five levels of specificity:

Table 2: Seirul·lo Vargas's proposal

Levels	Description
Generic exercise	All structures are worked with little or no similarity to the athlete's competition. For example: a player doing a bike ride in a recovery session.
General Specific Exercise	High level of specificity of the conditional and bioenergetic structure, but low level of the other structures.
Directed Specific Exercise	High level of specificity of the conditional, bioenergetic and coordinative structure. Decision-making is non-specific (or does not exist).
Special Specific Exercise	Decision-making is specific. Therefore, the specificity of the cognitive structure increases.
Competitive Specific Exercise	All structures are participating, there is a winner and a loser, and the application of the socio-affective structure increases.

Source: adapted from Fernández-Valdés Villa (2020, p. 42).

"In 1994, in the book *La Preparación Integral en el voleibol*, Gerard Moras proposes a plan based on Seirul·lo's proposal "(Fernández-Valdés Villa, 2020, p. 42) and increases the levels to seven (Moras, 2000): supplementary and compensatory training level 0, oriented level 0 (L0), level 1 (L1), level 2 (L2), level 3 (L3), level 4 (L4), and level 5 (L5).

3.5.1 CP/CL Level 0 (Supplementary and Compensatory Training)

Exercises "related to supplementary and compensatory training are performed" (Fernández-Valdés Villa, 2020, p. 42).

Compensatory exercises

Compensatory exercises aim at compensating for the imbalances generated by more specific tasks with an immediate effect. The goal is to reduce the imbalances created by these exercises, so they are related to their content. The abdominal muscles are the most commonly used in this type of work, although exercises involving antagonistic and stabilising muscles (rotator) should also be included. Therefore, it is important to do abdominal exercises after sessions in which the spine has supported heavy loads (plyometrics, Olympic lifting, etc.), in order to compensate for that aggression. However, compensatory abdominal exercises do not pursue the same strengthening purpose as exercises included in a specific abdominal training, hence the need to differentiate them. Among the abdominal exercises, those that mainly affect the internal oblique and transverse muscles will have the greatest capacity to compensate for the overload in the lumbar area.

Supplementary Exercises

> [They are] those that address the imbalances or potential injury risks that may arise from the specific characteristics [of football] and are usually planned throughout the macrocycle. In some way, the goal is to prevent the most frequent injuries in a certain sport to avoid them or, in case of occurrence, to make them be less severe. (Fernández-Valdés Villa, 2020, p. 42).

Depending on the objective, the following types of exercises can be used as supplementary or compensatory in the microcycle of a football team. Taking into account the characteristics of the sport, the core, the quadriceps-hamstrings compensation, the popliteus and its role in stabilisation, as well as the periarticular muscles of the hip will be explained. In addition, general breaks will be given to discuss strategies to follow for the main risks of neuromuscular injuries.

Core

The core is composed of the abdominal and lumbopelvic region; it also includes the abdominal and lumbar muscles, the diaphragm, the pelvic floor, and the gluteal muscles. It also comprises the muscles of the shoulder and waist since they are essential for the transfer of energy from the trunk to the limbs.

The core plays an important role in stabilising the range of motion of the spine and in maintaining optimal alignment and movement of the trunk over the pelvis, and it is the link between the lower and upper body as it transfers forces between these parts. For optimal performance, the core must be solid to avoid energy leaks within the kinetic chain. A dysfunctional core transfers forces inefficiently and puts more pressure on the muscles of the limbs, increasing the risk of injury.

There is no single exercise that includes all the muscles of the core. Developing total core stability requires a wide variety of exercises that address different planes of movement and force vectors, but also that challenge the core at different intensities.

The core is made up of muscles with local stabilising function (the internal unit), which provide segmental stabilisation, and global stabilisers and motors (the external unit), which generate and maintain strict control over movement. The internal and external units work synergistically to stabilise the core and generate powerful movements in the limbs.

The demands on the core during football occur in multiple positions and directions. "To develop total stability [of the core], a variety of different exercises that address different planes of movement and vectors must be incorporated" (León, 2021, https://www.living4football.club/preparacion-fisica-aplicada-al-futbol/entrenamiento-del-core-en-el-futbol/). Isometric exercises in which movement is prevented should be combined with dynamic exercises in which the range of motion must be controlled. They should seek neuromuscular control, capacity, and strength.

Traditional core exercises can improve the recruitment and resistance capacity of stabilising muscles, while free weight multi-joint exercises can improve stability under high load or speed during functional positions and movement, specific to the demands imposed on the core during football. Exercises have been classified into 4 categories, which are developed under the following subheadings.

Anti-extension

The co-contraction of the abdominal muscles increases the anti-extension stiffness of the core to prevent hyperextension of the lumbar spine. The external unit system that contributes to the anti-extension stability of the spine is the anterior oblique system. The variety of exercises is crucial to fully challenge the abdominal wall musculature because the obliques consist of several neuromuscular compartments that are regionally activated. When training for stability, it is preferable to emphasise motor patterns that incorporate simultaneous contraction of many muscles rather than exercises that focus on just a few.

Anti-rotation

The anti-rotation function of the core stabilises the trunk in the transverse plane of movement. Most football players do not need to improve their range of lumbar rotation. The thoracic spine should be where most rotation of the trunk takes place. A solid range of motion in the hip is important to avoid too much rotation in the lumbar spine.

Exercises to improve the rotational stability of the core emphasise the dissociation of the hip and spine. Poor dynamic control of the spine during rotation will result in reactive stiffening of the hip joints as a protective mechanism to avoid excessive rotation of the lower back. Improving central stability means that more hip movement can be produced without affecting the neutral lumbopelvic position. Therefore, improving rotational stability and core strength will facilitate the hip range of motion and power.

Rotational or anti-rotational spinal stability is a great breakthrough in sports training because it was proved that lumbar spine rotation is very harmful, yet most human movements are of a rotational nature; for example, counter-rotation of the pelvis and trunk during a kick.

Controlling and stabilising lumbar rotation is key to improving performance, and the health of the back, and exercises in which the core is forced to stabilise against rotational forces should be part of most training sessions. Two external unit systems that play an important role in generating and stabilising trunk rotation are the posterior oblique system and the anterior oblique system.

Anti-lateral Flexion

Antilateral flexion is the ability to stabilise the body in the frontal plane of movement. Pelvic stabilisers work in conjunction with core muscles to resist lateral flexion.

The lateral system plays an important role in anti-lateral flexion stability. Deficiency in the lateral system has implications throughout the kinetic chain and is associated with a higher incidence of lower limb injuries and low back pain.

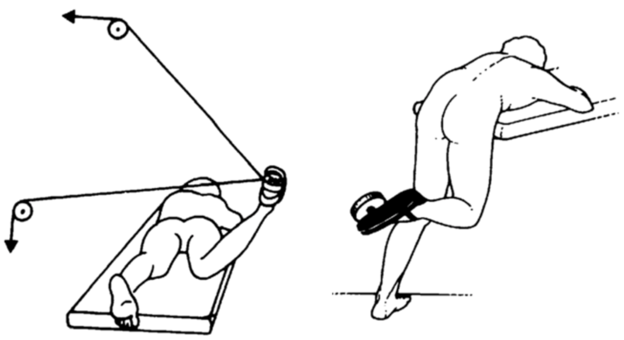
Anti- Flexion

Core anti-flexion stability resists flexion through the spine and counters forces that tend to bend the trunk forward. Traditional strength training exercises such as squats, lunges, back extensions, and various knee- and hip-dominant exercises are good for developing anti-flexion stability. During a squat and deadlift, the erector spinae and multifidus muscles are heavily activated.

Quadriceps-hamstrings Compensation

The hamstring muscle plays an important role in ACL injuries, which greatly affect female football players, as their contraction prevents anterior tibial translation with respect to the femur. With a physiological quad-hamstring ratio of 3:2, it is recommended to reduce this ratio in favour of the hamstrings. However, some studies have not observed a reduction in injuries when reducing the physiological ratio. Perhaps the problem lies in the way the hamstrings are worked out: it seems that by focusing on the rotational function of this muscle, a greater effect on knee stability can be achieved. Weighted shoes or pulleys can be used with the foot in inversion or eversion, depending on the area to be worked, to perform rotations at both the knee and ankle levels.

Image 8:

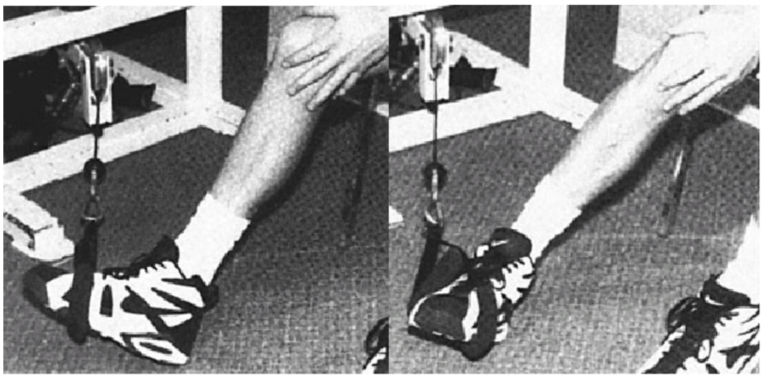


Source Génot, C., Neiger, H., Leroy, A. Pierron, G. Dufour, M., Péninou,G., 1998, p. 97.

The Popliteus and its Role in Stabilisation

The popliteal muscle is a part of the complex posterolateral anatomy of the knee with both static and dynamic functions. Its main actions are knee flexion and internal rotation. When it contracts, it causes lateral rotation of the femur over the tibia, pulling the lateral condyle backward. It is considered one of the main structures responsible for dorsolateral stability of the knee joint. Additionally, it helps to stabilise the lateral meniscus during flexion-rotation. In addition to balancing and controlling the neutral rotation of the tibia, it is also believed to unlock the knee when the body is in a squat position. It is proposed to work on this muscle with resisted knee flexion and internal rotation of the tibia. This can be achieved in a sitting position with the legs flexed to about 90 degrees, resisting internal rotation of the tibia with a band or other resistance placed around the foot (Image 9).

Image 9:

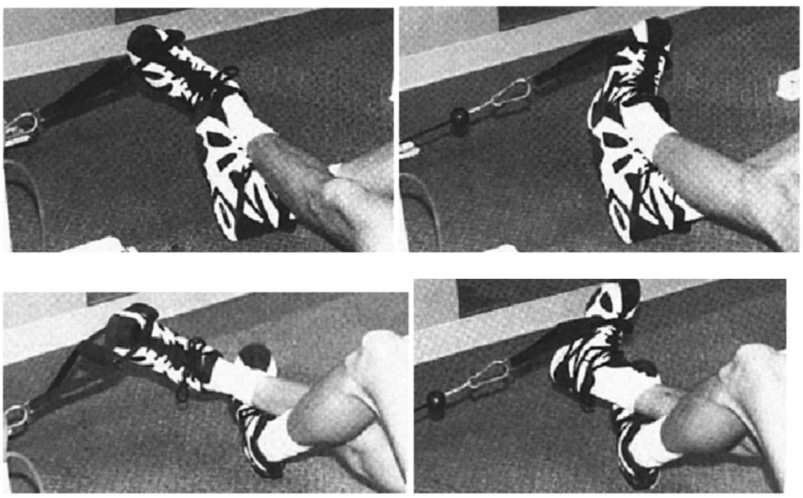


Source: Génot, et al, 1998, p. 122.

The Periarticular Muscle of the Hip

Due to the fact that some of its fibres attach to those of the vastus medialis, strengthening the adductor and abductor muscles reinforces the area, which increases its stability. The exercises will be performed with both pulleys and elastic resistance bands placed on the feet (Image 10).

Image 10:



Source: Génot, et al, 1998, p. 122.

In addition to exercises like the ones above, the following can also be used to reinforce:

1. Hip adductors in prone position.
2. Hip abductors in prone position.
3. Internal hip rotators in supine position.
4. External hip rotators in supine position.
5. In standing position, lateral kick towards adduction.
6. In standing position, lateral kick towards abduction.

Other exercises that include the hip area can be:

1. Hamstring kicks in hip extension in supine position.
2. Quadriceps kicks in prone position.
3. Knee flexion in supine position for work on the distal area of the hamstrings.
4. Psoas in quadruped position.
5. In standing position, forward kick of the anterior chain (especially psoas-quadriceps), facing away from the resistance source.
6. In standing position, backward kick of the posterior chain facing the resistance source.
7. In standing position, facing away from the resistance source and holding onto a support, perform a kick in the action of the psoas (hip flexion while keeping the knee in flexion of approximately 90°).

The aforementioned exercises should be performed in the following manner:

- Stabilising the trunk during execution, especially in the eccentric-concentric transition.
- Performing the action elastically (never reactively): This means that the eccentric braking will be performed in a progressive manner and that the

eccentric-concentric transition will be executed with great tension, but without causing any type of jerk.

- Trying to make the limb that is not performing work in stabilising the exercises. As some will be performed in the supine position, balance will not be compromised, but that will occur in those performed in standing position.

- Trying to develop maximum joint range of motion.

Below there is a table of proposed interventions in the coadjuvant training at different levels (given the specificity of some proposals). They could be used together with a supplementary or compensatory objective.

Table 3: Possible Neuromuscular Risk Factors and the Training Approach

Possible Neuromuscular Risk Factors	Neuromuscular training approach
Muscle fatigue	● Muscle resistance, strength, and power. ● High-intensity interval training. ● Progression to training under fatigue conditions.
Altered timing and magnitude of muscle activation.	Strength/power (plyometric).
Delay in the reaction time of the peroneal muscles	Dynamic stabilisation.
Muscle activation imbalances between the medial and lateral sides of the quadriceps and hamstrings	Proprioception.
Decreased coactivation of agonist and antagonist activation muscles	Muscle activation awareness exercises.
Decreased activation of hip muscles.	Muscle activation awareness exercises.
Deficits in trunk stability and muscle activation	Muscle activation awareness exercises.
Weakness in strength	● Agonist/antagonist strength balance. ● Compensatory muscle strength. ● Strength/power training. ● Overload eccentric training.

Control of the knee in the frontal plane: dynamic valgus	Good technique (alignment of lower limbs with flexion of trunk-hip-knee-ankle) during landings, direction changes, and deceleration actions.
Neuromuscular imbalances between limbs	● Symmetry technique in bilateral tasks. ● Unilateral tasks.
Inadequate muscle stiffness.	● Strength. ● Power.
Deficit in postural stability	Dynamic balance/stabilisation.
Altered proprioception	● Fundamental movement skills. ● Dynamic balance/stabilisation. ● Functional mobility.
Alteration in the feedforward mechanism	● Training with unexpected actions. ● Variability of the task ● Open agility drills. ● Coordination skills.

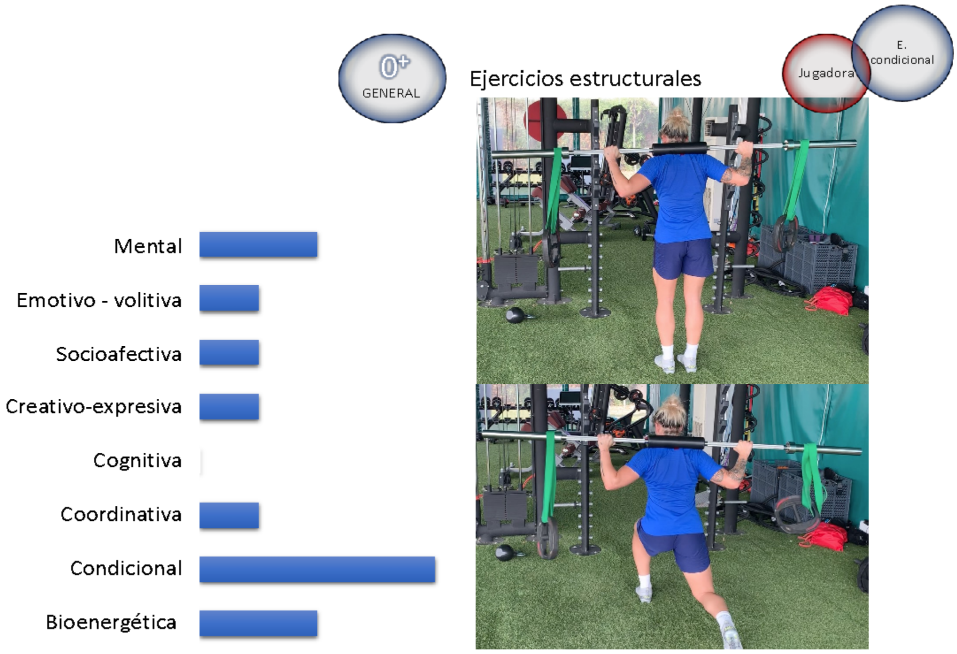
Source: adapted from Fort Vanmeerhaeghe et al. (2016).

3.5.2 Oriented Level 0 (L0)

> The fundamental muscle chains in sports movement are worked on, but without dynamic correspondence with the technique. We understand dynamic correspondence as the similarity in the movement performed with respect to the groups of sports movements explained earlier. At this level, some type of external resistance must be applied, which can be of any magnitude. This is called micro-training, as the objective is for the muscle tissues to better withstand the training loads and not so much the search for "transfer" of strength in the actual game. It fundamentally emphasises the conditional and bioenergetic structure. (Fernández-Valdés Villa, 2020, pp. 42-43).

This type of exercises will be used in structural and specific quality sessions as general exercises if seen as convenient for the purpose of the session.

Image 11: Example of a level 0 exercise oriented towards jump training

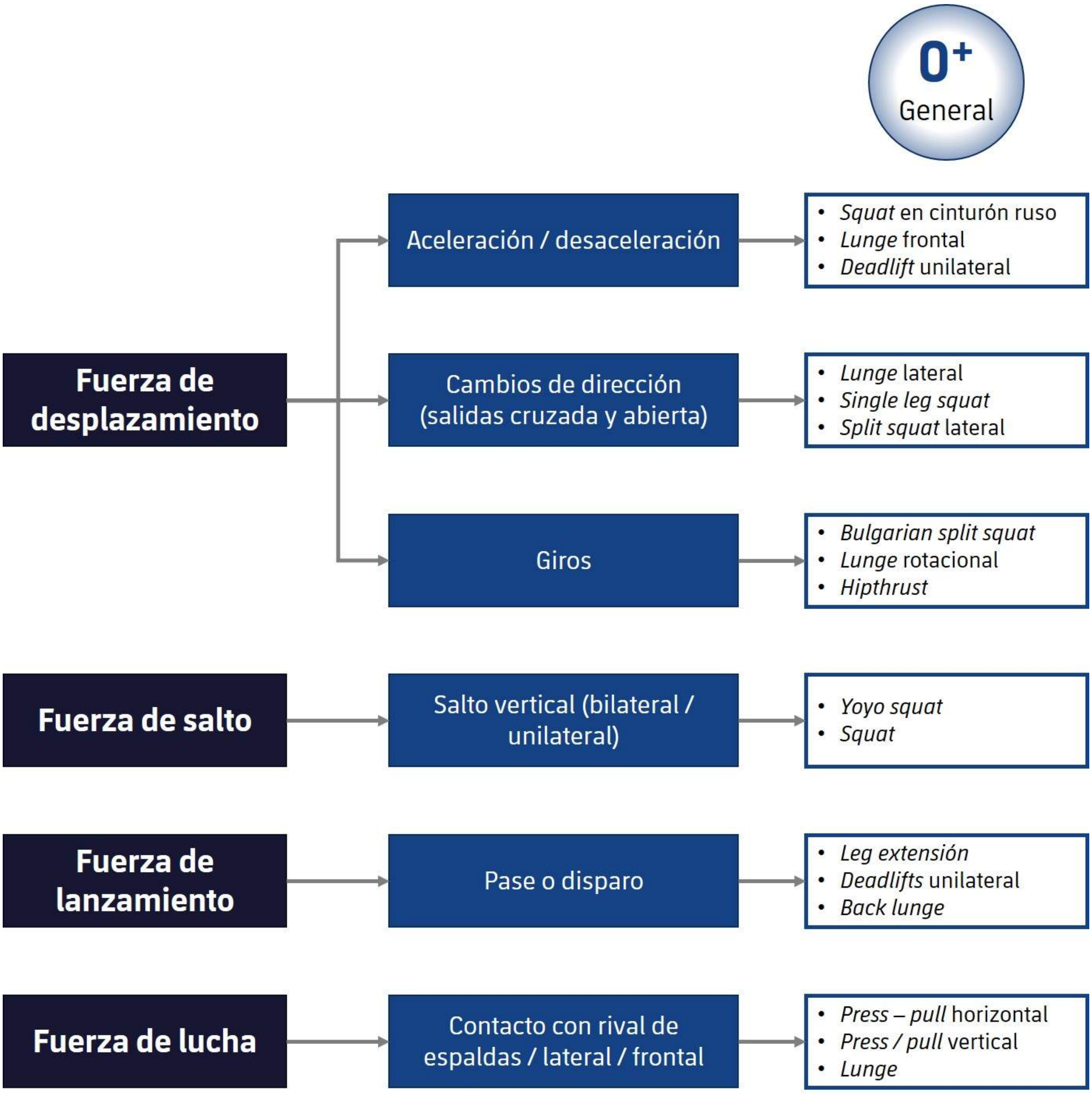


Source: prepared by the authors.

General	General
Ejercicios estructurales	Structural exercises
Jugadora	Female player
E. condicional	Conditional Structure
Mental	Mental
Emotivo-volitiva	Emotive-volitional
Socioafectiva	Socio-affective
Creativo-expresiva	Expressive-creative
Cognitiva	Cognitive
Coordinativa	Coordinative
Condicional	Conditional
Bioenergética	Bioenergetic

A proposal of (basic) exercises to train different groups of oriented level 0 exercises is presented here:

Image 12: Basic Exercises to Train Different Groups of Oriented level 0 Exercises



Source: prepared by the authors.

General	General
Fuerza de desplazamiento	Movement Strength
Aceleración/desaceleración	Acceleration/ Deceleration

Squat en cinturón ruso	Russian belt squat
Lunge frontal	Front lunge
Deadlift unilateral	Unilateral deadlift
Cambios de dirección (salidas cruzada y abierta)	Direction changes (cross and go step)
Lunge lateral	Lateral lunge
Single leg squat	Single leg squat
Spli squat lateral	Lateral split squat
Giros	Turns
Bulgarian Split squat	Bulgarian split squat
Lunge rotacional	Rotational lunge
Hipthrust	Hip thrust
Fuerza de salto	Jump Strength
Salto vertical (bilateral/unilateral)	Vertical jump (bilateral/unilateral)
Yoyo squat	Yoyo squat
Squat	Squat
Fuerza de lanzamiento	Throwing Strength
Pase o disparo	Pass or shot
Leg extensión	Leg extension
Deadlifts unitaleral	Unilateral deadlift
Bak lunge	Back lunge
Fuerza de lucha	Fight Strength
Contacto con rival de espaldas/lateral/frontal	Contact with opponent (backward/lateral/forward)

Press - pull horizontal	Horizontal press-pull
Press/pull vertical	Vertical press/ pull
Lunge	Lunge.

3.5.3 Level 1 (L1)

It has dynamic correspondence with the technique, and the applied external resistance should be high. In many training proposals, total dynamic correspondence with the sports movement cannot be achieved because the high external resistance applied will not allow it. It continues to emphasise the conditional and bioenergetic structure, but coordinative structure gains importance compared to L0 (Fernández-Valdés Villa, 2020, p. 43).

Image 13

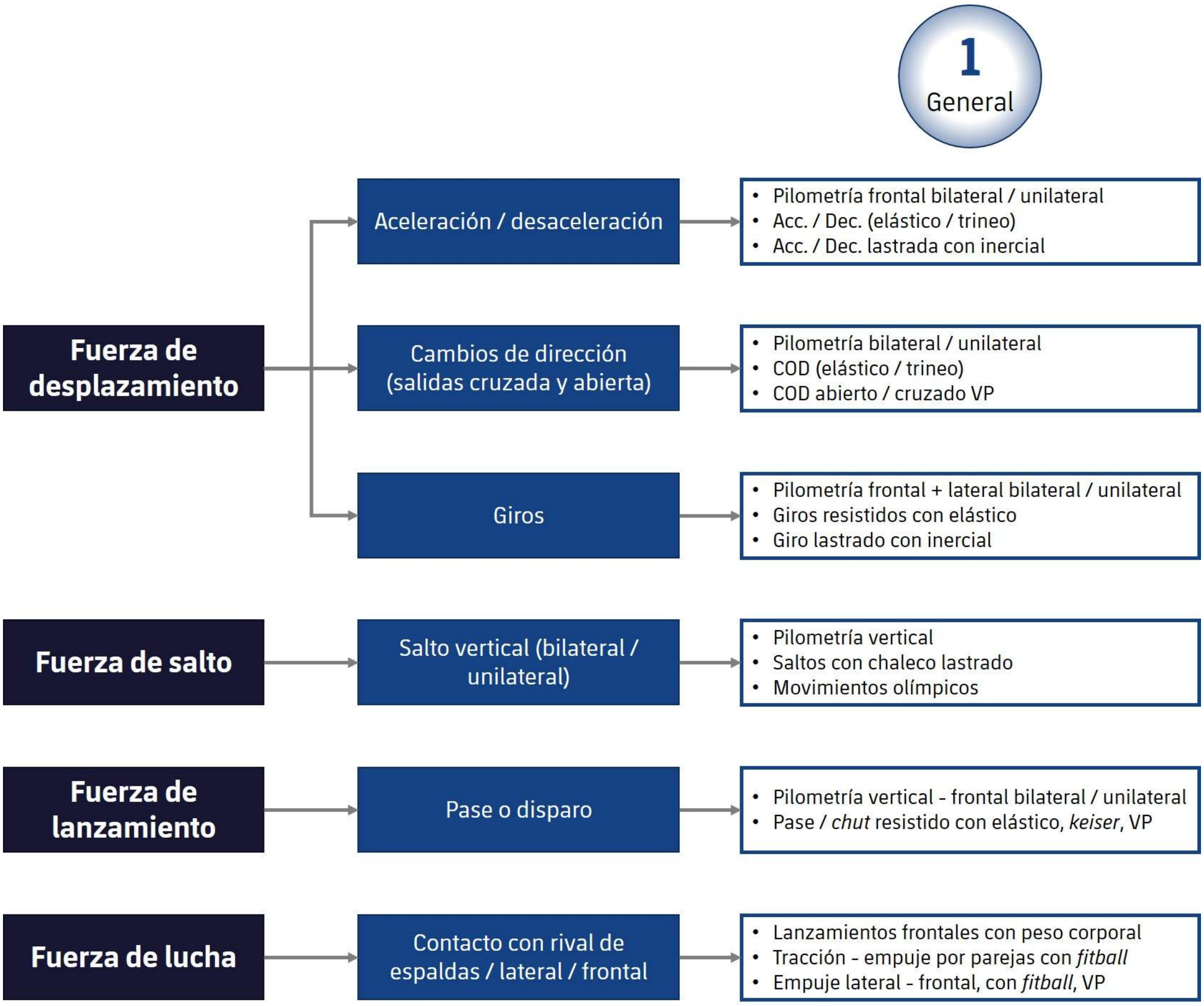
Source: prepared by the authors.

General	General

Resistencia externa – alta (aproximación al gesto deportivo)	External Resistance – high (approximation to sports gesture)
Mental	Mental
Emotivo – volitiva	Emotive – volitional
Socioafectiva	Socio-affective
Creativo -expresiva	Expressive-creative
Cognitiva	Cognitive
Coordinativa	Coordinative
Condicional	Conditional
Bioenergética	Bioenergetic
E. condicional	Conditional Structure
Jugadora	Female player
E. Coordinativa	Coordinative Structure

A proposal of (basic) exercises to train different groups of level 1 exercises is presented here:

Image 14: Basic Exercises to Train Different Groups of Level 1 Exercises



Source: prepared by the authors.

Pilometría frontal bilateral/unilateral	Front bilateral/unilateral plyometrics
Acc./Dec. (elástico/trineo)	Acc./Dec. (Elastic/sled)
Acc./Dec. Lastrada con inercial	Acc./Dec. Inertial load
COD (elástico/trineo)	COD (Elastic/sled)
COD abierto/cruzado VP	Open/ crossover COD VP
Pilometría frontal + lateral bilateral/unilateral	Lateral and Front bilateral/unilateral plyometrics
Giros resistidos con elásticos	Band resisted turns
Giro lastrado con inercial	Inertial load turns

Pilometría vertical	Vertical plyometrics
Saltos con chaleco lastrado	Weighted vest jumps
Movimientos olímpicos	Olympic movements
Pilometría vertical - frontal bilateral/unilateral	Vertical - front bilateral/unilateral plyometrics
Pase/chut resistido con elástico, keiser, VP	Resisted passes/shots with bands, Keiser, and VP
Lanzamientos frontales con peso corporal	Bodyweight frontal throws
Tracción – empuje por parejas con fitball	Partner push-pull with a stability ball
Empuje lateral – frontal, con firball, VP	Lateral-frontal push with stability ball and VP

3.5.4 Level 2 (L2)

In this level, there should be a high dynamic correspondence with the sports movement, but in this case, the external resistance applied must be medium or low - always lower than L1 -, being able to use, for example, resistance bands or other weights that guarantee an execution very close to the sports movement. It is an essential intermediate step between gym and field tasks that has traditionally been forgotten within classic strength programmes in [football]. It emphasises the conditional and bioenergetic structure similarly to the coordinative structure. It is important to highlight that both in L1 and L2, considering high or low external resistance will depend entirely on [the] athlete we are working with, conditioning the most suitable material for one or the other level. Thus, for example, the external resistance offered by a conical pulley and its benefits in adaptations (De Hoyo et al., 2015; Gonzalo-Skok et al., 2017; Madruga-Parera et al., 2020; Tous Fajardo, Gonzalo-Skok, Arjol-Serrano, & Tesch, 2016) can be used as L1 in untrained athletes as it is a high load, while in highly trained athletes who are familiar with it, it may represent an external resistance typical of L2. (Fernández-Valdés Villa, 2020, p. 43).

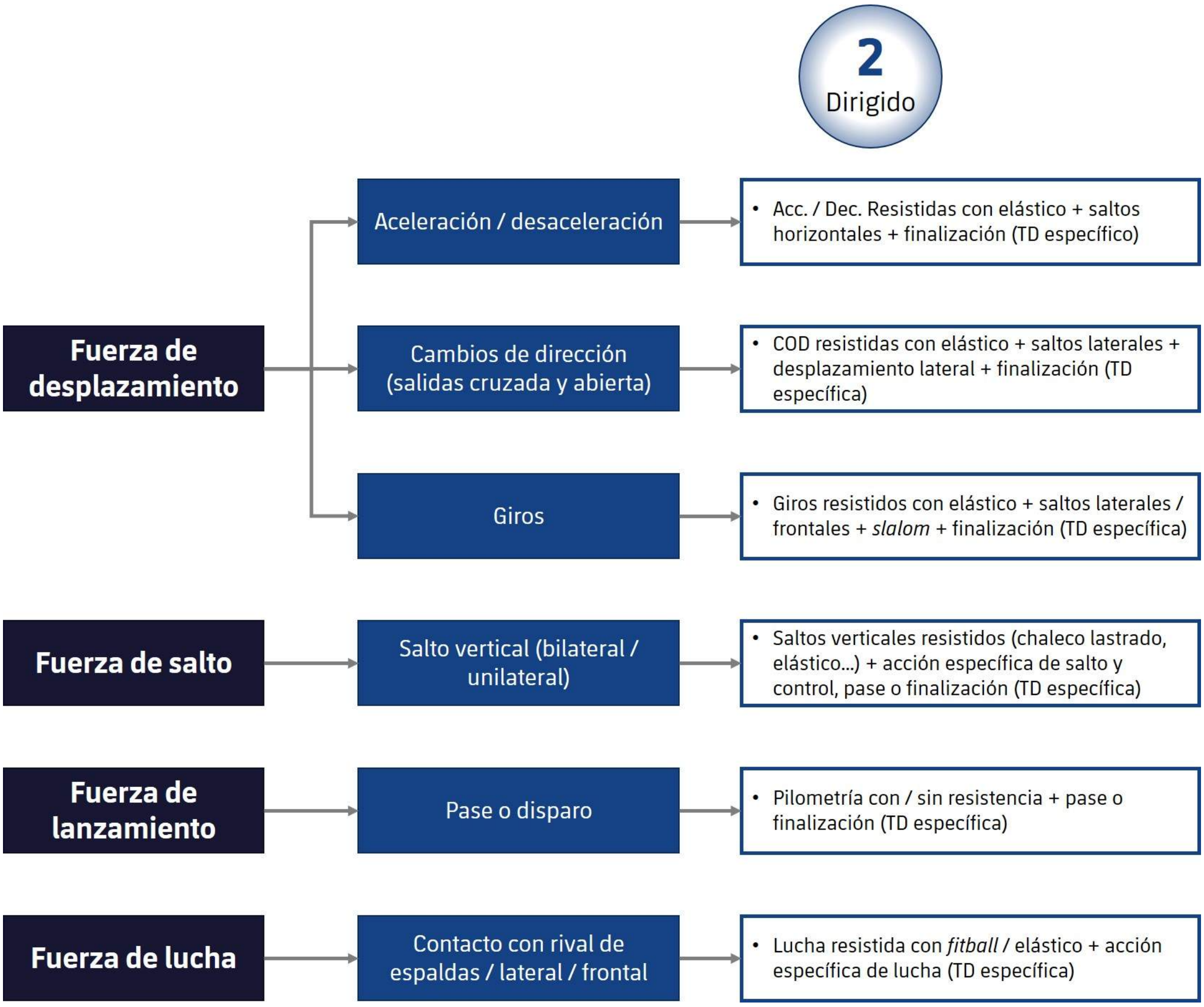
Image 15

Source: prepared by the authors.

Resistencia externa - baja (aproximación al gesto deportivo)	External Resistance- low (approximation to sports gesture)
Dirigido	Directed

A proposal of (basic) exercises to train different groups of level 2 exercises is presented here:

Image 16: Basic Exercises to Train Different Groups of Level 2 Exercises



Source: prepared by the authors.

Dirigido	Directed
Acc./Dec. Resistidas con elástico + saltos horizontales + finalización (TD especifico)	Acc./Dec. Band resisted + horizontal jumps + finish (specific TD)
COD resistidas con elástico + saltos laterales + desplazamiento lateral + finalización (TD específica)	Band resisted COD + sideways jumps + sideways movement + finish (specific TD)
Giros resistidos con elástico + saltos laterales + frontales + slalom + finalización (TD específica)	Band resisted turns + sideways jumps + frontal jumps + slalom + finish (specific TD)
Saltos verticales resistidos (chaleco lastrado, elástico…) + acción	Resisted vertical jumps (weighted vest, resistance bands, etc.) + specific jump

específica de salto y control, pase o finalización (TD específica)	and control action, pass, or finish (specific TD)
Pilometría con/sin resistencia + pase o finalización (TD específica)	Plyometrics with/without resistance + pass or finish (specific TD)
Lucha resistida con fitball/elástico + acción específica de lucha (TD específica)	Band resisted fight + specific fight action (specific TD)

> Next, we will develop the optimising levels (Level 3, Level 4, and Level 5), in which body weight is used, excluding the use of artificial external resistance. The only external resistance used in these levels is the force generated by other athletes (fight strength). (Fernández Valdés-Villa, 2020, pp. 43-44).

In this module, we will not detail the exercises since they are explained in other modules.

3.5.5 Level 3 (L3)

> This level has an close relationship with the technical gesture. It is worked without artificial external resistance to facilitate the correct execution of the movement. Force expression is refined based on the group of sports movements specific to each discipline. It is a fundamental part of this new strength training paradigm based on human movement. It allows the organisation of tasks by repetitions and sets to guide them towards a certain type of dominance of the conditional and bioenergetic structure. There is no decision-making yet. Despite working on the conditional and bioenergetic structure, it emphasises the coordinative structure. (Fernández Valdés-Villa, 2020, p. 44).

Image 17

Source: prepared by the authors.

Sin resistencia (gesto deportivo)	**Without resistance (sports gesture)**
Dirigido	**Directed**

3.5.6 Level 4 (L4)

t also has a great relationship with the technical gesture, the base of the exercise will be similar to that of L3, but in this case, a simple decision-making process will be introduced. It emphasises the coordinative and cognitive structure, as it stimulates the simple decision-making process. (Fernández Valdés-Villa, 2020, p. 44).

3.5.7 Level 5 (L5)

These are situations of reduced play or even real game situations in training. Following a progression with the previous levels, it will have the L3 and L4 structure as a base, but in this case, complex decision-making will be introduced, allowing the player to find the best solution for any situation in the game and allowing creative action to emerge. All structures converge similarly to real competition. (Fernández Valdés-Villa, 2020, pp. 44-45).

Image 18

Source: prepared by the authors.

Juego real	Real game

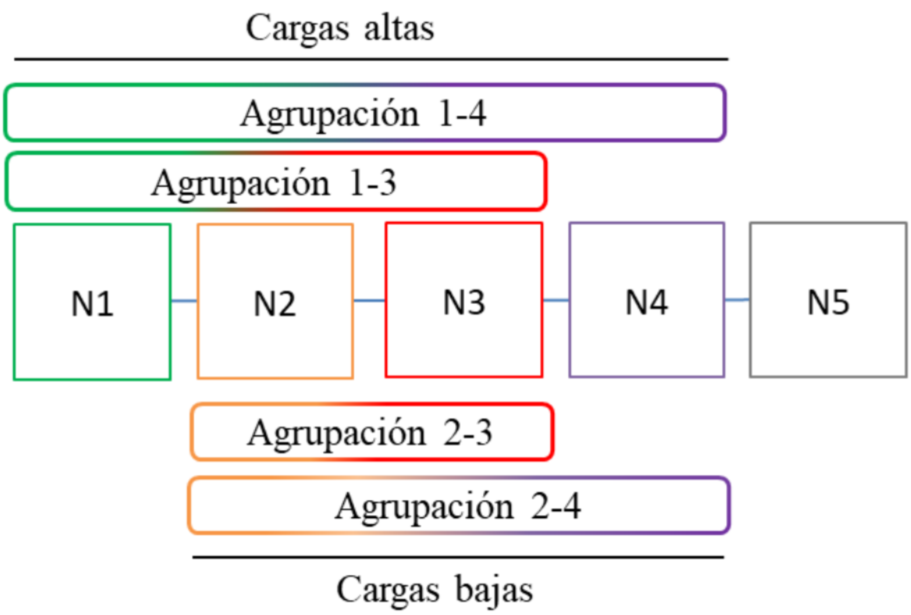
Competitivo	Competitive
Especial	Special
Toma de decisiones	Decision-making
Dirigido	Directed
Gesto técnico sin carga externa, pero la orientación es condicional. Ejercicios poliarticulares específicos de futbol, ejecutados a la velocidad real del juego. Ejemplo: circuito con diferentes habilidades	Technical gesture without external load, but with conditional orientation. Specific multi-joint exercises for football, executed at the real speed of the game. Example: circuit with different skills.
Resistencia externa baja: aproximación al gesto deportivo con sobrecargas que permitan realizar el gesto sin alterarlo. Ejemplo: un lastre en la carrera o aceleraciones con banda elástica	Low external resistance: approximation to the sports gesture with overloads that allow the gesture to be performed without altering it. Example: a weight in running or accelerations with an elastic band.
General	General
Resistencia externa alta: aproximación al gesto deportivo, con ejercicios con cadenas cinéticas y posiciones semejantes al movimiento deportivo	High external resistance: approximation to the sports gesture with exercises with kinetic chains and positions similar to the sports movement.
Cualquier carga: ejercicios no específicos, pero con cierta transferencia al gesto deportivo: ejercicios multiarticulares sin toma de decisión o muy simples	Any load: non-specific exercises, but with some transfer to the sports gesture: multi-joint exercises without decision making or very simple ones.
Genérico	Generic
Cualquier carga: ejercicios sin transferencia directa al gesto específico	Any load: exercises without direct transfer to the specific gesture.

Compensatorios: core stability, control neuromuscular, ADM.	Compensatory: core stability, neuromuscular control, ADM.
Complementarios: ejercicios de fuerza que previenen desequilibrios o estructuras en las que el entrenamiento no incide especialmente.	Complementary: strength exercises that prevent imbalances or structures in which training does not have a special effect.

3.5.8 Groups of Levels

Often, the exercises proposed in training do not belong to a single level, but to two of them, which configures the group (A). In the same way as during the game all structures converge and interact in a non-linear way, a true approximation to sports specificity cannot be given by applying the approximation levels gradually and in a linearly hierarchical manner. That is why, it is often recommended to combine levels, seeking their interaction and using combined or complex training studies as a reference (Alves, Rebelo, Abrantes, & Sampaio, 2010; Ebben, 2002). To classify them, we will keep the number of levels of the exercise base on the left and, as the second number, the variant added as a specific constraint. (Fernández Valdés-Villa, 2020, p. 45).

Image 19: Groups of Levels



Source: Fernández Valdés-Villa, 2020, p. 45.

Cargas altas	High loads
Agrupación	Group
Cargas bajas	Low loads

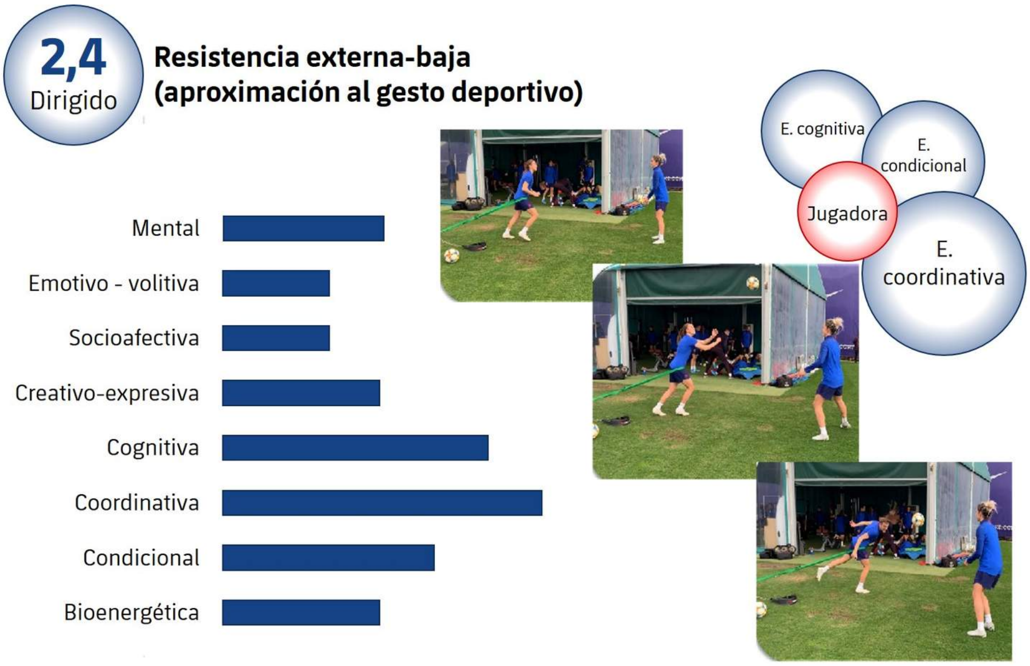
> Thus, for example, if we are performing an exercise with dynamic correspondence and high loads (L1) and we add as a constraint a technical action such as interacting with a ball, since the constraint is linked to the technique and this is associated with L3, we will say that the exercise is a group of L1 and L3 and we can catalogue it as G1-3. Or if we add, for example, a decision-making process that would be more linked to L4 to an exercise with elastic band resistance and great dynamic correspondence (L2), we will say that it is a task G2-4. (Fernández Valdés-Villa, 2020, pp. 45-46).

Image 20

Source: prepared by the authors.

Resistencia externa-alta (aproximación al gesto deportivo)	External Resistance- high (approximation to sports gesture)
General	General

Image 21



Source: prepared by the authors

E. Coordinativa	Coordinative Structure
Resistencia externa-baja (aproximación al gesto deportivo)	External Resistance- low (approximation to sports gesture)

Dirigido	Directed

Unit 3.6. Strength Training Constraints

> One of the main characteristics of [football] is the unpredictability of actions due to the high degree of uncertainty that arises when interacting with opponents and teammates in a shared space. Landings on one or two legs, fighting with opponents, receptions, passes or kicks to the ball constantly occur during the game in changing situations that force the athlete to adapt to each new situation. These unexpected actions can be more harmful to the athlete's structures (Besier, Lloyd, & Ackland, 2003; Besier, Lloyd, Cochrane, & Ackland, 2001; Lloid, 2001). For this reason, introducing unexpected situations for the athlete in training can help create anticipation mechanisms based on the position (Tous in Seirul·lo, 2017, Chapter Todo es fuerza).
>
> Newell (1986) introduces the concept of constraints, which are defined as the boundaries or qualities that limit the interactions of the components of the system. He divided these constraints into three types: those that are specific to the structure or functionality of the person (individual), which include individual characteristics such as experience, learning, development, morphology, and genes that interact to shape performance and knowledge acquisition in sports (Davids et al., 2008); secondly, those specific to the task, which can be modified by the coach or physical trainer to provoke adaptations of one type or another; and finally, those of the environment, which will be more influenced by the work environment of the place where we are and will vary depending on the club, the philosophy of the coaching staff, etc.... Thus, a constraint imposed in a sports task will act as a disturbance of the athlete's system in an individualised way. (Fernández Valdés-Villa, 2020, pp. 46-47).

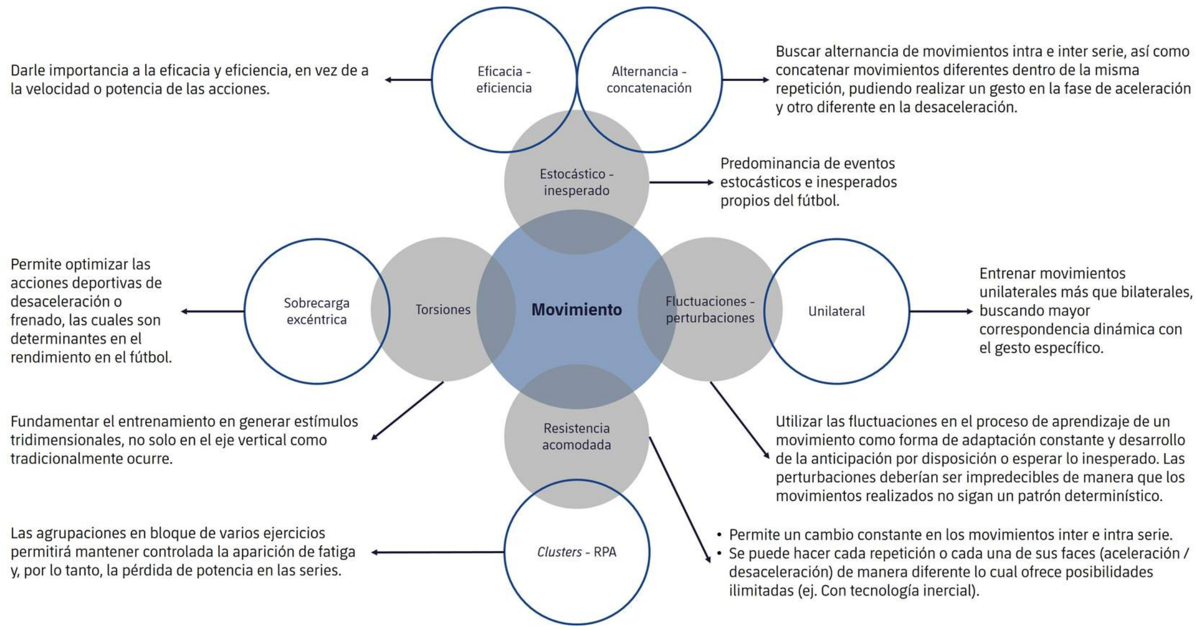
Constraints are further introduced in Module 1.

> These constraints are related to the athlete's structures and, in turn, to the levels of sports approximation. For example, if we incorporate a

ball as a constraint to an exercise, it accentuates the coordinative structure through L3 or G1-3. (Fernández Valdés-Villa, 2020, p. 47).

Unit 3.7 Proposal for Organising Simulating Situations in Coadjuvant Training

Image 22: Proposal for Organising Simulating Situations in Coadjuvant Training



Source: adapted from Seirul·lo Vargas (2017).

Eficacia-eficiencia	Effectiveness - efficiency
Alternancia-concatenación	Alternation-concatenation
Estocástico-inesperado	Stochastic-unexpected
Torsiones	Twists
Fluctuaciones – perturbaciones	Fluctuations - disturbances
Resistencia acomodada	Accommodation resistance

Unilateral	Unilateral
Sobrecarga excéntrica	Eccentric overload
Clusters – RPA	Clusters - RPA
Movimiento	Movement
Darle importancia a la eficacia y eficiencia, en vez de a la velocidad o potencia de las acciones	Giving importance to effectiveness and efficiency, rather than speed or power of actions.
Permite optimizar las acciones deportivas de desaceleración o frenado, las cuales son determinantes en el rendimiento en el fútbol	It allows optimising deceleration or stopping sports actions, which are determinant in football performance.
Fundamentar el entrenamiento en generar estímulos tridimensionales, no solo en el eje vertical como tradicionalmente ocurre	Training should be based on generating three-dimensional stimuli, not just in the vertical axis as traditionally occurs.
Las agrupaciones en bloque de varios ejercicios permitirán mantener controlada la aparición de fatiga y, por lo tanto, la pérdida de potencia en las series	Grouping several exercises together will enable the control of the appearance of fatigue and, therefore, the loss of power in the series.
Buscar alternancia de movimientos intra e inter serie, así como concatenar movimientos diferentes dentro de la misma repetición, pudiendo realizar un gesto en la fase de aceleración y otro diferente en la desaceleración	Seeking alternation of intra- and inter-series movements, as well as concatenating different movements within the same repetition, can be performed by making a gesture in the acceleration phase and a different one in the deceleration.
Predominancia de eventos estocásticos e inesperados propios de fútbol	Predominance of stochastic and unexpected events typical of football.
Entrenar movimientos unilaterales mas que bilaterales, buscando mayor	Training unilateral movements more than bilateral ones, seeking greater

correspondencia dinámica con el gesto específico	dynamic correspondence with the specific gesture.
Utilizar las fluctuaciones en el proceso de aprendizaje de un movimiento como forma de adaptación constante y desarrollo de la anticipación por disposición o esperar lo inesperado. Las perturbaciones deberían ser impredecibles de manera que los movimientos realizados no sigan un patrón determinístico	Using fluctuations in the learning process of a movement as a form of constant adaptation and development of anticipation based on position or waiting for the unexpected. Perturbations should be unpredictable so that the movements performed do not follow a deterministic pattern.
Permite un cambio constante en los movimientos inter e intra seria. Se puede hacer cada repetición o cada una de sus faces (aceleración/desaceleración) de manera diferente lo cual ofrece posibilidades ilimitadas (ej. Con tecnología inercial)	It allows a constant change in movements inter- and intra-series. Each repetition or each of its phases (acceleration/deceleration) can be done differently, offering unlimited possibilities (e.g., with inertial technology).

References

Alves, J. M. V. M., Rebelo, A. N., Abrantes, C. and Sampaio, J. (2010). Short-term effects of complex and contrast training in soccer players' vertical jump, sprint, and agility abilities. *The Journal of Strength & Conditioning Research*, *24*(4), 936-941.

Bernstein, N. A., Latash, M. L. and Turvey, M. T. (1996). *Dexterity and its development*. UK: Psychology Press.

Birklbauer, J. (2019). *Optimal variability for effective motor learning: A theoretical review and empirical work on movement variability.* Aachen, DE: Meyer & Meyer Verlag.

Bosch, F. and Cook, K. (2015). *Strength training and coordination: an integrative approach*. Rotterdam, NL: Publishers Rotterdam.

Button, C., Seifert, L., Chow, J. Y., Davids, K. and Araújo, D. (2020). *Dynamics of skill acquisition: An ecological dynamics approach*. Illinois, US: Human Kinetics.

Couceiro, M. S., Dias, G., Mendes, R. and Araújo, D. (2013). Accuracy of pattern detection methods in the performance of golf putting. *Journal of Motor Behavior*, *45*(1), 37-53.

Davids, K. W., Button, C. and Bennett, S. J. (2008). *Dynamics of skill acquisition: A constraints-led approach.* US: Human Kinetics.

Dias, G., Couceiro, M. S., Barreiros, J., Clemente, F. M., Mendes, R. and Martins, F. M. L. (2014). Distance and slope constraints: adaptation and variability in golf putting. *Motor Control*, *18*(3), 221-243.

Fajen, B. R., Riley, M. A. and Turvey, M. T. (2008). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, *40*(1), 79-107.

Fernández-Valdés Villa, B. (2020). *La variabilidad de movimiento en el entrenamiento de fuerza en los deportes de equipo* (Tesis de doctorado). Universitat de Barcelona, Barcelona, ES. Retrieved from: http://diposit.ub.edu/dspace/bitstream/2445/173644/1/BFVV_TESIS.pdf

Fort Vanmeerhaeghe, A., Romero Rodríguez, D., Montalvo, A. M., Kiefer, A. W., Lloyd, R. S. and Myer, G. D. (2016). Integrative neuromuscular training and injury prevention in youth athletes. Part I: identifying risk factors. *Strength and Conditioning Journal*, *38*(3), 36-48.

Grupo Movement-Readaptación de lesiones & Entrenamiento. (2016). Diferencia entre movimientos atractores y fluctuadores [Facebook post]. Retrieved from: https://www.facebook.com/MovementRehabEntrenamiento/posts/diferencia-entre-movimientos-atractores-y-fluctuadores-un-atractor-es-un-estado-/1034456359975339/

Hooren, B. van, Meijer, K. and McCrum, C. (2019). Attractive Gait Training: Applying Dynamical Systems Theory to the Improvement of Locomotor Performance Across the Lifespan. *Frontiers in Physiology*, *9*. Retrieved from: https://www.frontiersin.org/article/10.3389/fphys.2018.01934

Kelso, J. A. S. (1991). Behavioral and neural pattern generation: The concept of neurobehavioral dynamical systems. En H. P. Koepchen y T. Huopaniemi (Eds.), *Cardiorespiratory and motor coordination* (pp. 224-238). Berlín, DE: Springer.

Kelso, J. A. S., Schöner, G., Scholz, J. P. and Haken, H. (1987). Phase-locked modes, phase transitions and component oscillators in biological motion. *Physica Scripta*, *35*(1), 79.

León, M. (2021). Entrenamiento del Core en el Fútbol. Retrieved from: https://www.living4football.club/preparacion-fisica-aplicada-al-futbol/entrenamiento-del-core-en-el-futbol/

Moras, G. (2000). *La preparación integral en el Voleibol (1000 ejercicios y juegos)* (Vol. 1). Buenos Aires, AR: Paidotribo.

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G. and Zelaznik, H. N. (2018). *Motor control and learning: A behavioral emphasis.* Illinois, US: Human Kinetics.

Seirul·lo Vargas, F. (1993a). *Preparación física aplicada a los deportes de equipo*. Galicia, ES: Centro Galego de Documentación e Edicións Deportivas.

Seirul·lo Vargas, F. (1993b). Preparación física aplicada a los deportes de equipo: Balonmano. *Cuaderno Técnico Pedagógico*, 7.

Seirul·lo Vargas, F. (2017). *El entrenamiento en los deportes de equipo*. Barcelona, ES: Biocorp Europa.

Siff, M. and Verkhoshansky, Y. V. (1996). *Supertraining. Special strength training for sporting excellence.* Colorado, US: Sports Training Co.

Sole Forto, J. (2016). *Planificación del entrenamiento en los deportes colectivos* [Apuntes de cátedra]. Escrito inédito entregado a los alumnos durante el curso de Máster de Alto Rendimiento en Deportes Colectivos.

Tous-Fajardo, J. (1999). *Nuevas tendencias en fuerza y musculación*. Barcelona, ES: Hispano Europea.

Tous-Fajardo, J., Gonzalo-Skok, O., Arjol-Serrano, J. L. and Tesch, P. (2016). Enhancing change-of-direction speed in soccer players by functional inertial eccentric overload and vibration training. *International Journal of Sports Physiology & Performance*, *11*(1), 66-73.

Weineck, J. (2005). *Entrenamiento total* (Vol. 24). Buenos Aires, AR: Paidotribo.