Module 2. Coadjuvant Strength Training in Indoor Team Sports. (...)

BARÇA INNOVATION HUB
Universitas

1. Contextualization

2. Coadjuvant Training in the Structured Microcycle

3. Strength Training Adaptations: Are our efforts producing the desired results?

4. Goals of coadjuvant training: conditional structure demands in competitive environments.

5. Designing simulation situations, variability, and specificity in coadjuvant training.

References

1. Contextualization

Traditionally, strength training has been associated with individual sports. However, recent years have seen a rise in research focusing on strength training for team sports. Despite this, many physical trainers still prefer conventional strength training methods and are hesitant to adopt changes based on scientific research.

We now understand that training a team sport athlete requires a different approach than training a track and field runner. Our role as physical trainers is to ensure players improve with each training session. Although this seems obvious, it has led to various strategies throughout history. One major error in sports sciences has been analyzing athletes in isolation, trying to explain causes and effects separately. This has led to incorrect solutions for complex problems faced by athletes daily. While individual study is important, we must consider the overall phenomenon. For instance, we need to understand how a throw is executed in its entirety and complexity, recognizing that it involves the interaction of multiple subsystems. After understanding the whole movement, we can study each element and subsystem separately while considering causal relationships between different levels and incorporating the variable of time, acknowledging that changes occur at different time scales. We need to adopt a systematic approach, integrating our knowledge in an organized and coordinated way.

It is commonly believed that repeating isolated actions helps develop the ability to handle complex problems that arise during the game. However, it is crucial for athletes' behavior to adapt to the changing and uncertain situations of the game.

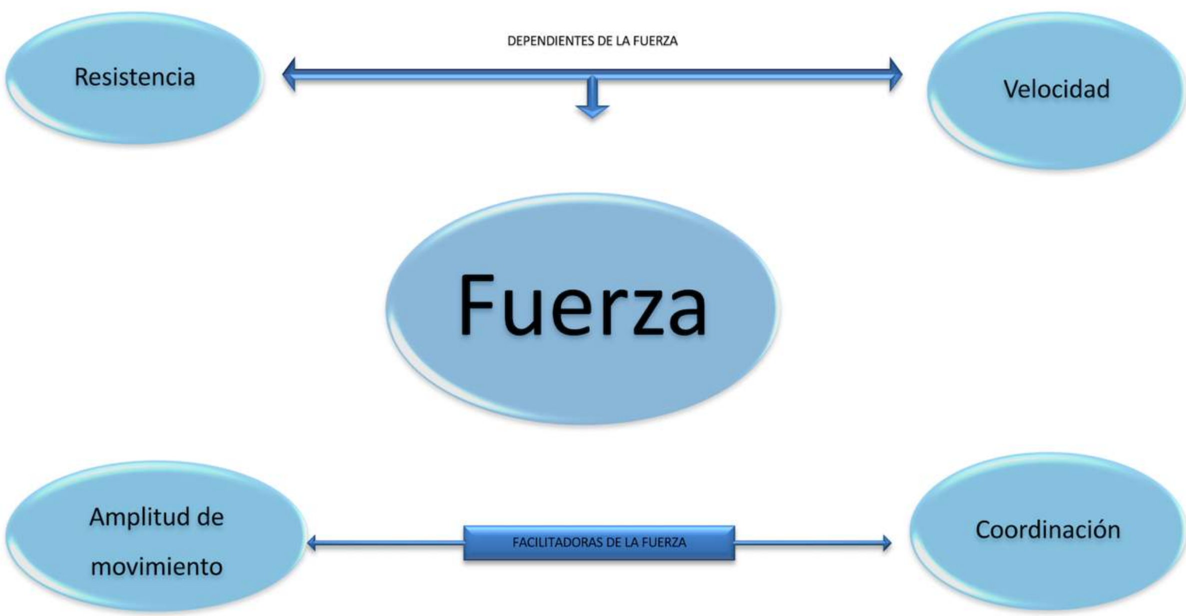
When updating our training systems, we often rely on past methods, what we know has worked before (or at least we think so), or recommendations from other professionals. Relying on proven methods and previous experiences can limit our ability to innovate and adapt to scientific advancements in training. To make significant progress, we must cultivate a research-based culture and be open to questioning our usual practices in favor of evidence-supported approaches. In our university studies, the subject that prepares us for our work is called training theory. Although theories should be based on scientific evidence, they often rely on models as well. Theories are supported by available scientific evidence when possible, but they must also be practical and useful in real-life applications. Thus, we must recognize that training is not just a science but also an art involving experience and intuition.

Strength training has evolved from its origins, which were initially linked to spectacle and overcoming external resistance (Wilmore et al., 1999). In team sports like football, basketball, and handball, applying maximum strength is not always necessary or feasible due to the speed of actions, as noted in the previous module. For example, precision in striking is achieved at approximately 80% of maximum speed (Tous-Fajardo, 1999). Therefore, we need to understand strength in the context of human movement and the specific demands of each sports situation.

Some authors define strength as the ability to generate muscular tension under specific conditions (Siff and Verkhoshansky, 1996). This view prompts us to reevaluate the traditional approach to strength training, which focused on developing contractile properties and muscle architecture, often overlooking motor learning. Technique and strength are interrelated, as both enhance the neuromuscular processes of movement.

Consequently, strength training should focus on movement in specific conditions, aiming to optimize motor action (Seirul·lo, 2017). Muscles execute sports movements, and generating muscular tension is crucial for movement. Thus, strength is considered the core physical quality from which other conditional abilities derive (Figure 1) (Cometti, 1998; Tous-Fajardo, 1999).

Figure 1: Strength is the core physical quality from which others derive



Source: elaboration based on Tous-Fajardo, 2017.

Endurance	DEPEND ON STRENGTH	Speed
	Strength	
Movement range	FACILITATE STRENGTH	Coordination

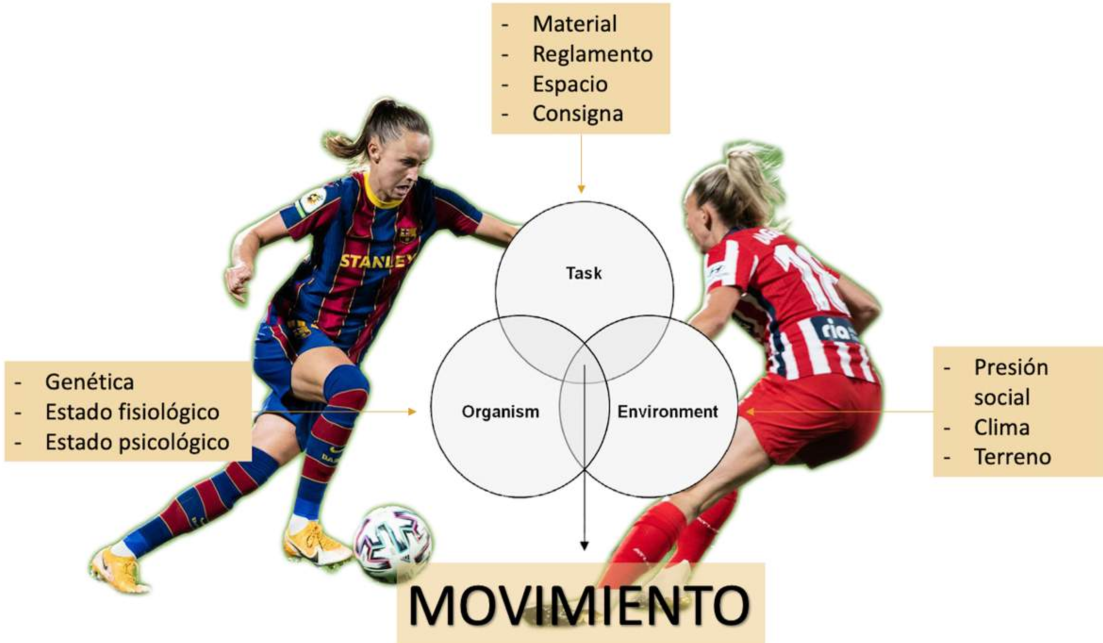
Source: elaboration based on Tous-Fajardo, 2017.

The study of muscular actions can be simplified into three aspects: the amount of force applied, the time needed to reach different force levels, and the ability to maintain force over time. These parameters relate to strength, power, and endurance. We can use strength to produce rapid movements or apply sustained force over an extended period. In sports, when classifying actions as maximum speed or anaerobic alactic endurance, we address the complex relationship between muscular strength and joint movement. Essentially, the ability to generate movement is the only physical quality for an athlete to succeed in their competitive environment. Therefore, coadjuvant training in the structured training methodology will focus on actions that occur frequently in each sport and the conditional and bioenergetic demands involved, considering the interdependence between the perception-action cycle discussed in previous modules.

The approach to sports training has shifted towards a broader, less reductionist perspective. Rather than focusing solely on physical abilities like speed, endurance, or strength, the ability to generate movement through muscular action is seen as the core foundation for developing sports actions. This functional approach helps us better understand the adaptive movements during competition and how individual factors (seen as a hypercomplex structure), environmental conditions, and specific action requirements interact.

Adaptive movements in sports arise from the complex interplay of various conditioning factors (Figure 2) (Araujo, 2006; Davids et al., 2013). Factors that may seem minor can significantly impact the adaptations occurring during training. Athletes use their perception of different environmental information to perform movements needed to respond to game scenarios and demands. Therefore, training sessions should be designed to enhance the coupling of the perception-action cycle, using information available in the game context.

Figure 2: Interaction athlete - environment - task



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<table>
<tr><td rowspan="4">Genetics

Physiological State

Psychological State</td><td colspan="3">Equipment

Rules

Space

Instruction</td><td rowspan="4">Social Pressure

Weather

Surface</td></tr>
<tr><td></td><td>Task</td><td></td></tr>
<tr><td>Organism</td><td></td><td>Environment</td></tr>
<tr><td colspan="3">MOVEMENT</td></tr>
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While all athletes have general objectives, the motor solutions they use during competition are varied and unique. These behaviors are influenced by each athlete's individual characteristics and the diversity and variability of contextual dynamics. Players adapt by exploring and perceiving action opportunities that arise in specific game situations.

Identifying the conditioning factors that contribute most to optimal behaviors during competition is crucial. By manipulating these conditioning factors during training, we can create situations that enhance the perception of relevant information and exploration of action possibilities to achieve defined goals (Araujo, 2006). It is important to understand that these factors do not act independently. The interdependence among them means they cannot be improved separately to reach their maximum potential (optimal). For example, you cannot optimize a player's tactical behavior without considering their movement capabilities, and a movement is only effective if it is coordinated with the team and opponents' movements.

Traditionally, it has been believed that past experiences are stored in different brain structures, serving as the basis for cognitive operations and movement generation (Memmert, 2009). However, the brain is a complex and integrative organ without a central governor (Fingelkurts and Fingelkurts, 2004). Each cortical area is influenced by interactions with other connected areas (Schöner and Kelso, 1988). Behavior results from a differentiated self-organization process that coordinates cortical and subcortical activity to achieve a common functional state and stabilize activity parameters. Thus, in indoor sports, decisions and actions stem from the interaction between the athlete and the environment, based on perceived activation patterns. The competitive environment, or ecology of the environment, must be respected to improve decision-making.

A player's movement affects the information available in their environment, which in turn influences their decisions and actions in the game, creating a feedback loop between perception and action. Decisions are limited by the athlete's skills and the possibilities of the environment. However, actions are influenced by the player's ability to detect relevant environmental information. Less experienced players often focus on irrelevant aspects of the game (Araujo, 2006; Gibson, 1979). It is crucial for them to learn to identify relevant stimuli and ignore irrelevant information for effective performance (Fajen et al., 2008). According to Gibson's concept of affordance, as presented in this certificate, performance in the game depends not only on the ability to perform effective actions but also on detecting action possibilities within the game context.

Separating perception and action processes in training can hinder the ability to perceive information and adapt to the necessary coordination in sports movements. For instance, practicing dribbling over cones without opposition may create visual dependence in the player, preventing them from lifting their head during a game. Here is a practical example (Figure 3) of manipulating parameters in strength tasks to foster these affordances and facilitate certain behaviors:

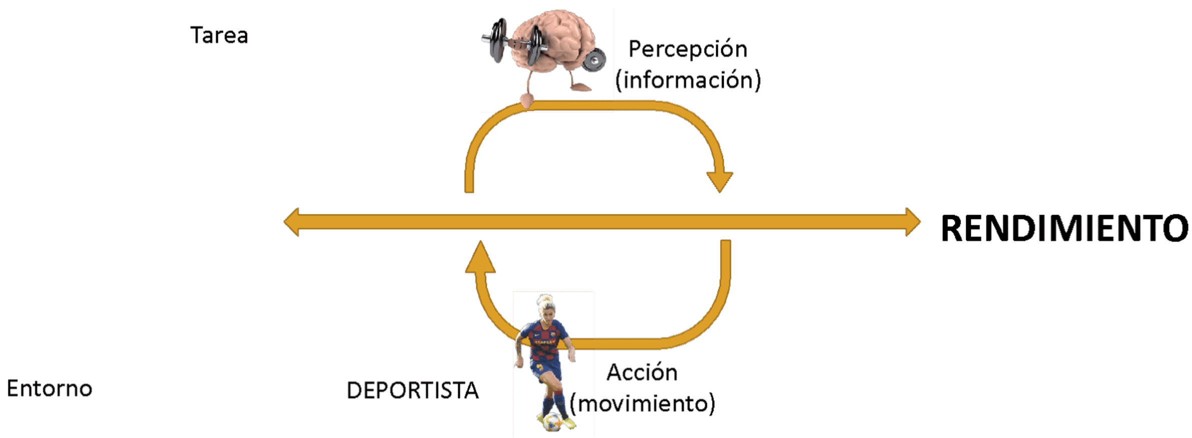
Figure 3: Practical example of affordance with a perceptual conditioning factor.

Source: Original work

By introducing the affordance concept, we aim to encourage the player to focus on the opponents' movements when performing an action.

Therefore, training tasks should be designed to respect the interdependent relationship between perception and action processes. By altering the task conditioning factors, we can influence key variables that regulate adaptive behavior, helping players achieve higher levels of adaptation (Figure 4).

Figure 4: Complex process that leads players to performance.



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	Task	Perception (information)		
	←—---------------------------- ------------------>			PERFORMANCE
Environment	ATHLETE	Action (Movement)		

Source: Original work

Behaviors emerge based on the contextual conditioning factors imposed on the task (e.g., number of opponents, spaces, rules). We'll explore task design in more depth later on.

Strength training, during the eccentric phase of the actions, is crucial for:

- ○ Generating hypertrophy during the competitive season
- ○ Reducing injury risk
- ○ Modifying the athlete’s anthropometric values
- ○ Compensating for cognitive structure

SUBMIT

Adaptive movements in sports arise from the complex interaction between various conditioning factors:

- [ ] Environment
- [ ] Task
- [ ] Variation
- [ ] Athlete

SUBMIT

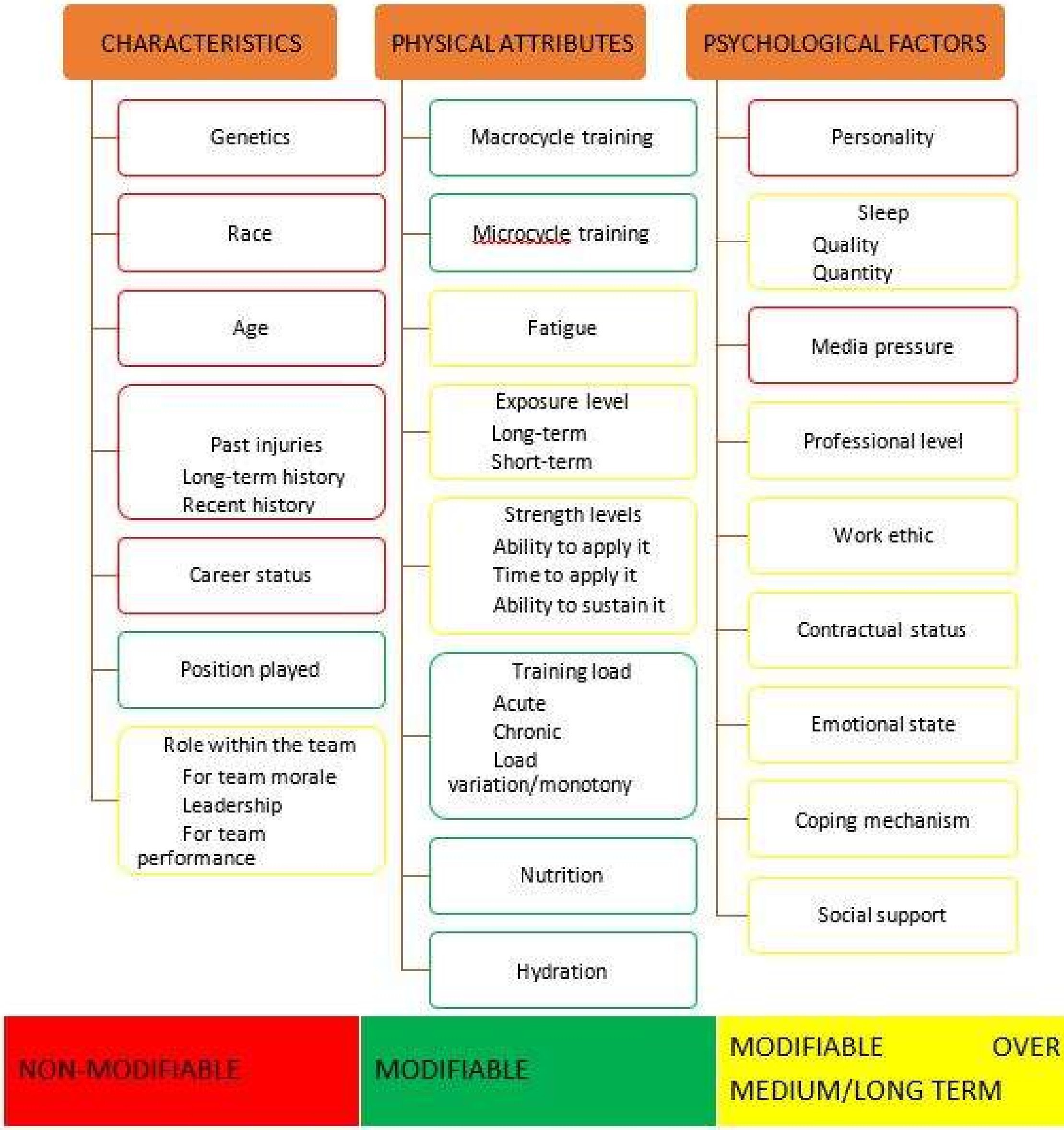
Dynamic systems can explore their conditioning factors and interact with them, allowing functional patterns to emerge in specific environments (Araújo, 2006). Functional patterns result from the player's preferred coordinations (Davids et al., 2013) and are expressed as order parameters (Davids et al., 2013). These stable or fluctuating coordinations arise when specific conditioning factors (control parameters) are in place (Balagué et al., 2008). Conditioning factors reduce the degrees of freedom, so the action is a direct result of the pressure exerted by dynamic conditioning factors. As a result, the player develops through the coordinations that emerge from the available degrees of freedom or the stabilization of specific coordinations.

We need to identify the conditioning factors affecting movement execution and the perception/action cycle so we can better guide training. We've identified the conditioning factors as the athlete, the environment, and the task. Let's delve deeper into these factors to create the ideal scenario for training.

Player Conditioning Factors

This refers to individual characteristics such as skills, physical abilities, and methods. It is critical to understand that performance cannot be isolated from the environment in which it takes place. However, this doesn't mean that studying individual characteristics in isolation is unimportant.

Figure 5: Player Conditioning Factors



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People, as complex systems, seem highly sensitive to initial conditions. The player's past experiences influence other conditioning factors (environment and task), shaping their perceptions and emotions for each movement situation, which strongly affects how they respond to game events.

Environmental Conditioning Factors —

In indoor sports, player performance is also shaped by movement within shared space with teammates and opponents. Social or socio-affective factors also play a critical role in influencing the player's perception of the environment. Environmental perceptions clearly influence players' actions and are shaped by their direct interpretation of the opportunities presented by the environment.

Task Conditioning Factors —

Task-specific conditioning factors are rules and limitations in the game, like shot clock restrictions or playing within the opponent's half in basketball. Players, as dynamic systems, must interact with their environment to coordinate their actions. Thus, training should take into account the environment's specificity and create tasks that mirror real game scenarios. This helps athletes learn to focus their attention and improve the connection between perception and action, making them more selective about the relevant information they use.

Interaction between conditioning factors —

The game's complexity is illustrated through static images where we can see how multiple dynamic interactions on a micro scale (player/s) produce non-linear macro patterns (team), related to game spaces developed earlier in this certificate (intervention, mutual aid, and cooperation).

Figure 6: Dynamic interactions on a micro scale (player/s) and macro scale (team).

This coadjuvant training module will focus on micro-scale interactions that relate to the player's intervention zone, indicated by the darker blue area in Figure 6, called the intervention zone.

Optimizing motor actions can bring significant benefits in competition, as actions like throwing, jumping, changing direction, and other motor skills are crucial for success in the sport. All of these actions rely, at least in part, on strength since any human movement results from joint torque or muscle force generated by muscle action (Oshita & Yano, 2012). Thus, complementing regular sports practice with other training methods, such as strength training, can help optimize performance through established synergies.

The need to achieve constant adaptations through strength training has traditionally involved principles from general training theory, such as progressive overload to promote internal responses that drive future adaptations. Most strength training research recommends increasing and varying stimulus magnitude, modifying volume, intensity, and load density. However, analytical training alone is insufficient for optimizing sports performance. Strength training can encompass a wide range of tasks, from analytical, decontextualized exercises to more representative and complex tasks. In recent years, scientific studies have proposed other strategies to promote adaptation through training loads. In summary, strength training should be applied holistically, synergistically, in an integrated and balanced manner with other physical abilities, player structures, and systems, following the complexity paradigm presented in the previous module.

Starting from a complexity perspective, we aim to achieve multisystem adaptations that alter the level of stress imposed on the athlete by training without necessarily increasing conventional load variables. This stress is created by setting conditioning factors, as explained earlier.

CONTINUE

2. Coadjuvant Training in the Structured Microcycle

In the past decade, athletes have increasingly been viewed as complex, unstable dynamic systems that change state due to accumulated imbalances from their experiences. Any change in the athlete's structures, systems, or subsystems will impact the others. Therefore, when designing training tasks, we must consider how our proposals will affect the player's overall behavior, not just the specific part of the system we target. Athletes cannot be seen as independent; their interactions with the environment generate various action possibilities. These action possibilities are specific to both the environment and the player. Thus, understanding how individual characteristics interact with the competitive environment is critical.

Paco Seiru-lo proposed a model where the athlete is at the center as the key element of training. He views the player as a dissipative organization resulting from the interconnectedness of various dimensions he calls structures (Figure 7) (Seirul-lo, 2017).

Figure 7: The structures that make up a player

Source: Original work

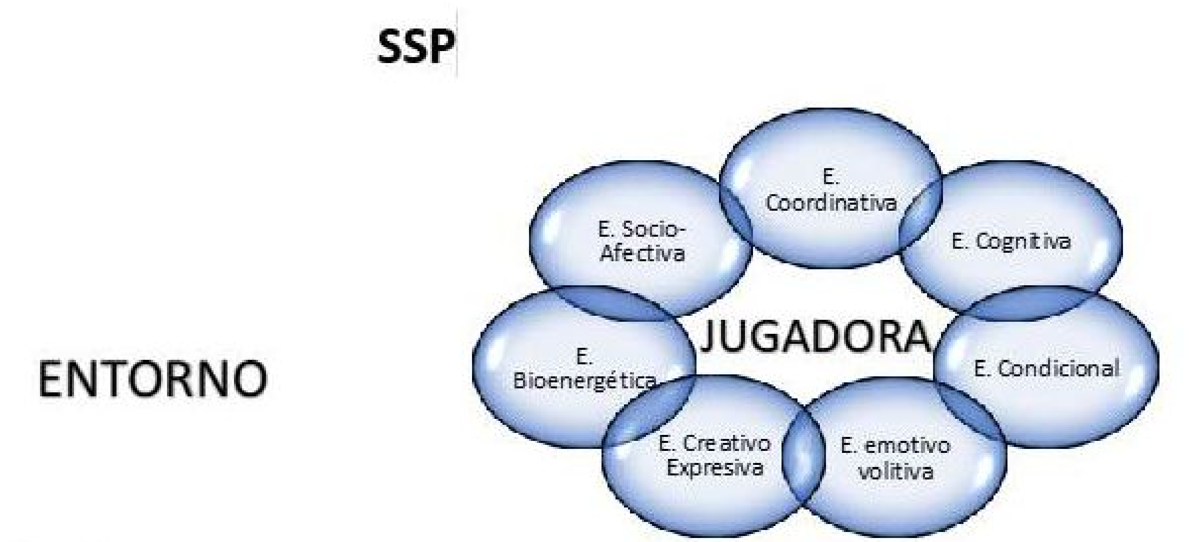
	Cognitive Structure	

Socio-affective Structure			**Conditional Structure**
Bioenergetic Structure			**Coordinative Structure**
	Creative-Expressive Structure	**Emotional-Volitional Structure**	

Source: Original work

This approach provides a systemic perspective of the player, considering their multifunctionality, which allows them to engage in tasks known as preferential simulation situations (PSS). These tasks impact all dimensions of the player with varying levels of priority, depending on the environmental conditions (see Figure 8).

Figure 8: Structures that make up a player and their relationship with the environment and preferential simulation situations



Source: Original work

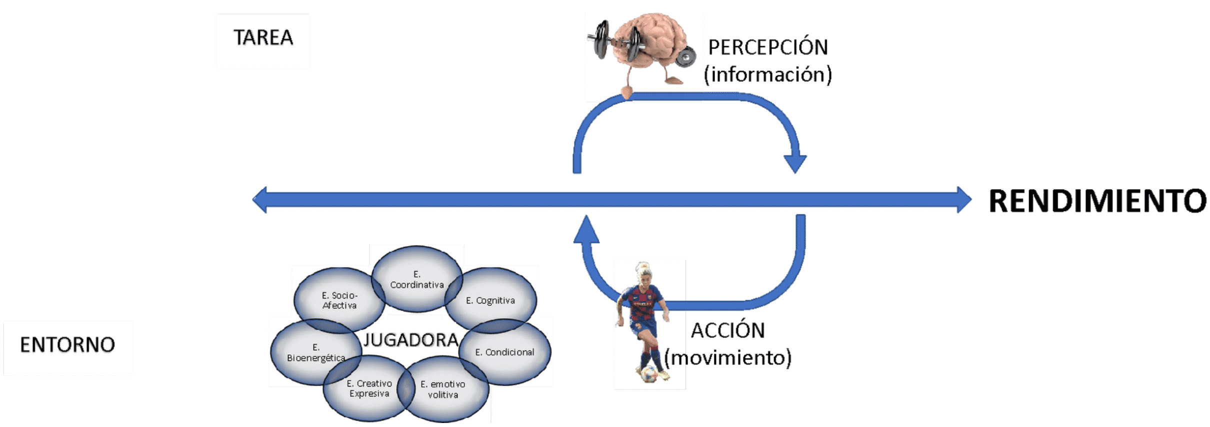
		PSS	
			Cognitive Structure

		Socio-affective Structure	**PLAYER**	
ENVIRONMENT		**Bioenergetic Structure**		
			Creative-Expressive Structure	**Emotional-Volitional Structure**

Source: Original work

The aim is to encourage dynamic interaction between the various open systems that make up the player, the environment, and the tasks, creating training situations that are more appropriate. Through training, we can work on those limiting factors that prevent players from performing at a higher level. The following figure illustrates the complex process by which players achieve performance. It is understood as a self-organization phenomenon that arises from the continuous dynamic interaction between the player's characteristics and the action possibilities offered by the specific competitive environment (Button et al., 2020; Renshaw et al., 2009). Gibson proposed how information detection (perception) regulates action and vice versa, and how task execution reinforces functional behaviors in dynamic performance environments (Figure 9) (Gibson, 1979).

Figure 9: Interaction between the player and the environment and its connection to the perception/action cycle



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Therefore, each athlete responds individually to the same task, depending on their characteristics and how they adapt to the game context.

Coadjuvant Training

When discussing structured training, it's essential to consider two complementary forms that make up the training process:

- Optimizing Training (OT): Focused on planning, designing, executing, and controlling training tasks with the goal of optimizing an athlete's performance throughout their sporting career (Seirul·lo, 2017; Tous-Fajardo, 1999). Essentially, this training prepares athletes for competition by ensuring that tasks are carried out in environments with game-specific elements.

- Coadjuvant Training (CT): This involves practices that help athletes maintain their health and state of achievement, allowing them to meet the demands of OT tasks daily (Tous-Fajardo, 1999). It also optimizes the components, structures, and systems needed by their sport to bring them closer to the desired level of performance.

Coadjuvant training directly enhances athletes' performance by preparing them to train at higher levels. It also aims to help them endure the competition's demands, perform necessary optimizing loads, and maximize individual potential from a systemic perspective.

During coadjuvant training, all structures are considered, but some are prioritized over others:

- Conditional and bioenergetic structure: This structure provides the physical and energy contribution to the player's activity. Its most representative values relate to the classical concepts of strength, speed, and endurance. The bioenergetic structure provides the energy for action (Colosio et al., 2018), while the conditional structure concerns the muscular actions that generate movement (Cronin et al., 2001).

- Coordinative structure: As previously discussed, this structure facilitates the desired execution of movement and is closely related to technique. Its purpose is to control the motor action (Newell et al., 2003), with spatial and temporal regulation, fitting within the perception/action cycle (Newell et al., 2003).

- Creative and expressive structure: To a lesser extent, this structure is also considered, as some tasks will remain open-ended to allow athletes to find motor solutions and be ready for any situation and condition (Bernstein et al., 1996).

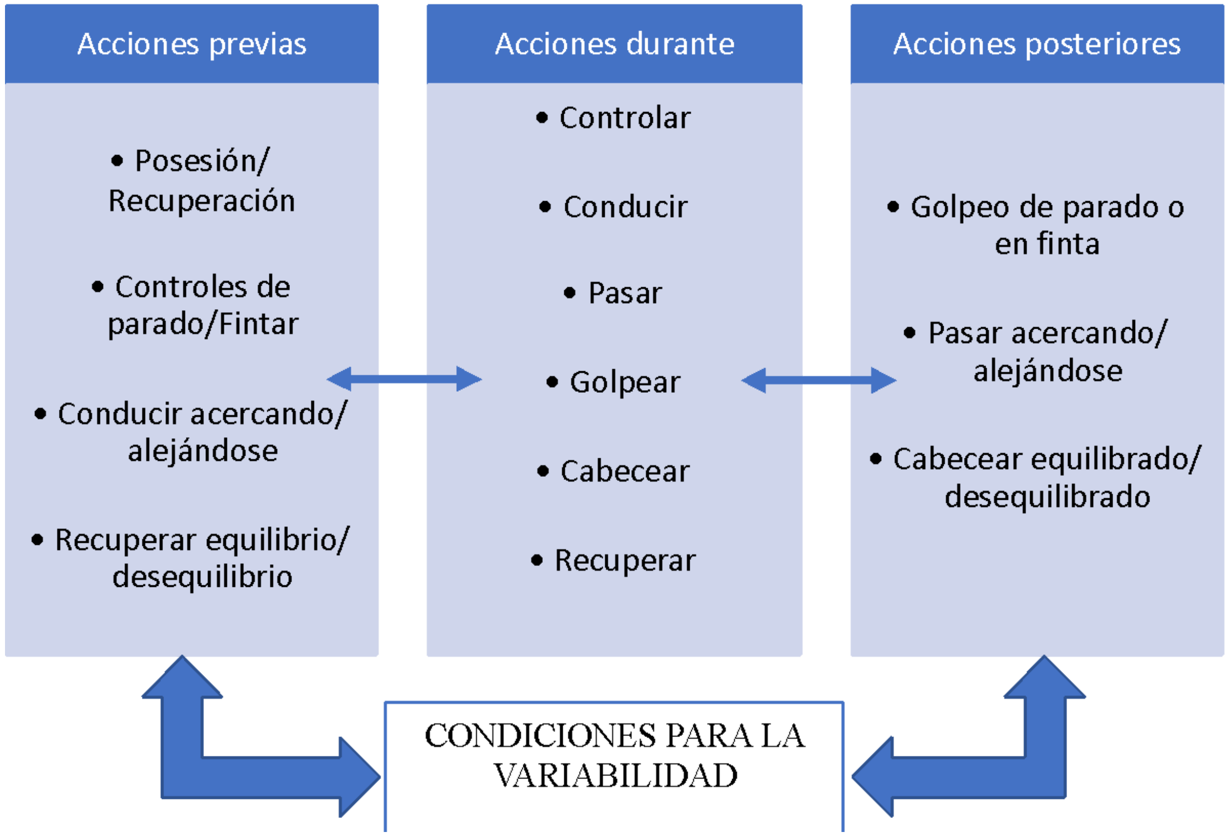
Movement Families in Coadjuvant Training

The goal of coadjuvant training is not to maximize an athlete's qualities, but rather to expose them to training situations that stress certain structures, forcing continuous adaptation through self-organization (Serrano, 2012). In indoor team sports, it is through movement that game situations are resolved, by interacting with both teammates and opponents. Therefore, sport-specific movements drive athletes' progression towards improved performance (Massafret cited in Seirul·lo, 2017).

It is important to identify the motor actions and basic skills specific to each sport that players will need in competition (Jukic et al., 2019; Kokstejn et al., 2019). Seirul·lo categorizes manifestations of strength into four main groups, according to their connection with basic motor skills such as throw, jump, displacement, or skills like combat (Seirul·lo, 2017), as discussed in the previous module.

- **Throw Strength or Ball Interaction:** Throw strength ensures that passing and throwing motor actions are executed with the appropriate levels of muscular tension to optimize their technical performance. Higher kicking speed is linked to a faster foot speed at ball impact, greater angular speed of the knee joint, and a quicker approach to the ball. To improve kicking performance, specific training exercises must be designed to address these factors (Cronin et al., 2001). Muscle strength significantly influences the ball's exit speed after impact. Significant correlations have been found between knee extensor strength (Manolopoulos et al., 2013), hip flexor strength (Dutta and Subramanium, 2001), and kicking performance. The various types of kicking in futsal, for instance, can be trained as follows (see Figure 10):

Figure 10: Throw Actions



Source: Original work

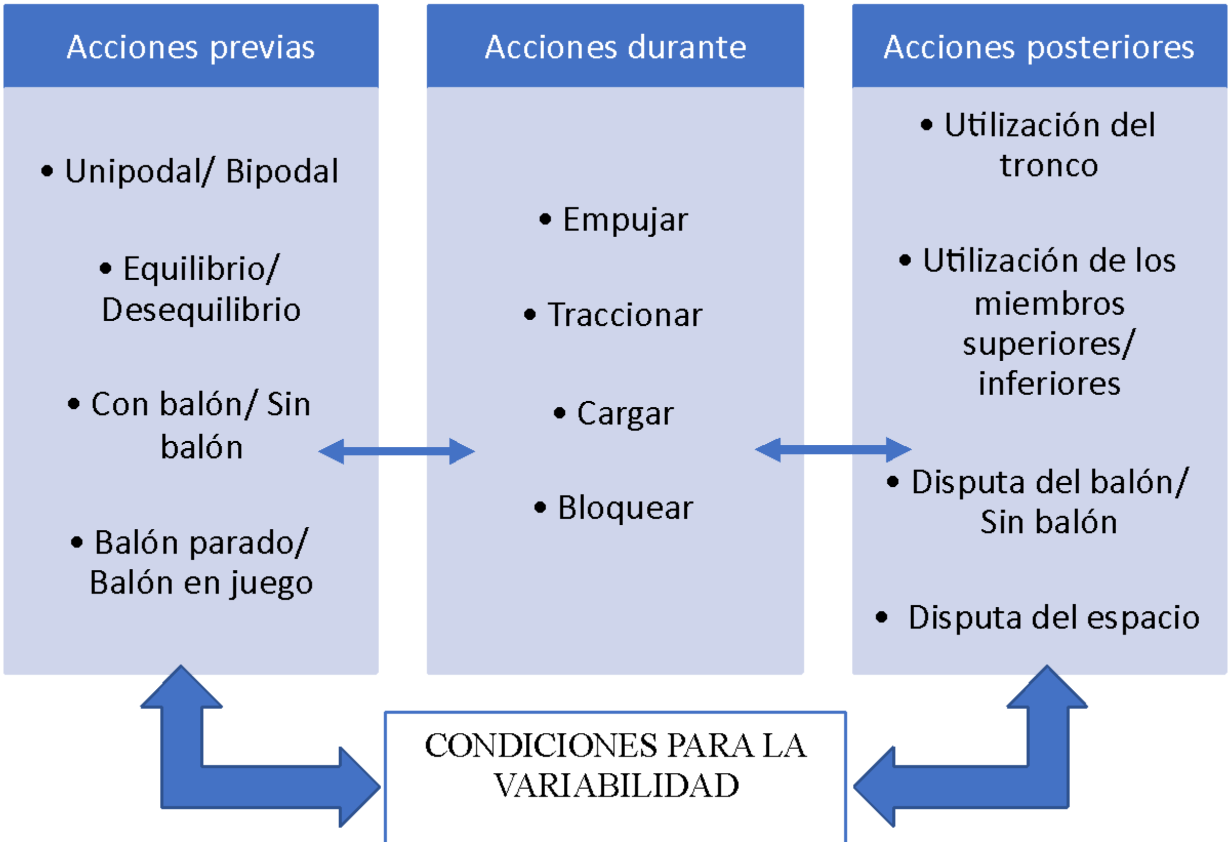
Actions (before)	**Actions (during)**	**Actions (after)**
Possession/Recovery	Controlling	Striking while stationary or feinting
Stationary controls/Feinting	Dribbling	Passing while approaching/moving away

Dribbling while approaching/moving away	Passing	Heading (balanced/unbalanced)
Recovering balance/imbalance	Striking	
	Heading	
	Recovering	
	CONDITIONS FOR VARIABILITY	

Source: Original work

- **Combat Strength:** This is a crucial aspect of indoor team sports, where gaining space and ball possession often leads to direct opposition with the opponent. These situations frequently demand complex motor skills, made even more challenging by the destabilizing presence of the opponent. As a result, players must find various solutions that require high levels of force application. Combat strength relies heavily on the feedforward control mechanism, which is based on anticipating situations by recognizing similarities to previous experiences. During the combat, muscular pre-activation occurs, helping protect the locomotor system from potentially harmful loads. This pre-conditioning of the musculoskeletal system comes from prior sports experiences, which contribute to continuous learning. This anticipation mechanism, aimed at minimizing perturbations and maintaining proper posture, is important in all training situations, but it is absolutely critical in combat strength. For example, valgus/varus moments and internal/external knee rotation double during unexpected direction changes compared to pre-planned situations. Different combat manifestations in football can be trained as follows (see Figure 11):

Figure 11: Combat Actions



Source: Original work

Actions (before)	Actions (during)	Actions (after)
Unipedal/Bipedal	Pushing	Use of the trunk
Balance/imbalance	Pulling	Using upper/lower body
With ball/without ball	Charging	Contesting the

		ball/Without ball
Ball stationary/Ball in play	Blocking	Contesting space
	CONDITIONS FOR VARIABILITY	

Source: Original work

- **Jump Strength:** Many technical-tactical actions require jumping for successful execution, such as finishing a layup, shooting at goal in handball, or heading in futsal. Therefore, it's essential to integrate jumping with variable spatial/temporal adjustments that change depending on the technical action and tactical decisions. The broader the motor repertoire for jumps, the greater the chances of success and lower the risk of injury. Jump performance is influenced by both neural and muscular factors. Jumping higher requires increased vertical acceleration before takeoff, generating the highest possible initial speed. To achieve this, athletes must produce maximum force in a short time (Ziv and Lidor, 2010) while increasing muscle mass and optimizing neural mechanisms through training (Ziv and Lidor, 2010). Different jump manifestations can be trained as follows (see Figure 12).

Figure 12: Jump Actions

Source: Original work

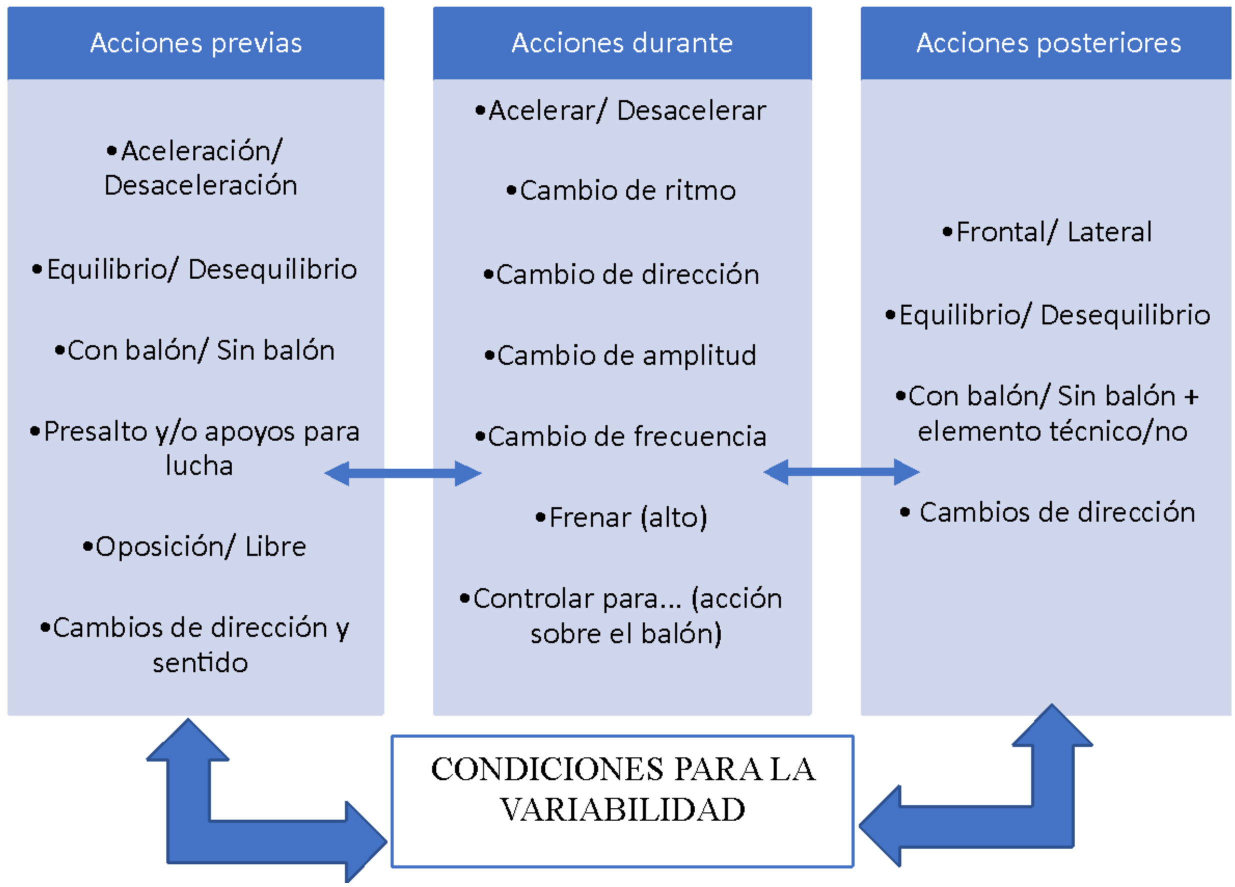
Actions (before)	Actions	Actions (after)

	(during)	
Front/Side/Back Run	Push/Take off	Reception/Landing
Balance/Imbalance	Unipedal/Bipedal	Unipedal/Bipedal
Support/Strike	Static/Dynamic	Opposition/Free
Set Piece/Live Ball		Stable/Unstable
Opposition/Free		Continuous Action
		Finish/Clearance
		Direction After Fall
	CONDITIONS FOR VARIABILITY	

Source: Original work

- **Displacement Strength**: Walking and running are basic motor skills consistently demonstrated in indoor sports, performed across the entire playing area in multiple directions and speeds, with frequent changes of direction and stops. Acceleration improvement is more affected by increased concentric strength, impulse, and knee extensor activity. Meanwhile, maximum speed improvement relates more to the stretch-shortening cycle, lower limb stiffness, and hip flexor strength (Sleivert and Taingahue, 2004). Reducing ground contact time is a key factor in improving maximum sprint speed (Weyand et al., 2010). The different manifestations of displacement can be trained as follows (Figure 13):

Figure 13: Displacement Actions



Source: Original work

Actions (before)	Actions (during)	Actions (a
Acceleration/Deceleration	Accelerate/Decelerate	Front/Si
Balance/Imbalance	Change of pace	Balance/Imb
With ball/Without ball	Change of direction	With Ball/W Ball + Tech Element/

Pre-jump and/or Support for Combat	Change of Range	Change of d
Opposition/Free	Change of Frequency	
Changes of Direction and Directionality	Stop	
	Control for... (Action on ball)	
	CONDITIONS FOR VARIABILITY	

Source: Original work

These different types of strength form what are known as movement families, a concept introduced by Moras (cited in Seirul·lo, 2017), which was already discussed in the previous module and relates to the sport-specific movements of each indoor sport. For instance, passing or shooting actions belong to the throw strength family. As we move towards more specialized exercises, these movement families begin to interconnect, with training sessions involving combinations of several, if not all, movement families—just as they would in an actual game.

What the players perceive in the game is heavily influenced by the situations we present to them in training. When players have encountered certain scenarios in training, they are more likely to recognize those same scenarios more clearly during matches. However, this can also make players overly reliant on familiar stimuli, making it harder for them to adapt to different situations in the game. The same holds true for the movements we teach during strength training sessions. If the training exercises are either too stimulating or not specific enough, players might mistakenly believe that the information is irrelevant, even when it's essential, leading to deafferentiation (a halt in information transmission to the tissues). Therefore, it's crucial for players to learn how to recognize key information during movements that are integrated into their interaction with the game.

Later in the task design section, we'll explore training tasks related to the various motor skills that have been introduced. These tasks will be designed with the athlete's different structures in mind and will be part of a progression that gradually incorporates sport-specific movement challenges. This progression will emphasize different aspects of the athlete's structure, gradually incorporating all elements until tasks resemble competition conditions. As previously mentioned, this module suggests that each training task should always be built upon a fundamental structure, typically based on physical or bioenergetic conditioning, coordinative, or basic cognitive tasks.

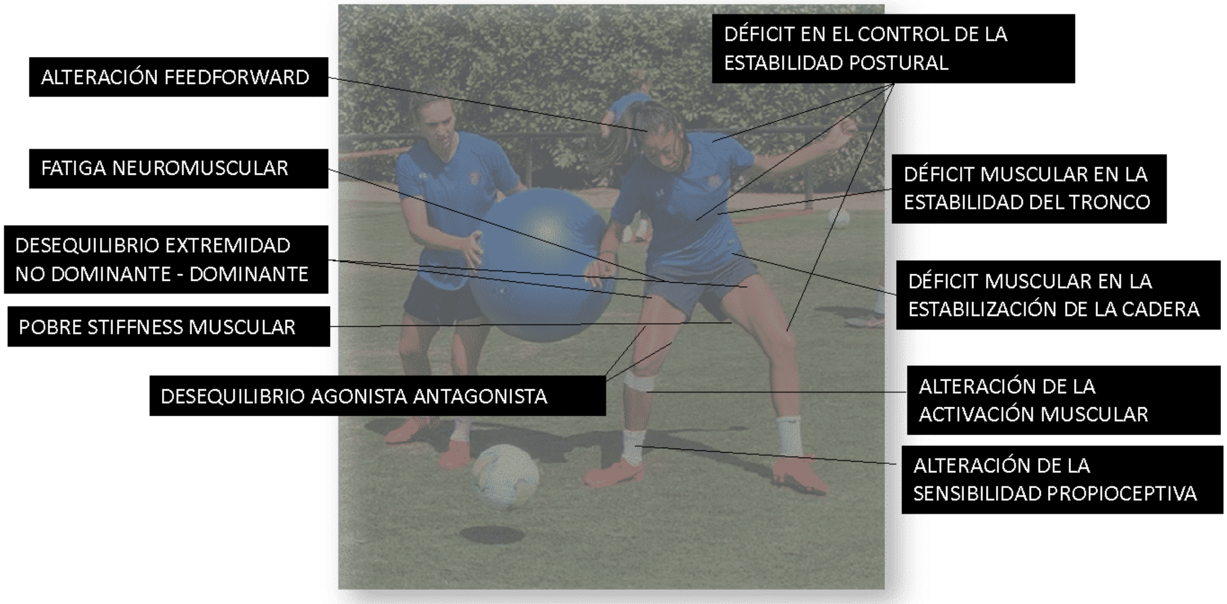
Types of Sessions

The different types of sessions in coadjuvant training within the structured microcycle each have specific objectives and characteristics, but together they provide an ecological foundation for optimizing the athletes' multifactorial processes. This integrative approach is key in enhancing athletic effectiveness within complex systems (Balagué Serre et al., 2014).

As reiterated throughout this module, every stimulus we expose our players to is designed to boost their performance and reduce their injury risk.

Neuromuscular/proprioceptive training has been proven to effectively reduce injury rates in sports where directional changes are common (Hübscher et al., 2010). Several factors can help explain the effectiveness of strength training in reducing injury risk (Figure 14).

Figure 14: Neuromuscular Risk Factors



Source: Adapted from Fort-Vanmeerhaeghe et al., 2016

Feedforward Alteration		Deficit in Postural Stability Control
Neuromuscular Fatigue		Trunk Stability Muscular Deficit
Imbalance Between Non-Dominant and Dominant Limb	**IMAGEN**	Hip Stabilization Muscular Deficit
Poor Muscle Stiffness		Muscle Activation Alteration
Agonist-Antagonist Imbalance		Proprioceptive Sensitivity Alteration

Source: Adapted from Fort-Vanmeerhaeghe et al., 2016

The figure above highlights the conditioning factors related to the player's tissues and their responses to different stimuli. However, models focusing solely on isolated performance or injury parameters fail to capture the full picture of the coordinative patterns that underlie performance or lead to injury. Therefore, understanding these coordinative patterns in greater depth is essential. As previously mentioned, motor actions are the result of the interplay between the athlete, the task, and the environment. Thus, not all identifiable limitations appear in every movement; sometimes they only emerge when the perceived information dictates the restriction, meaning the analysis of injury risk factors must consider the movement's context.

Both coadjuvant and optmizing training also have a preventive nature, protecting athletes from internal and external conditioning factors. As a result, every session type outlined below serves both injury prevention and performance optimization purposes to varying degrees. The types of sessions conducted in coadjuvant training include:

Recovery Coadjuvant Training

This type of training focuses on optimizing the recovery processes after sessions that have caused muscle damage due to their intensity, whether from training or competition. Recovery should be comprehensive and encompass all bodily structures, though primarily the conditional, cognitive, coordinative, emotional-volitional, and bioenergetic systems (Calleja-González et al., 2018). This work involves a multidisciplinary approach, collaborating with other teams and specialists such as doctors, physiotherapists, nutritionists, psychologists, and more.

Structural Coadjuvant Training

This is general training aimed at correcting, adjusting, anticipating, controlling, and protecting the athlete's body. It's often associated solely with body composition modification through decontextualized training. However, this training also conditions tissues to better withstand the high-intensity demands of competition-specific actions. Additionally, it focuses on achieving the necessary balance and readiness of the muscle chains involved in executing specific actions. In structural sessions, the focus should be to:

- Develop stabilizing muscles as key elements in facilitating efficient sensorimotor actions (Arboix-Alió et al., 2021).
- Condition the tissues to handle unexpected and eccentric actions.
- Enhance the efficiency and effectiveness of coordinative skills.
- If needed, structural sessions can be used to alter body composition, particularly to increase lean muscle mass and reduce body fat through applied hypertrophy.

During the preseason, the groundwork is laid for training that targets metabolic processes, not in isolation, but integrated with coordination demands specific to competition. The goal is to establish a stable functional state even under fatigue conditions.

Structural training is designed to optimize the athlete's physical and bioenergetic structures, ultimately improving coordination in competitive environments. This can be achieved through structural sessions that focus on metabolic goals (HIIT). The HIIT method alternates circuits of very high intensity, using exercises that engage a large portion of body mass, with recovery periods that vary depending on the objective. Among the metabolic training options, some target fat loss by temporarily raising the metabolic rate, thus increasing caloric expenditure and promoting the residual thermal effect known as EPOC (Excess Post-exercise Oxygen Consumption).

Coadjuvant training for specific qualities

This training is based on a methodological approach adapted from Seirul·lo (2017), which breaks the game down into work areas, content, and alternative ways to train this content according to their orientation and the levels of specificity that can be achieved without impairing technical execution. Work areas are understood as the four specific strength manifestations required: strength for displacement, jumps, combats, and throws. Content refers to the specific motor skill (technique) and all its variations, such as open starts, crossover starts, acceleration, deceleration, etc., each of which is related to one or more work areas. The organization of specific quality training is structured according to the similarity between the exercises and actual competitive situations (Seirul·lo, 1993). Exercises will be proposed based on orientation and varying levels of specificity. General orientation refers to actions that involve practicing various strength manifestations at different speeds and ranges, without necessarily being visually sport-specific but specific in intention. Directed orientation relates to actions that resemble the movements used in competition. However, exercises with special and competition-specific orientation are excluded from coadjuvant training, as they fall under optimizing training. Once the content is defined, the focus is placed on the orientation and specificity levels within the different areas of strength manifestations. Later, we will review the different practice systems used in coadjuvant strength training sessions for specific qualities.

CONTINUE

3. Strength Training Adaptations: Are our efforts producing the desired results?

Humans tend to behave in suboptimal ways—they strive to be just marginally better than their competitors, adapt for survival, and develop only the abilities most necessary to stay competitive in their environment. To develop players, it's essential to expose them to scenarios that force their system to reorganize and improve their adaptability. When players solve the same scenario in the same way repeatedly, they create an attractor that prevents them from finding alternative solutions. Instead of training for automatic responses, we should train for adaptability. For this reason, physical trainers must design tasks that encourage divergent responses, helping players become more flexible and adaptable in their performance. The ability to react in multiple ways to challenges will improve performance by expanding the athlete's adaptability to different environments. As a result, the player will develop a broader repertoire of situations where the system remains close to balance, making competitive stimuli less stressful and thus enhancing performance while likely reducing injury risk factors.

In conclusion, it is essential to understand the interactions that occur during competition in order to determine athletes' strength needs from a holistic perspective. With this understanding, we develop a training proposal using coadjuvant and optimizing exercises that are incorporated into structured training, prioritizing Seirul-lo's proposed frameworks through strength training rooted in sports-specific movements (Seirul·lo, 2017).

The types of sessions conducted in coadjuvant training include:

- [ ] Sessions focused on specific qualities
- [ ] Highly complex cognitive sessions
- [ ] Structural sessions
- [ ] Recovery sessions

SUBMIT

CONTINUE

4. Goals of coadjuvant training: conditional structure demands in competitive environments.

So far, this module has emphasized the advantages of strength training aimed at enhancing specific sports skills (such as jumps, displacements, changes of direction, throws, etc.), all of which involve the application of force, as discussed earlier. However, a common misinterpretation has led some trainers to focus solely on specific loads for strength training, overlooking that athletes already encounter high specificity during field sessions. Therefore, it is crucial not only to analyze the strength requirements for a sport but also to evaluate how well on-field exercises cover those specific strength needs in terms of quantity and quality. It's important to note that the more sport-specific the training load, the more stress it places on the musculoskeletal system, increasing the risk of injury. In contrast, the risk of injury from nonspecific training loads, like weightlifting, is significantly lower compared to many other sports activities (Preatoni et al., 2013). Despite this, sports medicine continues to explore the relationship between weight training and injuries. In this module, we will share our perspective on strength training, grounded both in scientific research and the invaluable practical experience of various professionals.

Tous proposes that the ultimate objectives of strength training are injury prevention and performance enhancement (Tous-Fajardo, 1999). The mechanisms through which strength training improves performance and reduces the risk of injury are essentially the same. Focusing on the conditional, coordinative, and bioenergetic structures, players who are strong and well-coordinated are better equipped to manage the forces encountered during play. This leads to more efficient movement, improving performance and reducing fatigue—a known factor contributing to injuries.

Strength training optimizes the ability to apply force (conditional/coordinative/bioenergetic structure).

—

There is a strong correlation between maximum running speed and strength and power levels (López-Segovia et al., 2011). This is because strength is the core physical ability, from which all other abilities derive, as previously mentioned. Strength correlates more strongly with acceleration capacity than with maximum sprint speed (Wisløff et al., 2004).

During sprint acceleration, changes of direction, and jumps, ground contact times are longer than during maximum sprinting, which allows for more force to be applied over time. The longer the ground contact, the more crucial the ability to apply force becomes, and this is where strength and power training significantly impact performance. Although strength training is widely acknowledged to play a key role in enhancing sprint performance, not all training programs improve athletes' maximum sprint speed (Shalfawi et al., 2013). This could point to inadequacies in some stimuli of the traditional training programs used to enhance sports skills. In highly trained athletes, specific strength training performed explosively is required (Bishop et al., 2011). Stronger players are better prepared to run faster and more frequently without suffering a drop in speed (López-Segovia et al., 2011). Strength training increases motor unit activation, reducing fatigue and limiting power loss during repeated high-intensity actions (Silva et al., 2013). In football, for example, stronger players maintain higher force and power output toward the end of a match, thanks to the positive relationship between strength and endurance (Silva et al., 2013), which is also linked to muscle and tendon stiffness (Bishop et al., 2011). Plyometric training increases the stiffness of the muscle-tendon unit, allowing muscles and tendons to store and release more elastic energy, reducing wasted energy (Saunders et al., 2004). This energy efficiency reduces oxygen consumption, explaining the strong link between running economy and endurance related to plyometric training (Saunders et al., 2004). Improvements in motor unit activation and synchronization, muscle-tendon stiffness, and the efficiency of the stretch-shortening cycle all enhance sprint performance and the ability to repeat sprints (Buchheit et al., 2010).

This summary shows that strength training enhances performance, but only when viewed from a reductionist and linear perspective. However, if we approach it from a more complex viewpoint, we cannot claim that improving a specific ability in isolation, without linking the conditional structure to the coordinative or cognitive ones, will optimize performance in competition.

Neuromuscular response

Performance is shaped by the need for players to control their movements (coordinative structure). As movements grow more complex, the central nervous system (CNS) finds it increasingly difficult to control them, potentially destabilizing movement patterns. The CNS gathers information needed to control body movements from three subsystems: the somatosensory, vestibular, and visual systems (Hewett et al., 2002; Lephart and Jari, 2002).

Although the visual and vestibular systems contribute, peripheral mechanoreceptors are the most important for training purposes. Mechanoreceptors are located throughout the body in the skin, joints, ligaments, tendons, and muscles. Afferent pathways transmit signals to three levels of motor control, involving areas like the cerebellum. Motor neurons are activated either directly in response to peripheral sensory inputs (reflexes) or by signals descending from higher brain centers (automatic or voluntary movement) (Fort and Rodríguez, 2013). Neuromuscular control refers to the precise activation of muscles that allows for coordinated and efficient actions (Williams et al., 2001). The strategies for neuromuscular control that produce coordinated and efficient movements involve intramuscular and intermuscular coordination.

Research now shows that the neuromuscular system's strategies can be adapted through training (Hewett et al., 2013; Hübscher et al., 2010). When learning new movements, they are initially performed with high levels of coactivation, but with practice, the movements transition to reciprocal activation (Lloyd, 2001). In sports, it's important to balance coactivation, which provides stability and protection, with reciprocal activation, which enhances muscle efficiency in sports actions (Figure 18). Along with these strategies, feedback and anticipation (feedforward or preactivation) mechanisms are essential for optimizing neuromuscular control during games.

Figure 15: Types of actions where cocontractions and inhibition occur

Source: Adapted from Fort and Rodríguez, 2013

<u>Notes on Figure 15</u>

Neuromuscular principles:

<u>Agonist-antagonist coactivation</u> = New actions / ballistic movements / increased execution speed / joint stability requirements

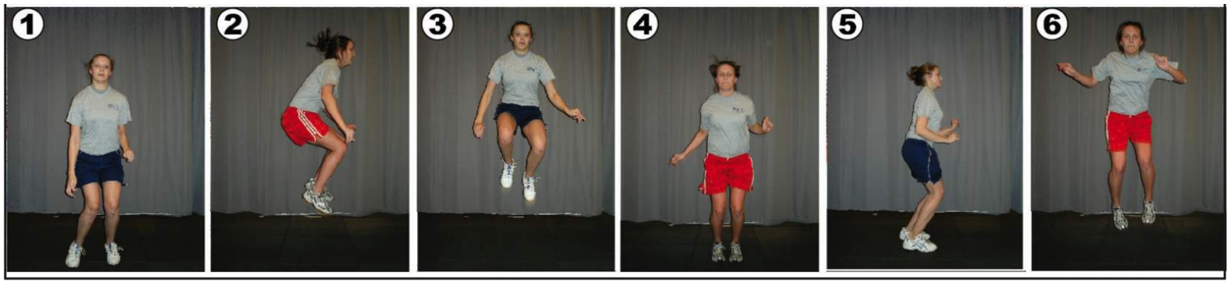
Reciprocal agonist-antagonist inhibition = Automated multi-joint movements / learning consolidation (from coactivation to inhibition)

Understanding how the neuromuscular system operates is key to designing more effective strength training that ensures the functional stability of tissues during sports actions, such as changes in direction or landing from jumps. This system is not only crucial for injury prevention and treatment but also for enhancing athletic performance (Fort and Rodríguez, 2013).

Coordination-based strength training.

Coordination-based strength training emphasizes the coordinative structure during strength tasks. We need to assess how movement control affects performance. If performance is limited by the load-bearing capacity of the musculoskeletal system, then training should focus on the

Figure 16: Dysfunctional movement strategies during landing. Knee and hip movement



Source: Hewett et al., 2010, https://goo.su/NSWkllY

1. Valgus in the extremity during landing.
2. Hips do not reach parallel (at maximum jump height).
3. Hips are not parallel during flight.
4. Feet during landing: shoulders are not aligned with feet.
5. Feet are not parallel (forward – backward).
6. Foot contact times are not simultaneous.

DIFFERENT STRATEGIES CAN BE CATEGORIZED AS FOLLOWS:	THE INTERVENTION, CONSIDERING ONLY THE COORDINATIVE STRUCTURE, WOULD BE AS FOLLOWS:

- *Ligament dominance:* This issue can be addressed by improving the muscles' ability to absorb ground reaction forces sufficiently, as joints and ligaments must absorb large forces over a short period.
- *Leg dominance:* This refers to the tendency to support all weight on one leg.
- *Quadriceps dominance:* This is characterized by a tendency to stabilize using the quadriceps.
- *Trunk dominance:* This occurs when athletes fail to adequately perceive their trunk's position in three-dimensional space and do not allow further movement after a perturbation.

DIFFERENT STRATEGIES CAN BE CATEGORIZED AS FOLLOWS:	THE INTERVENTION, CONSIDERING ONLY THE COORDINATIVE STRUCTURE, WOULD BE AS FOLLOWS:

Table 1: Intervention Based on Coordinative Structure

MECANISMO LESIVO	DESEQUILIBRIO NEUROMUSCULAR	INTERVENCIÓN
Aducción de rodilla en la caída	LIGAMENT DOMINANCE	Entrenar la técnica adecuada
Pequeño ángulo de Flexión de rodilla en la caída (desplazamiento adelante)	QUADRICEPS DOMINANCE	Fuerza de la cadena posterior
Caída asimétrica	LEG DOMINANCE	Entrenar simetrías (SIDE/SIDE)
Incapacidad para controlar el centro de masas	TRUNK DOMINANCE	Core Stability y entrenamiento de perturbaciones

INJURY MECHANISM	**NEUROMUSCULAR IMBALANCE**	**INTERVENTION**
Knee Adduction upon Landing	LIGAMENT DOMINANCE	Train Proper Technique
Small Knee Flexion Angle upon Landing (forward displacement)	QUADRICEPS DOMINANCE	Posterior Chain Strength
Asymmetrical Landing	LEG DOMINANCE	Train Symmetry (Side/Side)

Inability to Control Center of Mass	TRUNK DOMINANCE	Core Stability and Perturbation Training

Source: Original work

Neuromuscular imbalances should be trained in relation to the specific task and observe how movements are modified when exposed to specific stimuli.

Strength training should aim to optimize performance, with injury reduction being a natural outcome. This training should closely mimic competitive movements and respect the environment's dynamics where the movement occurs in the game. Thus, not only will strength levels or tissue quality improve, but the coordination necessary for efficient movement will also be enhanced. Efficiency involves improving energy flows, meaning the specific distribution of energy based on environmental information and interactions between players and their actions.

Strength training should include movement variability as a fundamental component of structured training methodology. This variability should be functional, not random. It will provide the player with greater adaptability and flexibility in the sensorimotor system, enabling competent maneuvering in various contexts. Functional variability is an indicator of a healthy motor action (Glazier et al., 2006). Tasks requiring athletes to adapt their behavior to task conditioning factors will enhance their interaction possibilities with the complex environment (Button et al., 2020). As Bernstein noted decades ago, repeating the same movement never results in an identical movement trajectory (Figure 20), regardless of practice, experience, or skill level (Bernstein et al., 1996).

Figure 17: Variability in Strength Training

Source: Original work

Variability in training can occur during the process or in the outcome. It can be linked to having various strategies available to solve the same task, increasing performance flexibility. Variability can also be observed when different components contributing to performance counteract each other's variations to ensure the outcome, as shown in Figure 16.

Therefore, introducing a coordinative overload is theoretically a way to create increasingly new or flexible sensorimotor patterns, allowing the player to continue learning and diversifying movement solutions for a given task. This complexity is necessary for systems to adapt to changing conditioning factors; a loss of complexity results in decreased adaptability.

Combining stability and flexibility in human behavior is inherently complex. Stability is necessary in movements, but since instability originates stable motor behavior (Davids et al., 2008), combining stability and flexibility poses a significant challenge for the neuromuscular system. The human body, through interactive processes among different structures, has multiple ways to stabilize and reorganize to counteract its instabilities (Spencer & Schöner, 2003).

Specific training loads on the field and competition-specific loads can create imbalances in athletes that increase the risk of injury. Therefore, it is crucial to seek balance and progression in strength training proposals from the nano level (e.g., developing tensegrity concerning muscle cells and the musculoskeletal system), to the micro level (intra- and intermuscular coordination in movement), and to the macro level (sports movements in competition). This proposal also relates to task orientation, and therefore to its level of specificity, representativeness, and complexity concerning competition.

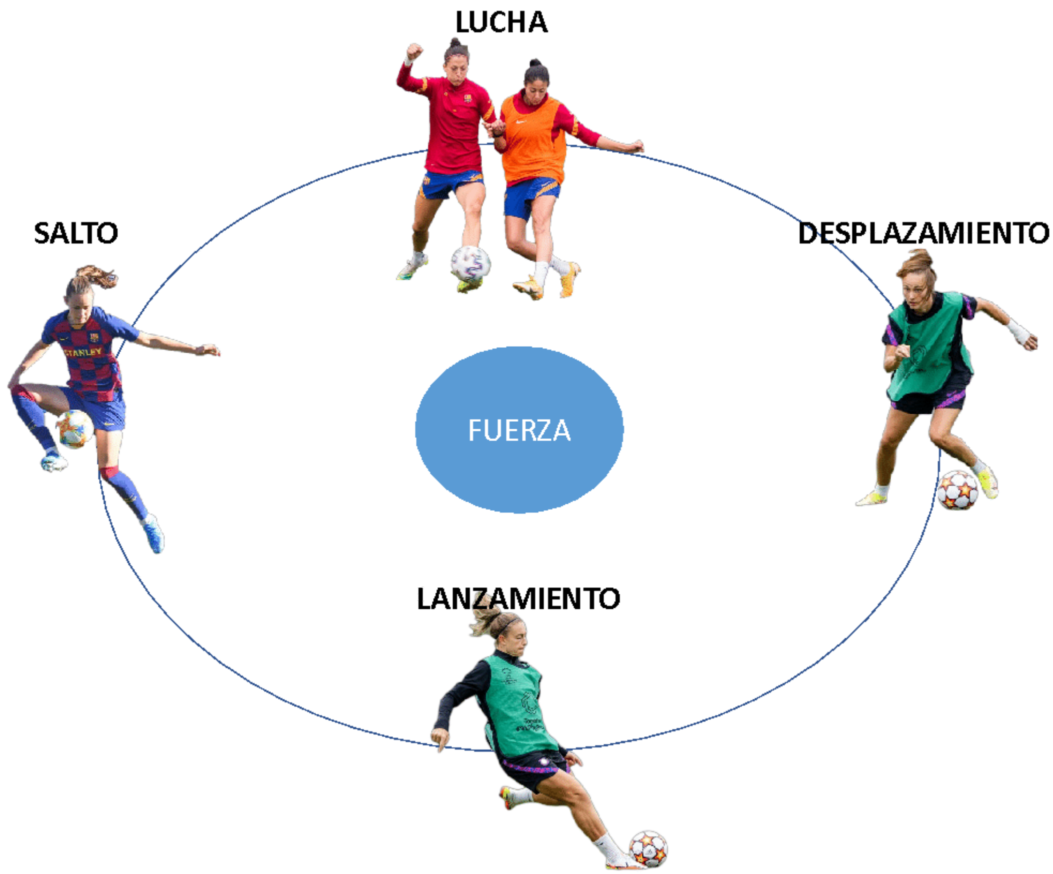
CONTINUE

5. Designing simulation situations, variability, and specificity in coadjuvant training.

As previously mentioned, strength training has evolved in its applied definition. Beyond the importance of muscular tension, the context and timing of applying this tension are critical, with strength being defined as the ability of a muscle or muscle group to generate muscular tension under specific conditions (Siff and Verkhoshansky, 1996).

Movement is integral to humans; we express and communicate through movement, solving problems encountered in the game through movements. Therefore, movement-oriented practice is fundamental for players to advance toward sports specialization. Understanding specific movements in the sport is essential. Four basic motor skills (areas) related to these sports movements include: throws, jumps, displacement, and combat (Figure 17).

Figure 18: Movement families in team sports



Source: Original work

	COMBAT	
JUMP	**STRENGTH**	DISPLACEMENT
	THROW	

Source: Original work

These strength manifestations form movement families linked to sports movements in most indoor team sports (Seirul-lo, 1993). As exercises become more specific, these movement families will interconnect, and the proposed exercises will blend several or even all movement families, just as they do in real play, where all are present.

To design training exercises for athletes, it is crucial to consider the degree of similarity between the exercise and the sports movement, known as specificity. Ensuring specificity means that the exercise and sports movement will mutually reinforce each other. This is known as transfer. For effective transfer to sports movement, the athlete must be exposed to a greater stimulus than usual, a concept known as overload. Adaptation is a highly individual process, differing from player to player, and this is referred to as individuality (or differentiated). To continue the adaptation process, the system must be progressively overloaded. However, it's crucial to recognize that this effect is temporary; if training is discontinued, the effects may fade, which is known as reversibility.

We need to thoroughly analyze sports movement to understand the connection between the simulation situation and the actual movement during competition. The challenge arises because many movements do not follow fixed and repetitive patterns, making it difficult to link them to strength training. The unpredictable nature of motor skills in sports complicates the analysis of sports movement, as it varies with different situations. Consequently, it is challenging to determine which types of training are the most effective. For instance, in basketball, futsal, handball, or hockey, the ability to move is so specific to the game situation that the same strength training principles used in individual sports like athletics cannot be applied, where movements are linear and unaffected by opponents. In athletics, running cannot be directly transferred to indoor team sports, where the environment demands constant adaptation of the running pattern. Nonetheless, even in open environments, skills appear to have a fixed structure. Improvising and adapting a movement to changing environmental demands does not imply that all movement components are unstable; some remain consistent. The effectiveness of a movement depends on the player's ability to adjust both stable and unstable components in response to environmental demands.

Degrees of Freedom

When moving and changing positions, there are numerous ways to perform the movement, making it complex for the body to choose the most efficient method. Movements involving multiple joints have different degrees of freedom, meaning there are many possible combinations of ranges of motion that can achieve the same result. Combined with the potential combinations of joint angles, these degrees of freedom increase because movements can typically be performed by more than one muscle. This broadens the options for selecting the most effective movement, making it nearly impossible to choose one definitive method Out of the many ways to move, only a few are economical and effective, but which ones are they? Clearly, we cannot and should not compare all these alternatives right before performing the movement, as it would be time-consuming and mentally exhausting, making the movement overly tiring. Therefore, there must be a mechanism in the motor control system that eliminates inefficient alternatives and selects the correct one. Bernstein suggests that the core of motor control is the more or less automatic elimination of superfluous alternatives or degrees of freedom (Bernstein et al., 1996).

Bernstein also identified a second significant issue with movement control: variability depending on the context (Fajen et al., 2008). In a changing environment, forces will vary constantly, so the same command from the central nervous system to the muscles will produce different movements in different contexts. If the performance of a movement (total joint angles) is often the same despite environmental influences, the muscles will need to be controlled differently in each situation. This means that if the expected joint angle in a movement pattern needs to be consistent, different muscle selection and actions might be required in each situation (considering movements and opponent resistance). Consequently, motor skills cannot be designed in a linear fashion due to both degrees of freedom and the influence of variable opposing forces.

The musculoskeletal system eliminates inefficient and unstable movement patterns within it. The movements we choose are interconnected, with more stable ones being more suitable for the system, as they are typically used to handle game situations. The body invests minimal energy in learning movement principles that are only applicable in a limited number of cases; it prefers to learn techniques that are broadly applicable. Thus, when learning movements, we primarily focus on identifying and applying rules that filter out inefficient movement methods and prevent rigid muscle use and, consequently, rigid movement patterns (e.g., cocontractions). Since the system aims to maximize the use of general application rules, movements, although they may appear different, become more similar (e.g., running and jumping differ in segment movement speed).

A player performs many different movements and skills during a game. These movements and skills are complex, involving many degrees of freedom (strength, speed, multiple joints and muscles) that need to be controlled (Fajen et al., 2008). If the brain had a separate motor pattern for each distinct movement, the catalog of motor patterns would be so extensive that processing it would be impossible, especially under time constraints. Schmidt, in the generalized motor program theory, states that similar movements are grouped together (Schmidt et al., 2018). Some movement components are common across various related movements, while others are variable. Without generalized motor patterns, any new movement would require extensive practice or might even be impossible due to the absence of a motor pattern. This strategy of seeking efficiency for controlling many tasks forms the basis for specificity and transfer of fixed training patterns.

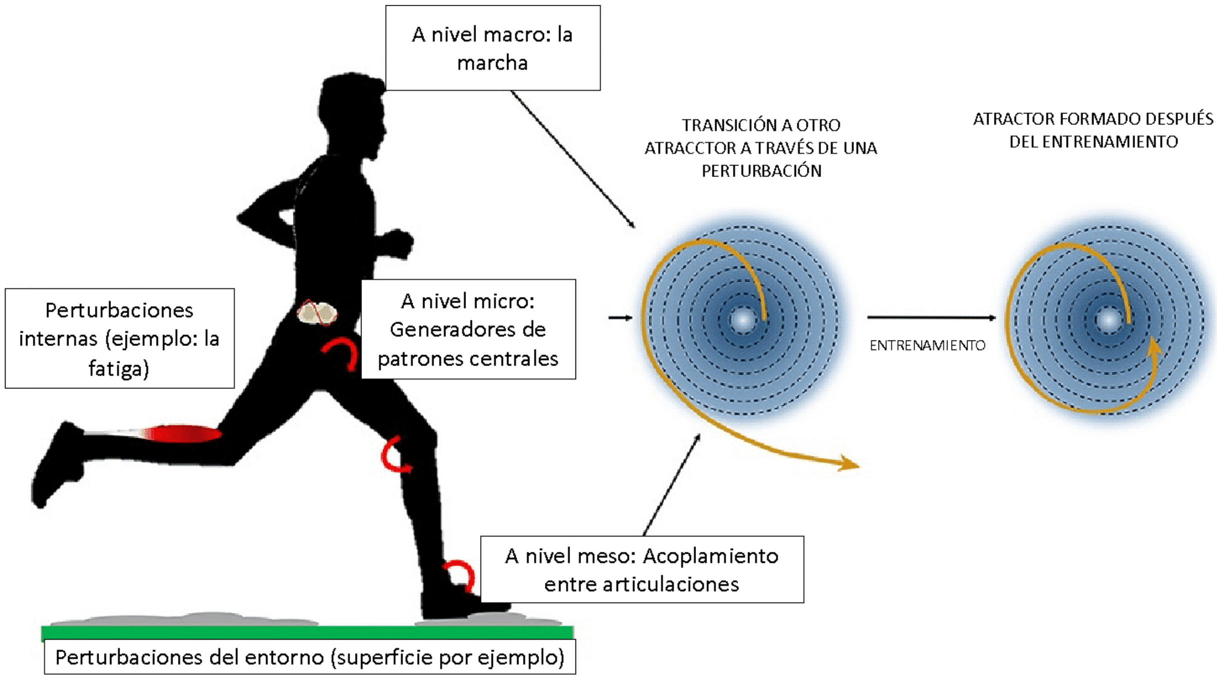
Attractors and Fluctuations

So far, we have examined how movements are designed by eliminating degrees of freedom, resulting in a stable and efficient movement—one that is hard to perturb and performs with minimal energy expenditure. A movement pattern consistently aims to be stable, and if stability is lost with the previous strategy, it may shift to a different form of stability. Phase transitions can even occur in response to minor perturbations if they cause abrupt changes between movements involving both stable and unstable patterns. The body in motion strives to transition from one stable pattern to another while avoiding unstable patterns whenever possible.

Stability and efficiency in movement are crucial not only for selecting general movement patterns but also for optimizing individual movements. Movement components are categorized into stable (low energy expenditure) and unstable (high energy expenditure) parts. In the literature, stable and economical movement components are called attractors (habitual patterns), while unstable components are referred to as fluctuations (also known as order parameters and control parameters in phase transition theory) (Kelso, 1991). These fluctuations are essential for adapting movement to environmental changes. If movement consisted only of stable parts, it would be rigid, and environmental influences would frequently cause errors due to the system's lack of adaptability.

Attractors represent coordination trends among system components (Davids et al., 2008) and can be identified at multiple levels, emerging from the self-organization of lower and higher-level components through circular causality (Kelso et al., 1987). This means that the behavior of higher-level components is influenced and constrained by the behavior of lower-level components, and vice versa (Figure 18).

Figure 19: Walking or Running



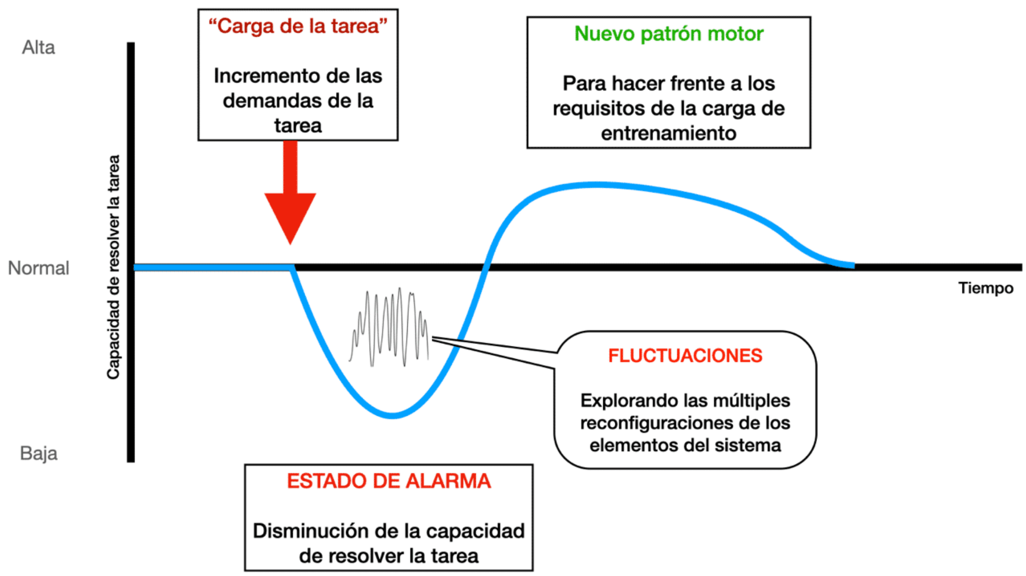
Fuente: van Hooren et al., 2019, https://goo.su/CTHj5i

Walking or running, gait, joint coupling, and central pattern generators (CPGs) can represent limit cycle attractors (cyclic coordination trends, simplified representations on the right) at macroscopic, mesoscopic, and microscopic levels. Internal and external perturbations, such as fatigue or an uneven surface, can lead to a phase transition to a potentially less effective or efficient attractor. Major perturbations can, for example, lead to problems like falling while walking or spraining an ankle while running. Training can enhance the stability of attractors so that larger or potentially more frequent or unpredictable perturbations can be managed without compromising stability (van Hooren et al., 2019, https://goo.su/CTHj5i)

In summary, a movement comprises attractors (stable patterns) and fluctuations (unstable patterns) that must meet two main criteria: maintaining overall movement stability and efficiency, and ensuring that fluctuations are sufficient yet limited to adapt to changing environmental demands. The fewer movement variables, the more controllable the movement becomes. Therefore, learning to move involves not just mastering various movement components but also understanding the relationship between stable and unstable components (Davids et al., 2008). During learning, it is crucial to identify which components should be used in a stable manner and which should be variable.

The learning process involves not only mastering different movement components but also properly distinguishing between attractors and fluctuations. At certain points in the initial learning process, especially with more complex movements, the developed attractors and fluctuations might not meet all criteria for optimal and efficient movement in the environment, thus being undesirable. The resulting attractors need to be perturbed again to develop a new and improved coordination (Figure 20).

Figure 20: Increasing Task Demands (Perturbation) to Generate a New Stable Attractor



Source: Original work

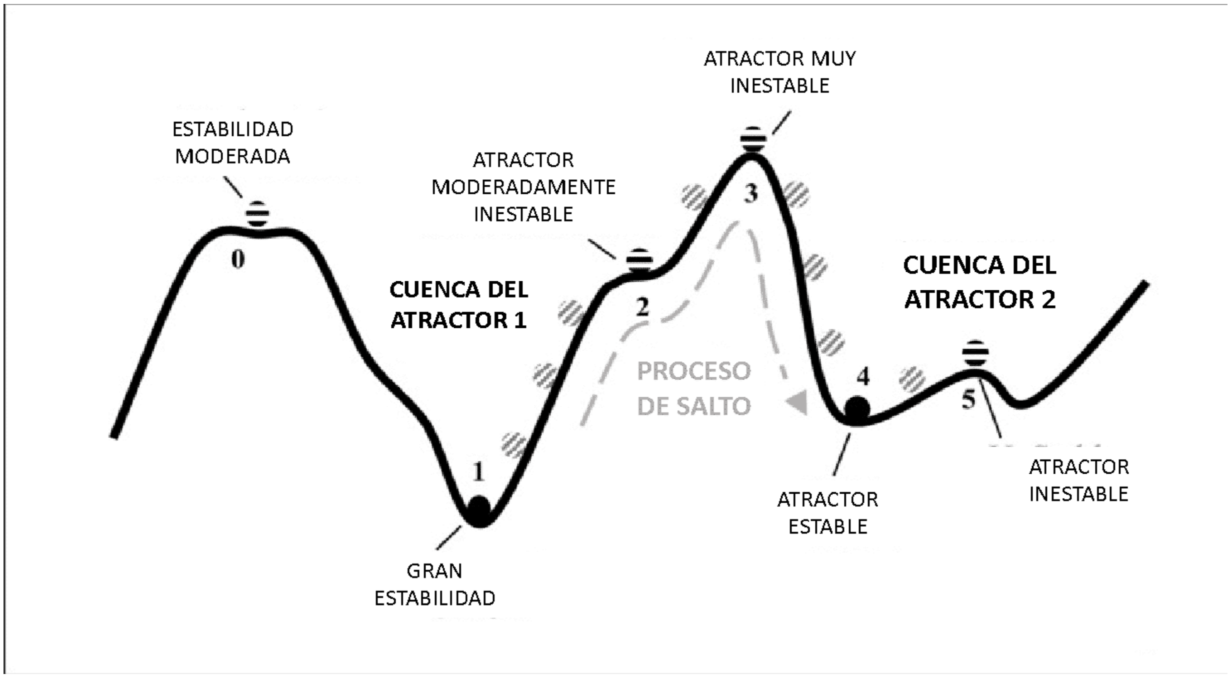
High		**“Task Load”** **Increased Task Demands**	**New Motor Pattern** **To Meet Training Load Requirements**
Normal	Ability to resolve tasks	**Time**	
		ALARM STATE **Decreased ability to resolve tasks**	**FLUCTUATIONS** **Exploring multiple reconfigurations of system elements**
Low			

Source: Original work

Modifying existing inadequate movement patterns is a key step to learning new and more coordinated movements. The focus is on learning the new pattern, but this process is often hindered by old, rigid patterns. Sometimes, the real challenge in learning is perturbing these old attractors.

Through training, the player achieves a balance between stable and variable parts of the movement. The stable parts become more robust and efficient, requiring less energy to perform. This can be visualized by considering a ball moving over a terrain with pits. If the pit is wide, the ball will be drawn towards it, but if it is deep, the ball will have difficulty escaping. This illustrates how training aims to maximize stability and minimize energy expenditure in movement, enabling the player to adapt more effectively to different situations. (Figure 21). An athlete will be drawn to certain movement patterns based on constraints imposed by their body, the environment, and the tasks they intend to perform.

Figure 21: Training



Source: Adapted from Bosch y Cook, 2015

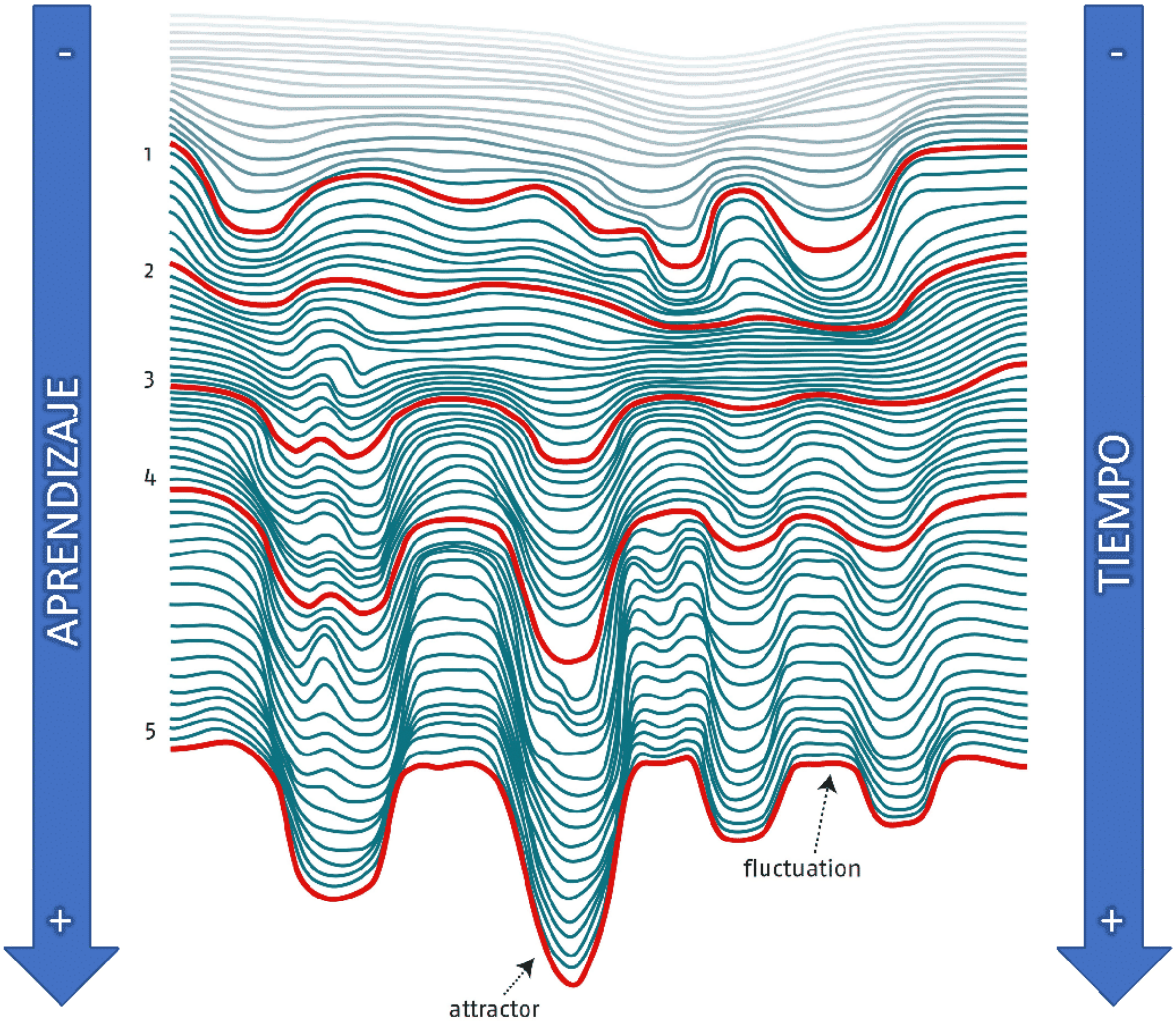
Moderate Stability	Moderately Unstable Attractor	Very Unstable Attractor	
	Attractor Basin 1	**Jump Process**	**Attractor Basin 2**
	High Stability	Stable Attractor	Unstable Attractor

When performing a movement for the first time, components from previously known similar movements are used. This approach limits the number of variables from the start, facilitating better control and successful execution of the movement.

However, if the selected attractors are not suitable, the movement becomes difficult to control, and performance decreases. In such cases, the body takes emergency measures by immobilizing several joints to regain control over the movement. This is known as the freezing of degrees of freedom. An example is a child kicking a ball for the first time, making all joints rigid, keeping knees extended, and immobilizing the torso to attempt to hit the target; this is a strategy to freeze degrees of freedom and maintain control over the complex throwing movement.

According to Bosch, while humans can perform an almost infinite number of movement tasks, there are relatively few basic movement patterns (running, jumping, and throwing) (Bosch and Cook, 2015). These basic movement patterns form the foundation for all movements. They are combined variably and adjusted to create a vast repertoire of complex movements. Attractors are the basic movements, and fluctuations are the movements that allow for adaptation and contextual adjustment. The attractor wells are deepened further to make movement performance more suitable and efficient for the body (Figure 22). Thus, strength training can play a crucial role in this process.

Figure 22: Attractors and Fluctuations in the Learning Process. The landscape of attractors and fluctuations evolves from the beginning (top) to the end (bottom) during the learning process



Source: Bosch and Cook, 2015, p.115.

With training, movement becomes extremely stable, and highly effective fluctuations are developed to adapt it to environmental demands. This allows movement control to become automatic. Mastering the movement enables its combination with perceptually complex environments.

Strength training helps refine fundamental movement patterns such as throws, jumps, runs, or combats. For example, coordinating ankle, knee, and hip extension during a jump is similar to the power clean exercise. Performing a power clean can teach the athlete how to optimize force production in that fundamental movement, and this skill can transfer to many other areas of the game.

It is essential that movements are interconnected and form part of a coherent matrix. There should also be relationships between 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 (Figure 23).

Figure 23: Movements

MOVIMIENTO OBJETIVO

MOVIMIENTO SIMULADO 1

Anclaje alto

MOVIMIENTO SIMULADO 2

Anclaje bajo

TARGET MOVEMENT

Source: Original work

SIMULATED MOVEMENT 1 -------------------------------- SIMULATED MOVEMENT 2

High Anchor -------------------------------- Low Anchor

The movement we aim to simulate, specifically the change in direction, is better represented by training task 2 (resistance from below). This is because resistance placed below forces the footballer to lower their center of gravity, mimicking the inertia involved in direction changes where gravity pulls the player towards the ground to varying degrees, depending on the speed prior to the movement.

Our system is designed to execute movements with varied muscle use, so we group movement solutions by similar intentions rather than by similar muscle activity. Our system focuses on reasoning from movement solutions to specific actions. Thus, when teaching a movement, it's crucial to include a clear intention in strength exercises.

Intention is fundamental to movement because there's a mechanism that supports movement control based on intention. Intended movements are guided by our attention. By concentrating on relevant aspects of the movement, we can control and learn the movement more effectively. Effective movement control involves directing attention towards the result of the action and using vision optimally, both central and peripheral.

An external focus, directed at the result of the movement, tends to be more effective than an internal focus on the execution details. This is because an external focus is based on the desired outcome, whereas an internal focus centers on the technical execution of the movement.

In summary, to optimize movement control and learning, it's important to incorporate clear intentions in strength exercises. Attention should be directed towards outcomes and vision should be used effectively. External focus, aimed at the result of the movement, is generally more beneficial than an internal focus on the details of the movement execution.

To enhance learning, it's essential to create an engaging environment in strength sessions, with motivation being a powerful driver of the learning process. Unknown links between sensory and motor patterns trigger motivation, starting the learning process when movements are successfully executed. For optimal learning, movements should not be repeated in the same way constantly. Variation is crucial for effective training. When planning physiological adaptations, variation should be a key feature of the training, alongside individualization.

Bernstein described the necessity of movement variation in learning as "repetition without repetition" (Bernstein et al., 1996). We learn not by repeatedly solving the same movement problem but by continuously tackling new movement problems. Learning and motivation are sparked by the appearance of unfamiliar sensory and motor patterns that do not fit into existing sensorimotor relationships. Learning occurs through encountering new experiences, rather than familiar ones.

In strength training, only a limited number of movements are typically performed compared to movements in competition, and traditional patterns are often not complex or diverse. Additionally, strength training provides minimal sensory stimulation, with little environmental information influencing the process.

In game movements, the visual system must estimate and calibrate both central and peripheral vision. For example, central vision helps judge contact timing, which plays a minimal role in strength training. Peripheral vision is crucial for control information through optical flow when moving through space, unlike in strength training where players usually do not move through space. This lack of sensory engagement makes strength training seem monotonous and boring. Traditionally, the only variation in strength training movements comes from changing the load on the bar. This monotony decreases cortico-spinal activity, reducing the ability to learn new skills. Monotony also hampers coordination transfer. Therefore, variation and avoiding monotony should be integral to strength training design.

Variable training enhances attractor wells by converting different movement variations into general application movements. This can only occur when tested and executed in all possible circumstances. During these tests, the number of effective control mechanisms will be significantly reduced, and only the remaining principles should be stored in long-term memory, eliminating or limiting inefficient behaviors.

Under the paradigm that strength training must be safe and free from injuries, it has been reasoned that training should remain within strict technical limits. But, actually, heavy loads pose a greater safety risk. Nevertheless, with low loads, safe and variable movements can be performed during strength training. Variation helps players develop fundamental movement control components. If strength training were viewed as coordination training against endurance, variable training would be a valuable method to explore stable and flexible patterns. Therefore, variable training can play a crucial role at every stage of an athlete’s development. Beginners can use it to establish a significant distribution between attractors and fluctuations, while elite athletes can use it to further enhance the difference between attractors and fluctuations in sports movements. Limited variation in exercises makes it challenging to identify generic principles, even if the exercises provide clear outcome information. Greater variation facilitates finding generic principles and linking them to relevant outcome information. However, excessive variation introduces too much information, reducing the relevance of outcome information. With extreme variation, moving towards random movement, anticipated and achieved results can no longer be compared, halting the learning process.

Thus, for exercise design, a general and simple rule is to choose exercises with maximum variation, ensuring the exercise intention remains close to the result of the sports movement to be optimized.

VARIATION IN STRENGTH TRAINING | SPECIFICITY | SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN ENERGY PRODUCTION. | SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN SENSORY RESPONSE. | PROG CO M

It is assumed that various motor programs are interconnected in the brain, which we refer to as specificity. Transfer refers to how movement patterns influence one another, and this is facilitated by specificity. Specificity can be divided into five categories:

- Similarity of movement due to similarities in the internal structure of the movement.

This includes similarity in intramuscular coordination (coordination within a muscle) and intermuscular coordination (cooperation between muscles).

- **Intramuscular Coordination**

Muscles can perform their work in various ways. Different types of muscle action (concentric, eccentric, isometric, and elastic) differ significantly, and proper movement execution involves clear transitions between them. Therefore, the specificity of an exercise at the intramuscular level largely depends on the type of muscle action involved. The first step to achieving specificity in strength training is ensuring similarity in the type of muscle action.

- **Intermuscular Coordination**

Strength training is also effective for optimizing muscle cooperation. Intermuscular coordination is complex and requires at least two conditions:

1. The movement must be executed effectively and efficiently, similar to the sports movement.
2. The movement must be controllable. This is only achievable if movement patterns are based on fixed principles that can be flexibly integrated into a complete pattern. This involves cocontractions and synergies that make the movement resistant to failure and control errors.

- **Similarity of movement due to similarities in the external structure (shape) of the movement.**

If various movement patterns result in externally similar movements (dynamic correspondence), there is a degree of specificity. This involves factors such as joint angles, movement speed, angular speed at joints, and direction of force application. Achieving high specificity and efficient transfer of exercises requires attention to similarities in the external structure of the movement.

VARIATION IN STRENGTH TRAINING	SPECIFICITY	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN ENERGY PRODUCTION.	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN SENSORY RESPONSE.	PROG CO M

This aspect of specificity is less applicable to strength training because energy production is not typically a limiting factor in performance compared to other neural factors. In other words, strength training does not focus on replicating the exact energy production used in a specific activity, as energy production is not usually the main determinant of performance. Instead, strength training aims to develop other neural aspects that enhance overall performance in various activities.

VARIATION IN STRENGTH TRAINING	SPECIFICITY	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN ENERGY PRODUCTION.	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN SENSORY RESPONSE.	PROG CO M

A distinction should be made between sensory organs that record environmental information (eyes, ears, vestibular system, touch, etc.) and those that record body state (proprioception, including muscle spindles, tendon sensors, and joint sensors). Therefore, there are two types of sensory organs: those that gather information from the environment and those that monitor the body's state. Sensory patterns influence movement. Sensory information from the environment perceived by sensory organs is generally not specific between strength training and sports movements. However, proprioception is crucial in strength training, especially for complex movements with low resistance and high speed. In these movement patterns, the main specificity is found in proprioception.

Similarity of movement due to similarities in movement intention.

The learning system reasons from the movement's intention to the process (muscle action), using intrinsic knowledge of results. An exercise will lead to transfer to a sports movement if the intention is similar in both cases.

Therefore, similarity in movement intention is a key feature of specificity. Specificity between movement patterns is influenced not only by similarity limits but also by other factors, such as:

- The need for overload to produce adaptations limits specificity.
- For sports movements lacking a clear intramuscular structure, as seen in slow sports movements, focusing on external structure may be more effective. Conversely, fast sports movements are better approached based on intramuscular and intermuscular structures, as replicating the external structure of fast movements with high resistance is challenging.
- Different types of strength training can positively impact one aspect of the movement but negatively affect another.

Proposal scheme for organizing simulation situations in coadjuvant training.

Based on the arguments presented, it's proposed to conduct strength training while respecting the strength configurating elements outlined by Tous (2017) and discussed in the previous module.

VARIATION IN STRENGTH TRAINING	SPECIFICITY	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN ENERGY PRODUCTION.	SIMILARITY OF MOVEMENT DUE TO SIMILARITIES IN SENSORY RESPONSE.	PROG CO M

In team sports, programming training stimuli presents challenges because, despite relying on athletics programming and knowledge, the complexity of player interactions and the environment complicates determining the appropriate intensity and volume. We must seek synergy between different training stimuli, addressing the complex nature of the load, which is not based solely on conditioning factors and bioenergetic parameters. Training should not only improve jumping or running abilities but also prepare athletes to interact effectively with the game context, including team dynamics. Decision-making is essential despite the complexity of the training process.

In the preseason, players must be progressively prepared for the demanding training and competition loads they will face. This period involves numerous adaptations; players need to adjust in all aspects: conditional structure (muscle, connective tissue, bone, etc.), bioenergetic structure, and coordinative structure, to reintegrate into the game after inactivity. If the coach changes the game model, players must adapt to the required behaviors and understand their teammates' behaviors. Therefore, starting with low-complexity tasks helps facilitate co-adaptation processes between players. Explosive actions, such as strikes or sprints in futsal, or jumps and high-intensity landings, should be introduced gradually in the preseason sessions and incorporated into more aggressive tasks over time. Initially, strength training will focus on protection rather than performance, starting with general sessions without emphasizing the coupling between perception and action cycles. Estimating the duration of this type of work in the preseason is challenging as it must adapt to player characteristics and club needs. For example, in a year with international competitions like the European Championship, where players return after competing and only have 7-10 days of rest, a longer adaptation phase may not be necessary. However, players who do not participate in the European Championship and have one month or more of vacation will require a longer adaptation period.

During the season, different types of microcycles can be planned based on the timing of the next match.

Figure 23: Different Microcycles

PARTIDO (DOM)		
1+	COMPLEMENTARIOS Y COMPENSATORIOS	ESTRUCTURAL
OFF	DESCANSO	
3-	CUALIDADES ESPECIFICAS	COMPENSATORIOS Y COMPLEMENTARIOS
2-	COMPLEMENTARIOS Y COMPENSATORIOS	ESTRUCTURAL
1-	POTENCIA	
PARTIDO -5 (SAB)		

MATCH (SUN)		
1	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL
OFF	REST	
3-	SPECIFIC QUALITIES	COMPLEMENTARY AND

		COMPENSATORY
2-	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL
1-	POWER	
MATCH - 5 (SAT)		

PARTIDO (DOM)		
1+	COMPLEMENTARIOS Y COMPENSATORIOS	ESTRUCTURAL
OFF	DESCANSO	
2-	COMPLEMENTARIOS Y COMPENSATORIOS	ESTRUCTURAL
1-	POTENCIA	
PARTIDO-4 (VIE)		

MATCH (SUN)		
1	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL
OFF	REST	
2-	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL
1-	POWER	
MATCH - 4 (FRI)		

MATCH (SAT)				
1	REST			
2-	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL		

1-	POWER		
MATCH -3 (WED)			

PARTIDO (DOM/SAB)		
1+/2-	COMPLEMENTARIOS Y COMPENSATORIOS	ESTRUCTURAL
1-	POTENCIA	
PARTIDO -2 (MIE/MAR)		

MATCH(SUN/SAT)		
1+ / 2-	COMPLEMENTARY AND COMPENSATORY	STRUCTURAL

1-	**POWER**
MATCH - 2 (WED/TUE)	

Source: Original work

During the season, within the structured microcycle, training will first depend on the previous match and the time required for players to return to their previous performance levels. Therefore, the early days of the week will involve low volume and intensity, with recovery and compensation sessions for players who did not participate in the match. For those who played, the efforts will be of low impact and low complexity. Should you train the day after the match or two days later? This decision will depend on factors such as the sport type, the season's timing, and the players' mental state.

Table 2: Sample Exercises for a Session +1 (Recovery)

Sample Exercises for a Session +1 (Recovery)	
1.	Dynamic low-intensity mobility exercises
2.	Hip muscle activation awareness exercises

3.	Strength exercises for compensatory muscles
4.	Structural upper body exercises
5.	Low-impact cardiovascular exercise, such as using a cycle ergometer

Source: Original work

Session -4 of the week aims to train the conditional structure. The exercises will be simple, making it the ideal day for structural training if needed, as there will be no interference between the optimizing training and coadjuvant training.

Table 3: Sample Exercises for a Session -4 (Structural)

Sample Exercises for a Session -4 (Structural)	
1.	1. Biseries of main and compensatory exercises
2.	Internal hip rotators in supine position
3.	External hip rotators in supine position
4.	Hamstring kick in hip extension while supine

5.	Quadriceps kick while prone
6.	Knee flexion while supine for distal hamstring work

Source: Original work

In session -3, we will focus on specific qualities. This will be the session with the highest load of the week, involving all player structures, although peripheral fatigue will not be the highest of the week, as polyarticular exercises will be performed, which do not produce significant residual fatigue.

Table 4: Sample Exercises for a Session -3 (Specific Qualities)

Sample Exercises for a Session -3 (Specific Qualities) Optimize jump strength	
1.	Triplet. Main (Squat) – Compensatory (2-support plank) – Application (drop with perturbation)
2.	Deadlift – Anti-extension – Unilateral jump
3.	Lateral lunge – Anti-rotation – Lateral step + jump with elastic resistance

Source: Original work

In session -2, we will perform compensatory and structural exercises with a protective role. We will reduce the training load to recover from the previous days' stimuli.

Table 5: Sample Exercises for a Session -2 (Structural Upper Body/Complementary and Compensatory)

Sample Exercises for a Session -2 (Structural Upper Body/Complementary and Compensatory)	
1.	Biseries. Main (push press) – Compensatory/complementary (shoulder stabilizers)
2.	Biseries. Main (pull up) – Complementary (scapular retractions)

Source: Original work

Session -1 will be dedicated to explosive actions. We will perform application exercises with low external resistance due to the speed of execution and low volume, ensuring that they do not cause fatigue that could affect the next day's match. In these sessions, we will use low-complexity stimuli, meaning we will focus on movements that do not increase the cognitive load of the session.

Table 6: Sample Exercises for a Session -1 (Structural Goal: Power)

Sample Exercises for a Session -1 (Structural Goal: Power)	
1.	Throws
2.	Plyometrics
3.	Olympic movements

Source: Original work

For a week with a match on Sunday and the next match on Sunday, the figure shows the distribution of 8.

Figure 24: Summary of the Microcycle During the Competitive Period (Futsal) with 1 Match Per Week

Source: Original work

Conditional State at Session Start

STRENGTH	COORDINATIVE	RELEASE	POWER	C
MORNING	MORNING	MORNING	MORNING	M
STRUCTURAL	COORDINATIVE	STRUCTURAL	SPEED	
STRENGTH FOCUS	ENDURANCE FOCUS	RELEASE	SPEED FOCUS	C

Source: Original work

These are simply examples that can be adjusted according to the team's needs, the time of the season, and each player's requirements. It is always crucial to prioritize what you believe will maximize the team's performance in both the short and long term.

In this module, we focused on explaining the importance of coadjuvant strength training in indoor team sports and how to design preferential simulation situations in different training sessions during a microcycle. However, it is essential to evaluate these exercises to understand how to progress.

To help players learn, we must create an engaging environment in strength sessions, where motivation acts as a strong driver of the learning process and helps form habits. This can be achieved through:

- ○ Closed training proposals
- ○ Demanding training sessions
- ○ Variation in training
- ○ Linear dynamics with a rigid and continuous order

SUBMIT

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