

## Cognitive processes in small-sided games Procesos cognitivos en pequeños juegos

\*Marcelo Couto Jorge Rodrigues, \*\*Lucas Savassi Figueiredo, \*Claudio Andre Barbosa de Lira, \*\*\*Lorenzo Laporta, \*Gustavo De Conti Teixeira Costa

\*Universidade Federal de Goia's (Brazil), \*\*Universidade Federal de Minas Gerais (Brazil), \*\*Universidade Regional Integrada do Alto Uruguai e das Missoes (Brazil)

**Abstract.** Team sports are played in highly unpredictable environments, in which players' cognitive processes are critical to successful Decision Making. Thus, it is important that training settings provide players a variety of game situations that will allow them to develop the cognitive processes related to their Decision-Making capacity. Accordingly, it is crucial to understand how to develop the cognitive processes to optimize teaching-learning processes and increase sports performance. Therefore, the aim of this point of view is to discuss the adoption of Small-Sided Games (SSGs) to develop cognitive processes related to Decision Making (perception, knowledge, and decision) considering the coaches' role in this process. Indeed, the multiple possibilities of modification of the SSGs lead to more opportunities to develop players' cognitive processes, since they rely more often on memory, knowledge, and decision towards solving the ever-changing situations experienced in the game. Hence, we propose that coaches have an important role in evaluating the players' needs and proposing the use of SSGs and their different manipulations. These diverse games are expected to promote practice variability and favor an unpredictable environment with several tactical experiences that represent a greater cognitive demand. In other words, since the processes related to Decision Making need to be activated more often and in different ways during diverse situations experienced in SSGs, players are provided with more opportunities to develop their cognitive processes.

**Keywords:** teaching; team sports; small-sided games; cognitive processes; training; decision making.

**Resumen.** Los deportes de equipo se practican en entornos muy imprevisibles, en los que los procesos cognitivos de los jugadores son fundamentales para tomar decisiones acertadas. Por ello, es importante que los entornos de entrenamiento ofrezcan a los jugadores múltiples posibilidades de juego, que les permitan desarrollar los procesos cognitivos relacionados con su capacidad de Toma de Decisiones. En consecuencia, es crucial entender cómo desarrollar los procesos cognitivos para optimizar los procesos de enseñanza-aprendizaje y aumentar el rendimiento deportivo. Por esta razón, el objetivo del presente punto de vista es discutir la adopción de los Pequeños Juegos (PJ) para el desarrollo de los procesos cognitivos relacionados con la Toma de Decisiones (percepción, conocimiento y decisión), teniendo en cuenta el papel de los entrenadores en este proceso. Así, las múltiples posibilidades de modificación de los PJ conducen a una mayor exigencia cognitiva a los jugadores, ya que éstos se apoyan con mayor frecuencia en los procesos perceptivo-cognitivos de memoria, conocimiento y decisión hacia la resolución de las situaciones siempre cambiantes que se viven en el juego. En este sentido, proponemos que el entrenador tenga el importante papel de analizar las necesidades de los alumnos y utilizar los PJ y sus diferentes manipulaciones. Se espera que estos juegos diversos promuevan la variabilidad de la práctica y favorezcan un entorno imprevisible con varias experiencias tácticas que representen una mayor demanda cognitiva. En otras palabras, dado que los procesos relacionados con la Toma de Decisiones necesitan ser activados más a menudo y de diferentes maneras durante los diversos PJ, se facilita el desarrollo de los procesos cognitivos.

**Palabras clave:** enseñar; deportes de equipo; pequeños juegos; procesos cognitivos; entrenamiento; toma de decisiones.

### Introduction

Since the publication of the Teaching Games for Understanding (TGfU) in 1982 by Bunker and Thorpe, several other models based on non-linear pedagogical theories have been proposed in order to overcome the traditional logic of teaching team sports. Employing non-linear pedagogy notions, coaches need to continually

access and assess the needs of players to support the process of searching, discovering and exploring practical solutions related to the sporting environment, in order to facilitate the generation of functional motor repertoires (Chow et al., 2007; Correia et al., 2019; Gómez-Criado & Valverde-Esteve, 2020; Pizarro et al., 2019). That is because non-linear pedagogy is based on ecological psychology, which leads to the manipulation of task constraints in order to stimulate the desired behavior for a given context and the stimulation of task variability, facilitating learning (Flores-rodríguez & Ramírez-macías, 2021; Práxedes et al., 2019; Práxedes,

Del Villar, et al., 2018). In other words, in a learning context based on the non-linear pedagogy, players will have different action possibilities, and will discover individual solutions for specific situations, depending on the existent constraints (Chow & Atencio, 2014). The concept of constraints was addressed by Newell (1986), and refers to the limitations or changes that somehow restrict the organization of the possible movements in a given context, which may involve physical characteristics, goals and allowed skills. That is, these constraints have the role of guiding the dynamics towards the desired goal (Chow et al., 2007; Correia et al., 2019).

All the teaching models based on non-linear pedagogical theories and on the TGfU model have a common characteristic: the use of Small-Sided Games (SSGs) and its constraints as a pedagogical tool (Gutiérrez, 2016). The SSGs, which are the focus of this study, are modified games played in smaller game spaces, with adapted rules and a reduced number of players than traditional games (Sarmiento 2018). These games are modified by the coaches in the sporting context based on the possibilities of adjusting the constraints (Clemente, 2014) in order to facilitate learning. Thus, SSGs are considered an important teaching tool to develop physical skills and tactical-technical behavior with similar training intensities to the ones of the formal game. This is achieved by exposing players to a high variability of information in the environment that depends on the specific characteristics of the games (i.e. game constraints) (Clemente et al., 2021; Hammami et al., 2017; Paul et al., 2016; Práxedes, Moreno, et al., 2018). These variable situations stimulate the players' ability to pay attention to key information that support the emergence of specific behaviors throughout the game (Coutinho et al., 2019; Davids et al., 2013; Travassos et al., 2012). In this regard, coaches are responsible for manipulating key game constraints to highlight information that are relevant to their training goals and help players to support their behaviors adequately based on these information (Sarmiento et al., 2018). This notion is well established in the literature, since studies show that the emergence of specific behaviors during SSGs depends on the constraints present during the game (Halouani et al., 2014; Hillhaas et al., 2011; Serra-Olivares et al., 2016). Therefore, changes in the game constraints will influence the athletes' behavior, the strategies, the tactical-technical elements performed and the players' motor solutions.

Although several studies in the SSGs literature

investigated its use in the development of physical resources and specific tasks of the sport (Clemente et al., 2021; Coutinho et al., 2019; Halouani et al., 2014), team sports are played in environments of constant unpredictability. As follows, players are constantly required to adapt their actions according to the game context. This uncertain environment affects player's perceptual-cognitive processes, such as Decision Making (DM), which is determinant to reach high levels of performance in sport (Práxedes, Moreno, et al., 2018; Silva et al., 2020). However, DM is influenced by knowledge and the ability to retrieve information from memory. This agrees with the notion that the individual's sporting actions reflect the interaction between the different perceptual cognitive processes (Vitor de Assis et al., 2020). Consequently, it is crucial to understand how to develop cognitive processes to optimize teaching-learning processes and increase performance. In this point of view, we aimed to highlight the need to understand these processes in team sports and how the SSGs can be employed during training sessions as a pedagogical tool that contribute to developing DM. This is particularly important because, literature indicates that it is possible to manipulate these games according to the purpose of the training to obtain specific results (Fernández-Espínola et al., 2020; Robles et al., 2020; Serra-Olivares et al., 2016; Torreblanca-Martínez et al., 2019). Therefore, we will discuss the adoption of SSGs for the development of cognitive processes related to DM, taking into account the coaches' role in this process. We hope to contribute to the literature adding to studies related to the optimization of cognitive variables in the sports teaching-learning process and helping coaches plan their training sessions.

### *Cognitive processes related to Decision Making*

In team sports, a motor action performed by an player involves more than physical variables that resulted in this movement, but also the underlying processes that led to the choice of that particular motor action (Gréhaigne et al., 2001). Playing well means having the ability to choose an appropriate action at a given situation when several other actions are possible, and performing it in the best possible way, which is the concept of DM (Gréhaigne et al., 2001; Vitor de Assis et al., 2020). Conforming to Bar-Eli, Plessner, and Raab (2011), expertise in DM arises from cognitive processes related to the ability to perceive, understand and generate responses, which highlights the cognitive processes of perception, knowledge and decision. That

said, we will discuss and how these three cognitive processes related to DM (perception, knowledge, and decision) operate in team sports and how coaches can develop these processes employing SSGs as a pedagogical tool during training sessions.

### *Perceptual-Cognitive Processes*

Knowing where and when to look is crucial for team sports performance, which implies that players need to use attention appropriately to direct their perceptual processes to relevant information during the game (Machado et al., 2020). Thus, the mental constructs called perceptual-cognitive skills refer to these abilities to identify and perceive information in a given environment (Scharfen & Memmert, 2019). Based on a proper employment of these skills, players are able to perform the corresponding motor action quickly and efficiently in order to meet the context's needs (Cardoso et al., 2021; Assis et al., 2020). Consequently, extracting information from the environment guides the individual to successful behaviors (Mann et al., 2007). That is why developing these perceptual-cognitive processes is important to guide behavior towards good decision-making in the sports environment.

Literature on DM indicates that high-level athletes employ qualitatively different perceptual-cognitive mechanisms and strategies that facilitate this process, allowing them to make more precise and faster decisions compared to less experienced athletes (Alves et al., 2013; Low et al., 2020; Mann et al., 2007). In other words, expert players are different from non-expert because they know how to identify areas that provide them relevant information and how to direct perceptual cognitive processes, such as their attention, in an appropriate way to extract this information (Mann et al., 2007; Scharfen & Memmert, 2019). Consequently, experts not only make good decisions that will be transformed into good sports actions, but also know how and when to apply these good actions based on the information generated in the different context of their sport practices (Iglesias Gallego et al., 2010; Mann et al., 2007). Thus, it is important to explore effective ways to improve the player's perceptual-cognitive processes, since these show a strong relationship with the practical structure of training sessions (Roca & Ford, 2020).

Many sensory systems influence the DM process, however Bar-Eli et al. (2011) propose that training these systems separately from the game context, as in teaching models based on direct instruction, may not benefit DM.

This occurs because the information during the game is constantly changing, which is not inherent to these direct instruction-based models. Considering this, we argue that coaches need to plan training sessions with tasks that allow players to explore the environment for relevant information under different game situations, in order to optimize the perceptual-cognitive skills of players. One of the ways that coaches can provide players with highly variable environments is through SSGs, which can be modified in terms of the size of the field, number of players, and rules (Arias et al., 2016; Timmerman et al., 2019). These multifold possibilities for SSGs modifications allow the modulation of the constraints of game situations and guide the players' perception of relevant information to achieve the task goals. Consequently, they allow players to adapt and diversify their action possibilities to an ever-changing game environment similar to a real competitive context (Práxedes, Moreno, et al., 2018). Accordingly, the meta-analysis carried out by Mann et al. (2007) indicate that activities that take place on high variability and unpredictability environments require from players perceptual-cognitive and motor demands similar to those present in the formal game are. The multitude of game situations experienced by players in the SSGs will serve as a basis for them to make adequate decisions based on the different possibilities of action.

### *Memory and Knowledge*

In addition to the information perceived from the environment, players' decisions are influenced by information that is available in their memory. In such way, memory may affect an individual's behavior based on previous experiences. Therefore, memory refers to the process of storing and retrieving these experiences from practice (Hockenbury & Hockenbury, 2010). The knowledge acquired by the players' through experience influence the perception and interpretation of the available information, which affects the player's response to a given game situation (Kirk & MacPhail, 2002; Machado et al., 2020). This type of knowledge obtained from sportive actions is called Tactical Knowledge, as defined by Gréhaigne and Godbout (1995). This knowledge may relate to rules and perceptual-cognitive processes (i.e. «Knowing what to do» or «Declarative Tactical Knowledge»), or to motor skills and problem solving during the game («Know how to do it» or «Tactical Processual Knowledge») (Fernández-Echeverría et al., 2015; Gréhaigne et al., 2001). Although this type of knowledge - especially declarative

tactical knowledge - is related to the verbalization of concepts, it is obtained from practical application, that is, when the players experiences the results of their actions and stores the outcomes in their long-term memory (Gréhaigne et al., 2001). In particular, it is worth pointing out that players with higher Tactical Knowledge (whether declarative or procedural) are capable of reading the game and identifying the different cues presented in sports practice more efficiently, allowing them to perceive and take better advantage of game opportunities (Praça et al., 2018). Consequently, these players are able to make better decisions during game situations, since they also use perceptual-cognitive mechanisms more efficiently to regulate their future actions (Ramos et al., 2020).

In this respect, SSGs can be an efficient tool to optimize the development of these forms of knowledge, given the multiple possibilities of modification. Whether adjusting the size of the field, the number of players or the proposed rules, the simplification of game situations are expected to reduce the complexity of the game. This would facilitate the players' understanding of the logic of the formal game, and increase their direct participation, resulting in more practice opportunities (Halouani et al., 2014; Práxedes, Moreno, et al., 2018). To illustrate, Praça et al. (2018) investigated soccer SSGs with numerical superiority, which required players to adapt their tactical behaviors to this specific game context. As expected, this particular modification influenced athletes' perceptual and physiological demands, based on the level of procedural tactical knowledge of players. Thus, we advise coaches to employ SSGs as a viable alternative for the development of tactical knowledge, since they provide multiple modifications possibilities in the game environment. When properly applied, these variable settings may induce the development of the cognitive processes related to DM, and the emergence of successful tactical behaviors in response to specific situations (Bredt et al., 2018; Correia et al., 2019). This may allow coaches to develop specific tactical aspects according to specific goals of the practice session.

### **Decision Making**

We proposed in this point of view that players' actions are a consequence of task conditions in a given game situation. In other words, depending on the analysis of the game situations carried out through perceptual-cognitive processes, and the knowledge stored in their memory, players will decide what do and how to

implement the selected answer (Kirk & MacPhail, 2002; Mann et al., 2007; Sousa et al., 2021). From this point, players reach the last stage related to DM, which is the decision itself. Perception and knowledge are thought to act like a filter, allowing players to consider and reject an action hypothesis in a given situation (Figure 1). That is, the player should consider a decision compatible to several aspects, including his technical abilities (Bar-Eli et al., 2011). These aspects will determine whether the decision will become valid (i.e. transformed into an action) or not (Gréhaigne et al., 2001). Therefore, although we focused on the perceptual-cognitive processes related to DM in this point of view, we do not ignore the importance of the technical skills in this process, which should be a tool for tactical performance (Kolman et al., 2019). Thus, the teaching of technical skills becomes important, as it is required in tactical behavior, increasing the possibilities for action and consequently diversifying the decisions to be made (Kirk & MacPhail, 2002). As an example, a soccer player will only have the option to kick the ball with the non-dominant leg as an option if he has a minimum proficiency in this motor skill, otherwise this will not be a viable decision possibility in the game. Hence, it is argued that the technique should not be taught/trained separately from the tactical and cognitive aspects, since these aspects are inseparable in team sports (Práxedes, Del Villar, et al., 2018). To illustrate, a volleyball setter needs to have a good overhead passing technique and a good ability to read the game towards to perform an efficient set to the hitters. Players without these well-trained features will hardly progress in sport.

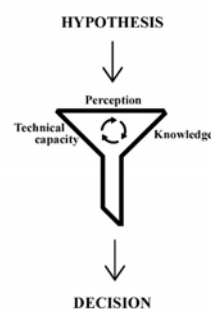


Figure 1. Perception, technical capacity and knowledge acting as a filter for the hypothesis to become a decision.  
Source: The Authors

Considering the proposed model, it is argued that perceptual training and DM can be implemented using SSGs, thus incorporating the technical skills inherent to specific tasks to the many possibilities of action in different game situations (Kirk & MacPhail, 2002). In such a way,

responding to the actions of teammates and opponents in reduced game situations would come closer to the actual demands imposed by the game, promoting the integration of cognitive processes associated with DM. This contrasts with training predetermined situations in a predictable context, which is a recurring fact in technical training under direct instruction models (Santos et al., 2016) that are still employed by coaches in team sports trainings even today. Therefore, the use of SSGs as a pedagogical tool for the development of sports performance must be emphasized, as it results in a higher level of sporting experience for players, since the technique is trained along with the DM elements (Kinnerk et al., 2018). This can be achieved through specific modifications in the SSGs, which may favor the occurrence of specific motor skills within an unpredictable game context that requires constant decisions to be made.

### ***The role of the coach in the teaching-learning process***

One way coaches can enhance the teaching-learning process is by promoting an environment with positive experiences for players, especially in the early years of practice. With this in mind, it is essential to provide the players meaning to what is taught, in order to facilitate their development (Feu et al., 2019; Fransen et al., 2018; Santos et al., 2016). When considering the SSGs as a teaching-learning pedagogical tool, the coach act as a facilitator in this process, providing greater motivation to the players when playing games. Indeed, literature indicates that SSGs are able to influence the direction and intensity of players' behaviors towards their goals (Alcalá & Garijo, 2017). Practice conditions that induce increased expectations and support for autonomy, such as the SSGs, generate positive physiological and psychological responses, including motor learning (Beltrán et al., 2018; Gil-Arias et al., 2017; Wulf & Lewthwaite, 2016). More than that, the coach may stimulate dialogues and encourage players to reflect, building enjoyable learning, aligned with the goals of the training sessions.

Regarding the implementation of SSGs by coaches, we emphasize that we do not propose a practice setting that is restricted to playing games, nor an authoritarian practice setting completely defined by the coach. We propose a practice setting in which a connection between the players' practice, behavior, and learning is considered. In this respect, we believe that the use of SSGs can be an effective way to establish this connection,

considering the player at the center of the teaching-learning process (Kinnerk et al., 2018; Práxedes, Moreno, Sevil, García-González, et al., 2016). Thus, Macnamara, Moreau, & Hambrick (2016) propose a practice setting that involves activities to improve performance in specific domains, developing a cooperative learning process with the player. Along these lines, it is up to the coach to understand and consider the characteristics of his players. Based on these information the SSGs should be employed in the training setting, along with its modifications, in order to generate multiple game situations that are both suitable to the players and to develop the competences aimed by the coach.

In practical terms, assessing the payers' decision-making, physical, tactical and technical skills, as well as other variables that are relevant in the training processes may provide relevant information to coaches (González-Villora et al., 2015; Klingner et al., 2021). Practice situations in which the assessment contexts are similar to the real performance environment are preferable, which can be the case of SSGs, that promotes more representative environments than isolated skills testing (Klingner et al., 2021). With this purpose, there are evaluation tools that can be used in the analysis of SSGs, such as: GPAI (Oslin et al., 1998), TSAP (Gréhaigne et al., 1997), GPET (García-López et al., 2013), and FUTSAT (Costa et al., 2011). Thus, coaches must employ appropriate tools to answer the questions that are inherent to the sports performance they intend to analyze.

### **Practical Applications**

Coaches are warranted to understand the specific characteristics and needs of their players in order to successfully use SSGs as a pedagogical tool to develop perceptual-cognitive abilities related to DM (e.g. perception, knowledge and decision). Furthermore, it is essential to comprehend how the manipulation of game constraints affects the emergence of specific behaviors. Thus, we will present some practical examples that elucidate the relationship between game constraints and the emergence of specific behaviors, helping coaches on how to manipulate the game constraints in order to developing specific abilities. The following studies investigated the use of SSGs in soccer trainings, a sport modality that has a wide range of investigations in this area.

The first SSGs constraints' manipulation that we will

portray is the adjustment in the number of players. In general, reducing the number of players per team in SSGs is a good strategy to improve the players' perceptual-cognitive ability to perceive and act. This is because players find themselves in a context where they will need to make more contact with the ball, which results in more DM processes while in possession of the ball (Práxedes et al., 2019). Similarly, using SSGs with numerical inequality may also develop improve cognitive performance, since these contexts amplify the information sources that regulate DM (Sousa et al., 2021). More specifically, decreasing the number of opponents (Práxedes, Moreno, et al., 2018) or inducing numerical superiority in the attack (Práxedes, Moreno, Sevil, Pizarro, et al., 2016) creates a context that allows players in possession of the ball to have more time to make decisions and organize their offensive actions, due to reduced pressure exerted by opponents.

Another type of SSGs constraints' manipulation relates to the rules of the game. These include restricting the amount of contacts with the ball per player, limiting technical actions, modifying the goals of the game, manipulating the number and shape of goals, among others (Fernández-Espínola et al., 2020). Among the multiple possibilities of SSGs, it seems that manipulating the goal of the game is decisive to facilitate Perceptual-cognitive learning. Namely, games in which players have the objective of scoring the goal present higher rates of decision-making and action execution in comparison with game formats in which the goal is to maintain ball possession (Serra-Olivares et al., 2011). However, coaches must be aware of the excessive use of rules, which can end up excessively restricting the number of possibilities for players' actions (Machado et al., 2019). This may not be ideal for DM training, as it may create a context that is too divergent from the formal game.

Adjusting the pitch size is yet another SSGs constraints' manipulation that coaches may use aiming to achieve the goals of the training session (Clemente et al., 2020). Literature indicates that manipulating the pitch size in SSGs affect perceptual-cognitive demands related to DM by influencing the area covered by the players (Clemente et al., 2020; Fernández-Espínola et al., 2020). This, in turn, influences the players' perception of space, conditioning their occupation and use, as well as the distances between players and their interactions (Clemente et al., 2020; Fernández-Espínola et al., 2020). In addition, reducing the size of the field will increase the number of technical actions performed (Sarmiento et al., 2018), and consequently will increase

the amount of decisions made per player.

Finally, it is important to emphasize that other variables may influence the development of processes related to DM in SSGs, such as the players' age and experience. In short, studies indicate that older and more experienced players present better tactical behavior in SSGs (Clemente et al., 2021; Fernández-Espínola et al., 2020), in addition to explore the game context more effectively, by better positioning themselves on the field (Clemente et al., 2020). However, coaches should be aware of an important issue reported by González-Víllora et al. 2010 and González-Víllora et al. (2013), in which players developed procedural tactical knowledge (i.e. knowledge more related to motor skills) more quickly than declarative tactical knowledge (i.e. knowledge more related to perceptual-cognitive processes). These findings suggest that, although we argue that players must practice in order to develop cognitive aspects related to DM, practice alone may not be enough for the development of these cognitive aspects in some cases. Thus, coaches must structure their training sessions so that information is provided through other ways than practice itself, seeking to develop cognitive abilities more efficiently.

### **Final considerations**

In conclusion, to use SSGs effectively in training sessions, coaches must consider the players' skills and experiences, so that pedagogical principles of modification are properly applied, aiming that players deal with tactical problems that are compatible with their skills. In this way, SSGs are a mean to increase and diversify the sources of information experienced by players, which develops, in a timely manner, their cognitive processes (Práxedes, Moreno, Sevil, García-González, et al., 2016). Considering that the perceived perceptual signals work as a basis for the players' decisions that need to be fast, accurate and reflected upon the demands of the game, these cognitive processes allow the individual to use the information of the environment to make adequate decisions, influencing the outcomes of the game (Scharfen & Memmert, 2019). Thus, the use of SSGs and its different manipulations can promote a variability of practice and favor an unpredictable environment with several tactical experiences that represent a greater cognitive demand. In other words, since the processes related to DM (perception, knowledge and decision) need to be activated more often and in different ways during diverse SSGs, the

development of cognitive processes is facilitated. In summary, we argued in this point of view that employing SSGs might be effective for the development of players in team sports. In fact, evidence presented throughout this point of view indicates that SSGs may favor physical, technical-tactical, and psychological performance, in addition to cognitive performance. However, in order to achieve such benefits, coaches must conduct the use of this pedagogical tool during practice sessions considering the players' characteristics, needs, and goals.

Finally, future investigations are necessary to deepen the understanding on how the SSGs develops cognitive processes during the pedagogical practice of team sports and their relationship with the development of tactical-technical, psychological, and physical aspects in players. Particularly, we believe it is important direct more attention to the SSGs itself, and not to a given teaching model. This would allow a better understanding on this pedagogical tool's benefits, and on how to optimize its use during training sessions. Once these aspects are addressed, it would be possible to latter investigate the use of SSGs within specific pedagogical proposals, aiming to maximize the results of the teaching process. Thus, we suggest that future studies should evaluate specifically how different court sizes, number of players, or modifications in the rules affect the development of these cognitive processes in different sports practices, not only in soccer as we approached in the practical applications section of this study. We believe that these studies may provide coaches specific knowledge for the teaching-learning process in each sport, guiding the use of SSGs in training sessions conforming to the specific goals players must achieve.

### Financing

Ministry of Science, Technology, Innovation and Communications (MCTIC) and National Council for Scientific and Technological Development (CNPq).

### Conflict of interests

There is no conflict of interest.

### Author contributions

Conception and design of the manuscript: [GCTC, MCJR e LL]. Manuscript writing: [MCJR, LSF e CABL]. Manuscript translation: [LSF e GCTC]. Correction of the manuscript to adjust to the topics covered [All

authors]. All authors read and approved the final version of the manuscript.

### References

- Alcalá, D. H., & Garijo, A. H. (2017). Teaching Games for Understanding: A Comprehensive Approach to Promote Student's Motivation in Physical Education. *Journal of Human Kinetics*, 59(1), 17–27. <https://doi.org/10.1515/hukin-2017-0144>
- Alves, H., Voss, M. W., Boot, W. R., Deslandes, A., Cossich, V., Salles, J. I., & Kramer, A. F. (2013). Perceptual-cognitive expertise in elite volleyball players. *Frontiers in Psychology*, 4(MAR), 1–9. <https://doi.org/10.3389/fpsyg.2013.00036>
- Arias, A. G., Arroyo, M. P. M., Rabaz, F. C., Domínguez, A. M., & Del Villar Álvarez, F. (2016). Manipulación de los condicionantes de la tarea en Educación Física: Una propuesta desde la pedagogía no lineal. *Retos*, 29, 22–27.
- Bar-Eli, M., Plessner, H., & Raab, M. (2011). Judgement, Decision Making and Success in Sport. In *e-conversion - Proposal for a Cluster of Excellence*.
- Beltrán, H. C., Reigal, R. E., Uribe, S. F., Reyes, F. V., & Ríos, L. J. C. (2018). Self-determined motivation and state of flow in an extracurricular program of small sided games. *Anales de Psicología*, 34(2), 391–397. <https://doi.org/10.6018/analesps.34.2.258621>
- Bredt, S. G. T., Morales, J. C. P., Andrade, A. G. P., Torres, J. O., Peixoto, G. H., Greco, P. J., Praça, G. M., & Chagas, M. H. (2018). Space Creation Dynamics in Basketball Small-Sided Games. *Perceptual and Motor Skills*, 125(1), 162–176. <https://doi.org/10.1177/0031512517725445>
- Cardoso, F. da S. L., Afonso, J., Roca, A., & Teoldo, I. (2021). The association between perceptual-cognitive processes and response time in decision making in young soccer players. *Journal of Sports Sciences*, 39(8), 926–935. <https://doi.org/10.1080/02640414.2020.1851901>
- Chow, J. Y., & Atencio, M. (2014). Complex and nonlinear pedagogy and the implications for physical education. *Sport, Education and Society*, 19(8), 1034–1054. <https://doi.org/10.1080/13573322.2012.728528>
- Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research*, 77(3), 251–278. <https://doi.org/10.3102/003465430305615>
- Clemente, F. M. (2014). Uma visão integrada do modelo teaching games for understanding: adequando os estilos de ensino e questionamento à realidade da educação física. *Revista Brasileira de Ciências Do Esporte*, 36(2), 587–601. <https://doi.org/10.1590/S0101-32892014000200021>

- Clemente, F. M., Afonso, J., Castillo, D., Arcos, A. L., Silva, A. F., & Sarmento, H. (2020). The effects of small-sided soccer games on tactical behavior and collective dynamics: A systematic review. *Chaos, Solitons and Fractals*, 134, 109710. <https://doi.org/10.1016/j.chaos.2020.109710>
- Clemente, F. M., Afonso, J., & Sarmento, H. (2021). Small-sided games: An umbrella review of systematic reviews and meta-analyses. *PLoS ONE*, 16(2 February), 1–22. <https://doi.org/10.1371/journal.pone.0247067>
- Correia, V., Carvalho, J., Araújo, D., Pereira, E., & Davids, K. (2019). Principles of nonlinear pedagogy in sport practice. *Physical Education and Sport Pedagogy*, 24(2), 117–132. <https://doi.org/10.1080/17408989.2018.1552673>
- Costa, I. T., Garganta, J., Greco, P. J., Mesquita, I., & Maia, J. (2011). Sistema de avaliação táctica no Futebol (FUT-SAT): Desenvolvimento e validação preliminar. *Motricidade*, 7(1), 69–84. [https://doi.org/10.6063/motricidade.7\(1\).121](https://doi.org/10.6063/motricidade.7(1).121)
- Coutinho, D., Gonçalves, B., Santos, S., Travassos, B., Wong, D. P., & Sampaio, J. (2019). Effects of the pitch configuration design on players' physical performance and movement behaviour during soccer small-sided games. *Research in Sports Medicine*, 27(3), 298–313. <https://doi.org/10.1080/15438627.2018.1544133>
- Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and Sport Sciences Reviews*, 41(3), 154–161. <https://doi.org/10.1097/JES.0b013e318292f3ec>
- Fernández-Echeverría, C., Moreno Arroyo, A., Gil Arias, A., Claver Rabaz, F., & Moreno Arroyo, M. P. (2015). Estudio del conocimiento procedimental, experiencia y rendimiento, en jóvenes jugadores de voleibol (Study of procedural knowledge, experience and performance in young volleyball players). *Retos*, 2041(25), 13–16. <https://doi.org/10.47197/retos.v0i25.34467>
- Fernández-Espínola, C., Robles, M. T. A., & Fuentes-Guerra, F. J. G. (2020). Small-sided games as a methodological resource for team sports teaching: A systematic review. *International Journal of Environmental Research and Public Health*, 17(6). <https://doi.org/10.3390/ijerph17061884>
- Feu, S., García-Rubio, J., de Gracia Gamero, M., & Ibáñez, S. J. (2019). Task planning for sports learning by physical education teachers in the pre-service phase. *PLoS ONE*, 14(3), 1–18. <https://doi.org/10.1371/journal.pone.0212833>
- Flores-rodríguez, J., & Ramírez-macías, G. (2021). *Pedagogía no lineal en balonmano. Defensa zonal de una y dos líneas en partidos reducidos Non-linear pedagogy in handball. One and two lines zone defence in small-sided games*. 2041(2015), 604–613.
- Fransen, K., Boen, F., Vansteenkiste, M., Mertens, N., & Vande Broek, G. (2018). The power of competence support: The impact of coaches and athlete leaders on intrinsic motivation and performance. *Scandinavian Journal of Medicine and Science in Sports*, 28(2), 725–745. <https://doi.org/10.1111/sms.12950>
- García-López, L. M., Villora, S. G., Gutierrez, D., & Serra, J. (2013). Development And Validation Of The Game Performance Evaluation Tool (Gpet) In Soccer. *SPORT TK-Revista EuroAmericana de Ciencias Del Deporte*, 2(1), 89–99. <http://revistas.um.es/sporttk/article/view/185791/153701>
- Gil-Arias, A., Harvey, S., Cárceles, A., Práxedes, A., & Del Villar, F. (2017). Impact of a hybrid TGfU-Sport Education unit on student motivation in physical education. *PLOS ONE*, 12(6), 1–17. <https://doi.org/10.1371/journal.pone.0179876>
- Gómez-Criado, C., & Valverde-Esteve, T. (2020). Nonlinear pedagogy and its application in a volleyball didactic unit: a practical approach (La pedagogía no lineal y su aplicación en una unidad didáctica de voleibol: un enfoque práctico). *Retos*, 2041(39), 805–810. <https://doi.org/10.47197/retos.v0i39.78223>
- González-Villora, S., García-López, L. M., Del Campo, D. G. D., & Contrerasjordan, O. R. (2010). Estudio descriptivo sobre el desarrollo táctico y la toma de decisiones en jóvenes jugadores de fútbol (12 años). *Infancia y Aprendizaje*, 33(4), 489–501. <https://doi.org/10.1174/021037010793139644>
- González-Villora, S., Serra-Olivares, J., Pastor-Vicedo, J. C., & da Costa, I. T. (2015). Review of the tactical evaluation tools for youth players, assessing the tactics in team sports: football. *SpringerPlus*, 4(1), 1–17. <https://doi.org/10.1186/s40064-015-1462-0>
- González Villora, S., García López, L. M., Gutiérrez-Díaz, D., & Pastor-Vicedo, J. C. (2013). *Tactical awareness, decision making and skill in youth soccer players (under-14 years)*.
- Gréhaigne, J., & Godbout, P. (1995). Tactical Knowledge in Team Sports From a Constructivist and Cognitivist Perspective. *Quest*, 47(4), 490–505. <https://doi.org/10.1080/00336297.1995.10484171>
- Gréhaigne, J., Godbout, P., & Bouthier, D. (1997). Performance Assessment in Team Sports. *Journal of Teaching in Physical Education*, 89–111. <https://doi.org/10.4324/9780203100578-12>
- Gréhaigne, J., Godbout, P., & Bouthier, D. (2001). The Teaching and Learning of Decision Making in Team Sports. *Quest*, 53(1), 59–76.
- Gutiérrez, D. (2016). Game-Centered Approaches: Different Perspectives, Same Goals—Working Together for Learning. *Research Quarterly for Exercise and Sport*, 87(1), S23–S24. <https://doi.org/10.1080/>



- 02701367.2016.1200422
- Halouani, CHTOUROU, H., GABBETTI, T., CHAOUACHI, A., & CHAMARI, K. (2014). SMALL-SIDED GAMES IN TEAM SPORTS TRAINING: ABRIEF REVIEW. *Journal of Strength and Conditioning Research*.
- Hammami, A., Ksarsaid, P. E., Gabbett, T., Solutions, G. P., Slimani, M., & Bouhlel, E. (2017). Does Small-Sided Games Training Improve Physical-Fitness and Specific Skills for Team Sports/ ? A Systematic Review with Meta-Analysis. *J. Sports Med. Phys. Fitness*. <https://doi.org/10.23736/S0022-4707.17.07420-5>
- Hill-haas, S. V, Dawson, B., Impellizzeri, F. M., & Coutts, A. J. (2011). Physiology of Small-Sided Games Training in Football A Systematic Review. *Sports Medicine*, 41(3), 199–220.
- Hockenbury, D. H., & Hockenbury, S. E. (2010). *Discovering psychology*. Macmillan.
- Iglesias Gallego, D., García González, L., García Calvo, T., León del Barco, B., & Villar Álvarez, F. del. (2010). Expertise development in sport: contributions under cognitive psychology perspective. *Journal of Human Sport and Exercise*, 5(3), 462–475. <https://doi.org/10.4100/jhse.2010.53.16>
- Kinnerk, P., Harvey, S., MacDonncha, C., & Lyons, M. (2018). A Review of the Game-Based Approaches to Coaching Literature in Competitive Team Sport Settings. *Quest*, 70(4), 401–418. <https://doi.org/10.1080/00336297.2018.1439390>
- Kirk, D., & MacPhail, A. (2002). Teaching Games for Understanding and situated learning: Rethinking the Bunker-Thorp model. *Journal of Teaching in Physical Education*, 21(2), 177–192. <https://doi.org/10.1123/jtpe.21.2.177>
- Klingner, F. C., Huijgen, B. C., Den Hartigh, R. J., & Kempe, M. (2021). Technical–tactical skill assessments in small-sided soccer games: A scoping review. *International Journal of Sports Science & Coaching*, 1747954121110495. <https://doi.org/10.1177/174795412111049532>
- Kolman, N. S., Kramer, T., Elferink-Gemser, M. T., Huijgen, B. C. H., & Visscher, C. (2019). Technical and tactical skills related to performance levels in tennis: A systematic review. *Journal of Sports Sciences*, 37(1), 108–121. <https://doi.org/10.1080/02640414.2018.1483699>
- Low, B., Coutinho, D., Gonçalves, B., Rein, R., Memmert, D., & Sampaio, J. (2020). A Systematic Review of Collective Tactical Behaviours in Football Using Positional Data. In *Sports Medicine* (Vol. 50, Issue 2). Springer International Publishing. <https://doi.org/10.1007/s40279-019-01194-7>
- Machado, G., González-Villora, S., Sarmiento, H., & Teoldo, I. (2020). Development of Tactical Decision-making Skills in Youth Soccer Players: Macro- and Microstructure of Soccer Developmental Activities as a Discriminant of Different Skill Levels. *International Journal of Performance Analysis in Sport*, 20(6), 1072–1091. <https://doi.org/10.1080/24748668.2020.1829368>
- Machado, J. C., Ribeiro, J., Palheta, C. E., Alcântara, C., Barreira, D., Guilherme, J., Garganta, J., & Scaglia, A. J. (2019). Changing rules and configurations during soccer small-sided and conditioned games. How does it impact teams' tactical behavior? *Frontiers in Psychology*, 10(JULY). <https://doi.org/10.3389/fpsyg.2019.01554>
- Macnamara, B. N., Moreau, D., & Hambrick, D. Z. (2016). The Relationship Between Deliberate Practice and Performance in Sports: A Meta-Analysis. *Perspectives on Psychological Science*, 11(3), 333–350. <https://doi.org/10.1177/1745691616635591>
- Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). *Perceptual-Cognitive Expertise in Sport/ : A Meta-Analysis*. 457–478.
- Newell, K. (1986). Constraints on the development of coordination. *Motor Development in Children: Aspects of Coordination and Control*.
- Oslin, J. L., Mitchell, S. A., & Griffin, L. L. (1998). The Game Performance Assessment Instrument (GPAI): Development and preliminary validation. *Journal of Teaching in Physical Education*, 17(2), 231–243. <https://doi.org/10.1123/jtpe.17.2.231>
- Paul, D. J., Gabbett, T. J., & Nassis, G. P. (2016). Agility in Team Sports/ : Testing , Training and Factors Affecting Performance. *Sports Medicine*, 46(3), 421–442. <https://doi.org/10.1007/s40279-015-0428-2>
- Pizarro, D., Práxedes, A., Travassos, B., del Villar, F., & Moreno, A. (2019). The effects of a nonlinear pedagogy training program in the technical-tactical behaviour of youth futsal players. *International Journal of Sports Science and Coaching*, 14(1), 15–23. <https://doi.org/10.1177/1747954118812072>
- Praça, G. M., Bredt, S. G. T., Torres, J. O., Custódio, I. J. O., Andrade, A. G. P., Morales, J. C. P., Chagas, M. H., & Greco, P. J. (2018). Influence of numerical superiority and players' tactical knowledge on perceived exertion and physical and physiological demands in soccer small-sided games. *Rev. Psicol. Deport*, 27, 31–38.
- Práxedes, A., Del Villar Álvarez, F., Moreno, A., Gil-Arias, A., & Davids, K. (2019). Effects of a nonlinear pedagogy intervention programme on the emergent tactical behaviours of youth footballers. *Physical Education and Sport Pedagogy*, 24(4), 332–343. <https://doi.org/10.1080/17408989.2019.1580689>
- Práxedes, A., Del Villar, F., Pizarro, D., & Moreno, A. (2018). The Impact of Nonlinear Pedagogy on Decision-Making

- and Execution in Youth Soccer Players According to Game Actions. *Journal of Human Kinetics*, 62(1), 185–198. <https://doi.org/10.1515/hukin-2017-0169>
- Práxedes, A., Moreno, A., Gil-Arias, A., Claver, F., & Villar, F. Del. (2018). The effect of small-sided games with different levels of opposition on the tactical behaviour of young footballers with different levels of sport expertise. *PLoS ONE*, 13(1), 1–14. <https://doi.org/10.1371/journal.pone.0190157>
- Práxedes, A., Moreno, A., Sevil, J., García-González, L., & del Villar, F. (2016). A preliminary study of the effects of a comprehensive teaching program, based on questioning, to improve tactical actions in young footballers. *Perceptual and Motor Skills*, 122(3), 742–756. <https://doi.org/10.1177/0031512516649716>
- Práxedes, A., Moreno, A., Sevil, J., Pizarro, D., Villar, F. Del, & Del Villar, F. (2016). Efecto de la Igualdad y Desigualdad Numérica en Juegos Modificados sobre el Rendimiento Táctico en Jóvenes Futbolistas. *Journal of Sport Pedagogy & Research*, 2(1), 22–29.
- Ramos, A., Coutinho, P., Davids, K., & Mesquita, I. (2020). Developing Players' Tactical Knowledge Using Combined Constraints-Led and Step-Game Approaches—A Longitudinal Action-Research Study. *Research Quarterly for Exercise and Sport*, 00(00), 1–15. <https://doi.org/10.1080/02701367.2020.1755007>
- Robles, M. T. A., Collado Mateo, D., Fernández Espínola, C., Viera, E. C., & Fuentes Guerra, F. J. G. (2020). Effects of teaching games on decision making and skill execution: A systematic review and meta analysis. *International Journal of Environmental Research and Public Health*, 17(2). <https://doi.org/10.3390/ijerph17020505>
- Roca, A., & Ford, P. R. (2020). Decision-making practice during coaching sessions in elite youth football across European countries. *Science and Medicine in Football*, 4(4), 263–268. <https://doi.org/10.1080/24733938.2020.1755051>
- Santos, S. D. L., Memmert, D., Sampaio, J., & Leite, N. (2016). The spawns of creative behavior in team sports: A creativity developmental framework. *Frontiers in Psychology*, 7(AUG), 1–14. <https://doi.org/10.3389/fpsyg.2016.01282>
- Sarmiento, H., Clemente, F. M., Harper, L. D., Teoldo, I., Owen, A., Figueiredo, A. J., Sarmiento, H., Clemente, F. M., Harper, L. D., Costa, T., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer – a systematic review. *International Journal of Performance Analysis in Sport*, 18(5), 693–749. <https://doi.org/10.1080/24748668.2018.1517288>
- Scharfen, H. E., & Memmert, D. (2019). Measurement of cognitive functions in experts and elite athletes: A meta-analytic review. *Applied Cognitive Psychology*, 33(5), 843–860. <https://doi.org/10.1002/acp.3526>
- Serra-Olivares, J., García-López, L. M., & Calderón, A. (2016). Game-based approaches , pedagogical principles and tactical constraints: examining games modification. *Journal of Teaching in Physical Education*, 35(3), 208–218.
- Serra-Olivares, J., González, S., García, L. M., Castilla, U., & Mancha, L. (2011). Comparação Do Rendimento De Jogo De Jogadores De Futebol Entre 8-9 Anos Em Dois Jogos Modificados 3 Contra 3. *Cuadernos de Psicología del Deporte*, 11, 77–91.
- Silva, A. F., Conte, D., & Clemente, F. M. (2020). Decision-making in youth team-sports players: A systematic review. *International Journal of Environmental Research and Public Health*, 17(11), 1–23. <https://doi.org/10.3390/ijerph17113803>
- Sousa, H., Gouveia, E. R., Marques, A., Sarmiento, H., Lopes, H., & Ihle, A. (2021). The effect of balanced versus unbalanced football small-sided games on decision-making in youth football players. *Retos*, 42, 744–749. <https://doi.org/10.47197/RETOS.V42I0.88052>
- Timmerman, E. A., Savelsbergh, G. J. P., & Farrow, D. (2019). Creating appropriate training environments to improve technical, decision-making, and physical skills in field hockey. *Research Quarterly for Exercise and Sport*, 90(2), 180–189. <https://doi.org/10.1080/02701367.2019.1571678>
- Torreblanca-Martínez, V., Cordero-Ojeda, R., & González-Jurado, J. A. (2019). Análisis de variables condicionales y técnico-tácticas mediante juegos reducidos. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación*, 35, 87–90. <http://eds.a.ebscohost.com/eds/pdfviewer/pdfviewer?vid=3&sid=2df212ef-6f97-4d13-8658-b7fa8534e6bb%40sdc-v-sessmgr03>
- Travassos, B., Araújo, D., Davids, K., Vilar, L., Esteves, P., & Vanda, C. (2012). Informational constraints shape emergent functional behaviours during performance of interceptive actions in team sports. *Psychology of Sport and Exercise*, 13(2), 216–223. <https://doi.org/10.1016/j.psychsport.2011.11.009>
- Vítor de Assis, J., González-Villora, S., Clemente, F. M., Cardoso, F., & Teoldo, I. (2020). Do youth soccer players with different tactical behaviour also perform differently in decision-making and visual search strategies? *International Journal of Performance Analysis in Sport*, 20(6), 1143–1156. <https://doi.org/10.1080/24748668.2020.1838784>
- Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin and Review*, 23(5), 1382–1414. <https://doi.org/10.3758/s13423-015-0999-9>