JYU DISSERTATIONS 501

Timo Laakso

From Individual to Collective Tactical Behaviour in Youth Football

Effects of Players Roles and Field Location

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF SPORT AND
HEALTH SCIENCES

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ABSTRACT

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The main purpose of this thesis was to investigate the tactical behaviour in football in order to gain more understanding on how demands on the field constrain the way that the players expose possibilities for action. The aim was also to investigate the effects of players' roles (e.g., defenders, midfielders, and attackers) in different field locations and sub-phases of game. The findings support the idea that it is important to understand how manipulated constraints in team games practice can influence the tactical behaviour of players and how players explore such variations. Fifteen U15 male players (age 13.2 ± 1.03 years; years of practice 4.2 ± 1.10 years) from the same club participated in this study (2016/2017 season). For the purposes of the analysis, on advice from the coaching staff, participants were categorised according to their main playing role, resulting in sub-samples of five defenders (centre-back and full-backs), seven midfielders (centre midfielders and lateral midfielders) and three attackers (forwards).

The theoretical framework of this study is based on ecological dynamics. Accordingly, tactical behaviours of players and teams result from information exchanges that emerge among players, based on their action capabilities (physical, technical, and tactical). Ecological dynamics views competitive performance of sports teams as emerging from the sharing of available affordances (opportunities or possibilities for action) that exist in a performance environment. To optimize players' tactical abilities, coaches need to design training sessions with representative learning tasks that ensure that practice has similar perceptual-action relationship to competitive matches. Toward this goal, Small-sided and conditioned games (SSCGs) are commonly used in football training. SSCGs reproduce randomness, unpredictability, and complexity of the formal match and may involve 1-vs-1, 2-vs-1, and 3-vs-3 formats. SSCGs offer various possibilities for manipulating key informational task constraints (e.g., number of players, pitch dimensions etc.) to induce different training responses according to the learning aim.

In the first study it was observed that field location as well as players' role constrained players' tactical behaviour for dribbling and shooting in 1-vs-1 football situations. In the second study, in the analysis of the 2-vs-1 football situations, similar results were observed. A general main effect of field location was observed with changes in spatial-temporal relations of players between field locations. Related to participants' roles, defenders revealed subtle differences on their tactical behaviour when compared with midfielders and attackers. At the end, in

the third study, an effect of players' roles in teams' tactical actions of play and effectiveness were observed between teams of defenders, midfielders and attackers. Due to differences in performance context, players with different playing roles seem to exploit affordances and perform differently in competitive 3-vs-3 SSCGs (small-sided and conditioned games).

Based on the findings of this doctoral dissertation, implications for the design of practice tasks can be advocated. Attackers and defenders can be exposed to different relative positions to the goal for training dribbling and shooting, with changes in the preferred foot of both attackers and defenders. That personal constraint manipulation will encourage greater exploration of possibilities for action of attackers to shoot when presented with a more open or closed angle to the goal. Such a manipulation may even encourage participants to explore shooting with the non-preferred foot, depending on the affordances offered by information from the positioning of defenders, relative to the goal. Also, for defenders, such a manipulation will help them to improve their defensive positioning relative to the goal, and to identify and prevent the use of the preferred foot of attackers. This exploration of capabilities for action of other performers, based on some key information, will allow learners to become more effective and flexible in their behaviours. Players' roles seem to have an impact on their current capabilities for action. Thus, to improve player performance, early exposure to diverse experiences in the contexts of play and in required perception and action capacities instead of specialization (as defenders or attackers) can/may help learners to improve their adaptability to the different performance contexts to which they are exposed during competition.

Keywords: football, ecological dynamics, tactical behaviour, Small-Sided and Conditioned Games, player's roles

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Football has had a crucial role in my life and my career is long, but modest. I started to kick the ball as a 4-year-old and played for almost 35 years. After that I coached for several years and lastly, I became a researcher. Nowadays I have a great privilege to follow football as a role of father. My two youngest kids play football in local teams JJK and JyPK.

I thank the Faculty of Sport and Health Sciences of the University of Jyväskylä for the opportunity to combine teaching and this doctoral dissertation. I was lucky to have a total of three supervisors. First, I would like to express my special appreciation to Professor Bruno Travassos. Without Bruno's expertise, knowledge, and valuable help during the whole process I would have never been able to finish this thesis. Me and my family have spent several enjoyable months in Covilha, Portugal with a great hospitality of Bruno and his family. The time spent on this thesis took so long, that my second supervisor, emeritus professor Jarmo Liukkonen retired in the meantime. Jarmo has been a part of my academic career since 2002, when I started my licentiate thesis. Jarmo has always been eager to help and to comment and I really admire his common wisdom of academic issues and of life generally. After Jarmo, I was fortunate to have professor of practice Mihaly Szerovay as my supervisor. As a former football player, Mihaly was familiar with the thematic of football and Misi's commitment to my thesis was invaluable. He always finds time to discuss, and he encouraged me with his calm and discreet way to make my own decisions. He was also a great help with the linguistic quality of my texts. Football is a team sport. The better players you have in the team, the better your team usually plays. I was really honoured to have Professor Keith Davids and Professor Pekka Luhtanen to my co-writers' team. Keith is highly respected, and his professional ability was tremendous during this process. Pekka is extremely recognized in the domain of football. His knowledge and experience of football is unique and his modesty as a person is totally respectable.

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FIGURES

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ORIGINAL PUBLICATIONS AND AUTHOR CONTRIBUTION

The present thesis is based on the following original articles.

Laakso, T., Travassos, B., Liukkonen, J. & Davids, K. 2017. Field location and player roles as constraints on emergent 1-vs-1 interpersonal patterns of play in football. Human Movement Sciences 54, 347-353.

Laakso, T., Davids, K., Liukkonen, J. & Travassos, B. 2019. Patterns of play in 2-vs-1 contexts of football: the effects of field location and player roles. Frontiers of Psychology, 10:1407.

Laakso, T., Davids, K., Luhtanen, P., Liukkonen, J. & Travassos, B. 2021. How football team composition constrains emergent individual and collective tactical behaviours: Effects of player roles in creating different landscapes for shared affordances in small-sided and conditioned games. International Journal of Sports Science & Coaching, 0(0) 1-9.

As the first author of the original publications, considering the comments from the co-authors, my responsibility has been to formulate the research questions, to design the experiments, to collect all the data and to take the main responsibility of writing the manuscripts.

CONTENTS

1 GENERAL INTRODUCTION

Football has a long and rich history, though it was formalised as we know it today by the establishment of the Football Association in 1863. The earlier versions of the game existed much earlier in Mesoamerican cultures, China, and Ancient Greece. The game soon spread to continental European countries and later to South America and other areas. The governing world body, the Federation of the International Football Association (FIFA), was set up in 1904 and the first Olympic football competition was held in 1908. Currently football is the most popular game in the world when considering the number of spectators or the number of players. Over 265 million people in 211 member associations play it on every continent in the world (FIFA 2017). Football is also the most popular game in Finland, with a total of almost 141000 licensed players (Suomen Palloliitto, 2021).

The game of football has gone through a massive evolution from a violent game with no rules to a highly complex team sport where performance is a consequence of the capacity of each player, with their own physical, technical, and tactical skills, to link with each teammate to accomplish a shared purpose in relation to opponents (Stolen et al., 2005). The present level of football development, characterized by great dynamics and a fast game pace, requires exceptional physical preparedness, high levels of movement technique (Sever & Zorba, 2017), tactical awareness and mental stability (Momčilović et al., 2020). Every football match puts several demands on players. According to Güllich, (2013) these demands include physical, technical, and tactical aspects, and because of this multifaceted nature it is a difficult sport to achieve a high level of performance (Güllich, 2013; Sarmento, Anguera et al., 2018). Football is intermittent in nature, requiring high intensity running and sprinting (Di Salvo et al., 2006). The elements of athleticism and endurance are obvious requirements for the expert performer; therefore, specific technical and decision-making skills are thought to be the most critical aspect of soccer (Bush et al., 2015; Reilly et al., 2000). These qualities are needed in contesting and retaining possession of the ball, maintaining a high work-rate for 90 minutes of play, reacting quickly and appropriately as opportunities arise and regulating mental attributes before and during match-play (Reilly & Doran, 2003). During a match, players perform a number of individual

technical-tactical skills including heading, shooting, tackling and crossing, with passing being the most commonly executed skill, which they may execute between 40-60 times a match (Dellal et al., 2011). Consequently, players unintentionally (and unexpectedly) change the intervals of high and low intensity, as well as their duration, according to changes in the game environment. During a match, a player performs between 1400 and 1600 changes of intensity and direction of movement, or changes every 3.5-4 seconds (Verheijen, 1998). On the other hand, players sprint every 90 seconds, on average, and have high-intensity efforts every 30 seconds (Reilly et al., 2000). Therefore, the game of football can be described as a complex activity with acyclic intervals (Momčilović et al., 2020).

A variety of performance analyses mainly give insight into players' individual football performance. However, it should be considered that the performance of football players is not merely determined by their individual characteristics but also conditioned by the opposition-cooperation relationship between teammates and opponents during the game. Twenty-two players, representing two opposing teams, play football on a 105 x 68 m pitch with a ball, regulated by playing rules, with the aim of winning the match by scoring more goals than the opponent (Olthof, 2019). Thus, "there is a conflict in the relation between the players present on the pitch: ball possession entitles players to attack and score a goal, but opponent players will make every effort to prevent that. This creates cooperation of players within a team and competition between players of opponent teams" (Olthof, 2019, 12).

In this respect, "football can be characterized by its temporary interactions between players, formation of sub-groups and unpredictability, and rather than a limited focus on only individual performance, football science can benefit from a more comprehensive understanding of football performance" (Olthof, 2019, 13). The available literature describes football as a game including sub-systems with intra- and inter-dynamic interactions. So, the dynamical structure of team sports could be investigated from individual (Travassoss et al., 2011) to collective (Folgado et al., 2014; Frencken et al., 2011) interactions.

2 THEORETICAL FRAMEWORK

2.1 Football as a dynamical system

In line with the ecological dynamics approach, "individual players and sports teams can be modelled as complex social systems, which are inherently nondeterministic (not completely predictable). Such social neurobiologigal systems exhibit functional patterns of coordination at a global system level. These coordination tendencies continuously emerge from ongoing interactions between system components (within and between individual players)" (Davids et al., 2013, 155). Functional patterns of coordinated behaviour emerge via performer-environment relations through processes of self-organization through performers' interactions with each other under specific task and environmental constraints (Araújo et al., 2006). In complex social neurobiological systems, self-organization is the fundamental principle for explaining how order emerges amongst different components (Davids et al., 2006).

According to Travassos, Araújo, Duarte et al., (2012) "ecological dynamics conceives sport performance as a continuous process of co-adaptation between players in space and time to identify the most functional possibilities for action" (Travassos, Araújo, Duarte et al., 2012**,** 85). They also suggest, that "in order to understand the performance of a team or player, there is a need to investigate how players and teams manage the relations with teammates and opponents in space and time during emergence of patterns of play at different levels" (Travassos, Araújo, Duarte et al., 2012, 85), that is, the dynamic interactions between different sub-systems of player-player (or dyadic), a group of players and intra and inter-team coordination (Olthof, 2019). On different levels, the basic unit of analysis is the attacker-defender relationship, which constitutes the lower level (dyadic relation) of the game dynamics analysis. In football, "attacker-defender, midfielder-midfielder and defender-attacker interactions will also be forged and broken constantly as each team intermingles with the other in their contest for

possession of the ball" (McGarry et al., 2002, 777). The aim of each player is to couple and decouple the spatial-temporal relations with a direct opponent to promote stability or instability in the dyadic relation, according to the team dynamics. In dyadic subsystems, each defender seeks to counteract the movements of immediate attackers in order to maintain system symmetry (to prevent the immediate attacker from gaining a positional advantage that allows him/her to threaten the goal) (Davids et al., 2005; McGarry et al., 2002). However, with decreasing interpersonal distances between opposite players, a state of "criticality" in one or more dyadic systems may be attained (Passos, Araújo, Davids & Shuttleworth, 2008). In this case, a sudden change in the structural organization of the systems towards one or two possible states may be about to occur, suggesting an advantage for the attacker (e.g., the defenders are not able to balance the attackers' action and the attackers may move past their immediate opponent) or an advantage for a defender (e.g., the attacker is not able to break system symmetry and a defender may intercept the ball, reversing the attacker-defender roles). Either way, system stability during team games can be broken and a new pattern of coordination in the team game can suddenly emerge through a process known as system-breaking (Duarte et al., 2010: Passos, Araújo, Davids & Shuttleworth, 2008). Vilar, Araújo, Davids, Travassos, Duarte, et al. (2012) suggest, that "the key point is how attackers manage the spatial-temporal relations with defenders during performance (i.e., captured by variables like relative velocity, interpersonal distance and interpersonal distance to the goal area). Attackers apparently need to account for the positioning of their teammates (group dynamics) when trying to gain an advantage over the defensive unit. The number of options for attackers to pass to a teammate is also extremely important in successful offensive patterns and the creation of goal-scoring opportunities" (Vilar, Araújo, Davids, Travassos, Duarte et al., 2012, 34). Thus, the dyadic relations between attackers and defenders should be continuously integrated in the group and team dynamics by considering intra-team and inter-team coordination, which reflects the cooperation within a team or competition between teams, respectively (Olthof, 2019).

Accordingly, the tactical behaviours of players and teams result from information exchanges that emerge among players based on their action capabilities (physical, technical, and tactical) (Folgado et al., 2018; Travassos, Duarte et al., 2012). Players and teams constantly interact to form synergies and create information, making decisions and organizing actions, according to collective *possibilities for action* of the team, known as affordances (Araújo et al., 2006; Gibson, 1979). In football, the players are able to perceive the availability of space and other players, which provides information about the possibilities for action (affordances) such as an open space, space to run into or time to shoot. Ecological dynamics views competitive performance of sports teams as emerging from the sharing of available affordances (Silva et al., 2013). According to Gibson (1979), affordances are opportunities or possibilities for action that exist in a performance environment. Players' adaptations to changes in competitive performance environments are regulated by the environmental information surrounding each individual, which they perceive in order to interact with other individuals

(Gonçalves et al., 2017). Information in team sports changes instantaneously, and ecological dynamics reveals how performers perceive properties of performance environments as opportunities to act (i.e., affordances) (Gibson, 1979). For each individual as well as collective sub-units of players (e.g., attackers, defenders, midfielders), previous research has revealed that affordances emerge as a functional relation between players and the game environment, and consequently its use is dependent on each individual's intentions, motivations, values and capabilities (Araújo et al., 2017). According to their individual capacities and intentions, different individuals in a specific game environment could use different affordances due to differences in their situational intentions, skill levels and attunement to the information that supports the actions required by their roles (Jordet et al., 2020; Laakso et al., 2017).

Specifically, affordances capture the fit between individual performer constraints and relevant properties of specific performance environments sustaining players' tactical behaviour. As Davids et al. (2013) suggest, "perceiving an affordance through the visible tactical behaviour is to perceive how one can act under specific performance conditions, which need to be simulated carefully in training tasks. In team sports, we have observed that individuals couple actions to relevant properties of performance environments" (Davids et al., 2013, 156). These environments can be e.g., the distance to a teammate/opponent (Travassos, Araújo et al., 2012), goal or target area (Travassos et al., 2018; Vilar, Araújo, Davids, Travassos, Duarte et al., 2012) and the location of the ball relative to a teammate/opponent (Travassos, Araújo et al., 2012; Vilar, Araújo, Davids & Travassos, 2012). According to Davids et al. (2013), "affordances are dynamic, continuously changing across ongoing performer-performer(s) interactions, providing the rationale for a more extensive focus on manipulation of Small-Sided and Conditioned Games (SSCG) and the changing of tactical behaviour of players in team games training" (Davids et al., 2013, 156).

2.2 From individual to collective tactical behaviour

From the concept of affordances, tactical behaviour can be broadly defined as the capability of individuals to select functional actions to achieve a specific task goal from a number of action possibilities (Hastle, 2001). Tactical behaviour in open games like football cannot be understood as a normative and linear process (Newell et al., 2003). Actions and decisions are commonly described as unique to every situation and cannot be prepared in advance (Petiot et al., 2021).

In football, players' tactical behaviours are based upon information coming from different sources like the ball, teammates and opponents, with opponents trying to restrict the time and space available for play. All the attacking and defending players are constantly performing different skills. For example, to progress on the field by means of passing, all the attackers need to move to create an open space by moving to the sides of the field or helping the ball carrier to pass the ball by moving away from the defender. In this sense, we can say that the

tactical behaviour of a pass does not emerge only due to the decision of the ball carrier but by the interpersonal relations that they constantly forge and break with other players to create the spatial-temporal conditions for a successful pass. According to Correia et al. (2012), in team ball sports the number of possibilities for action is large and constantly changing, requiring that players constantly adjust their tactical actions to the emergent individual but also to collective opportunities for play. Araújo & Davids (2009) suggest, that "in order to determine the different possibilities of action towards achieving a specific goal and then select a response, the athlete must engage in an active and continuous process of searching and exploring relevant information to the game context" (Araújo & Davids, 2009). In this respect, the tactical behaviour of an athlete is based on intentional adaptations to the constraints imposed in a specific game situation or during the performance of a specific task (Araújo & Davids, 2009; Travassos, Duarte et al., 2012). For instance, studies have found that good players are able to direct their attention to relevant information and to anticipate probable events during play (Aksum et al., 2020; Vítor de Assis et al., 2020). Such abilities allow players to make coherent decisions, a quality known as tactical intelligence (Casanova et al., 2009).

2.3 Understanding players' roles to improve game understanding

Match performance of football is the result of the interaction of technical, tactical and physical activities presented by players within a match (Bush et al., 2015; Dellal et al., 2012). As in other team sports, the football team's success is the result of individual, group and collective tactics combined with an appropriate level of technical and physical performance of players from different playing positions playing different roles in a football match (Bush et al., 2015; Yi et al., 2018). A football team "consists of 11 individuals, all of which must undertake specific roles and associated functions in each specific position in order to make a successful team" (Hughes et al., 2012, 404). These positions describe both the player's main role and their scope of operation on the pitch. Therefore, players are placed in certain positions to fulfil specific tasks. Although modern players should be able to play in different positions, the truth is that every position on the team is associated with a number of specific tasks. Traditionally, players' roles can be defined as follows. Goalkeepers are the only players who can touch the ball with their hands in their own penalty area. They are typically the last line of defence, and their role is to prevent the opponent from scoring. The defenders are the players situated in front of the goalie and, in general, a defender's primary area of play is the defensive third of the field. The main responsibility of defenders is to block shots and stop the other team's offence from passing, receiving, shooting and scoring. In 11-per-side versions of football, the role of defenders when in possession of the ball is to initiate attacks by creating space to pass the ball to the midfield players and ensure the creation of space for supportive passes to maintain ball possession under pressure. The midfielders' role is to operate between

attackers and defenders, creating variability in the exploration of possibilities for the action of attackers to destabilize the defending team and then score goals. The attackers' main role is to perform in the areas of the field outnumbered by defenders, with restrictions on space and time to receive the ball, dribble and create opportunities to assist or to shoot at the goal. Attackers should have good skills with the ball to win 1-vs-1 contests with immediate opponents and to dribble into critical scoring spaces. Therefore, for greater efficiency, the players are placed in different positions in order to meet specific tasks and provide team superiority (Stølen et al., 2005).

Accordingly, the positional difference should not be disregarded when evaluating players' match performance, and an individualised criterion is needed to identify the characteristics and demands of each playing position (Butterworth et al., 2013). Sarmento et al. (2014) reviewed previous studies and concluded that players' positions were previously classified into either three (defenders, midfielders and attackers) or five groups (central defenders, external defenders, central midfielders, external midfielders and attackers). The latter category may provide more detailed information about the players' match performance on the field, as players are given a more specific tactical role in modern football (Sarmento et al., 2014; Yi et al., 2018).

Most of the previous research mainly concerns the physical demands or anthropometric and physiological characteristics of different positional roles based on time-motion analysis. Researchers have found physiological and anthropometric differences across playing positions. For example, adult elite football players cover 8 to 14 km during an official match, of which 1.5 to 3.3 km are performed with high intensity (Mohr et al., 2003). Accordingly, variations in physical patterns are given by positional roles. Modric et al. (2019) found central defenders having the shortest and central midfielders having the greatest covered distances. Also, other studies have revealed that central backs are the playing position with lower overall performance than other players, covering on average 9.5 km to 10.5 km during matches, while midfielders run greater distances of about 10.5-11.5 km (Gai et al., 2019; Rivilla-García et al., 2019). Central defenders seem to cover less total distance and perform less high-intensity running compared to other positions (Bradley et al., 2009; Di Salvo et al., 2006; Rampinini, Coutts et al., 2007), whereas fullbacks and midfielders seem to perform more sprint activity (Di Salvo et al., 2009). Yet, strikers and wings have a greater decline in high-intensity bursts when their own team have ball possession (Di Salvo et al., 2006). In other studies, the longest total distance during a game was covered by the central midfielders, ahead of external defenders, forwards and central defenders (Andrzejewski et al., 2014). Fullbacks and forwards showed higher sprinting ability and better agility, while central defenders covered the shortest total distance and presented the least sprinting time. However, strikers have been found to perform the most maximal sprints and for longer durations, followed by midfielders and defenders (O'Donoghue, 1998). In addition, it has been reported that fullbacks and midfielders show the best performance in the intermittent exercise test and have the highest maximal oxygen intakes (Reilly et al., 2000). Rienzi et al. (2000) also

identified that defenders perform more backwards movement than strikers with high-intensity backwards and lateral movement. Furthermore, different soccer-related activities such as slide tackling, powerful heading and long passing give extra physiological stress to the player (Bangsbo, 1994), with different playing positions having to perform specific activities for different proportions of match time. For example, strikers and centre backs are significantly more engaged in situations where they have to jump or are required to head the ball, whereas defenders tend to make more tackles (Reilly, 2003; Bangsbo, 1994). In elite football, forwards are the fastest players, and according to some studies they sprint the longest distances in a game. The slowest players are goalkeepers, followed by midfielders (Rienzi et al., 2000). Given the fact that there are different requirements in the match, differences were found in elite players based on their physical characteristics in the different positions they play.

Therefore, it is possible that due to the specific game-related roles of players in different positions (e.g., making goals, organizing the build-up), in addition to physical capabilities, playing position may also influence the tactical behaviour of players (Deprez et al., 2015; Pocock et al., 2019). Some initial investigations have attempted to address this issue and demonstrated that midfielders make better decisions compared to defenders and forwards (Höner, 2005). However, there has been limited research investigating the position-specific tactical match demands that characterize the dyadic and group relations of players from different playing positions. Research is needed to measure tactical behaviour in different game contexts, such as build-up (i.e., wing and central defence situations) and offensive (i.e., midfield and forward situations) game-based decisions. For improvement of performance of players from different playing positions and for the development of most adequate training processes, there is a need to not only characterize individual capabilities but also to understand players spatial-temporal relations, which characterize the tactical behaviour of different playing positions.

2.4 Training processes in football

According to Passos, Araújo, Davids & Shuttleworth (2008), "traditionally, during training in team sports like football, tasks are often designated for performance without opponents or with passive opposition to simplify decision-making during repetitive drills under conditions of reduced uncertainty" (Passos, Araújo, Davids & Shuttleworth, 2008, 127). This is because active opposition creates variability and uncertainty for the interpersonal interactions that emerge between players during training (Davids et al., 2013). The use of static markers may benefit repetition of discrete performance outcomes during practice, especially early in learning (Chow et al., 2007). Davids et al. (2013) suggest, that "these drills can enhance the development of speed, endurance, flexibility, power and performance of specific technical actions by increasing the number of shots at the goal, passes to teammates, dribbling sequences, and interceptions/tackles made. For

example, when coaching dribbling in football, learners are first taught to control the ball in isolation so that they can later concentrate on running between players with the ball. These drills, in which information is reduced, may constitute a useful step before progression to more realistic and dynamic learning contexts". (Davids et al., 2013, 155.)

According to Davids et al. (2013), the main problem of these type of drills is when "designed to improve physiological or technique performance, is that they tend to isolate an action from the performance context (creating what has been termed ''closed'' environments) and may not allow functional performance behaviours to emerge during interpersonal interactions of players (in more ''open'' environments)" (Davids et al., 2013, 155). Competitive team games are unpredictable, noisy and dynamic performance environments in which information sources rarely are assured in advance and emergent actions are highly context-dependent (Travassos, Duarte et al., 2012; Vilar, Araújo, Davids, & Button, 2012).

Increasing players' tactical awareness under different simplified but dynamic scenarios requires the coaching staff to design and develop representative practice environments, maintaining similar perceptual-motor relations to the competitive settings (Pinder et al., 2011). In this sense, small-sided games and conditioning games (SSCGs) are suggested to be an excellent practice tool to stress the players' decision-making and move towards a better understanding of tactical performance (Davids et al., 2013).

Hill-Haas et al. (2011) describes SSCGs as "a modified games played on reduced pitch areas, often using adapted rules and involving a smaller number of players than traditional football games" (Hill-Haas et al., 2011, 201). SSCGs were adopted as a structured coaching method by legendary Dutch coach Rinus Michels, who with Johan Cruyff built the great Ajax team of the early 1970s. The first studies of SSCGs were based on the relationship between playing area dimensions, number of players involved, and the physiological effects generated (Halouani et al., 2014). Recently, the studies have demonstrated that aside from improving the physical capacity of the players, SSCGs can also be designed to develop the tactical and skill components of team performance (Davids et al., 2006; Chow et al., 2006). SSCGs are nowadays widely considered to offer many practical advantages, leading to their popularity as a training modality in football at all ages and levels. The primary benefits of SSCGs are that, even though these games are often less structured, they appear to replicate the movement demands, physiological intensity and technical requirements of competitive match play while also requiring players to make decisions under pressure and when fatigued (Gabbett & Mulvey, 2008; Owen, 2003). In high-performance sports, it has been well documented that maximum benefits are achieved when the training stimuli are similar to competitive demands (Bomba, 1983). Also, Katis & Kellis (2009) consider, that "due to the smaller pitch and the smaller number of players during these games, each player comes into contact with the ball and deals with common game situations more often. These situations require good technical skills, such as passing, dribbling, and kicking, as well as tactical skills, such as running without the ball, unmarking and cooperation with other players". (Katis & Kellis, 2009,

417.) In addition, compared with traditional fitness training sessions, SSCGs have been thought to increase player compliance and motivation, perceived to be sport-specific (Little, 2009).

In addition, SSCGs reproduce the unpredictability, randomness, and complexity of a formal match (Travassos, Vilar et al., 2014). SSCGs offer various possibilities for the manipulating of key informational task constraints (number of players, pitch dimensions, etc.) to induce different training responses according to the learning aim (Davids et al., 2013; Sampaio et al., 2014; Travassos, Araújo et al., 2012; Travassos, Gonçalves et al., 2014). These manipulations are used to shape the key task constraints that performers need to satisfy in practice sessions. The intention is to expose players to particular situations and conditions that represent key aspects of competitive performance (Ometto et al., 2018). From an ecological dynamic's perspective, performance behaviours emerge from the dynamic interaction of each individual and with the task (Davids et al., 2013). Consequently, the manipulation of SSCG formats allows for the highlighting of constraints of competitive contexts and guiding of individual and collective tactical behaviours; it also provides opportunities to experience the physical, physiological, and technical demands of competition in a contextualized way (Travassos, Gonçalves et al., 2014).

According to Davids et al. (2013), the manipulation of constraints in SSCGs can be exemplified "in terms of a) environmental constraints (i.e. playing on wet/dry or hard/soft surfaces, in high/low temperatures, on natural/artificial grass), b) task constraints (e.g. number of players involved, field dimensions, number of goals or rules of the game) or c) individual constraints (e.g. technical, physical, chronological age groupings, fatigue status and previous experience)" (Davids et al., 2013, 4). Accordingly, SSCGs offer several possibilities for manipulation of key task constraints to shape the emergence of co-adaptive team behaviours through an exploration of performance solutions. The majority of recent SSCG studies have focused on manipulation of task constraints, such as the pitch dimensions and number of players in SSCGs.

2.4.1 Pitch size/dimensions

Football is normally played "by two teams of 11 players performing in an area of approximately 100 × 60 m. However, during training, it is common to reduce both the number of players on each team and the size of the pitch". (Rampinini, Impellizzeri et al., 2007, 659.) Different pitch sizes are usually used for the same format of play to explore the effects of having more or less space and time to make decisions and to execute actions, depending on the demands of the game. According to Aguiar et al., (2012) "research has shown that using different pitch dimensions and formats can elicit different physiological and tactical responses, as well as time-motion activity. However, studies have not reached consensus on the influence of the pitch size on the physiological response of the players. The origin of this disagreement is probably based on the fact that research has been carried out using several pitch sizes". (Aguiar et al., 2012, 106.)

However, as Fradua et al. (2012) suggest, "the objective criteria for determining an individual playing area or length and width of the pitch in SSCGs for training aspects have not yet been explored. Previous studies have not accounted how they estimated pitch sizes used in their investigation about physiological conditioning). For example, Rampinini, Impellizzeri et al. (2007) used the playing areas most frequently prescribed by coaches in different SSCGs, while the remaining studies have not provided any justifications for the relation between pitch size and number of players. Whereas most implemented a longer length than width (Casamichana & Castellano, 2010; Hill-Haas et al., 2011), others did the opposite (Rampinini, Impellizzeri et al., 2007; Williams & Owen, 2007)". (Fradua et al., 2012, 574.)

Hill-Haas et al. (2011) suggest, that "the total pitch area, both in absolute and relative terms, can be varied, and this may influence the intensity of SSCGs. The relative pitch area per player is defined as the total pitch area divided by the total number of players". (Hill-Haas et al., 2011, 203.) This is the area per player (ApP, expressed as m^2/player) or Individual Interaction Space (IIS) (see Aquiar et al., 2012; Castillo et al., 2020; Rampinini, Impellizzeri et al., 2007). Using the relative pitch area, it is possible to compare the effects of different numbers of players in SSCGs without having possible effects caused by smaller or larger pitch sizes. That is, for example, if a 3-vs-3 game is played on a pitch of 15 x 25 m, the area per player is 62.5 m^2. Using the same area per player in a 6-vs-6 game (62 m^2), the pitch size is 24 x 31 m. In the study of Silva, Duarte et al. (2014) "each field dimensions was calculated using official football field dimensions - 105 x 68 m as a reference. Length and width were reduced in proportion to the number of players involved in the SSCG, providing size estimates of the intermediate field- 47.3 x 30.6 (length x width). The small and large field measures were set by subtracting and adding 10% to the intermediate field measures, respectively". (Silva, Duarte et al., 2014, 3.)

The evidence about the relationship between the pitch size and the development of individual tactical skills is not homogenous among the current studies. Some previous studies have shown no significant effects of changing pitch dimensions on the improvement of individual tactical skills such as passing, receiving, dribbling, or making interceptions (Tessitore et al., 2006; Owen et al., 2004). However, the use of a small playing pitch seems to require a higher number of individual tactical demands (Casamichana & Castellano, 2010; Kelly & Drust, 2009). In some studies, researchers have found a higher number of shots and tackles on smaller pitches (Kelly & Drust, 2009). The increase of tackles in smaller pitch sizes may be due to the smaller area per player, which causes greater proximity to opponents and hence greater physical contact (Owen et al., 2004). On the contrary, some studies have shown that by reducing the size of the pitch the distance with opponents is decreased and the difficulty for players to keep possession of the ball is increased (Vilar et al., 2014).

In this context, games on a smaller pitch tend to increase the frequency of tactical-technical actions like ball control, dribbling, making interceptions and maintenance or loss of ball possession. Apparently, players are closer to each

other, and they are likely to be in contact with the ball a greater number of times, making the game more dynamic and increasing the ability of quick decision-making (García-Angulo et al., 2020; Williams & Owen, 2007). Alternatively, Costa et al. (2010) showed, that on a smaller pitch, the proximity between the players generated, particularly in players with lower-level of skill, greater difficulty in performing the actions, reducing the efficiency of technical-tactical actions, and leading to more interruptions in the game. The study by Silva, Garganta et al. (2014) showed, that the increase of pitch dimensions demonstrated an increase in effective team play space and distance between teams. This collective behaviour caused a decrease in the emergence of technical-tactical actions (e.g., dribbling, shooting). The greater distance between the players to the scoring target tends to reduce the chance of a shot completion and increasing the distance between the players decreases the affordances for dribbling with the ball (Duarte et al., 2012).

Clemente and Sarmento (2020) summarize the evidence, that "a small relative area per player (<100 m2) could significantly increase instances of most of the individual tactical actions made by players. However, if an objective of the game is to increase ball possession, very large pitches (>300 m2) are recommended". (Clemente & Sarmento, 2020, 113.) Sarmento, Clemente et al. (2018) in turn summarize, that "it appears that bigger pitches are more adequate for increasing the physical demand of the games, while also allowing for tactical principles associated with longitudinal and lateral exploration to be developed. The consequence of bigger sizes can be a decrease in the number of technical actions. However, coaches should consider adjusting the pitch dimensions per player to achieve the main goals of the training session". (Sarmento, Clemente et al., 2018, 18.)

2.4.2 The number of players

Clemente & Sarmento (2020) suggest, that "changing the number of players involved in SSCGs is a constraint often used by coaches. Typically, in previous studies, SSGC formats can be classified as extreme (1-vs-1), small (2-vs-2 to 4-vs-4), medium (5-vs-5 to 8-vs-8) and large (9-vs-9 to 11-vs-11) games (Owen et al., 2014). The format of play may be balanced (i.e., both teams have the same number of players) or unbalanced (i.e., additional neutral players, such as floaters, provide a temporary numerical advantage to the team with possession of the ball and, conversely, a numerical disadvantage to the team not in possession)". (Clemente & Sarmento, 2020, 13.)

Most of the studies that manipulated the number of players involved have sought to simultaneously identify the effects of field dimension manipulation (see Aquiar et al., 2012; Silva, et al., 2015). These studies reveal that SSCGs with smaller dimensions and fewer players constrained participants to stay closer to each other. These constraints led to a greater number of confrontations between attacking and defensive players, increasing the performance of basic tactical behaviours directly related to contesting the ball, pressuring the opponents, and breaking lines (Silva, Esteves et al., 2015). Furthermore, having fewer players on a smaller pitch increased the number of individual tactical actions performed by

players due to the lower number of possibilities for actions to support the ball and progress on the field (Silva, Esteves et al., 2015).

Jones & Drust (2007) found that the number of ball contacts increased in small-sided game with a smaller number of players (4-vs-4 compared to 8-vs-8). Similarly, Katis & Kellis (2009) reported that the use of 3-vs-3 promotes more short passes, kicks, dribbles, tackles, and goals than 6-vs-6 SSCG format. Silva, Garganta et al. (2014) suggests that 3-vs-3 games would enable more 1-vs-1 challenges than 6-vs-6 games and, due to the limited playing area, less time for decision-making. The study of Clemente et al. (2020) reveals that number of conquered balls, lost balls, received balls and shots increased in 3-vs-3 games, compared to 6-vs-6 games. Generally, when small-to-medium-sided games (e.g., 2-vs-2 to 4-vs-4) were compared to medium-to-large-sided games (e.g., 5-vs-5 to 11-vs-11), it was found more passes, ball contacts, involvements, dribbles, and shots in the small-to-medium-games (Clemente et al., 2020).

The formats with a greater number of players (3-vs-3 compared to 9-vs-9) have been shown to have meaningfully greater values of blocks, headers, interceptions, and long passes (Owen et al., 2011). Owen et al. (2014) reported that a greater number of headings and interceptions was found in larger games. Therefore, formats with a greater number of players can be used to train the skills of defenders, because they have to make a valuable number of headers and defensive actions like interceptions or blocks. On the other hand, the formats with fewer players could be used to train the skills of the midfielders or attackers, in order to improve skills like dribbling, short passes and shots (Sgro' et al., 2018).

Based on previous studies, if the objective of coaches is to develop the individual tactical skills of players, it is probably best to design SSCGs with a smaller number of players on a smaller pitch. Contrarily, a greater number of players may support the development of group or collective tactical behaviours. Therefore, the advance of having more players in SSGCs is that the bigger formats are closer to the real game conditions (Katis & Kellis, 2009). So, if the objective of SSCGs is to develop collective skills and/or specific knowledge of the game, it might be best to involve more players and to increase pitch dimensions.

The manipulation of task constraints could also include some other aspects. Previous studies have focused on the change in scoring target size, the number of targets involved in practice task and comparisons of having targets to shoot at or not (Ometto et al., 2018). In these studies, researchers have tried to identify how changes in scoring target constraints affect the tactical principles used by teams in SSCGs. The results confirmed that use of different types of scoring targets modifies spatial-temporal interactions between players and promotes differences in the field areas explored by players to achieve performance objectives (Clemente et al., 2014; Costa et al., 2010; Travassos, Gonçalves et al., 2014).

Regarding changes in target size, Silva et al. (2014) demonstrated that the reduction in the size of the targets (from 6 x 2 m to 3 x 2 m) increased the number of individual actions, such as player movement with the ball towards the goal and actions to slow down an opponent´s attempt to move forward with the ball. This manipulation increased the number of technical-tactical actions of

completion, increasing ball possession and the frequency with which the attacking team loses possession of the ball (Silva et al., 2014). Serra-Olivares et al. (2015) compared the maintenance of ball possession and number of penetrations between constraints in SSCGs played with mini goals, compared to SSCGs where the aim was to maintain ball possession and dribble across the goal line. This study found no differences between variables in maintenance of ball possession and the number of penetrations. The study of Travassos, Gonçalves et al. (2014) found, that a greater number of scoring targets caused the ball to remain longer in the lateral areas of the pitch and defensive sector. In the same study, according to pitch location the teams began to move further from each other. In SSCGs where the game is played with only one central goal on each side, the space between two teams is smaller and the majority of actions occur in the central corridor of the field. The ball stays longer in the central corridor next to the scoring target, in order to reach the goal more easily (Travassos, Gonçalves et al., 2014) and similarly, the use of additional mini goals on the goal line near the side lines causes teams to have more proximity to each other and, consequently, to reduce the pressure on the opposition defensive area and the central corridor. Figueiredo et al. (2016) reported no differences in the length of time the ball remained in the lateral areas, but this study did report an increase in the number of shots on the goal in SSCGs with the greatest number of goal scoring targets.

As a conclusion, there are many variables to control which can influence the tactical behaviour and the intensity of SSCGs, so previous studies have investigated the impact of modifying and/or combining them (Little & Williams, 2006). However, despite previous studies being focused on the manipulation of task constraints, there is a need to integrate the manipulation of tasks with individual constraints, such as players' roles, to better understand the impact of such manipulation according to players' specific capabilities.

3 GENERAL OBJECTIVES

Based on the above, the main purpose of this thesis was to investigate the tactical behaviour of players in football, understanding how demands on the field constrain the way that they expose possibilities for action. The aim was also to investigate effects of players' roles (e.g., defenders, midfielders, and attackers) in different locations on the field and sub-phases of the game.

In view of this, the objectives of this investigation were to understand:

1 How do field location (left-, middle-, and right-zones) and players' roles (e.g., defenders, midfielders, attackers) constrain emergent 1-vs-1 interpersonal patterns of play in youth football?

2 How are interpersonal patterns of coordination between defenders and attackers in 2-vs-1 sub-phases influenced by field location effects relative to the goal and by manipulating participants' team performance roles (e.g., defenders, midfielders, attackers)?

3 How does the team composition of players with different roles (e.g., defenders, midfielders, attackers) constrain emergence of individual and collective tactical behaviours and effectiveness during competitive 3-vs-3 SSCGs?

To this end, three articles were developed in alignment with the previous research questions:

In Article 1, the specific aim was to analyse patterns of interpersonal coordination that sustain decision-making of performers in 1-vs-1 sub-phases of football in different field locations near the goal (in left-, middle- and right-zones of the attacking third of the field). Furthermore, we also investigated the effects of players' roles (e.g., defenders, midfielders, and attackers) on interpersonal patterns of coordination that underpin decision-making in 1-vs-1 sub-phases of football.

In Article 2, the aim was to analyse the adaptive behaviours of players that sustained 2-vs-1 sub-phases of football in different field locations near the goal

(left-, middle- and right-zones) and manipulated participants' team performance roles (e.g., divided into defenders, midfielders, and attackers).

In Article 3, the aim was to examine how the team composition of players with different roles constrains emergence of individual and collective tactical behaviours, as well as effectiveness, during competitive 3-vs-3 small-sided and conditioned games (SSCGs) in youth soccer players.

4 METHODOLOGY

4.1 Participants

Fifteen male players (under 15 years, age 13.2 ± 1.03 years, years of practice 4.2 ± 1.10 years, mean height 176.3 ± 7.46 cm and mean weight 66.9 ± 8.70 kg) from the same club in a national-level Finnish team participated in this study (2016/2017 season). For purposes of analysis, participants were divided into three groups according to their main playing role on the field (defenders, midfielders, and attackers). On the advice of the coaching staff, participants were categorised into their main team performance role, resulting in sub-samples of 5 defenders (centre backs=2 and fullbacks=3), 7 midfielders (central midfielders=3 and wide midfielders=4) and 3 attackers (forwards). All players were right-foot dominant and were part of the U15s team club. All participants undertook five training sessions per week (90 minutes per session) and played one official GK+11 vs 11+GK competitive match (mostly on weekends).

4.2 Task and procedures

4.2.1 Article 1

Each participant performed in the role of a ball dribbler (attacker) and defender at all three field locations. Attacker-defender dyads engaged in an area of 10 m x 5 m positioned to represent the different locations under competitive performance conditions. The starting distance between attacker and defender dyads was 3 m (see Figure 1). At the end of this area were the goalkeeper's area and a

regular-sized football goal (2.44 m x 7.32 m) protected by a goalkeeper. A regulation-sized ball (size 5) was used in all trials. Participants were divided in three groups according to their main playing roles on the field (defender, midfielder, or attacker). All participants performed in the 1-vs-1 trials, starting from all three zones as an attacker and as a defender. The total number of trials was 129. All the players had time to rest between trials to avoid fatigue effects. 1-vs-1 dyads were initiated first from the right zone, then from the midfield zone and last from the left zone.

Each trial started when both the attacking and defending participants were ready in their starting positions and the attacking player was signalled to begin. The defender was allowed to start defending as soon as the attacker moved the ball. The aim of the attacker was to dribble past the defender and shoot at the goal. If this occurred, the trial was over. The aim of the defender was to prevent the attacker from scoring a goal, within the rules of the game. The trial was considered to be complete when the ball moved outside the borders of the playing area. We removed the trials that ended with a shot at the goal or when the ball moved outside the borders of the playing area without the ball carrier dribbling past the defender. This helped us to only capture and describe the interactional dynamics during performance sequences when the ball carrier successfully dribbled past the defender. For this reason, twelve trials in total were removed from further analysis.

Each participant's movements were captured with a digital video camera (Sony HRX-MC50E) placed 4 m above the ground, forming an angle of approximately 45° with the longitudinal axis of the performance area, to capture movements during the whole task. All the video recordings captured the displacement trajectories of all participants without the camera being moved. The video recordings were digitized with TACTO software (see Duarte et al., 2010 for additional information). The displacement trajectories of the ball and participants were tracked using a computer mouse by following in every frame the projection of their centre of gravity on the playing surface. The obtained coordinates were transformed into real coordinates using the direct linear transformation method (2D-DLT) and filtered with a Butterworth low-pass filter (6 Hz) (Winter, 2005).

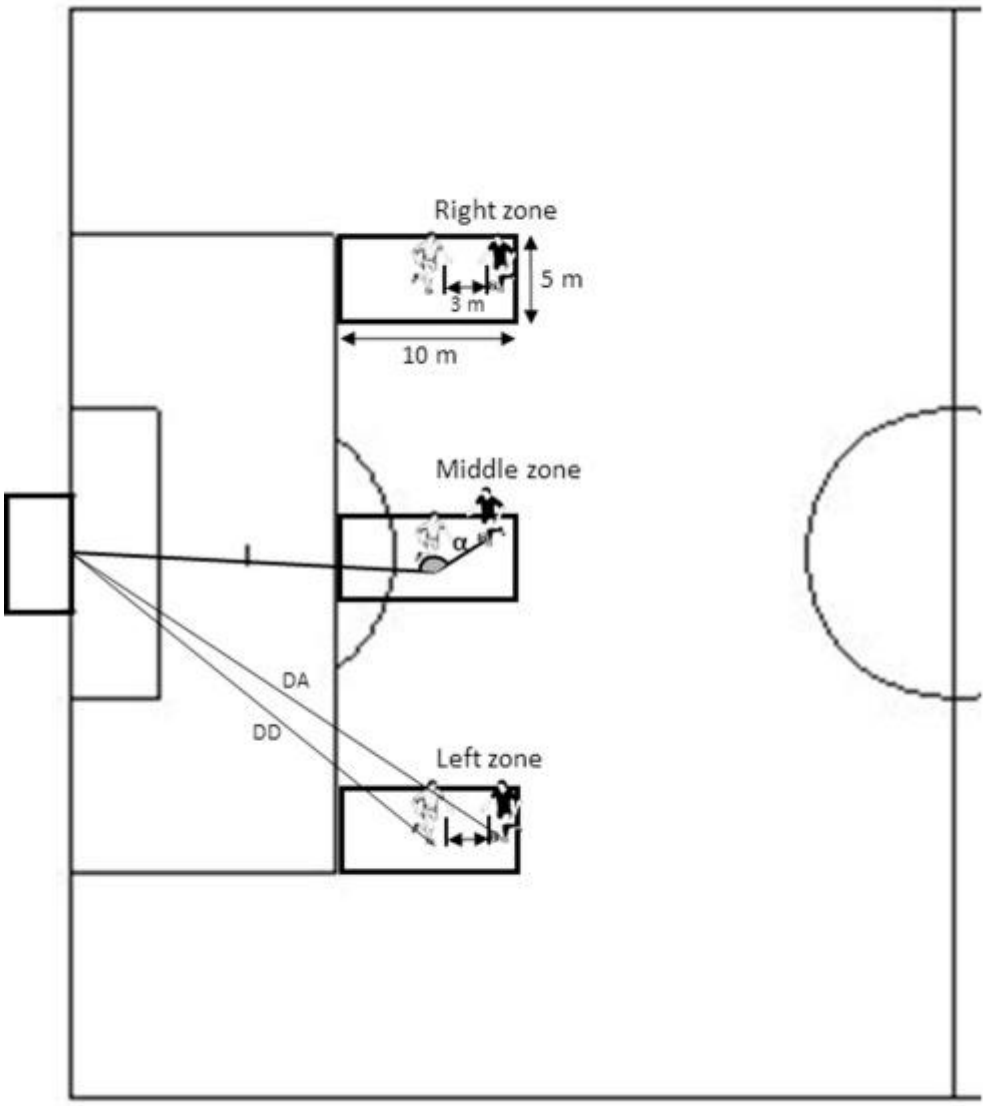

FIGURE 1 Representation of the three areas of play (left, middle and right) with the definition of the starting zone and their location in relation to the goal: α represents the relative angle between the goal, defender and attacker player; DD represents the distance between the defender and the centre of the goal; DA represents the distance between attackers and the centre of the goal.

4.2.2 Article 2

All 2-vs-1 sub-phases were tested during four sessions in one week of summer break of the competitive season (July) on an artificial grass pitch. The temperature was about 17-19° C. The first session was used to familiarise the players with the task conditions in all field zones, and the three next sessions were used for testing purposes. Each participant performed in a game to simulate a 2-vs-1 subphase as a ball carrier, second attacker and defender at three different field locations. The 2-vs-1 sub-phases took place in an area of 10 x 5 m (Headrick et al., 2011; Passos, Araújo, Davids, Gouveia, et al., 2008) in three different field locations (left, middle and right) under competitive performance conditions (see

Figure 2). The task constraints included a regular-sized goal (2.44 m x 7.32 m) protected by a goalkeeper. A regulation-sized ball (size 5) was used in all trials. The starting distance between the attacker and defender was 3 metres. When performing in the left or right side of the field, the second attacker's starting place was in the inner side of the field to keep the wing free for a possible dribble. That is, when in the right-side zone of the field, the second attacker was placed to the left of the ball carrier, and when in the left zone to the right of the ball carrier. In the middle zone, the second attacker was placed at the side of the first attacker's non-dominant foot. The area for the second attacker to move was 5 x 1.30 m (Figure 2). Before practice, all the players were informed about the rules and goals of the tasks and encouraged to compete like in the competitive game. Also, the goalkeepers were informed to act as in a competitive game. No coach feedback or encouragement was allowed during the trials.

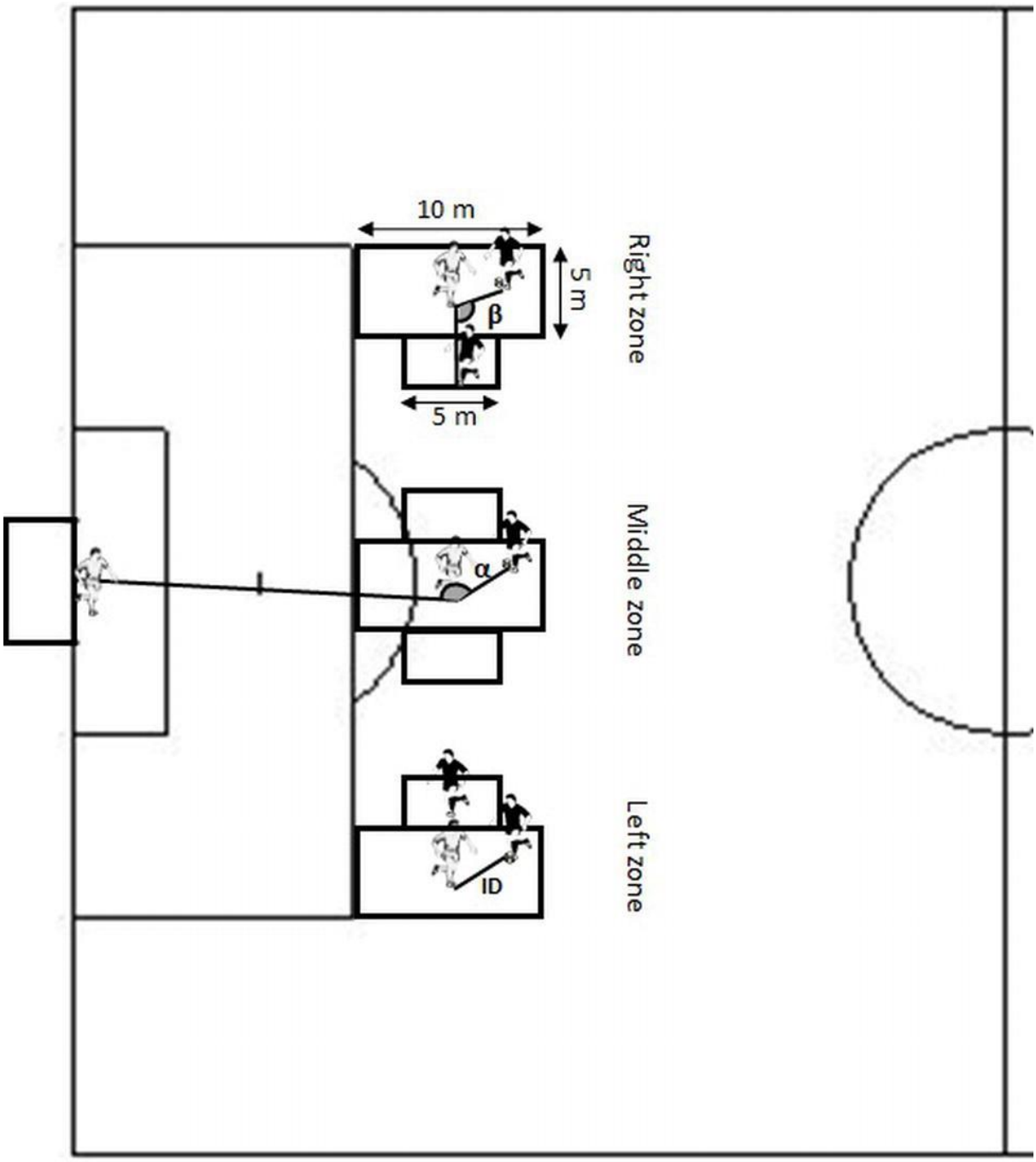

FIGURE 2 Representation of three areas of play (left, middle and right) of the ball carrier and defender and the area of the second attacker and their location in relation to the goal: α represents the interpersonal angle between the ball carrier, defender and second attacker (IABDA); β represents the interpersonal angle between the goal target, defender, and ball carrier (IAGDB); ID repsesents the interpersonal distance between the ball carrier and defender.

Before data collection, all participants engaged in a thorough warm-up routine, which included 15 min. of jogging, 10 min. of technical actions with a ball and 10 min. of stretching. Each trial started when both the attacking and defending participants were ready in their starting positions and the attacking participant was

requested to start the trial. As soon as the attacker moved the ball, the defender could start defending. After crossing the midline of the play area (5 m from the end of the attacking area), the attacker could dribble or pass the ball to the second attacker. The aim of the attacking participants was to dribble past the defender and shoot at the goal or pass the ball to the second attacker, who could shoot at the goal. If these events occurred, the trial was over. The aim of the defender was to prevent the attackers from scoring a goal, within the laws of the game. The trial was considered over when the defender intercepted the ball or when the ball moved outside the borders of the play area.

All participants performed the 2-vs-1 sub-phases in all three zones acting as an attacker (ball carrier), a second attacker and a defender, resulting in a total number of 142 trials. In each trial, two attacking players with the same positional roles attacking one defending player with a different positional role (e.g., defender + defender vs midfielder or midfielder + midfielder vs attacker). After each trial, the attacking teams and the opposition changed to promote variability in pairs and roles in the next trials. The players did not perform two consecutive trials with the same pair or opponent, or in the same zone. Participants rested about 3-4 minutes between trials to avoid fatigue. All trials were randomly allocated between left, middle, and right zones, resulting in 50 trials in the left zone, 41 in the middle and 51 in the right performance area. The experimental protocol allowed us to analyse the effects of the participants' performance roles in attack, and the distribution of trials by role comprised defenders (49 trials), midfielders (45 trials) and attackers (48 trials).

Participant movements were captured with a single digital video camera (Sony HRX-MC50E) placed 4 m above the ground, forming an angle of approximately 45° with the longitudinal axis of the performance area, to capture participant movements during the whole experimental task. All video recordings captured the displacement trajectories of all participants without the camera being moved. The movements of participants in each trial were digitized with TACTO software at 25 Hz (Duarte et al., 2010; Fernandes & Malta, 2007). The displacement trajectories of the participants and the ball were tracked using a computer mouse by following in every frame a working point located between the players' feet on the ground plan. After calibration of the pitch, with real measures of six control points for each zone (4 corners of the zone of play, and the two goalpost positions), the x and y virtual coordinates of the players were extracted. The obtained virtual coordinates were transformed into real coordinates using the direct linear transformation method (2D-DLT) to avoid parallax errors and filtered with a Butterworth low-pass filter (6Hz) to reduce the noise of the process of digitizing (Winter, 2005).

4.2.3 Article 3

All 3-vs-3 small-sided games were played in one training session during the summer break of the competitive season (July) on an artificial grass pitch with an ambient temperature of about 18-20 °C. In the summer break, the team only had daily training sessions, no official games. Before data collection, all participants

engaged in a thorough warm-up routine (15 min. of jogging, 10 min. of technical actions with ball and 10 min. of stretching). Each team played against each other (i.e., defenders vs midfielders, defenders vs attackers, attackers vs midfielders) in a playing area of 30 m x 25 m (Owen et al., 2004) The total number of games was 9. A regulation-sized ball (size 5) was used in all games. The small-sided game constraints included a regular-sized goal (2.44 m x 7.32 m) protected by a goalkeeper for both sides (Gk+3 vs 3+Gk). The playing time for each game was 5 minutes. All the players/teams had time to rest 10 min. between games to avoid fatigue. The team's direction of play was systematically changed, but the goalkeepers stayed, guarding the same goals.

The Gk+3 vs 3+Gk sub-phase was played with official football rules, with some modifications: i) the offside rule did not apply; ii) when the ball left the field or a goal was scored, the game was always restarted by the goalkeeper of the team with ball possession, with both teams located in their own pitch half; and iii) when the goalkeeper opened the game and after the first player touched the ball, both teams were allowed to play without restrictions.

All participants were informed about the rules and goals of the task/exercise before the small-sided games and encouraged to compete to win games. The goalkeepers were also instructed to perform as if in a competitive game. There was no coach feedback or encouragement allowed during the games to avoid potential biasing effects of feedback on individual participant performance. The aims of the small-sided games were to score, prevent goals and try to win each game.

Participant movements were captured with a digital video camera (Sony HRX-MC50E) placed 7 m above the ground, forming an angle of approximately 45° with the longitudinal axis of the performance area, to capture participant movements during the whole task (for more details, see Fernandes et al., 2010). All the video recordings captured the displacement trajectories of all participants without the camera being moved.

4.3 Reliability

4.3.1 Article 1

To test the reliability, ten trials were selected at random, and the displacement trajectories of attacker and defender players (n=20) were re-digitised by the same experimenter. Intra-digitiser reliability was assessed using technical error of measurement (TEM) and coefficient of reliability (R) (N.B. TEM =$\sum$D2/2N, where D is the difference between pre- and post-test measures and n is the sample size; R=1−TEM2/SD2, where SD is the standard deviation of all measures) (Goto & Mascie-Taylor, 2007). The intra-TEM yielded values of 0.254 m (2.43%) with a corresponding coefficient of reliability (R= 0.981).

4.3.2 Article 2

After one month, fifteen trials were selected at random, and the displacement trajectories of attackers and defenders (n=45) were re-digitised by the same experimenter. Intra-digitiser reliability values were assessed using technical error of measurement (TEM) and coefficient of reliability (R) statistics (for details, see Goto & Mascie-Taylor, 2007). The intra-TEM yielded values of .235 m (2.25%) with a corresponding coefficient of reliability (R=.991).

4.3.3 Article 3

To assess the tactical behaviours of teams and players and based on variables recorded in previous studies (see Andrzejewski et al., 2014; Hughes & Probert, 2006), a notational analysis system was created with four categories: i) team behaviours, ii) players' offensive individual actions, iii) players' defensive individual actions, and iv), ball possession effectiveness (see Table 1 for independent variables and their description).

TABLE 1 Description of the independent variables.

Variables	Description
Team tactical behaviour	
Ball possession	The time a team has possession of the ball during one attack
Players involved	The number of players involved in that attack during ball possession
Participants' offensive actions	
Successful passes	Number of successful passes made by the team from one player to each other
Diagonal and vertical passes	Number of diagonal and vertical passes a team completed in one attack
Lateral and backward passes	Number of lateral and backward passes a team completed in one attack
Penetrative passes	A pass that split the last line of defence and plays a teammate through to shoot at the goal
Dribbles	Successfully completed dribbles made by a participant past layer an opponent
Players' defensive actions	
Ball recoveries	A player successfully wins the ball back for his own team
Interception	A player successfully intercepts an opponent's pass
Ball possession effectiveness	
Lost balls	A team loses the ball possession to an opponent or the ball goes out of play after an attempted interception or tackle
Shots	A team ends the ball possession with a missing shot, a shot resulting in a goal, or a shot saved by a goalkeeper.

All data were collected by the first author. In line with recommendations in previous research, all the variables coded were discussed and described by the authors (Andrzejewski et al., 2014; Hughes & Probert, 2006). The same sample of matches was coded after an interval of two weeks to check reliability of measurements. Intra-observer reliability was calculated using the Cohen K index (Hughes & Franks, 2008). Values of K=0.913 were found, ensuring an adequate reliability of data.

4.4 Data analysis

4.4.1 Article 1

To measure variations in interpersonal patterns of coordination between participants in the 1-vs-1 sub-phases, variations in the relative distance between the attacker and defender players to the centre of the goal (RDPG), and the relative angle (α) between the centre of goal, defender, and attacker (RAGDA) (see Figure 1), were calculated. These methods are based on methods used in previous research by Vilar, Araújo, Davids, Travassos, Duarte, et al. (2012). Values of RDPG were calculated as the difference between the value of the attacker's distance to the centre of the goal (DA) and the defender's distance to the centre of the goal (DD). Values of RAGDA were calculated by measuring the inner product of the defender's vector to the centre of the goal, and the defender's vector to the attacker (see Figure 1). Each trial was normalized to the total time taken to perform the trial independently due to differences in the temporal length of each trial, and for purposes of comparison. Data were averaged for every 10% portion of the total normalized time in each trial. The value of 0% corresponds to the moment of trial initiation (when the attacker was given a signal to start the trial with a dribble). The value of 100% corresponds to the moment when the attacker moved into the target zone to shoot at the goal or when the ball was played out of the performance area.

Magnitude-based inferences and precision of estimation were used to avoid the shortcomings of research approaches supported by null-hypothesis significance testing (Batterham & Hopkins, 2006). Comparisons of RDPG and RAGDA data among field zones and players' roles were assessed via standardized mean differences, computed with pooled variance and respective 90% confidence intervals (Cumming, 2012; Hopkins, Marshall, Batterham, & Hanin, 2009). The field zones comprised the left, middle and right performance areas, and the players' roles comprised the different combinations of Defenders, Midfielders and Attackers, functioning as attackers or defenders respectively (AADD – Attacker attacks, Defender defends (27 trials); AAMD – Attacker attacks, Midfielder defends (27 trials); DAAD – Defender attacks, Attacker defends (21 trials); DAMD – Defender attacks, Midfielder defends (18 trials); MAAD – Midfielder attacks, Attacker defends (18 trials); MADD – Midfielder attacks, Defender defends (18 trials)). Thresholds for effect sizes statistics were trivial (0-0.19); small (0.2-0.59); moderate (0.6-1.19); large (1.2-1.99); and very large (≥2.0) (direction of observed effects were represented by −ive and +ive). Differences in means for both pairs of scenarios were also expressed in percentage units with 90% confidence intervals (CI) (Hopkins et al., 2009). The relationships between values of relative distance and relative angles were analysed using Pearson's Product Moment Correlation using SPSS 22.0 software (IBM SPSS Inc., Chicago, USA).

4.4.2 Article 2

Descriptive statistics were reported for all performance measures recorded. Comparisons between the field zones and participants' roles were assessed using standardized mean differences with 90% confidence intervals. The smallest worthwhile differences were estimated from the standardised units multiplied by 0.2. (Cumming, 2012; Hopkins, Marshall, Batterham, & Hanin, 2009). Effect size statistics were reported using the following ranges: trivial (0 to 0.19); small (0.2 to 0.59); moderate (0.6 to 1.19); large (1.2 to 1.99); and very large (>=2.0). Magnitudes of clear effects were considered on the following scale: 25-75%, possibly; 75-95%, likely; 95-99%, very likely; >99%, most likely (observed effects were represented by -ive and +ive directions) (Hopkins et al., 2009). Correlation values between variables were accessed through Pearson correlation using SPSS 22.0 software (IBM SPSS Inc., Chicago, USA). Thresholds for correlation coefficients (r) were: 0.30, small; 0.49, moderate; 0.69, large; 0.89, very large; and 1.00, near perfect (Hopkins et al., 2009).

4.4.3 Article 3

A Shapiro-Wilks test was used to assess the normality of data distribution. Due to the existence of non-normal distribution of data, differences between performance variables were assessed using a non-parametric test. A Kruskall-Wallis test was conducted to evaluate differences between the values observed for teams composed of defenders, midfielders, and attackers. Observed significant effects were followed using the Bonferroni post hoc test. All statistical analyses were performed using the Statistical Package for Social Sciences software V24.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.), and statistical significance levels were set at $p<.05$. Additionally, *Cohen's d* was calculated to obtain the magnitude of differences through an effect-size calculator for non-parametric tests (www.psychometrica.de/effect_size.html), classifying values as very low (0-0.2), low (0.2-0.6), moderate (0.6-1.2), high (1.2-2.0) or very high (>2.0) (Hopkins et al., 2009).

4.5 Study approval and ethics

The study was approved and accepted by the local Ethics Committee according to the Declaration of Helsinki. The club, all parents and the participants provided prior informed and written consent for participation in the study.

5 RESULTS

5.1 Article 1

5.1.1 The effects of field zones

Analysis of the relative distance values between players and the goal revealed main effects for field zones: Left-Middle (d=−1.22(90%CI: −1.62 to−0.83), moderate−ive), Left-Right (d=−0.75 (90%CI: −1.13 to−0.37), small−ive), and Right-Middle (d= 0.49 (90%CI: 0.11-0.87), trivial). Generally, the left zone showed lower relative distance values between players and the goal than the other two zones, with the middle zone revealing the higher values. In the left zone, the relative distance decreased from values around 5-1.3 m. In the middle and right zones, the relative distance started at values near 5.5 m and decreased in the middle to values around 2.5 m and on the right to values near 1.7 m (see Figure 3, left panel). Analysis of values of the relative angle between the goal, defender and attacker revealed main effects for field zones: Left-Middle (d=−6.12 (90%CI: −6.98 to−5.25), very large−ive), Right-Middle (d=−5.67 (90%CI: 4.84-6.51), very large−ive, and Left-Right (d=−0.04 (90%CI: −0.4-0.33), unclear). Generally, higher relative angle values were observed in the middle zone than in the left or right zones. In the middle zone, angle values were near 180° and in the left and right zones angle values were near 130°-140°. Interestingly, at the end of the trial in the left zone, an increase in relative angle values nearer to 150° was observed. In the right zone, relative angle values were maintained nearer to 135° (see Figure 4, left panel). Analysis of the relationships between values of the relative distance and relative angle for each field zone revealed interesting effects. There was a strong negative correlation between the two variables in the left ($r = -0.935$, $p<0.001$) and right zones ($r = -0.992$, $p<0.001$) and a strong positive correlation in the middle zone ($r = 0.963$, $p<0.001$).

5.1.2 The effects of player roles

Analysis of the relative distance values between players and the goal showed small effects for differences in player roles between DAAD-AADD (d=−0.6 (90%CI: −0.08 to−1.09), small−ive), DAAD-AAMD (d=−0.99 (90%CI: −0.47 to−1.53), small−ive), and DAAD-DAMD (d=−0.74 (90%CI: −1.29 to−0.18), small−ive), DAAD-MAAD (d=−0.6 (90%CI:−1.17 to−0.02), small−ive). In general, the patterns of play of defenders as attackers and attackers as defenders, compared to other roles, revealed lower values of relative distance at the end of the trials (see Figure 3, right panel).

Analysis of the relative angles between the goal, defender and attacker players revealed unclear effects of player role (see Figure 4, right panel).

Analysis of the relationships between values of relative distance and relative angle for each dyad revealed a strong negative correlation between the two variables, AADD ($r = -0.860$, $p<0.001$); AAMD ($r = -0.866$, $p<0.001$); DAA ($r = -0.697$, $p<0.05$); DAMD ($r = -0.975$, $p<0.001$); MAAD ($r = -0.915$, $p<0.001$); MADD ($r = -0.899$, $p<0.001$). Interestingly, the weakest correlations were observed between defenders as attackers and attackers as defenders, in line with previous research findings.

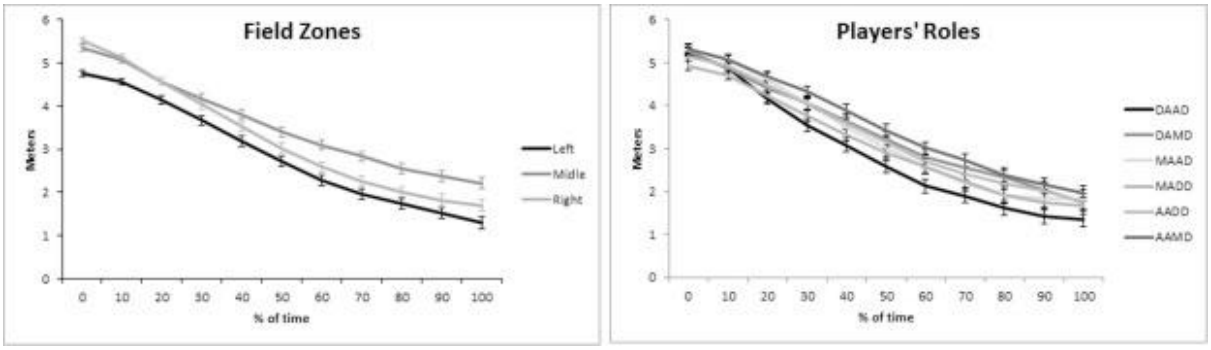

FIGURE 3 Mean values and standard deviations of the relative distance between attacker and defender to the centre of the goal: left panel represents variations in the mean relative distance according to field zones; right panel represents variations in the mean relative distance according to players' roles.

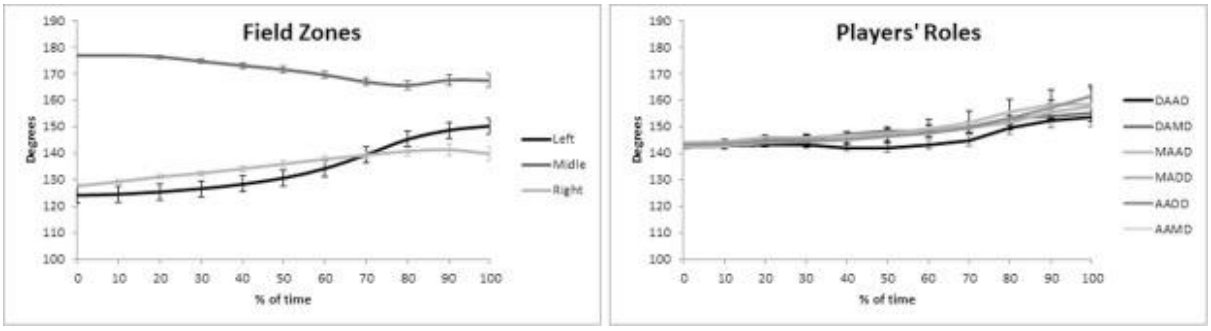

FIGURE 4 Mean values and standard deviations of the relative angle between the goal, defender and attacker player: left panel represents variations in the mean relative angle according to field zones; right panel represents variations in the mean relative angle according to the players' roles.

5.2 Article 2

5.2.1 Effects of field location

Analysis of ID (interpersonal distance between the ball carrier and defender) revealed main effects for field zones. Small higher values were observed in comparisons of the left and middle zones (likely −ive). Moderate higher values were observed in comparisons of the middle and right zones (very likely +ive). Unclear values were observed in comparisons of the left and right zones (unclear). Generally, the middle zone revealed the lowest ID values, while the right zone revealed the highest ID values (see Table 2 and Figure 4).

TABLE 2 Descriptive statistics and differences in means for field location and players' roles. ID (interpersonal distance between the ball carrier and defender), IABDA (interpersonal angels between ball carrier, defender and second attacker), IAGDB (interpersonal angels between the goal target, e.g., the center of the goal, defender, and the ball carrier).

	(Mean ± SD)			Difference in means (d; 90% CL)		
			Field location			
Variables	**Left**	**Middle**	**Right**	**Left vs Middle**	**Left vs Right**	**Middle vs Right**
ID (meters)	3.21 ± 1.42	2.68 ± 1.49	3.67 ± 1.73	−0.35 [−0.7–0.01]	0.28 [−0.04 0.62]	0.60 [0.26 0.95]
IABDA (degrees)	121.34 ± 20.57	107.77 ± 22.28	115.94 ± 23.22	−0.63 [−0.98–0.27]	−0.24 [−0.57 0.608]	0.36 [0.01 0.07]
IAGDB (degrees)	122.9 ± 20.76	135.72 ± 23.87	140.40 ± 17.12	0.57 [0.22 0.92]	0.91 [0.58 1.24]	0.22 [−0.13 0.57]
			Players' role			
Variables	**Defenders**	**Midfielders**	**Attackers**	**Defenders vs Midfielders**	**Defenders vs Attackers**	**Midfielders vs Attackers**
ID (meters)	3.75 ± 1.81	3.30 ± 1.59	2.77 ± 1.13	−0.26 [−0.6 0.07]	−0.65 [−0.98–0.31]	−0.38 [−0.73–0.04]
IABDA (degrees)	120.83 ± 19.88	110.45 ± 19.22	114.74 ± 26.86	−0.52 [−4.7 3.62]	−0.25 [−3.69 3.18]	0.18 [−3.29 3.66]
IAGDB (degrees)	131.71 ± 20.55	136.77 ± 20.35	130.45 ± 24.07	0.24 [−3.72 4.21]	−0.06 [−3.67 3.57]	−0.28 [−3.92 3.36]

Analysis of IABDA (interpersonal angels between ball carrier, defender and second attacker) revealed main effects for field zones. Moderate higher values were observed in comparisons of the left and middle zones (very likely -ive). Small higher values were observed in comparisons of the middle zone and right zone (likely +ive). Unclear values were observed in comparisons of the left and right zones (unclear). Generally, the left zone revealed higher values of IABDA, while the middle zone revealed lower values (see Table 2 and Figure 5).

Analysis of IAGDB (interpersonal angels between the goal target, e.g., the center of the goal, defender, and the ball carrier) revealed main effects for field zones. Small lower values were observed in comparisons of the left and middle zones (very likely +ive). Unclear values were observed in comparisons of the middle and right zones (unclear). Moderate higher values were observed in comparisons of the left and right zones (most likely +ive). Generally, the right zone revealed the higher values, and the left zone revealed the lower values of IAGDB (see Table 2 and Figure 5).

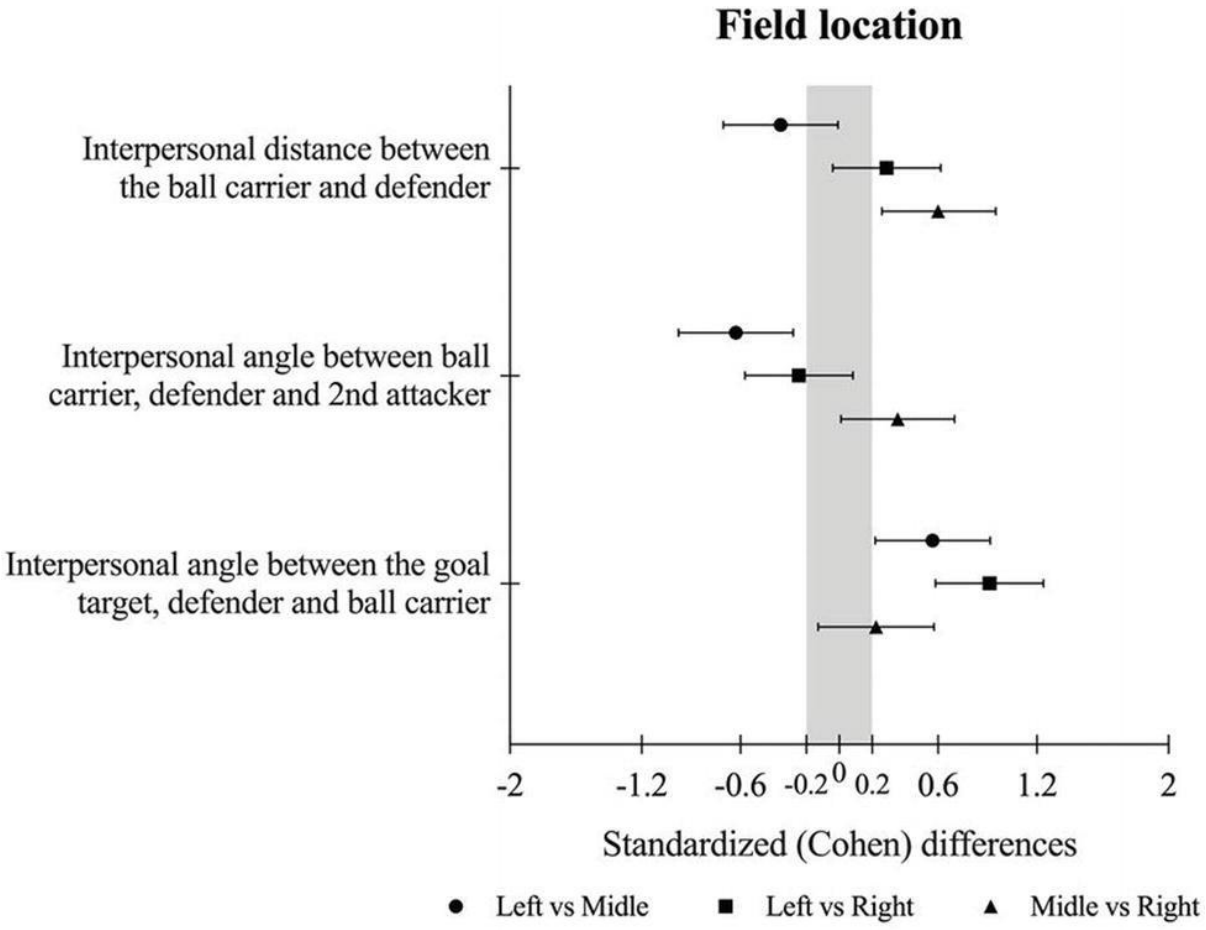

FIGURE 5 Standardized (Cohen) differences of ID, IABDA and IACDB for field zones (left vs. middle vs. right).

Analysis of relationships between ID, IABDA and IAGDB for each field zone revealed interesting effects. In the left field zone, a large negative correlation was revealed between ID and IABDA values (r = -0.76, R2 = 0.57 (90%CI: -0.84 to -0.64), most likely -ive), a large positive correlation between ID and IAGDB values (r = 0.72, R2 = 0.52 (90%CI: 0.59 to 0.82), most likely +ive), and a moderate negative correlation between IABDA and IAGDB values (r = -0.46, R2 = 0.21 (90%CI: -0.62 to -0.24), most likely -ive). On the right, an unclear correlation was revealed between ID and IABDA values (r = 0.08, R2 = 0.01 (90%CI: -0.16 to 0.31), unclear), a large negative correlation between ID and IAGDB values (r = -0.70, R2 = 0.48 (90%CI: -0.8 to -0.55), most likely -ive), and a moderate negative correlation between IABDA and IAGDB values (r = -0.56, R2 = 0.31 (90%CI: -0.7 to -0.37), most likely -ive). In the middle zone, a near perfect positive correlation was revealed between ID and IABDA values (r = 0.93, R2 = 0.87 (90%CI: 0.9 to 0.96), most likely ive), and unclear correlations between ID and IAGDB (r = 0.15, R2 = 0.02 (90%CI: -0.37 to 0.1), unclear) and IABDA and IAGDB values (r = 0.10, R2 = 0.02 (90%CI: -0.14 to 0.33), unclear).

5.2.2 Effects of players' role

Analysis of players' roles as attacking players revealed subtle changes in emergent interpersonal coordination tendencies (see Table 2 and Figure 6). When defenders acted as attacking players, small higher values of ID were observed, compared to midfielders (possibly -ive), and a moderate higher ID was observed, compared to attackers (very likely -ive). Also, when midfielders acted as attacking players, small higher ID values were observed, compared to attackers (possibly -ive). No other effects on IABDA and IAGDB were revealed in analysis of effects of player roles when participants acted as attacking players (see Table 2 and Figure 6). Analyses of relationships between ID, IABDA and IAGDB for each player role were unclear.

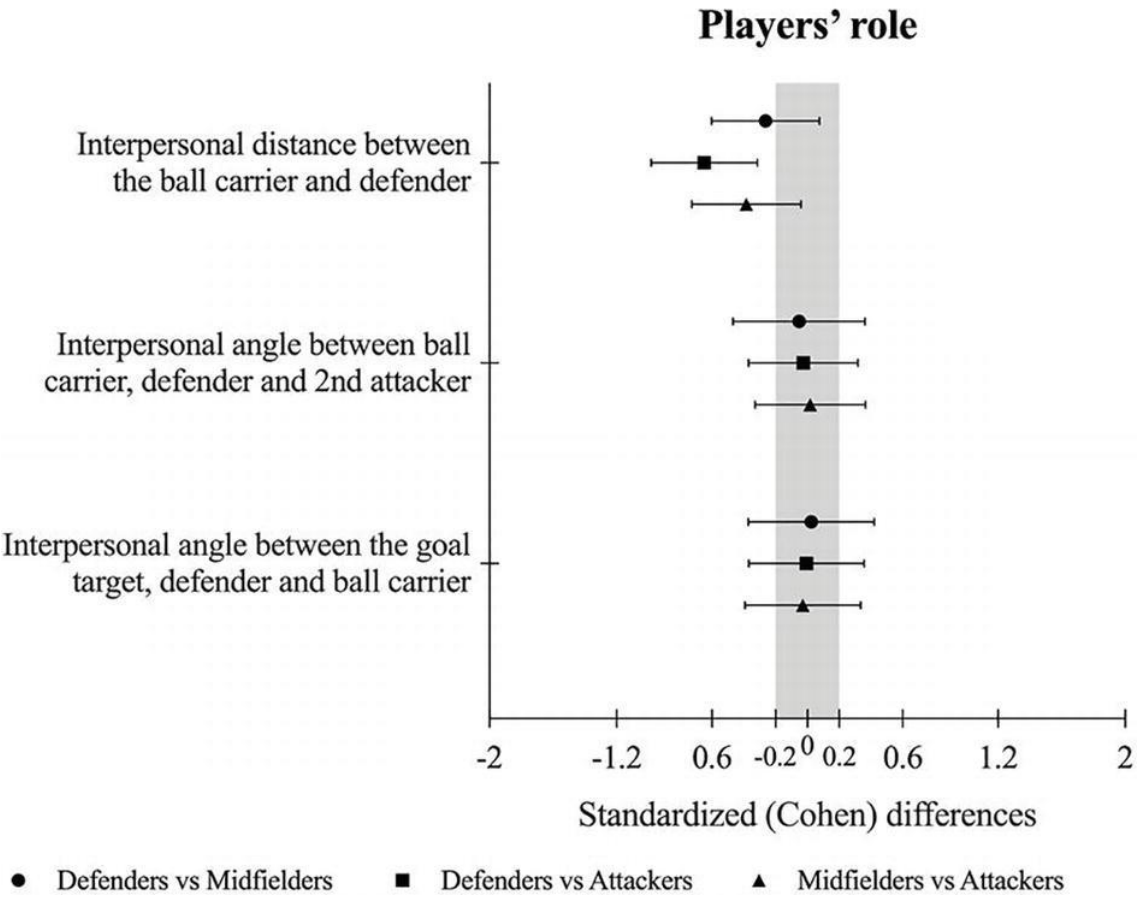

FIGURE 6 Standardized (Cohen) differences of ID, IABDA and IAGDB for players' role (defenders vs. midfielders vs. attackers).

5.3 Article 3

Regarding team tactical behaviour, no statistically significant differences were observed for the variables: ball possession and players involved in the attack in teams composed of different roles ($p>0.05$) (see Table 3).

Analysis of participants' offensive individual actions did not reveal significant differences between teams with players in different roles for the following variables: number of completed successful passes, lateral and backward passes and penetrative passes ($p>0.05$). However, statistically significant between-team differences in performance variables were observed for the number of diagonal and vertical passes and dribbles completed ($p<0.05$) (see Table 3). For diagonal and vertical passes, post hoc analysis revealed that the team of midfielders revealed the higher number of diagonal and vertical passes (1.22 ± 0.67) during performance, with significant differences in relation to the values displayed by the team of attackers (0.73 ± 0.59, $p<0.05$, $d = 0.71$, moderate effect). No other differences were observed for diagonal and vertical passes between the teams ($p>0.05$). Regarding the number of dribbles completed, post hoc analysis revealed that the team of attackers displayed the highest number of successfully completed dribbles (0.53 ± 0.78), with significant differences in relation to the values displayed by the teams of defenders (0.18 ± 0.39, $p<0.05$, $d = 0.65$, moderate effect) and midfielders (0.16 ± 0.37, $p<0.05$, $d = 0.66$, moderate effect). No differences in that performance variable were observed between the teams of defenders and midfielders ($p>0.05$).

Analysis of participants' defensive individual actions did not reveal significant differences between teams for the variables of ball recoveries and balls intercepted ($p>0.05$) (see Table 3). However, even without a statistically significant outcome, a tendency for the team of defenders to intercept a greater number of passes was recorded.

Finally, analysis of ball possession effectiveness revealed significant differences for the variables of lost possession and shots at goal between the teams' roles ($p>0.05$) (see Table 3). For lost possession, post hoc analysis revealed that the team of attackers displayed the highest number of lost balls (0.65 ± 0.74), with significant differences in relation to the values displayed by the team of defenders (0.28 ± 0.45, $p<0.01$, $d = 0.60$, moderate effect). Significant differences were also displayed between defenders (0.28 ± 0.45) and midfielders (0.57 ± 0.64, $p<0.03$, $d = 0.53$, low effect) for this variable, although no differences were observed between the teams of midfielders and attackers ($p>0.05$). Regarding the variable shots at goal, post hoc analysis revealed that the team of defenders displayed the highest number of shots completed (1.28 ± 0.84), with significant differences in relation to the values displayed by the team of midfielders (0.63 ± 0.78, $p<0.01$, $d = -0.80$, moderate effect). No differences in this performance variable were observed between the teams of defenders and midfielders and midfielders and attackers ($p>0.05$).

TABLE 3 Inferences for the effects of the game scenarios' comparisons on performance measures.

Variables	Teams' constitution			χ^2	*p value* d_{Cohen}		
	Defenders	**Midfield-ers**	**Attackers**		**Def vs Mid**	**Def vs Att**	**Mid vs Att**
				Team behaviour			
Ball possession	6.81±4.73	6.94±4.09	8.07±5.11	1.72	-	-	-
Players involved	1.82±0.73	1.87±0.70	1.78±0.80	0.31	-	-	-
				Players' offensive actions			
Successful passes	0.86±0.96	1.24±1.34	0.98±1.12	1.41	-	-	-
Diagonal & vertical passes	0.98±0.83	1.22±0.67	0.73±0.59	8.75*	-	-	**0,00** **0.33**
Lateral & back-ward passes	0.31±0.51	0.55±0.76	0.38±0.67	1.48	-	-	-
Rupture passes	0.12±0.44	0.5±1.08	0.48±0.99	4.09	-	-	-
Dribbles	0.18±0.39	0.16±0.37	0.53±0.78	7.57*	-	**0.02** **-0.40**	**0.01** **0.44**
				Players' defensive actions			
Ball recoveries	0.12±0.39	0.13±0.34	0.10±0.30	1.27	-	-	-
Balls intercepted	0.22±0.42	0.11±0.31	0.13±0.33	2.74	-	-	-
				Win rate			
Lost balls	0.28±0.45	0.57±0.64	0.65±0.74	7.62*	-	**0.01** **0.41**	-
Shots at goal	1.28±0.84	0.63±0.78	0.95±0.98	11.51**	**0.00** **0.34**	-	-

* p<.05; ** p<.001

6 DISCUSSION

The main purpose of this thesis was to investigate tactical behaviour in football, understanding how demands on the field constrain the ways in which players expose possibilities for action. The aim was also to investigate the effects of players' roles (e.g., defenders, midfielders, and attackers) in different field locations and sub-phases of the game. The findings support the idea that it is important to understand how manipulated constraints in team game practice can influence the tactical behaviour of players and how players exploit such variations. Generally, in the first study it was observed that field location as well as players' role constrained players' tactical behaviour of dribbling and shooting in 1-vs-1 football situations. In the second study, in the analysis of the 2-vs-1 football situations, similar results were observed. A general main effect of field location was observed with changes in the spatial-temporal relations of players between field locations. Related to participants' roles, defenders revealed subtle differences in their tactical behaviour when compared with midfielders and attackers. At the end, in the third study, effects of players' roles in teams' tactical actions of play and effectiveness were observed between teams of defenders, midfielders and attackers.

6.1 Individual tactical behaviour in 1-vs-1 sub-phases

The results of this study are in line with previous research (Headrick et al., 2011), where proximity-to-goal constrained values of defender-to-ball distance. We found a clear effect of field locations on emergent interpersonal patterns of coordination between an attacker and defender in 1-vs-1 sub-phases. Our results revealed how variations in field locations near the goal (left, middle and right zones) constrained interpersonal patterns of coordination between attackers and defenders, particularly the relative distance and relative angle values that emerged between them and the goal. These results are also in line with other studies (Travassos, Araújo, et al., 2011; Vilar, Araújo, Davids, Travassos, Duarte, et al., 2012)

and highlight the relative position of the goal as a key informational variable that sustained participants behaviours of shooting and dribbling. Additionally, the exploration of possibilities for action in the 1-vs-1 dyad (Study 1) was constrained by players' main roles according to the relative position on the field. It can be assumed that players' past experiences in a specific performance role may have strongly influenced their tendencies to engage in interpersonal coordination with other participants. An interesting result of this study was that players' foot preferences can also be considered as a key constraint to define the action capabilities of attackers to explore shooting and dribbling. This means that in the left zone the attackers could attempt to dribble past the defender with the right foot to open up a shooting angle with the goal. In the right zone, dribbling with the right foot tended to close the shooting angle with the goal. Thus, in the left zone, to prevent attackers from using their favoured foot to dribble, defenders sought to minimize interpersonal distances and the relative angle to the goal.

6.2 Individual tactical behaviour in 2-vs-1 sub-phases

In this research, the aim was also to increase the knowledge of spatial-temporal relations in attacker-defender dyadic systems. These relations have been previously reported in 1-vs-1 sub-phases of play (Headrick et al., 2011; Vilar, Araújo, Davids, Travassos, Duarte, et al., 2012). In the context of football, research findings have revealed that attackers need to lead the interactions in spatial-temporal relations with defenders by promoting unpredictable changes in the values of key variables such as interpersonal distance, relative angles with players and with the goal, and relative velocity to achieve successful outcomes (Schulze et al., 2018). On the other hand, defenders try to constrain attackers' actions and maintain spatial-temporal equilibrium with them to enhance sub-system stability and successfully perform (Clemente et al., 2013; Duarte et al., 2012). In most team games, attackers try to gain an advantage by rapidly creating a temporary numerical overload against defenders in a specific location of the field. Particularly in football, the creation of offensive or defensive numerical superiority near the ball is directly related to successful performance in terms of attacking space behind a defensive line or in recovering the ball (Vilar et al., 2013). Thus, a 2-vs-1 sub-phase is the minimum sub-phase of game that represents such a numerical (overload) advantage for an attacking team. During this sub-phase, the ball carrier and the 2nd attacker need to manage the spatial-temporal relations with an immediate opponent to support the emergence of two possibilities for action: (s)he can dribble and face the defender in a 1-vs-1 situation if the defender is protecting a passing line to the second attacker or (s)he can draw out the defender and pass the ball to the support attacker if a passing line emerges through the defender being drawn towards the ball dribbler. Despite its relevance for understanding the spatial-temporal changes that support the emergence of possibilities for action in overload situations little research has been conducted to observe actual competitive interactions during performance in this important sub-phase. In

2-vs-1 sub-phases, the additional teammate increases the available affordances for the ball carrier (dribbling, shooting, passing), not allowing the defender to perform as conservatively. Thus, defenders tried to cope with the increase in affordances for attackers by dividing their efforts to occupy passing lines and inhibit the emergence of dribbling/shooting lines for the ball carrier (Vilar, Araújo, Davids, Travassos, Duarte, et al., 2012).

6.3 Players' roles as a constraint on individual and collective tactical behaviour

In this research, the purpose was also to investigate how the team composition of players with different roles constrains individual and collective tactical behaviours, as well as ball possession effectiveness, during competitive 3 vs 3 SSCGs. In line with our expectations, in 3-vs-3 SSCGs results revealed variations in individual offensive and defensive tactical behaviours according to the teams' composition, as well as in the ball possession effectiveness of the composed teams. Nevertheless, no differences were observed for team behaviours in analyses of time spent with ball possession and the number of players involved in each attack. These results reinforced the co-adaptive behaviours of players of different roles through the creation of particular game dynamics and according to their roles' dispositions and capacities.

In football, normally played with 11-a-side game, there is a huge difference between the types of specialization of players' roles. Each role (generally categorised as defenders, midfielders and attackers) has specific technical, tactical and physical playing demands, which may need to be adapted due to varying performance constraints. Team roles in football accomplish differences in the perceptual scanning frequency, with central midfielders revealing the highest mean frequency and attackers the lowest mean frequency of emergent scanning behaviour (Jordet et al., 2020). Pervious research (Aksum et al., 2020) has also revealed that players are perceptually attuned to information specifying affordances for action through, for example, visual exploratory actions, which entail eye, head and body movements, supporting the pick-up of visual information. Thus, our findings reinforce previous studies that show that players' roles are a key constraint on the nature of the individual tactical actions that they learn to perform. Our evidence is well aligned with previous data, for example, evidencing roles' effects on players' spatial-temporal relations to perform or on the exploratory movements used to perceive the specifying properties of the surrounding environment (Jordet et al., 2020; McGuckian et al., 2018) that sustain affordances.

7 CONCLUSIONS

The obtained results were in line with some previous studies (Gonçalves et al**.,** 2016), suggesting that different individual and collective tactical abilities emerge according to players' roles over different game dimensions (i.e., from individual to collective). The results of 1-vs-1 sub-phases revealed that when a defender attacks and an attacker defends, lower values in interpersonal distance emerged in comparison with other players' role combinations. In competitive performance environments, defenders typically do not have many opportunities to experience 1-vs-1 as attackers and vice versa. The findings suggest that perception of the individual capabilities of the defenders to dribble and shoot at goal afforded a decrease in the relative distance between them and as an option reduced their possibilities for action (Travassos, Araújo, et al., 2012). As expected, players' roles seem to have an impact on their current capabilities for action.

Also, the participants' main performance roles constrained interpersonal coordination tendencies in the 2-vs-1 sub-phases. The results revealed higher interpersonal distance values for defenders when attacking, compared to participants with other main performance roles. Midfielders revealed higher interpersonal distance values than attackers when also acting as attacking players. These findings quite clearly suggest that familiarity and the experience of players, acting in their main performance role of another, may influence their interaction tendencies with other participants, especially in exploiting affordances.

SSCGs (small-sided and conditioning games) are commonly used for practice because they replicate the physical, tactical, and technical elements of a football match. SSCGs also simulate the complexity of interactions with team members, opponents, and the ball. These games are widely used to improve football skills and prepare for full-sized matches, regardless of playing level or players' age (Olthof et al., 2017). In SSCGs, players have to make fast and accurate game-like decisions, often under pressure and when tired. Our findings suggested how the main playing role of a performer may constrain and promote different emergent collective behaviours and individual actions in 3-vs-3 SSCGs. Due to differences in performance context, players with different playing roles seem to exploit affordances and perform differently in competitive conditions. The previous

studies of this thesis also observed similar results of effects of players roles in 1-vs-1 contexts and 2-vs-1 sub-phases in football.

In line with our expectations, in 3-vs-3 SSCGs results revealed variations in individual offensive and defensive tactical behaviours as well as in the ball possession effectiveness according to teams' compositions. Nevertheless, no differences were observed for team behaviours in analyses of time spent with ball possession and the number of players involved in each attack. These results reinforced the co-adaptive behaviours of players of different roles through the creation of particular game dynamics, and according to their role dispositions and capacities. An ecological dynamics rationale for the current findings suggest that players' main team roles seem to have an impact on their perception-action systems (i.e., the way they use information to regulate their actions), changing their capabilities for action during these learning experiences (intrinsic effectivities or readiness for action) (Araújo et al., 2006). Our findings show that players' roles are a key constraint on the nature of the individual tactical actions that they learn to perform. Our evidence is well aligned with previous data, for example, evidencing roles' effects on players' spatial-temporal relations to perform or on the exploratory movements used to perceive the specifying properties of the surrounding environment (Jordet et al., 2020; McGukian et al., 2018) that sustain affordances.

8 PRACTICAL IMPLICATIONS OF THE STUDY

The obtained results provide a number of practical implications for a football coach. These findings can help coaches in better selecting the type of SSCGs according to the purpose of the training session. Particularly the coaches of youth teams usually mix up players into small teams without at all considering the impact of team composition on the emergent tactical behaviours of players and teams during practice. Coaches may also easily manipulate practice task constraints, like different field locations in 1-vs-1 or 2-vs-1 sub-phases, to influence the players' tactical behaviour. The selection of used drills or SSCGs is unfortunately too often dependent of the available space and players involved in one practice session.

Implications for the design of practice tasks can be suggested. Attackers and defenders can be exposed to different relative positions to the goal for training dribbling and shooting, with changes in the preferred foot of both attackers and defenders. That personal constraint manipulation will encourage greater exploration of possibilities for attackers to shoot when presented with a more open or closed angle to the goal. Such a manipulation may even encourage participants to explore shooting with the non-preferred foot, depending on the affordances offered by information from the positioning of defenders, relative to the goal. Also, for defenders, such a manipulation will help them to improve their defensive positioning, relative to the goal, and to identify and nullify use of the preferred foot of attackers. This exploration of capabilities for action of other performers, based on some key information, can allow learners to become more effective and flexible in their behaviours.

Players' roles seem to have an impact on their current capabilities for action. Thus, to improve player performance, early experience of diverse experiences in the contexts of play and in required perception and action capacities instead of specialization (as defenders or attackers) should help learners to improve their adaptability to the different performance contexts to which they are exposed during competition (Davids et al., 2013).

The findings of Study 1 suggest that coaches should manipulate practice task constraints (i.e., design 1-vs-1 sub-phases in different locations on the field

and manipulating players' foot preferences) to increase opportunities for the participants to become better attuned to the informational variables that constrain their performance. By manipulating task constraints such as field location for attacker-defender dyads or individual constraints such as placing right- or left-footed participants in different areas of play, participants may learn how to detect functional information for decision-making in 1-vs-1 sub-phases.

Clear implications for practice could result from Study 2. The implications of the manipulation of the relative position of the goal target (Coutinho et al., 2020) in relation to the 2-vs-1 sub-phases or the attacker-defender participants' performance roles allow coaches to improve the design of practice tasks according to the planned goals. Also, in line with previous studies, this study allows identification of the task constraints that coaches can stress to improve players' decisions and action according to each task condition (Correia et al., 2012).

These observations are important to understand how manipulated constraints in team games practice can change interpersonal coordination tendencies and how players explore such variations. The results also suggest that the manipulation of different field playing locations should be promoted in practice. Further research is required to understand the dynamics of this game sub-phase during training sessions or in the game environment, that is, what is really the transfer between such spatial-temporal coordination tendencies in training and competition and how it happens at different levels of relations (from individuals to teams).

The manipulation of the relative position of the goal could highlight the behaviour of defenders to effectively manage spatial-temporal relations with opponents and constrain affordances according to the current effectiveness (capacities) of players (for instance, use of a preferred foot). Such manipulations have implications for specificity of practice, highlighting the importance of conditioning for footwork and the management of spatial-temporal relations with opponents, which can be best attained in sub-phase practices (rather than ladder drills) because of the perception of information for action (affordances).

In line with that, coaches should constantly promote changes in the field location of 2-vs-1 sub-phases in order to promote the creation of new possibilities for the action of players. Also, the definition of different couples of attackers and defenders according to different levels of effectiveness seems to be a good constraint to create new spatial-temporal information and promote new possibilities for the action of players according to their effectiveness. Further research is required to understand the contribution of such manipulations to the learning process.

The obtained results of this study (Study 3) allow coaches to understand how manipulating team composition through modifying players' roles in SSCGs can change the affordance landscape and training session dynamics. The findings suggest that coaches should manipulate SSCG situations for players to experience a variety of playing roles to increase opportunities for the players to explore synergy formation with teammates. These manipulations could help players to develop new effectiveness (capabilities) to explore competitive performance

environments from different perspectives, rather than just from the roles developed in an early specialization process.

Coaches could design SSCGs with a team of defenders against midfielders or attackers to promote specific skills and collective behaviours. For example, it may be useful to prepare the defenders to face a team based on possession play while developing the confidence to stay on the ball (fewer lost balls and more shots). Also, it allows the players to learn how to perform individually and collectively to regain spatial-temporal equilibrium relative to ball location while exploring the possibility to recover it. Also, a SSCG with a team of midfielders against a team of attackers could be used to promote spatial-temporal balance in defence, providing affordances for making or preventing diagonal and vertical passes and for recovering ball possession. The lower defensive coordination of the attacking team seems to enhance the perception of space by the midfielders to progress on the field through passing actions and progress towards games against defenders in further phases of development. Finally, a SSCG with a team of attackers against of a team of defenders may be useful to develop the defensive ability of players against highly skilled teams. It allows improvement of players' defensive capability to face the dribbles of attackers and also practise recovering ball possession.

Coaches are able to recognize how teams constituted by players of different roles influence the tactical exploration of possibilities for action during performance as well as their effectiveness percentages. These findings could also inform sport practitioners on the need for players to be exposed to more specialized (i.e., role-based) and more general (varying roles) affordances in the design of SSCGs. Coaches could have elements to design SSCGs to improve the individual tactical skill of players in different roles. For example, by using SSCGs with a larger number of players and larger pitch size, it is possible to practise the skills of defenders, because larger pitch size increases longer passes and crosses. These individual tactical elements are crucial for defenders to practise headers, blocks, and interpretations. When using a smaller number of players in SSCGs, coaches can train the skills of midfielders and attackers. In these games, dribbling, short passes, and shots are in focus. Players' main team role seems to have an impact on their current capabilities for action that can emerge during performance. In line with that finding, this data implies that coaches or practitioners should constantly promote changes in the field dimensions and other properties of SSCGs, allowing players to explore different performance sub-phases or different playing roles, promoting opportunities for exploration of different possibilities for action. Although many coaches might be aware of the advantage of having their players engage in different playing roles, one reason for not doing so is that their focus is on winning the next game. They are not able to see the main point of practising football. At early ages it is not about winning games but rather to train good and diverse players for the future. Those players who have good perception and decision-making skills and who are able to play various different roles are able to adjust to a different style of play.

However, it is important to highlight that practitioners or coaches need to carefully manipulate key task constraints (like number of players or pitch size), always considering players' age and skill level, as well as the tactical principles of play that coaches intend to emphasize. The same SSCGs cannot be used by all teams with the same purposes because the affordances offered for the players will be different. This might be also a problem when a club designs a program/agenda for all its teams (from U7 to U16). By doing this, the major benefit of that program (i.e., the same style of play in all age categories) might not be accomplished, because of too-challenging or too-easy drills/SSCGs. Consequently, to reach efficiency in training process, the coach must have some knowledge that allows him/her to manipulate key task constraints to influence the emergence of specific tactical behaviours aligned with the training aims and game model (s)he/the club has defined.

Modern football might be at a moment facing its next step of evolution. All players, not depending on their position in the field, particularly during the development process, could be more and more able to contribute to the development of "all-round" players. These players are able to switch their roles quickly and fluently depending on the balance and space available on the field. Previous studies have revealed that players in different roles in football receive the surrounding information in different ways and they also have different scanning frequencies in game situations (Aksum et al., 2020; Jordet et al., 2020). So, the more that especially young players play in different roles, the more they enhance their ability to perceive and scan their game-related environment. In a new role, the players have to engage in different types of problem-solving and also to adjust their movements towards teammates and opponent differently. The players perception- and decision-making skills can stimulate taking on a new position on the field. Players' anticipations, reactions, and adaptation to changing situations are influenced by players' and the team's perception of changing events on the field.

This emerging evolution has also been reflected in the top-level teams' traditional formats of play (like 4-4-2 or 4-3-3, etc.). Teams more and more often utilise positional changes to use many different systems in one match. The change of playing system is called a hybrid system. These systems can change depending on whether the team is attacking or defending or even when playing in certain areas of the field. Moreover, positional changes and rotational movements have become common. Many current successful coaches attempt to take advantage of positional interchanges in order to get their players into positions where they can make use of their strengths. One of these phenomena in modern football tactics is the hybrid midfielder. A hybrid player is able to combine different positions in one game. Ideally, the player can utilise their strengths in both positions in the particular phase of the game. For hybrid systems, the coaches need hybrid players, players who are capable of playing in almost any position on the pitch. Footballers these days are expected to be able to merge great athleticism and high energy with intelligence, which enables them to play a variety of

roles. This need for fluidity has seen extra responsibility placed on midfielders, and their importance in teams has soared.

The top-level teams nevertheless still select their players and place them in specific roles. Most typical of these is the goalkeeper, who is specialized to prevent the opposing team from scoring. However, even the goalkeeper role has changed during recent years. Previously, the main role of the goalkeeper was to guard the goal with their hands, but the modern goalkeeper is more of an additional defender or defensive midfielder or "sweeper-keeper". The modern goalkeeper has excellent skills of stopping shots but also good abilities and skills to pass the ball with their feet outside the penalty box and help their team maintain ball possession. Goalkeepers are always unmarked and have a vision of the whole field. Some modern goalkeepers may have over 20 passes per game; according to La Liga statistics, Barcelona goalkeeper Ter Stegen completed 41 passes in a game against Real Madrid in the 2019-2020 season (Tribuna, 2020). Besides a goalkeeper, it is obvious that the top teams in particular purchase players for a specific role. The coaches might need a tall fullback to strengthen the defence, or a fast left-footed winger or attacker who scores 20 goals per season. Teams have certain principles of play and coaches want their team to be able to fulfil those principles as well as possible.

In summary, playing in a different role as a junior or having hybrid players or top-level players in a team is not either/or issue. One way to develop the players is to train them in various SSCGs and by having opportunities to explore, feel and play in different roles.

9 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Despite the obtained results, some limitations should be acknowledged. In this thesis, only U15 players from one team were considered for analysis. Further research should be developed with a larger sample of players and in order to identify if similar spatial-temporal coordination tendencies could be observed with players of different ages and levels of practice. Further research is also required to better understand how variations in the specific capacities of sport performers (e.g., foot preference of participants, different levels of expertise, or even different physical capabilities and levels of fatigue) impact on the emergent dynamics of interpersonal patterns of coordination in different games sub-phases. Also, independently of the age and level of practice, further studies should evaluate the technical/tactical proficiency of players and their level of fitness and maturation in order to understand the impact of individual characteristics on the spatial-temporal coordination tendencies developed in 1-vs-1 and 2-vs-1 sub-phases of football.

The obtained result is that changes in contextual game constraints, such as the relative position of the goal, promote adaptive behaviours of players to perform. In line with that, coaches should constantly promote changes in the field location of 2-vs-1 sub-phases in order to promote the creation of new possibilities for the action of players. Also, the definition of different couples of attackers and defenders according to different levels of effectiveness seems to be a good constraint to create new spatial-temporal information and promote new possibilities for the action of players according to their effectiveness. Further research is required to understand the contribution of such manipulations to the learning process.

Additionally, further research should be developed to understand the impact of individual changes at the team level, by changing the number of players involved in practice games. In this particular format, it means that variations in players' roles may not promote adaptive behaviours at the team level but only in the process of synergy formation at individual (i.e., organization of actions) and sub-group levels of performance (i.e., coordinated activities between players)

(Duarte et al., 2012). These findings emphasize that the exploitation by players of available affordances in SSCGs, as key learning environments, is particularly sustained by an increased capacity to be attuned to the nature of the surrounding information. Further research is required to understand the impact of manipulating players' roles on emergent collective behaviours of SSCG teams in practice environments, using different metrics of analysis related to the spatial-temporal relationships that emerge between players during performance.

Nevertheless, the findings suggest the need for further research and investigations with a larger sample and different SSCGs formats (i.e., 4-vs-4, 5-vs-5, 6-vs-6, or 7-vs-7) in order to discover whether similar results may be observed with players of different ages and levels of practice. In fact, the effectiveness of players, the teams' constitution or even the structure of play used seems to influence the exploitation of possibilities for action and should be considered as a part of the formula of the design of training sessions to improve the learning and performance development of players.

YHTEENVETO (FINNISH SUMMARY)

Jalkapallolla on värikäs historia. Se on lajina läpikäynyt valtavan muutoksen alkuperäisestä väkivaltaisesta ja ilman sääntöjä pelattavista pelistä monimutkaiseksi peliksi, jossa peliesitykseen vaikuttavat urheilijan psyykkiset, tekniset ja taktiset taidot (Stolen et al., 2005). Jalkapallo on tänä päivänä maailman suosituin urheilulaji ja sillä on yli 265 miljoonaa harrastajaa. Sitä pelataan kaikilla mantereilla ja lajilla on 208 lajiliittoa. Suomen Palloliitto on Suomen suurin ja kansainvälisin urheilun lajiliitto. Jalkapallo on Suomen harrastetuimpia lajeja ja sillä on noin 141 000 lisenssipelaajaa.

Jalkapallo huipputasolla edellyttää yleistä urheilullisuutta ja laajaa lajinomaista tekniikkaa. Pelin luonne on intervallityyppinen, jossa vaihtelevat sekä kovavauhtiset ja nopeat että lyhyet ja pitkät juoksut. Pelaaja suorittaa pelin aikana useita lajinomaisia teknisiä suorituksia kuten laukauksia, puskuja päällä, taklauksia sekä erimittaisia syöttöjä. Pelaaja liikkuu suurimman osan peliajasta ilman palloa ja vaihtelee liikkumisnopeuttaan sekä liikuttua matkaa pelitilanteen vaatimalla tavalla. Pelin aikana pelaaja tekee 1400–1600 suunnan- tai intensiteetin muutosta ja näitä muutoksia liikkeessä tapahtuu noin joka neljäs sekunti. Toisaalta pelaaja tekee täysivauhtisen juoksun joka puolentoista minuutin välein.

Jalkapalloa on tutkittu paljon erilaisten pelianalyysien avulla. Nämä analyysit keskittyvät paljolti yksittäisen pelaajan tekemien ratkaisujen analysointiin. Jalkapallossa kuitenkin pelaajien, pelitilanteen ja ympäristön jatkuva dynaaminen vuorovaikutus vaikuttaa sekä pelaajien että joukkueen käyttäytymiseen pelitilanteissa. Pelaajien päätökset perustuvat ympäristöstä kerättyyn informaatioon pallon sijainnista, oman joukkueen ja vastustajan pelaajien liikkeistä ja sijoittumisesta sekä kentällä käytettävissä olevasta tilasta ja ajasta (Araújo et al., 2006). Taitojen oppimisen ekologinen malli (Davids et al., 2005; Newell, 1986) sisältää juuri nämä kolme tekijää, jotka ovat pelaaja, ympäristö ja tehtävä. Yhden tekijän muuttuminen muuttaa myös kahta muuta tekijää ja etenkin niiden vuorovaikutusta. Pelaajien ja eri joukkueiden välinen vuorovaikutus vaikuttaa informaation määrään, päätöksentekoon sekä joukkueiden järjestelmälliseen toimintaan. Ekologisen mallin mukaan joukkueen pelissä toimiminen perustuu pelin tarjoamien ärsykkeiden (tarjoumien) jakamiseen ja käyttämiseen (Silva et al., 2013). Näin pelaajien ennakointiin, reagointiin ja mukautumiseen pelitilanteessa tapahtuviin muutoksiin vaikuttaa se, miten joukkueen pelaajat havainnoivat kenttää ja pelitapahtumia. Tässä lähestymistavassa analysoidaan vastakkain pelaavien joukkueiden pelaajien ja myös oman joukkueen pelaajien välistä jatkuvaa vuorovaikutusta (Araújo et al., 2006). Eri joukkueiden pelaajat kilpailevat periaatteessa koko ajan pallonhallinnan saamisesta ja sen säilyttämisestä sekä pelivälineen siirtämisestä mahdolliseen maalintekopaikkaan pelikentällä. Tätä dynaamista vuorovaikutusta voidaan havaita kaikissa eri pelimuodoissa virallisesta 11-vs-11 pelistä erilaisiin pienpeli- ja harjoitusmuotoihin (esim. 1-vs-1, 2-vs-1, 3-vs-3) asti (McGarry, 2002).

Kaikki pelaajat eivät pysty havaitsemaan ja käyttämään ympäristön tarjoumia samalla tavalla hyödyksi, johtuen tilannekohtaisista tavoitteista,

taitotasosta sekä tottumisesta pelipaikkakohtaisen informaation vastaanottamiseen (Jordet et al., 2020). Havainnoimalla ympäristöään pelaaja kerää ja käsittelee informaatiota ja pyrkii valitsemaan tilanteeseen parhaiten sopivan ratkaisun (päätöksenteko). Tämän tiedon avulla pelaaja ratkaisee, miten hän missäkin tilanteessa toimii. Ekologisessa mallissa taktinen käyttäytyminen määritellään pelaajan kyvyksi valita useasta toimivasta vaihtoehdosta tilanteeseen sopivin tietyn tavoitteen saavuttamiseksi (Hastle, 2001). Joukkueen ajatellaankin olevan dynaaminen kokonaisuus, joten joukkueen onnistumiseen pelitilanteessa vaikuttavat pelaajien fyysiset, psyykkiset, tekniset ja taktiset taidot (Davids et al., 2005).

Pelaajilla on modernissa jalkapallossa varsin erilaisia pelipaikkakohtaisia ja erikoistuneita taktisia rooleja (Yi et al., 2018). Aikaisemmissa tutkimuksissa on tutkittu eri pelipaikoilla pelaavien pelaajien taktisia ratkaisuja. Hyökkääjien on todettu laukovan enemmän maalia kohti ja myös tekevän maaleja enemmän verrattuna muiden pelipaikkojen pelaajiin (Gai et al., 2019). Keskikenttäpelaajien puolestaan on todettu antavan enemmän onnistuneita syöttöjä kuin muiden pelipaikkojen pelaajien (Liu et al., 2016; Redwood-Brown et al., 2012). Puolustajien on todettu tekevän enemmän syötön katkoja keskikenttäpelaajiin ja hyökkääjiin verrattuna (Yi et al., 2018). Aikaisemmissa tutkimuksissa on myös todettu, että eri pelipaikkojen pelaajilla on erilaiset havainnon kohdistamisfrekvenssit eli miten paljon pelaaja liikuttaa päätään ja nostaa katsettaan pallosta pois kerätäkseen informaatiota peliympäristöstä (Jordet et al., 2020). Keskikentän keskustan pelaajilla on todettu olevan suurimmat ja hyökkääjillä pienimmät frekvenssit (Jordet et al., 2020). Pelaajat saavat informaatiota päätöksentekoon suurimmaksi osaksi visuaalisten ärsykkeiden avulla. Näihin ärsykkeisiin sisältyy silmien, pään ja vartalon liikkeet, jotka tukevat pelaajien visuaalisen informaation muodostumista (Aksum et al., 2020; McGukian et al., 2018). Näin ollen voidaan olettaa, että pelaajien käyttäytymiseen kentällä vaikuttavat havainnon kohdistamisfrekvenssin (Jordet et al., 2020) lisäksi koko ajan tapahtuvat toimet peliympäristön laajamittaiseen havaitsemiseen (McGukian et al., 2018). Viimeaikaisten tutkimusten mukaan eri pelipaikkojen pelaajilla (hyökkäävät tai puolustavat pelaajat) ilmenee erilaista yksilöllistä käyttäytymistä erilaisissa pelitilanteissa. Pelaajien ratkaisuja suhteessa oman joukkueen sekä vastustajan pelaajiin, tilaan ja aikaan on selvitetty jalkapallon 1-vs-1 (Laakso et al., 2017) ja 2-vs-1 tilanteissa (Laakso et al., 2019).

Ekologisessa mallissa yksilön ratkaisut syntyvät ympäristön, pelaajan ja tehtävän dynaamisessa vuorovaikutuksessa. Näitä peruselementtejä voidaan manipuloida asettamalla toiminnalle tiettyjä rajoitteita eli reunaehtoja. Rajoitteet voivat mahdollistaa pelaajan taktisten ominaisuuksien kehittymisen heidän oppiessaan mukautumaan vaihtelevissa tilanteissa ja kehittämään erilaisia toimintatapoja tavoitteen saavuttamiseksi pelitilanteissa. Ympäristön rajoitteet voivat olla esimerkiksi pelaaminen kuivalla/märällä kentällä, pehmeällä/kovalla pinnalla tai luonnon- tai tekonurmella. Pelaajaan liittyvät rajoitteet ovat luonteeltaan fysiologisia tai psykologisia, kuten pelaajan pituus ja paino tai pelaajan aikaisemmat kokemukset ja motivaatio. Tehtävään liittyvät rajoitteet ovat laajin ja tärkein jalkapallon harjoittelussa. Tällaisia rajoitteita ovat esimerkiksi tehtävän tavoite,

pelin säännöt, pelaajien lukumäärä, pelialueen koko ja -muoto sekä maalien sijoittelu tai lukumäärä. Valmentajalla on huomattavasti suuremmat mahdollisuudet vaikuttaa nimenomaan tehtävärajoitteisiin muihin rajoitteisiin verrattuna. Pienpelit (SSCG eli Small-Sided and Contitioned Games, SSCGs) ovat pelimuotoja, jotka tarjoavat lukuisia mahdollisuuksia tehtävärajoitteiden manipuloimiseen pelaajien ja joukkueiden taktisen käyttäytymisen opettamiseen. Suurin osa aikaisemmista pienpelitutkimuksista on keskittynyt kentän koon sekä pelaajamäärän manipulointiin.

Pienpelit ovat yleisesti käytettyjä harjoitusmenetelmiä jalkapallossa sekä ammattilais- että juniorijoukkueissa. Pienpelien suurimpana hyötynä on se, että niissä jäljitellään pelaajien kilpapelin kaltaisia liikevaatimuksia, fysiologista intensiteettiä ja teknisiä vaatimuksia samalla kun pelaajien pitää tehdä nopeita päätöksiä paineen alla ja usein väsyneenä (Dellai et al., 2011; Gabbett & Mulvey, 2008). Pienessä tilassa nopeasti vaihtuvat tilanteet tuottavat ennakoimattomuutta, satunnaisuutta sekä virallisen 11-vs-11 pelimuodon monimuotoisuutta (Travassos et al., 2014). Lisäksi pienpelien hyötynä on aikatehokkuus eli niiden avulla valmentaja pystyy yhdistämään esimerkiksi intervalliharjoituksen pelinomaiseen harjoitteluun (Gabbett & Mulvey, 2008). Pienpelejä pelataan usein virallista 11-vs-11 peliä pienemmällä pelaajamäärällä, pinta-alaltaan ja muodoltaan muokatulla kentällä sekä sovelletuilla säännöillä (Hill-Haas et al., 2011).

Väitöskirjan keskeisenä tavoitteena oli tutkia taktista käyttäytymistä jalkapallossa erityisesti kentän sijainnin (lähellä rangaistusaluetta vasemmalla, keskellä ja oikealla) toimiessa rajoitteena pelaajien toimintaan 1-vs-1 ja 2-vs-1-tilanteissa. Tavoitteena oli myös tutkia miten eri peliroolit (puolustaja, keskikenttäpelaaja ja hyökkääjä) vaikuttavat eri kentän kohdissa ja pienpeleissä tapahtuviin pelitilanteisiin. Tulosten mukaan on tärkeää ymmärtää miten rajoitteiden manipuloiminen voi vaikuttaa pelaajien taktiseen käyttäytymiseen ja pelaajien väliseen vuorovaikutukseen. Ensimmäisen artikkelin tulosten mukaan sekä kentän sijainti että pelaajien peliroolit rajoittivat pelaajien taktista käyttäytymistä kuljetuksessa ja laukaisuissa 1-vs-1-tilanteissa. Toisessa artikkelissa 2-vs-1-tilanteissa havaittiin samankaltaisia tuloksia kuin 1-vs-1-tilanteissa. Eri kentän kohtien välillä oli havaittavissa muutoksia pelaajien välisissä suhteissa tilaan ja aikaan nähden. Puolustajien taktinen käyttäytyminen erosi hieman keskikenttäpelaajiin ja hyökkääjiin verrattuna. Kolmannessa artikkelissa havaittiin eroja eri peliroolien pelaajista (puolustajat, keskikenttäpelaajat, hyökkääjät) koostuneiden joukkueiden taktisessa käyttäytymisessä.

Väitöskirjan tutkimusaineisto koostui 15 alle 15- vuotiaasta poikapelaajasta (ikä 13,2 ± 1,03 vuotta, harjoitteluvuosia 4,2 ± 1,10 vuotta). Tutkimusta varten pelaajat jaettiin valmentajien arvioiden perusteella kolmeen ryhmään. Näin muodostuneisiin ryhmiin saatiin 5 puolustajaa (laitapuolustajat ja keskuspuolustajat), 7 keskikenttäpelaajaa sekä 3 hyökkääjää. Koehenkilöt kuuluivat Jyväskylän Jalkapalloklubin (JJK) joukkueeseen, joka osallistui Suomessa pelattaviin sarjoihin kaudella 2016–2017. Kaikki koehenkilöt olivat oikeajalkaisia ja pelasivat ikäkauden ykkösjoukkueessa. Koehenkilöillä oli seuran ohjaamia harjoituksia viisi

kertaa viikossa (90 minuuttia/harjoitus) sekä virallisia tai harjoitusotteluita viikonloppuisin.

Viime vuosina erilaiset pelin- ja liikkeen analysointiohjelmat ovat yleistyneet jalkapallossa. Joukkuelajeissa joukkueen kollektiivista dynamiikkaa voidaan yksilö-ympäristötasolla tutkia pelaajien liikkeiden tallentamisella. Liikkeiden tallentaminen ja niiden uudelleen rakentaminen/mallintaminen aidossa ympäristössä on yksi keskeisimmistä tekijöistä tutkittaessa kollektiivista käyttäytymistä joukkuelajeissa. Näiden menetelmien yleistymisen myötä on yleistynyt myös erilaiset matemaattiset menetelmät, joita käytetään pelaajien spatiaalisten koordinaattien uudelleen rakentamiseen. Yksi keskeisimmistä seikoista liikkeen videopohjaisessa analysoimisessa on virtuaalisen datan (mitä nähdään tietokoneen ruudulla?) muuttaminen todelliseksi dataksi (eli mitä tapahtui todellisuudessa?) mahdollisimman pienellä virhemarginaalilla.

Suora lineaarinen transformaatiomenetelmä (2D-DLT) on yleisimmin käytetty algoritmi kameran kalibrointiin ja datan uudelleen rakentamiseen. Tässä väitöstutkimuksessa sekä 1-vs-1- että 2-vs-1-pelitilanteet tallennettiin käyttämällä yhtä digitaalista kameraa (Sony HRX-MC50E), joka sijaitsi 4 metriä korkealla ja kuvasi liikuttamatta jokaisen alueen tapahtumat noin 45 asteen kulmassa. Koehenkilöiden liikkeet jokaisella suorituspaikalla digitalisoitiin käyttämällä TACTO-ohjelmaa. Pelitilannekuvaa pyöritettiin hidastettuna (1/2 normaalinopeudesta) ja jokaisen pelaajan ja pallon liikeratoja seurattiin TACTO-ohjelmassa käyttämällä hiiren kursoria tarkan seurantapisteen sijaittua pelaajan lantion kohdalla. Kentän kalibrointi tapahtui määrittelemällä tietokoneen näytöllä sijaitsevasta pysäytyskuvasta pelialueen x- ja y-koordinaatit sekä 0-piste käyttäen hiiren kursoria. Nämä virtuaaliset koordinaatit muutettiin oikeiksi koordinaateiksi käyttämällä suoraa lineaarista tranformaatiomenetelmää (2D-DLT). 3-vs-3-pienpelit kuvattiin samalla kameralla 10 metrin korkeudesta. Kaikki pienpelit editoitiin aluksi videopätkiin, joiden kesto riippui ajasta, jonka pallo oli peleissä pelattavissa. Aika katkesi aina, kun joukkue teki maalin tai pallo pelattiin kentän rajojen ulkopuolelle. Seuraava videopätkä lähti liikkeelle siitä hetkestä, kun maalivahti avasi pelin oman joukkueen pelaajalle. Tutkimukseen valittujen teknisten muuttujien lukumäärät laskettiin hand-notation-systeemillä. Jokainen joukkueen pelaajan tekemä tekninen suoritus laskettiin (pallonhallintaa lukuun ottamatta) hidastustoiminnan avulla (kuvanopeus 12 kuvaa/sekunti).

Ensimmäisen artikkelin tavoitteena oli tarkastella pienpelien pienimmän yksikön (1-vs-1) avulla eri pelipaikkojen pelaajien taktista käyttäytymistä eri kentän kohdissa tapahtuvissa 1-vs-1-tilanteissa (ks. Figure 1 sivulla 30). Tilanteissa jokaisen pelipaikan pelaajat (puolustaja, keskikenttäpelaaja ja hyökkääjä) toimivat vuorollaan sekä pallollisena pelaajana (hyökkääjänä) että puolustavana pelaajana (puolustaja). Eli tilanteissa tutkittiin puolustaja vs. keskikenttäpelaaja-, puolustaja vs. hyökkääjä-, keskikenttäpelaaja vs. puolustaja-, keskikenttäpelaaja vs. hyökkääjä-, hyökkääjä vs. puolustaja- sekä hyökkääjä vs. keskikenttäpelaajaparien taktista käyttäytymistä 10 x 5 metrin kokoisella alueella sekä vasemmalta, keskeltä, että oikealta puolelta lähellä rangaistusalueen rajaa. Pelaajien välistä taktista käyttäytymistä mitattiin ensinnäkin hyökkäävän ja puolustavan pelaajan

suhteellisina etäisyyksinä maalin keskikohdasta mitattuna, ja toiseksi maalin keskikohdan, puolustavan pelaajan ja hyökkäävän pelaajan muodostaman kulman avulla.

Tämän tutkimuksen tulokset tukevat Headrickin et al. (2011) tutkimusta, jossa etäisyys maaliin rajoitti puolustajan ja pallon välistä etäisyyttä. Tässä tutkimuksessa havaittiin selvästi, että eri kohdissa (oikealla, keskellä tai vasemmalla) olevat alueet lähellä maalia rajoittavat pelaajien välisiä suhteita erityisesti hyökkääjien ja puolustajien suhteellisissa etäisyyksissä ja suhteellisissa pelaajien välisissä kulmissa, joita esiintyy 1-vs-1-tilanteissa. Nämä tulokset tukivat myös aiempia tuloksia (Travassos et al., 2011; Vilar, Araújo, Davids, Travassos, Duarte, et al., 2012), joissa maalin sijainti näytti olevan keskeinen muuttuja, joka vaikutti hyökkäävien pelaajien pallon kuljettamiseen ja laukaisemiseen 1-vs-1-tilanteissa. Myös pelaajien erilaiset peliroolit toimivat rajoitteina pelaajien välissä suhteissa. Näin ollen voidaan olettaa, että pelaajien aikaisemmat kokemukset tietystä peliroolista vaikuttivat pelaajien välisiin suhteisiin muiden pelaajien kanssa. Puolustajien hyökätessä ja hyökkääjien puolustaessa pelaajien väliset etäisyydet olivat pienimmillään. Osaselityksenä tähän voi olla tosiasia, että pelitilanteessa puolustajalla ei ole montaa mahdollisuutta kokea 1-vs-1-tilannetta hyökkääjänä ja päinvastoin. Tulokset tukevat aikaisempia tutkimuksia (Headrick et al., 2011), joissa ilmeni, että mikäli pallollinen pelaaja onnistui kuljetuksessa ja laukaisussa maalia kohti, hän pystyi tilanteessa säilyttämään merkittävästi suuremman pelaajien välisen etäisyyden hänen ja puolustavan pelaajan välillä.

Mielenkiintoinen tulos tässä tutkimuksessa oli myös se, että pelaajien jalkaisuus (kaikki oikeajalkaisia) näytti olevat avainrajoite, joka rajoitti hyökkäävän pelaajan mahdollisuuksia kuljettaa ja laukaista. Jalkaisuus näytti vaikuttavan siihen, että hyökkäävällä pelaajalla oli vasemmalla alueella mahdollisuus kuljettaa puolustavan pelaajan ohi oikealla jalalla oikealta puolelta päästäkseen sopivaan laukaisukulmaan. Oikealla alueella oikealla jalalla kuljettaminen usein pienensi laukaisukulmaa maaliin nähden. Estääkseen maalilaukauksen vasemmalla alueella, puolustajan on yritettävä minimoida pelaajien välinen etäisyys ja kulma maaliin nähden.

Toisen artikkelin tavoitteena oli lisätä ymmärrystä puolustaja-hyökkääjäparien tilaan ja aikaan liittyvistä (spatiaalis-temporaalisista) suhteista. Näitä erilaisia suhteita on raportoitu aiemmissa tutkimuksissa 1-vs-1-tilanteissa (Headrick et al., 2011; Vilar, Araújo, Davids, Travassos, Duarte, et al., 2012). Jalkapallossa, kuten muissakin joukkuepeleissä, tutkimukset ovat osoittaneet, että hyökkääjien tulee olla aloitteentekijä vuorovaikutustilanteessa puolustajien kanssa. Hyökkääjien tulee luoda yllättäviä muutoksia pelaajien välisiin etäisyyksiin, suhteellisiin kulmiin pelaajien ja maalin välillä tai suhteelliseen nopeuteen (rytminvaihto) saavuttaakseen toivotun lopputuloksen eli puolustajan ohittamisen (Shultze et al., 2018). Toisaalta puolustajat pyrkivät rajoittamaan hyökkääjien toimintaa ja säilyttämään eri etäisyyksien tasapainon ja vakauden hyökkääjiin nähden onnistuakseen omassa toiminnassaan eli maalinteon estämisessä (Clemente et al., 2013; Duarte et al., 2012). Useimmissa joukkuepeleissä hyökkääjät pyrkivät saavuttamaan edun itselleen aikaansaamalla nopeasti hetkellisen

ylivoiman itselleen jossakin kentän kohdassa. Erityisesti jalkapallossa ylivoima pallon läheisyydessä vaikuttaa usein onnistuneeseen suoritukseen hyökkäyksessä tilan saamisella puolustuslinjan taakse tai puolustuksessa pallon riistoon (Vilar et al., 2013). 2-vs-1-tilanne on pienin mahdollinen pienpeliyksikkö, jossa edellä mainittua ylivoimaa on mahdollista aikaan saada hyökkäävälle joukkueelle. Tässä pienpelissä pallollisen hyökkääjän ja pallottoman hyökkääjän on oleellista pyrkiä luomaan yksittäistä puolustajaa vastaan tilanne, joka mahdollistaa kaksi vaihtoehtoista ratkaisua: pallollinen pelaaja voi kuljettaa ja haastaa puolustajan 1-vs-1-tilanteessa, jos puolustaja sulkee liikkeellään syöttölinjan pallottomaan hyökkääjään nähden tai pallollinen voi houkutella puolustajan lähelle itseään ja sen jälkeen syöttää pallo toiselle hyökkääjälle syöttölinjan avautuessa. Huolimatta tilapäisen ylivoiman luomisen keskeisestä roolista eri tilanteiden voittamisessa, sitä on tutkittu aidoissa 2-vs-1-tilanteissa erittäin vähän. 2-vs-1-pienpeleissä ylimääräinen hyökkääjä lisää pallollisen hyökkääjän mahdollisuuksia toimia (kuljettaa, syöttää, laukaista) samalla tehden puolustajan sijoittautumisen vaikeammaksi. Puolustaja pyrkii hyökkääjien lisääntyneistä mahdollisuuksista huolimatta sijoittumaan syöttölinjalle ja estämään pallollisen kuljettamista ja laukaisuja (Vilar, Araújo, Davids, & Travassos, 2012).

Toisessa artikkelissa tarkasteltiin miten kentän erilaiset kohdat suhteessa maaliin (vasemmalla, keskellä ja oikealla rangaistusalueen rajalla (ks. Figure 2 sivulla 32) sekä pelaajien peliroolien (puolustajat, keskikenttäpelaajat, hyökkääjät) manipulointi vaikuttivat pelaajien välisiin suhteisiin 2-vs-1-tilanteissa. Tutkimuksessa kaikki pelaajat toimivat vuorollaan hyökkääjinä ja puolustajina, riippumatta pelipaikasta. Ylivoimahyökkääjinä toimi aina saman roolin pelaaja (esim. puolustaja + puolustaja vastaan keskikenttäpelaaja tai keskikenttäpelaaja + keskikenttäpelaaja vastaan hyökkääjä). Pelaajien välistä taktista käyttäytymistä mitattiin ensinnäkin pallollisen pelaajan ja puolustajan välisellä etäisyydellä maalin keskustasta (suhteellinen etäisyys). Toiseksi mitattiin pelaajien väliset kulmat seuraavasti: a) pallollinen hyökkääjä – puolustaja – toinen hyökkääjä ja b) maalin keskusta – puolustaja – pallollinen hyökkääjä. Oikealta alueelta hyökättäessä palloton hyökkääjä aloitti alueen vasemmalla puolella ja vasemmalta alueelta hyökätessä palloton hyökkääjä aloituspaikka oli alueen oikealla puolella (ks. Figure 2 sivulla 32). Keskimmäisellä alueella palloton hyökkääjä sijoittui aina pallollisen pelaajan ei-dominoivan jalan puoleiselle sivulle eli tässä tapauksessa aina alueen vasemmalle puolelle.

Keskimmäisellä alueella todettiin alhaisempia mitattuja arvoja sekä pelaajien välisissä etäisyyksissä että molemmissa mitatuissa kulmissa. Tulos on ristiriidassa ensimmäisen artikkelin tulosten kanssa, mutta selittyy sillä, että 2-vs-1-tilanteissa ylimääräinen hyökkäävä pelaaja lisää pallollisen pelaajan mahdollisuuksia kuljettaa, syöttää tai laukoa. Näin puolustajan toiminta on erilaista 1-vs-1- tilanteiden puolustajan toimintaan verrattuna hänen joutuessa hyökkääjien lisääntyvien mahdollisuuksien takia sekä katkomaan syöttölinjaa että estämään pallollisen hyökkääjän etenemistä laukaisulinjalle. Havainnot tuloksissa oikealla ja vasemmalla alueella olivat myös ristiriitaisia. Yhtenä selittävänä tekijänä tähän on se, että kaikki pelaajat olivat oikeajalkaisia, mikä rajoitti näin pallollisen

pelaajan mahdollisuuksia syötölle tai laukaukselle. Tämä tarjoaa puolustajalle erilaisia mahdollisuuksia puolustaa. Huomioitavaa on myös se, että pallollisen parempi jalka (oikea) oli oikealla alueella ”ulkopuolella” tarjoten pallolliselle pelaajalle mahdollisuuden ohittaa puolustaja oikealta puolelta. Näin toimiessaan tilanne tarjoaa puolustajalle mahdollisuuden puolustaa sijoittumalla selkeämmin maalin ja hyökkäävän pelaajan linjalle (kulma maali – puolustaja – hyökkääjä oli korkeampi oikealla alueella kuin vasemmalla). Tähän tilanteeseen mukautuminen mahdollistaa puolustajalle suuremman etäisyyden säilyttämiseen pallolliseen nähden ja tarjoten pallolliselle pelaajalle mahdollisuuden ohittamiseen hänet oikealta puolelta. Näin pallollinen joutuu laukaisemaan pienemmästä kulmasta maalia kohti. Puolustaja pyrkii säilyttämään linjan maalin ja pelaajan välissä varmistaen, ettei pallollinen pysty laukomaan paremmalla jalalla. Tilanne on päinvastainen vasemmalta alueelta, jossa aloitustilanteessa toinen hyökkääjä on alueen oikealla puolella. Pallollinen hyökkääjä pyrki saavuttamaan tilaa kuljettamalla keskelle tai avaamaan mahdollisten syöttölinjan toiselle hyökkääjälle. Näissä tilanteessa puolustaja pyrki ohjaamaan pallollista hyökkääjää vasemmalle estäen näin paremman jalan käytön ja samalla siirtymällä syöttölinjalle toisen hyökkääjän ja pallollisen väliin, jolloin kulma ”pallollinen – puolustaja – toinen hyökkääjä” kasvoi, kun puolestaan kulma ”maali – puolustaja – hyökkääjä” pieneni. Kun puolustaja prässää pallollista pelaajaa, hänen tavoitteenaan on estää syöttö toiselle hyökkääjälle lisäten näin kulman ”pallollinen – puolustaja – toinen hyökkääjä” suuruutta hetkellisesti antaen tilaa hyökkääjälle suhteessa maaliin.

Pelaajan pelirooli toimi myös rajoitteena pelaajien välisiin suhteisiin 2-vs-1-tilanteissa. Tulosten mukaan puolustajilla oli korkeammat arvot pelaajien välisissä etäisyyksissä muihin pelirooleihin verrattuna puolustajien toimiessa hyökkääjän roolissa. Keskikenttäpelaajilla oli hyökkääjiä suuremmat arvot pelaajien välisissä etäisyyksissä edelleen hyökkääjän roolissa toimiessa. Näiden tulosten johtopäätöksenä voidaan todeta, että eri peliroolien tuttuus ja pelaajien aiemmat kokemukset eri pelipaikoilla toimimisessa vaikuttavat vuorovaikutukseen muiden pelaajien kanssa erityisesti erilaisten tilanteissa ilmenneiden mahdollisuuksien havaitsemiseen ja käyttämiseen.

Kolmannen artikkelin tavoitteena oli selvittää miten eri pelirooleista koostuvat joukkueet rajoittavat yksilöllistä ja kollektiivista taktista käyttäytymistä sekä pelin tehokkuutta 3-vs-3-pienpeleissä. 3-vs-3 on pienin pienpeliyksikkö, jossa on mahdollista tutkia joukkueena pelaamista esimerkiksi syöttösuuntia, ylivoiman rakentamista, tuen tarjoamista hyökkäyksessä ja puolustuksessa. Pienpelijoukkueet koostuivat saman pelipaikan pelaajista ja jokainen pienpeliryhmä pelasi toisiaan vastaan (puolustajat vs. keskikenttäpelaajat, puolustajat vs. hyökkääjät ja keskikenttä vs. hyökkääjät). 3 vs. 3-pienpelit pelattiin virallisiin maalivahtien vartioimiin jalkapallomaaleihin (2,44 m x 7,32 m) ja kentän koko oli 30 x 25 metriä. Pelaajien ja joukkueiden taktisia osa-alueita mitattiin käyttämällä aikaisemmissa tutkimuksissa käytettyjä muuttujia ja näistä muuttujista muodostettiin kuvailevaan analyysiin neljä luokkaa: a) joukkueena pelaaminen, b) pelaajien yksilölliset ratkaisut hyökkäyspelissä, c) pelaajien yksilölliset ratkaisut puolustuspelissä ja d) voittamiseen liittyvät tekijät.

Tuloksissa havaittiin eroja yksilön hyökkäys- ja puolustuskäyttäytymisessä sekä pallonhallinnassa eri joukkueiden välillä. Pallonhallinnassa ja pelaajien osallistumisessa hyökkäyksissä (lukumäärä) ei havaittu eroja joukkueena toimimista selvitettäessä. 11-vs-11 pelissä on isoja eroja eri pelaajarooleihin erikoistumisen välillä. Jokaisella roolilla, jotka määritellään useimmin puolustajiin, keskikenttäpelaajiin ja hyökkääjiin, on erityisiä teknisiä, taktisia ja fyysisiä vaatimuksia, jotka täytyy omaksua pelipaikkojen vaihtelevien suoritusrajoitteiden takia. Aikaisempien tutkimusten mukaan eri pelipaikkojen pelaajilla on erilaiset havainnon kohdistamisfrekvenssit: keskikentän keskellä pelaavilla on todettu olevan suurimmat ja hyökkääjillä pienimmät frekvenssit (Jordet et al., 2020). Jalkapallossa pelaajan päätöksentekoon tarvittava informaatio hankitaan suurimmaksi osaksi visuaalisten ärsykkeiden avulla. Näihin ärsykkeisiin sisältyy silmien, pään ja vartalon liikkeet, jotka tukevat pelaajien visuaalisen informaation muodostumista (Aksum et al., 2020; McGukian et al., 2018). Tämän tutkimuksen tulokset tukevat aikaisempia tutkimuksia, joissa pelaajan peliroolin on todettu olevan avainrajoite yksilön taktisen käyttäytymisen oppimiseen. Tämä tutkimus on myös sopusoinnussa aikaisempien tutkimusten kanssa, joiden mukaan eri pelipaikkojen pelaajilla (hyökkäävät tai puolustavat pelaajat) ilmenee erilaista yksilöllistä käyttäytymistä erilaisissa pelitilanteissa. Näin ollen voidaan olettaa, että pelaajien käyttäytymiseen kentällä vaikuttavat havainnon kohdistamisfrekvenssin (Jordet et al., 2020) lisäksi koko ajan tapahtuvat toimet peliympäristön laajamittaiseen havaitsemiseen (McGukian et al., 2018).

Puolustajien tehtävä 11-vs-11 pelissä on, pallon ollessa vastustajalla, estää vastustajaa etenemästä maalintekoalueelle. Toisaalta oman joukkueen pallonhallintatilanteissa, puolustajat pyrkivät luomaan tilaa keskikenttäpelaajille pallon vastaanottamiseen, mutta he pyrkivät myös rakentamaan hyökkäyspeliä tarjoamalla peliä tukevien syöttöjen mahdollisuuksia. Puolustajien joukkue, vastoin odotuksia, laukoi maalia kohti enemmän kuin keskikenttäpelaajien joukkue. Tämä voi selittyä puolustajien suoraviivaisesta pyrkimyksestä pallon riiston jälkeen eteenpäin ja tässä tutkimuksessa käytetty kentän koko mahdollisti 1–2 syötöllä jo laukaisusektorille pääsyn. Keskikenttäpelaajien joukkue syötti läpisyöttöjä sekä enemmän syöttöjä eteenpäin hyökkääjien joukkueeseen verrattuna. Keskikenttäpelaajien rooli on rakentaa peliä hyökkääjien ja puolustajien välillä, ja he etsivät murtavia syöttölinjoja eteenpäin hyökkääjille. Keskikenttäpelaajien joukkue, aikaisemman havainnon mukaisesti, laukoi maalia kohti puolustajien joukkuetta vähemmän. Tämä voi selittyä keskikenttäpelaajien taipumuksesta syötellä ja etsiä mahdollisuuksia murtaviin syöttöihin, ja on myös osoituksena, miten pelaajien aikaisemmat kokemukset eri pelipaikoilta vaikuttavat peliesitykseen 3-vs-3-pienpeleissä. Hyökkääjien tehtävänä pelissä on usein pelata hyökkäysalueella vastustajien välittömässä vartioinnissa. He pyrkivät pienessä tilassa ja vähäisessä ajassa vastaanottamaan pallon, kääntymään tai kuljettamaan ja laukomaan maalia kohti. Hyökkääjien ratkaisut vaativat usein nopeaa tilanteiden lukua ja luovuutta heidän pyrkiessään luomaan epätasapainoa puolustuslinjaan. Hyökkääjien joukkueella esiintyi enemmän kuljetuksia kuin muilla joukkueilla,

mutta myös vähemmän läpisyöttöjä ja syöttöjä eteenpäin kuin keskikenttäpelaajien joukkueella.

Tämän tutkimuksen tulokset olivat ristiriidassa aiempien tutkimusten kanssa, joissa hyökkääjät laukovat eniten maalia kohti ja tekevät enemmän maaleja kuin muiden pelipaikkojen pelaajat. Tämä selittyy osaksi sillä, että hyökkääjät käyttävät 3-vs-3-pienpeleissä erilaista havaintoon perustuvaa informaatiota, käytettävissä olevia mahdollisuuksia toimia ja liikemalleja 11-vs- 11 peliin verrattuna. Tähän tulokseen vaikuttaa varmasti myös se, että aiemmissa tutkimuksissa on tutkittu 11-vs-11 peliä, jossa hyökkääjien rooli on viimeistellä maaleja ja heidän laukaisuaktiivisuutensa on pelipaikasta johtuen suurempaa muiden pelipaikkojen pelaajiin verrattuna. Hyökkääjien suuremmat arvot pallonmenetyksissä tässä tutkimuksessa puolustajiin verrattuna saattavat osaksi selittyä sillä, että hyökkääjät ovat 11-vs-11 pelissä taipuvaisia ottamaan tiettyjä riskejä 1-vs-1-tilanteissa, yleensä hyökkäyspäässä. Pienpeleissä 1-vs-1-tilanteissa pallonmenetykset saattavat kostautua vastustajan maalilaukauksina tai maaleina 11-vs-11 peliä tehokkaammin, koska hyökkääjien pallonmenetykset epäonnistuneissa 1-vs-1-tilanteissa tapahtuvat normaalissa pelissä yleensä kaukana omasta maalista.

Tutkimuksen tulokset osoittavat, että pelaajan varsinainen pelipaikka voi rajoittaa ja tuottaa erilaista kollektiivista ja yksilöllistä käyttäytymistä 3-vs-3-pienpeleissä. Eri pelipaikkojen pelaajat käyttävät eri tavalla hyväksi ympäristön tarjoamia ärsykkeitä ja pelaavat näin ollen eri tavalla pienpeleissä. Väitöskirjan artikkeleissa 1 ja 2 saatiin samanlaisia tuloksia peliroolin vaikutuksesta 1-vs-1- ja 2-vs-1-tilanteisiin.

Väitöskirjan tuloksilla voi olla paljon käytännön merkitystä jalkapallovalmentajille. Nämä tulokset auttavat ensinnäkin valmentajaa entistä paremmin valitsemaan harjoituksissa käytetyt pienpelit vastaamaan harjoitukselle asetettuja tavoitteita. Jalkapalloharjoituksissa käytetään usein erilaisia tehtäviä (harjoitteita) tai pienpelejä. Tehtävärajoitteet ovat tärkein rajoitteiden kategoria jalkapallotaitojen oppimisessa. Rajoitteiden tehtävänä on manipuloida harjoitteissa olevaa informaatiota ja luoda oppimisympäristöön tarjoumia, eli mahdollisuuksia toimintaan. Eli rajoitteiden ensisijainen tehtävä on mahdollistaa tarjoumien etsiminen, tunnistaminen ja hyödyntäminen. 1-vs-1- ja 2-vs-1-pelitilanteet suunnitellaan usein vain käytettävissä olevan tilan mukaan. Valmentajien tulisi kuitenkin järjestää pelaajille tilanteita, joissa he joutuvat ratkaisemaan em. tilanteita eri etäisyyksillä maalista sekä erilaisista kulmista maaliin nähden oikealta, keskeltä ja vasemmalta. Näin hyökkäävät pelaajat joutuvat etsimään erilaisia ratkaisuja kuljettaa ja laukaista erilaisista kulmista maaliin nähden ja tämä voisi ohjata pelaajia laukomaan myös heikommalla jalalla. Puolustajille tilanteet eri kentän kohdissa tarjoavat kokemuksia erilaisiin sijoittumisiin maaliin ja kentän rajoihin nähden ja samoin hyökkääjien jalkaisuuden tunnistamiseen ja näin myös paremman jalan käytön estämiseen. Manipuloimalla tehtävien rajoitteita, kuten harjoitteet eri kentän kohdista tai sijoittamalla pelaajat jalkaisuuden mukaan eri laitoihin kentällä, valmentaja luo pelaajille erilaisia tilanteita, missä havainnoida peliympäristöä. Peliympäristöstä saatua informaatiota keräämällä ja käsittelemällä pelaajat pyrkivät valitsemaan uuteen muuttuvaan tilanteeseen parhaiten sopivan

ratkaisun. Kentän eri kohdissa tapahtuvat tilanteet tarjoavat pelaajille siis uusia mahdollisuuksia toimintaan.

3-vs-3-pienpelien tulokset osoittavat eroja yksilöllisessä taktisessa käyttäytymisessä puolustettaessa ja hyökätessä eri pelirooleista koostuvien joukkueiden kesken. Saatujen tulosten perustelu ekologisen dynamiikan mallin pohjalta osoittaa, että pelaajien peliroolilla kentällä saattaa olla vaikutusta heidän havainto-toimintakehäänsä eli miten he käyttävät pelitilanteessa saamaansa informaatiota toimintansa säätelyyn. Mitä enemmän etenkin nuoret pelaajat pelaavat eri pelipaikoilla, sitä enemmän he laajentavat havaintokehäänsä ja saavat erilaisia peliin liittyviä ärsykkeitä toimintaansa. Pelaajat havainnoivat peliympäristöään ja mukauttavat toimintaansa tarjoumien avulla saavuttaakseen pelille asetetut tavoitteen. Uudessa pelipaikassa pelaaja joutuu tekemään ongelmanratkaisua, sopeuttamaan omia liikkeitään oman joukkueen pelaajiin ja vastustajiin nähden uudella tavalla, ja ennen kaikkea pelaajan havainto- ja päätöksentekotaidot saavat uusia ärsykkeitä. Kääntäen voidaan ajatella tietylle pelipaikalle varhain erikoistumisen rajoittavan havaintokehän laajenemista uusien tarjoumien puuttumisen takia. Valmentajien tulisi siis tarjota pelaajille mahdollisuutta erilaisissa pienpeleissä ja peliryhmityksissä pelata eri pelipaikoilla erilaisten havainto- ja liikemallien kehittymisen takia.

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ORIGINAL PAPERS

I

FIELD LOCATION AND PLAYER ROLES AS CONSTRAINTS ON EMERGENT 1-VS-1 INTERPERSONAL PATTERN OF PLAY IN FOOTBALL

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Full Length Article

Field location and player roles as constraints on emergent 1-vs-1 interpersonal patterns of play in football

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ABSTRACT

This study examined effects of player roles on interpersonal patterns of coordination that sustain decision-making in 1-vs-1 sub-phases of football in different field locations near the goal (left-, middle- and right zone). Participants were fifteen U-16 yrs players from a local competitive amateur team. To measure interpersonal patterns of coordination in the 1-vs-1 dyads we recorded: (i) the relative distance value between each attacker and defender to the centre of the goal, and (ii), the relative angle between the centre of the goal, each defender and attacker. Results revealed how variations in field locations near the goal (left-, middle- and right-zones) constrained the relative distance and relative angle values that emerged between them and the goal. It reveals that relative position of the goal is a key informational variable that sustained participants' behaviours for dribbling and shooting. Higher values of relative distance and angle were observed in the middle zone, compared to other zones. Players' roles also constitute a constraint on the interpersonal coordination for dribbling and shooting. Additionally, it seems that players' foot preference constrains the dynamics of interpersonal patterns of coordination between participants, especially in left and right zones. The findings suggest that to increase participants' opportunities for action, coaches should account with field positions, players' roles and preference foot.

1. Introduction

In the past decade researchers have increasingly recognized decision-making in team sports as one of the most influential aspects explaining performance (Araújo, Davids, & Hristovski, 2006; Griffin & Butler, 2005; Gréhaigne, Bouthier, & David, 1997; Turner & Martinek, 1995). Decision-making in team sports has been previously investigated with the aims of describing and explaining emergent behaviours of participants from an ecological dynamics perspective. Accordingly, decision-making emerges from a coupling of perception and action, predicated on individuals' action capabilities and information in a performance environment for identifying action possibilities (i.e., affordances) in line with specific intentions and task goals (Araújo et al., 2006; Fajen, Riley, & Turvey, 2009; Paterson, Van der Kamp, Bressan, & Savelsbergh, 2016).

This perspective proposes that decision-making should be investigated through identification of information that sustains individual behaviours and changes in emergent coordination tendencies between participants and teams (Araújo, Davids, Chow, & Passos, 2009; Passos, Araújo, Davids, & Shuttleworth, 2008). To achieve that aim, interactions between performers and their surroundings have been studied through identifying spatiotemporal patterns of interpersonal coordination that sustain actions in

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specific competitive performance contexts (Bartlett, Button, Robins, Dutt-Mazumder, & Kennedy, 2012; Castellano & Álvarez, 2013; Duarte et al., 2012; Sampaio, Lago, Gonçalves, Maçãs, & Leite, 2013; Travassos, Araújo, Vilar, & McGarry, 2011). In this line of reasoning, attacker-defender couplings have been deemed the fundamental unit of analysis for studying spatiotemporal relations that emerge between competing performers in team game performance (Davids, Araújo, & Shuttleworth, 2005; McGarry, Anderson, Wallace, Hughes, & Franks, 2002).

Previous research has sought to develop understanding of the forged and broken couplings that continuously emerge in attacker-defender dyadic systems. For instance, in basketball, interpersonal distance was identified as a key physical variable for explaining interpersonal interactions in a competitive dyadic system (Araújo et al., 2006). Following such ideas, it was observed in rugby union that interpersonal distance values of less than 4 m, combined with relative velocity of at least 1 m/s, was influential in predicting an attacker running past the defender with the ball in 1-vs-1 dyads (Passos, Araújo, Davids, Gouveia, et al., 2008). In football, the values of interpersonal distance and relative velocity, capturing interpersonal relations in such dyads have revealed some contextual dependency, based on proximity-to-goal. Previous research has revealed that changes in proximity-to-goal of 1-vs-1 (near to far from the goal) dyads influenced decision-making behaviours and intentionality of participants in relation to the ball (Headrick et al., 2011). In analyses of performance in 5-a-side futsal games it has also been reported that the angle to the goal is a key informational variable that sustained performers' behaviours in shooting at goal (Travassos et al., 2011; Vilar et al., 2012). The relevance of this interpersonal relation needs to be considered to understand decision-making behaviours in 1-vs-1 football dyads (Clemente, Couceiro, Martins, Dias, & Mendes, 2013)

Based in the extant literature further work is needed to consider variations in performance contexts and to provide information to impact significantly on coaching practice (Mackenzie & Cushion, 2012). There is also a need to understand how interpersonal patterns of coordination between attackers and defenders in 1-vs-1 dyads are influenced by field location effects relative to the goal. The specific aim of this study was to analyse patterns of interpersonal coordination that sustain decision-making of performers in 1-vs-1 sub-phases of football in different field locations near the goal (in left-, middle- and right- zones of the attacking third on field). Based on previous work, we expected to observe an effect of field location on emergent patterns of coordination in 1-vs-1 sub-phases. Furthermore, we also investigated effects of players' roles (e.g., attackers, midfielders and defenders) on interpersonal patterns of coordination that underpin decision-making in 1-vs-1 sub-phases in football. Based on previous research (Gonçalves, Figueira, Maçãs, & Sampaio, 2014), suggesting that different technical and tactical abilities of players with different roles support their exploration of interpersonal relations with opponents, we expected to observe different patterns of coordination emerging, depending on participants' main roles as defenders or attackers.

2. Methods

2.1. Participants

Fifteen male players (under-15 yrs age group; mean age 13.2 ± 1.03 years; years of practice 4.2 ± 1.10 years) participated in this study, categorised according to their team role, resulting in 5 defenders, 7 midfielders and 3 attackers. All players were right-footed and played in the club's first team. Players typically undertook four field training sessions per week (~90 min per session) plus a gym session (~60 min per session) to improve balance, coordination and strength, and played a competitive game at the weekend. The club and parents of participants provided prior informed consent for participation in the study. The study was approved and accepted by the Ethics local Committee according to the Declaration of Helsinki.

2.2. Task and procedures

Each participant was asked to perform in the role of a ball dribbler (attacker) and defender at three field locations. Attacker-defender dyads competed in an area of 10 m × 5 m positioned to represent the different locations (described below) under competitive performance conditions. The starting distance between attacker and defender was 3 m (see Fig. 1). At the end of this area, there was the goalkeeper's area. A regular size football goal (2.44 m × 7.32 m) protected by a goalkeeper was used. Participants were divided in three groups according their playing position on the field (defender, midfielder or attacker). All participants performed in the 1-vs-1 trials starting from all three zones as an attacker and also as a defender, resulting in a total number of 129 trials. In order to seek reliability of the tracking system, a sequential order to the roles participants were required to adopt between field zones. All trials were initiated first from the right zone, then from the midfield zone and last from the left zone. To ensure that participants sought to constantly use adaptability during the emerging interactions between attackers and defenders, dyadic system opponents were changed trial by trial (i.e., participants intermittently switched between acting as attackers and as defenders from trial to trial). All the participants had time to rest between trials in order to avoid fatigue effects. In order to ensure a balanced number of trials per player role, each defender performed three trials, each midfielder performed two trials and each attacker performed six trials in each field zone.

Each trial started when both the attacking and defending participants were ready in their starting positions and the attacking player was requested to start the trial. As soon as attacker moved the ball, the defender was allowed to start defending. The aim of the attacker was to dribble past the defender and shoot at goal. If this occurred, the trial was over. The aim of the defender was to prevent the attacker from scoring a goal, within the laws of the game. The trial was considered completed when the ball moved outside the borders of the playing area (A regulation ball size 5 was used in all trials). All the trials that ended with a shot at goal or with the ball moved outside the borders of the playing area, without the ball carrier dribbling past the defender, were removed from further

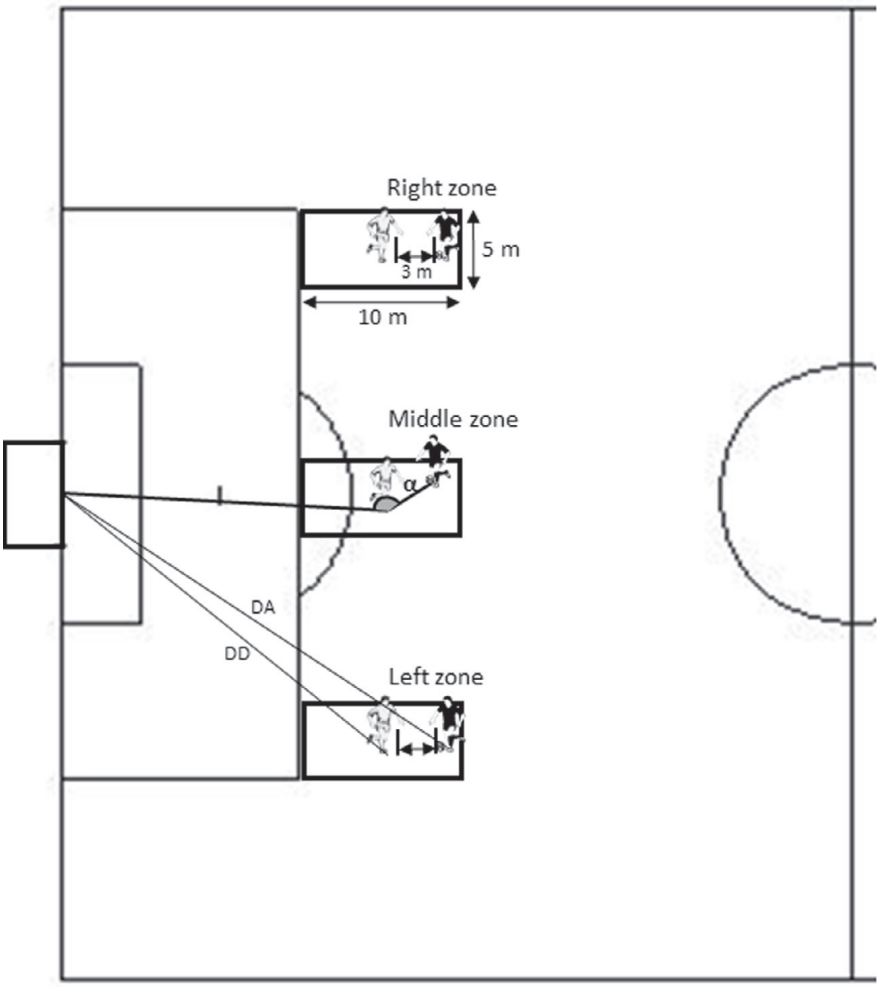

Fig. 1. Representation of the three areas of play (left, middle, right) with the definition of the starting zone and their location in relation to the goal. α – represents the relative angle between goal, defender and attacker player. DD – represents the distance between defender to the centre of goal. DA – represents the distance between attackers to the centre of goal.

analysis in the study. The elimination of such trials helped us to only capture and describe the interactional dynamics during performance sequences when the ball carrier successfully dribbled past the defender. Twelve trials in total were removed from further analysis for this reason.

Each participant's movements were captured by using a digital video camera (Sony HRX-MC50E) placed 4 m above ground forming an angle of approximately 45° with the longitudinal axis of the performance area to capture movements during the whole task. All the video recordings captured the displacement trajectories of all participants without moving the camera. The video recordings were digitized with TACTO software (see, Duarte et al., 2010, for additional information). The displacement trajectories of the ball and participants were tracked using a computer mouse, by following, in every frame, the projection of their centre of gravity on the playing surface. The obtained coordinates were transformed into real coordinates using the direct linear transformation method (2D-DLT) and filtered with a Butterworth low pass filter (6 Hz) (Winter, 2005).

2.3. Reliability

Ten trials were selected at random and the displacement trajectories of attacker and defender players (n = 20) were re-digitised by the same experimenter. Intra-digitiser reliability were assessed using technical error of measurement (TEM) and coefficient of reliability (R) (N.B. TEM = $\Sigma D^2/2N$, where D is the difference between pre- and post-test measures and N is the sample size. $R = 1 - \text{TEM}^2/SD^2$, where SD is the standard deviation of all measures) (Goto & Mascie-Taylor, 2007). The intra-TEM yielded values of 0.254 m (2.43%) with a corresponding coefficient of reliability ($R = 0.981$).

2.4. Data analysis

To measure variations in interpersonal patterns of coordination between participants in the 1-vs-1 sub-phases, variations in

relative distance between the attacker and defender players to the centre of goal (RDPG), and the relative angle (α) between the centre of goal, defender and attacker (RAGDA) (see Fig. 1), were calculated, based on methods used in previous research by Vilar et al. (2012). Values of RDPG were calculated as the difference between the value of the attacker's distance to the centre of the goal (DA) and the defender's distance to the centre of the goal (DD). Values of RAGDA were calculated by measuring the inner product of the defender's vector to the centre of the goal, and the defender's vector to the attacker (see Fig. 1). Due to differences in the temporal length of each trial, and for purposes of comparison, each trial was normalized to the total time taken to perform the trial independently. Data were averaged for every 10% portion of the total normalized time in each trial. The value of 0% corresponds to the moment of trial initiation (when the attacker was given a signal to start the trial with a dribble). The value of 100% corresponded to the moment when the attacker moved into the target zone to shoot at goal or when ball was played out of the performance area.

Magnitude-based inferences and precision of estimation were used to avoid the shortcomings of research approaches supported by null-hypothesis significance testing (Batterham & Hopkins, 2006). Comparisons of RDPG and RAGDA data among field zones and players' roles were assessed via standardized mean differences, computed with pooled variance and respective 90% confidence intervals (Cumming, 2012; Hopkins, Marshall, Batterham, & Hanin, 2009). The field zones comprised the left, middle and right performance areas, and the players' roles comprised the different combinations of Defenders, Midfielders and Attackers, functioning as attackers or defenders respectively (AADD – Attacker attacks, Defender defends (27 trials); AAMD – Attacker attacks, Midfielder defends (27 trials); DAAD – Defender attacks, Attacker defends (21 trials); DAMD – Defender attacks, Midfielder defends (18 trials); MAAD – Midfielder attacks, Attacker defends (18 trials); MADD – Midfielder attacks, Defender defends (18 trials)). Thresholds for effect sizes statistics were trivial (0–0.19); small (0.2–0.59); moderate (0.6–1.19); large (1.2–1.99); and very large (≥2.0) (direction of observed effects were represented by −ive and +ive). Differences in means for both pairs of scenarios were also expressed in percentage units with 90% confidence intervals (CI) (Hopkins et al., 2009). The relationships between values of relative distance and relative angles were analysed using Pearson's Product Moment Correlation using SPSS 22.0 software (IBM SPSS Inc., Chicago, USA).

3. Results

3.1. The effects of field zones

Analysis of relative distance values between players and the goal revealed main effects for field zones: Left-Middle ($d = -1.22$ (90%CI: −1.62 to −0.83), moderate −ive), Left-Right ($d = -0.75$ (90%CI: −1.13 to −0.37), small −ive), and Right-Middle ($d = 0.49$ (90%CI: 0.11–0.87), trivial). Generally, the left zone showed lower relative distance values between players and the goal than the other two zones, with the middle zone revealing the higher values. In the left zone, the relative distance decrease from values around 5–1.3 m. In the middle and right zones, relative distance started at values near 5.5 m and decreased in the middle to values around 2.5 m and on the right to values near 1.7 m (see Fig. 2, left panel).

Analysis of values of the relative angle between goal, defender and attacker revealed main effects for field zones: Left-Middle ($d = -6.12$ (90%CI: −6.98 to −5.25), very large −ive), Right-Middle ($d = -5.67$ (90%CI: 4.84–6.51), very large −ive, and Left-Right ($d = -0.04$ (90%CI: −0.4–0.33), unclear). Generally, higher values of relative angle were observed in the middle zone, than in the left or right zones. In the middle zone angle values were near 180° and in the left and right zones angle values were near 130°–140°. Interestingly, at the end of the trial in the left zone, an increase in relative angle values to nearer 150° was observed. In the right zone, relative angle values were maintained nearer to 135° (see Fig. 2, right panel).

Analysis of relationships between values of relative distance and relative angle for each field zone revealed interesting effects. There was a strong negative correlation between the two variables in the left ($r = -0.935$, $p < 0.001$) and right zone ($r = -0.992$, $p < 0.001$) and a strong positive correlation in the middle zone ($r = 0.963$, $p < 0.001$).

3.2. The effects of player roles

Analysis of relative distance values between players and the goal showed small effects for differences in player roles between DAAD-AADD ($d = -0.6$ (90%CI: −0.08 to −1.09), small −ive), DAAD-AAMD ($d = -0.99$ (90%CI: −0.47 to −1.53), small −ive),

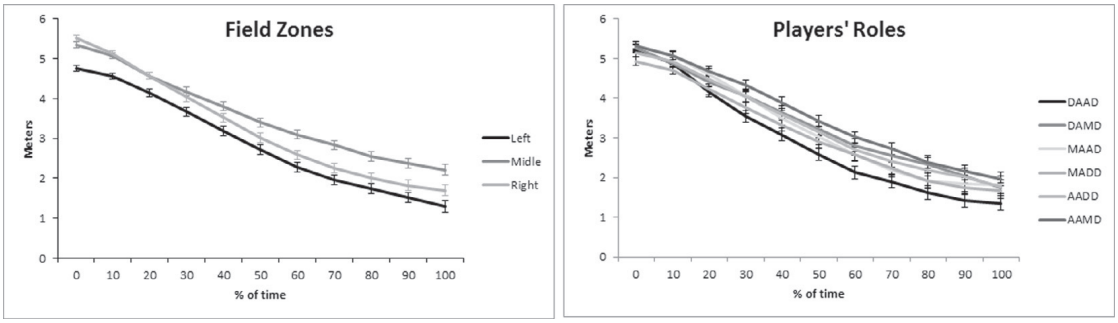

Fig. 2. Mean values and standard deviations of relative distance between attacker and defender to the centre of goal. Left panel – variations on mean relative distance according to field zones. Right panel – variations on mean relative distance according to players' roles.

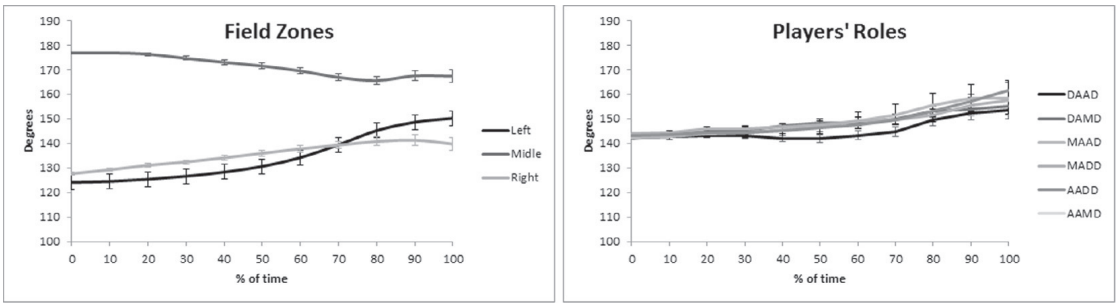

Fig. 3. Mean values and standard deviations of relative angle between goal, defender and attacker player. Left panel – variations on mean relative angle according to field zones. Right panel – variations on mean relative angle according to players' roles.

and DAAD-DAMD ($d = -0.74$ (90%CI: -1.29 to -0.18), small $-$ive), DAAD-MAAD ($d = -0.6$ (90%CI: -1.17 to -0.02), small $-$ive). In general, patterns of play of defenders as attackers and attackers as defenders, compared to other roles, revealed lower values of relative distance at the end of the trials (see Fig. 3, left panel).

Analysis of relative angle between goal, defender and attacker player revealed unclear effects of player role (see Fig. 3, right panel).

Analysis of relationships between values of relative distance and relative angle for each dyad revealed a strong negative correlation between the two variables, AADD ($r = -0.860$, $p < 0.001$); AAMD ($r = -0.866$, $p < 0.001$); DAA ($r = -0.697$, $p < 0.05$); DAMD ($r = -0.975$, $p < 0.001$); MAAD ($r = -0.915$, $p < 0.001$); MADD ($r = -0.899$, $p < 0.001$). Interestingly, the weakest correlations were observed between defenders as attackers and attackers as defenders, in line with previous research findings.

4. Discussion

In this study, we sought to examine the interpersonal patterns of coordination that sustained decision-making of participants in 1vs1 sub-phases in football at different field locations near the goal (left-, middle- and right-zones). Also, the effect of players' roles (i.e., attackers, midfielders and defenders) on interpersonal patterns of coordination in 1-vs-1 sub-phases in football was analysed.

In line with previous research, the results clearly confirmed an effect of field locations on emergent interpersonal patterns of coordination between an attacker and defender in 1-vs-1 sub-phases (Headrick et al., 2011). Headrick et al. (2011) showed how proximity-to-goal constrained values of defender to ball distance. Our results revealed how variations in field locations near the goal (left-, middle- and right-zones) constrained interpersonal patterns of coordination between attackers and defenders, particularly the relative distance and relative angle values that emerged between them and the goal. In line with other previous studies, our results highlighted relative position of the goal as a key informational variable that sustained participants' behaviours for dribbling and shooting (Travassos et al., 2011; Vilar et al., 2012). Changes in the value of the informational variable 'angle to goal' constrained the dynamics of the 1vs1 dyad, with clear implications for the interpersonal relations that participants explored to be successful, namely the distances and angles between them. Additionally, the exploration of possibilities for action in the 1vs1 dyad was constrained by players' main roles according to the relative position on-field. It is likely that the participants' past experiences in a specific performance role may have strongly influenced their tendencies for engaging in interpersonal coordination with other participants under the constraints of competition.

4.1. The effect of field locations

Higher values of relative distance between attackers and defenders were observed in the middle zone, compared to other zones. At the same time, results of relative angle values between players and the goal were also higher (close to 180°) in the middle zone, than in the left and right zones (near 130° to 140°). The relationship between both variables revealed a positive correlation for middle zone in contrast to right and left zones which revealed negative correlations. A possible explanation for such positive correlations, with higher, more stable values of relative distance near to 180° and higher distance values in the middle zone might be related to the high number of opportunities for ball dribblers to explore opportunities for shooting at goal. These results are in line with data reported in previous work by Vilar et al. (2012), suggesting that shooting opportunities emerged by attackers promoting a misalignment in their co- positioning with defenders relative to the ball and the goal. In their study defenders sought to maintain 'attacker-defender-goal symmetry' by placing themselves between the goal and the immediate attacker, maintaining a functional distance to intercept the ball or block a possible shot. This was a challenging task in the middle-zone since the actions of the defenders were constrained by greater opportunities for attackers to exploit space and move left, right or through the middle creating an open angle to shoot at goal. Since attackers had more such affordances (opportunities for action) with the ball, defenders were constrained to be more conservative in positioning, typically by increasing the value of their relative distance with the attacker (Headrick et al., 2011). Interestingly, similar behaviours have been observed at a team level after manipulations of the number of goal targets in a practice task (e.g., 3 goals rather than 1 goal to shoot at). Increasing the number of goal targets available for attackers resulted in the defending teams retreating on field and increasing the distance between them and the attacking team (Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio,

2014). Increasing the number of possibilities for action promotes co-adaptations of participants and teams to adopt more conservative interpersonal patterns of coordination, characterized by greater distance values and stability in the spatial equilibrium/symmetry between performers and the goal(s) location (Travassos et al., 2014).

We also observed lower values of relative distances in the left, compared to the right zone. Also, an increase in relative angles, at the end of the trial, to values near to 150° was noted in the left zone. In the right zone, the relative angle variable maintained values near to 135°. Interestingly, negative correlations were observed between values of relative distances and angles. When the value of relative distance decreased, the result was an increase in the value of relative angle to maintain the alignment between players and the goal. Differences observed in the relative distance and relative angles, at the end of the trials, between participants in the left and right zones can be explained by the fact that all the players were right-footed. This physical characteristic meant that, in the left zone the attackers could attempt to dribble past the defender with the right foot to open up a shooting angle with the goal. In the right zone, dribbling with the right foot tended to close the shooting angle with the goal. Thus, in the left zone, to prevent attackers from using their favoured foot to dribble and open an angle for shooting at goal, defenders sought to minimize interpersonal distances and the relative angle to the goal. The observed increase in relative angle, at the end of the trial, in the left zone, may represent attempts of attackers to dribble, open the angle to goal and shoot with their favoured right foot. In line with the ecological approach and the notion of affordances, this finding suggests that the exploration of possibilities for action is forged on the relation between emergent spatial relations, relative to the capacities (effectivities) of participants to act and achieve specific performance aims (Araújo et al., 2006; Fajen et al., 2009; Paterson et al., 2016). Indeed, the interpersonal patterns of coordination observed were forged on the acquisition of a perception-action coupling between both attackers and defenders, considering their own action capabilities in relation to the determined spatial relations and the proposed task goals (Travassos et al., 2014; van Andel, Cole, & Peping, 2017). Further research is required to better understand how variations in the specific capacities of sport performers (e.g., foot preference of participants, different levels of expertise, or even different physical capabilities and levels of fatigue) impact on the emergent dynamics of interpersonal patterns of coordination in different games sub-phases.

Clearly, implications for the design of practice tasks can be advocated. Attackers and defenders can be exposed to different relative positions to the goal for training dribbling and shooting, with changes in the preferred foot of both attackers and defenders. That personal constraint manipulation will encourage greater exploration of possibilities for action of attackers to shoot when presented with a more open or closed angle to the goal. Such a manipulation may even encourage participants to explore shooting with the non-preferred foot, depending on the affordances offered by information from the positioning of defenders, relative to the goal. Also, for defenders, such a manipulation will help them to improve their defensive positioning, relative to the goal, and also to identify and nullify use of the preferred foot of attackers. This exploration of capabilities for action of other performers, based on some key informational, will allow learners to become more effective and flexible in their behaviours (Button et al., 2013).

4.2. The effect of players' roles

Due to different technical and tactical abilities facilitating participants' exploration of the performance environment, it was also expected that different patterns of coordination would emerge in the 1-vs-1 sub-phase between participants with different roles in the squad (Gonçalves et al., 2014). Our results revealed that when a defender attacks, and an attacker defends, lower values in interpersonal distance emerged in comparison with other players' role combinations. This finding can be explained by the capability of opponents to perceive affordances (the potential for actions) of other people, as they can do for themselves (Mark, 2007), consequently changing the interpersonal patterns of coordination that sustain performance. Also, lower correlation values were observed between such variables in these player dyadic systems.

In fact, in competitive performance environments, defenders typically do not have many opportunities to experience1-vs-1 opportunities as attackers and vice versa, changing the exploration of the environment and potential for action when different roles are required (Travassos et al., 2013). Thus, the findings suggest that perception of the individual capabilities of the defenders to dribble and shoot at goal afforded a decrease in the relative distance between them as an option to reduce their possibilities for action (Travassos et al., 2012). Previous research (Vilar et al., 2012), has suggested that, when a ball dribbler was able to shoot and score a goal, he was able to maintain a significantly larger interpersonal distance value between him and a marking defender.

In line with an ecological dynamics approach, these findings suggested that participants' actions emerged from perception of information arising continuously from environmental interactions according to current capabilities for action of individuals (Araújo et al., 2006; Davids et al., 2005). Players' roles seem to have an impact on their current capabilities for action. Thus, to improve player performance, early experience of diverse experiences in the contexts of play and in required perception and action capacities instead of specialization (as defenders or attackers) should help learners to improve their adaptability to the different performance contexts to which they are exposed during competition (Davids, Araújo, Correia, & Vilar, 2013).

5. Conclusions

To summarize, these data support the idea that different field locations near the goal (in left-, middle- and right- zone) constrain the interpersonal coordination that sustain 1-vs-1 sub-phases in football. Players' roles also constitute a constraint on the interpersonal coordination for dribbling and shooting. Data implied that players' foot preference can be considered a key constraint to define the action capabilities of attackers to explore the dribbling and shooting. The findings suggest that coaches should manipulate practice task constraints (i.e. design 1-vs-1 sub-phases in different locations on field and manipulating players' foot preferences on participants' dyads) to increase opportunities for the participants to become better attuned to the informational variables that

constrain their performance. By manipulating task constraints, such as field location for attacker-defender dyads or individual constraints such as placing right- or left-footed participants in different areas of play, participants may learn how to detect functional information for decision-making in 1-vs-1 sub-phases.

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II

INTERPERSONAL DYNAMICS IN 2-VS-1 CONTEXTS OF FOOTBALL: THE EFFECTS OF FIELD LOCATION AND PLAYER ROLES

by

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Interpersonal Dynamics in 2-vs-1 Contexts of Football: The Effects of Field Location and Player Roles

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This study analyzed the spatial-temporal interactions that sustained 2-vs-1 contexts in football at different field locations near the goal. Fifteen male players (under 15 years, age 13.2 ± 1.03 years, years of practice 4.2 ± 1.10 years), 5 defenders, 7 midfielders, and 3 attackers, participated in the study. Each participant performed a game to simulate a 2-vs-1 sub-phase as a ball carrier, second attacker, and defender at three different field locations, resulting in a total number of 142 trials. The movements of participants in each trial were recorded and digitized with TACTO software. Values of interpersonal distance between the ball carrier and defender and interpersonal angles between players and between the goal target, defender, and ball carrier were calculated. The results revealed a general main effect of field location. Generally, the middle zone revealed the lowest values of interpersonal distance and angle between players and the right zone and the highest values of interpersonal distance between players and interpersonal angle between players and the goal. Related with participants' roles, defenders revealed subtle differences as attackers on interpersonal distances and relative angles compared with midfielders and attackers. Findings supported that field location is a key constraint of players' performance and that players' role constraint performance effectiveness in football.

Keywords: football, patterns of play, affordances, effectiveness, players' roles

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INTRODUCTION

Team sports have been investigated, as complex adaptive systems, with the aim of describing and explaining emergent behaviors of players from an ecological dynamics perspective. This approach requires analysis of the continuous interactions between attacking and defending players who, fundamentally, compete to gain/retain possession of the ball and move it into favorable attacking positions in critical scoring spaces in the playing area (Araújo and Davids, 2016). McGarry (2009) highlighted the dynamical nature of these continuous interactions, which can be observed at different levels of analysis from the entire competitive context to relevant game sub-phases (i.e., 1-vs-1, 2-vs-1, 3-vs-2, etc.). For this reason, a team game has been conceptualized as a complex adaptive system whose behaviors are driven or perturbed by interactions of multiple, smaller sub-systems composed of attackers and defenders interacting under constraints (Travassos et al., 2013b). For instance, research has highlighted specific contextual performance constraints that change the

emergent behaviors of players and teams. These task constraints include the number of players involved (Silva et al., 2014), the field dimensions (Vilar et al., 2014a), the number of goals (Travassos et al., 2014a), or even contextual performance constraints such as game pace or match outcome (Sampaio et al., 2013).

In line with the ecological dynamics perspective, the adaptive behaviors of players and teams to constant changes in contextual constraints is a result of information exchanges among the competing and cooperating players in relation to game demands (Travassos et al., 2012; Folgado et al., 2018). That is, players and teams constantly interact to create information, make decisions, and organize actions when functioning as a team during competitive performance. This view of competitive performance in teams, in ecological dynamics, is based on the sharing of spatial-temporal information that continuously supports the utilization of individual, sub-group, and team affordances (i.e., possibilities or opportunities for action to achieve a specific performance goal) (Silva et al., 2013). For each individual, as well as collective sub-systems, evidence has revealed that affordances are sustained by variations in space-time relations defined by the co-positioning of teammates and opponents, co-variations in their displacement trajectories and their movement velocities with respect to field markings and dimensions, and the location of scoring targets like goals, baskets, and try lines, for example (Vilar et al., 2012b; Silva et al., 2013; Gesbert et al., 2017). Also, players who have different team roles usually exhibit different physical, technical, and tactical capabilities (also effectivities) during performance (Varley et al., 2017; Lovell et al., 2018) and, consequently, explore and use the space-time relations in a different way for the identification of affordances for play (Laakso et al., 2017; Baptista et al., 2018). Previous research revealed that manipulating players' roles constraint the spatial-temporal patterns of play from 1-vs-1 (Laakso et al., 2017) to 7-vs-7 (Baptista et al., 2018).

Research investigations have explored and exemplified these ideas in many different team sports including basketball (Araújo et al., 2006; Esteves et al., 2012), rugby union (Passos et al., 2008), Futsal (Travassos et al., 2012; Vilar et al., 2013b), and also in association football (Duarte et al., 2012; Clemente et al., 2013; Laakso et al., 2017).

In the context of association football, research findings have revealed that attackers need to lead the interactions in spatial-temporal relations with defenders, by promoting unpredictable changes in the values of key variables such interpersonal distance, relative angles with players and with the goal, and relative velocity to achieve successful outcomes (Schulze et al., 2018). On the other hand, defenders try to constrain attackers' actions and maintain spatial-temporal equilibrium with them to enhance sub-system stability and successfully perform (Duarte et al., 2012; Clemente et al., 2013). That is, evidence suggests how attackers vary key movement displacement parameters to de-stabilize an "unwanted" symmetrical relationship with a marking defender in a dyad. In contrast, defenders use actions to maintain system stability and prevent attackers from breaking up their temporary dyad.

As previously reported, the field location of these ongoing interactions has a substantial effect to constrain the spatial-temporal relations in attacker-defender dyadic systems (Headrick et al., 2011; Vilar et al., 2012c; Laakso et al., 2017). Variations in proximity to the goal area or in field "longitudinal corridors of play" (middle or wing zones) result in emergence of different coordination dynamics of key variables like relative distance and the angle between an attacker and defender in relation to the goal (Headrick et al., 2011; Laakso et al., 2017). Although the effects of these constraints are clear, previous studies have mainly reported their influence in 1-vs-1 sub-phases of play.

In most team games, attackers try to gain an advantage by rapidly creating a temporary numerical overload against defenders in a specific location of the field. Particularly in association football, the creation of offensive or defensive numerical superiority near the ball is directly related to successful performance in terms of attacking space behind a defensive line or in recovering the ball (Vilar et al., 2013a). Thus, the 2-vs-1 sub-phase is the minimum sub-phase of game that represents such numerical (overload) advantage to an attacking team. During this sub-phase, the ball carrier and the support attacker need to manage the spatial-temporal relations with an immediate opponent to support emergence of two possibilities for action: (s)he can dribble and face the defender in a 1-vs-1 if the defender is protecting a passing line to the second attacker or (s)he can draw the defender and pass the ball to the support attacker if a passing line emerges by the defender being drawn toward the ball dribbler. Despite its relevance for understanding the spatial-temporal changes that support the emergence of possibilities for action in overloads, little research has been conducted to observe actual competitive interactions during performance in this important sub-phase. In addition, there is a need to improve understanding of how interpersonal patterns of coordination between attackers and a defender in 2-vs-1 sub-phases are influenced by field location effects relative to the goal. A key issue is whether a defender changes co-positioning behavior, when constrained by the field location in football. Clear implications for practice could result from this study. The implications of the manipulation of the relative position of the goal target (Coutinho et al., 2018) in relation to the 2-vs-1 sub-phases or the attacker-defender participants' performance roles (Laakso et al., 2017) allow coaches to improve the design of practice tasks according to the planned goals. Also, in line with previous studies, this study will allow to identify the task constraints that coaches can stress to improve players' decision and action according to each task condition (Correia et al., 2012). Thus, the aim of this study was to analyze the adaptive behaviors of players who sustained 2-vs-1 sub-phases in football at different field locations near the goal (left, middle, and right zones on field) and manipulate participants' team performance roles (i.e., divided into roles as attackers, midfielders, and defenders). In line with previous research in 1-vs-1 sub-phases (Laakso et al., 2017), we expected to observe changes in interpersonal distances and relative angles between players and the goal at different field location with high correlations between interpersonal distances and angles for right and left zones and low correlations in middle zone. Also, it was expected changes in interpersonal distances according to participants' team performance roles as attackers or defenders on the emergent spatial-temporal patterns of interaction in the 2-vs-1 sub-phase.

MATERIALS AND METHODS

Participants

Fifteen male players (under 15 years, age 13.2 ± 1.03 years, years of practice 4.2 ± 1.10 years) participated in this study. The sample size was calculated with G*Power (Version 3.1.5.1 Institut für Experimentelle Psychologie, Düsseldorf, Germany) for an effect size of 0.7, an α of 0.05, and a power of 0.8 (1–β). The total sample size computed by this method was a minimum of 15 players with a statistical power of 82.4%.

For the purposes of analysis, with the advice of the coaching staff, the participants were categorized into their main team performance role, resulting in sub-samples of five defenders (center-backs and full-backs), seven midfielders (center midfielders, lateral midfielders), and three attackers (forwards). All players belong to one youth team competing in a national Finnish level (2016/2017 season). All participants were right-footed and played in the first team of the club. The participants participated in five training sessions per week (90 min per session) and played an official competitive match at the weekend. The club, all parents, and the participants provided prior informed and written consent for participation in the study. The study was approved by the Ethics Committee of University of Jyväskylä according to the Declaration of Helsinki.

Task and Procedures

All players were tested during four sessions in 1 week of summer break of competitive season (July) in an artificial grass pitch. The temperature was about 17–19°. The first session was used for the players being familiarized with task conditions in all field zones, and the three next sessions were used for testing purposes. Each participant performed in a game to simulate a 2-vs-1 sub-phase as a ball carrier, second attacker, and defender at three different field locations. The 2-vs-1 sub-phases occurred in a predefined area of 10 × 5 m (Passos et al., 2008; Headrick et al., 2011) in three different field locations (Left, middle and right) under competitive performance conditions (See **Figure 1**). The task constraints included a regular size goal (2.44 m × 7.32 m) with a goalkeeper. The starting distance between attacker and defender was 3 m. When performing in the left or on the right side of the field, the second attacker was placed in the inner side of the field in order to maintain free the wing for a possible dribble. That is, when in the right-side zone of the field, the second attacker was placed to the left of ball carrier, and when in the left zone, to the right of ball carrier. In the middle zone, the second attacker was placed at the side of the first attacker's non-dominant foot. The area for the second attacker to move was 5 × 1.30 m (**Figure 1**). Before practice, all the players were informed about the rules and the goals of the tasks and encouraged to compete like in the game. The goalkeepers were also informed to act as in a competitive game. No coach feedback or encouragement was allowed during the conditions.

Before data collection, all participants engaged in a thorough warm-up routine. Each trial started when both the attacking and defending participants were ready in their starting positions and the attacking participant was requested to start the trial.

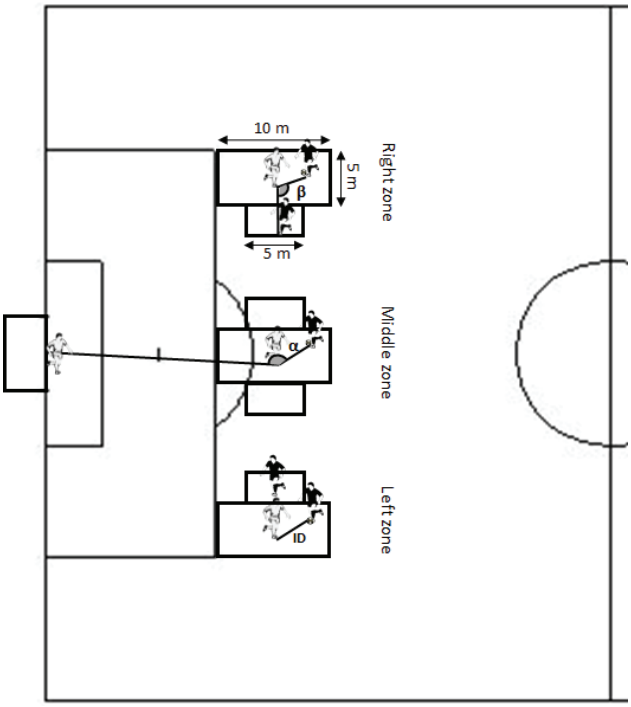

FIGURE 1 | Representation of the three areas of play (left, middle, right) of ball carrier and defender and the area of second attacker and their location in relation to the goal. α – interpersonal angle between ball carrier, defender and second attacker (IABDA); β – interpersonal angle between goal target, defender and ball carrier (IAGDB); ID – interpersonal distance between ball carrier and defender.

As soon as the attacker moved the ball, the defender could start defending. After crossing the midline of the playing area (5 m from the end of attacking area), the attacker could dribble or pass the ball to the second attacker. The performance aim of attacking participants was to dribble past the defender and shoot to the goal or pass the ball to the second attacker who could shoot at goal. If these events occurred, the trial was over. The aim of the defender was to prevent the attackers from scoring a goal, within the laws of the game. The trial was considered over when defending participants intercepted the ball or when the ball moved outside the borders of the playing area. A regulation ball size 5 was used in all trials.

All participants performed the 2-vs-1 trials in all three zones acting as an attacker and as a defender, resulting in a total number of 142 trials. In each trial, two attacking players with the same positional roles attacking one defending player with a different positional role (e.g., Defender + Defender vs Midfielder or Midfielder + Midfielder vs Attacker). After each trial, the attacking teams and the opposition change to promote variability in pairs and roles in next trials. Any player performed two consecutive trials in the same zone nor playing with the same pair, or opponent. Participants rest about 3–4 min between trials to avoid fatigue. All trials were randomly allocated between left, middle, and right zones, comprising 50 trials in the left zone, 41 in the middle, and 51 in the right performance area. The experimental protocol

allowed us to analyze the effects of participants' performance roles in attack, and the distribution of trials by role was defenders (49 trials), midfielders (45 trials), and attackers (48 trials).

Participant movements were captured by using a single digital video camera (Sony HRX-MC50E) placed 4 m above ground forming an angle of approximately 45° with the longitudinal axis of the performance area to capture participant movements during the whole experimental task. All video recordings captured the displacement trajectories of all participants without moving the camera. The movements of participants in each trial were digitized with TACTO software at 25 Hz (Fernandes and Malta, 2007; Duarte et al., 2010). The displacement trajectories of the participants and the ball were tracked using a computer mouse, by following, in every frame, a working point located between players' feet on the ground plan. After calibration of the pitch, with real measures of six control points for each zone (4 corners of the zone of play, and the two goalposts position), the x and y virtual coordinates of the players were extracted. The obtained virtual coordinates were transformed into real coordinates using the direct linear transformation method (2D-DLT) to avoid parallax error and filtered with a Butterworth low pass filter (6 Hz) to reduce the noise of the process of digitizing (Winter, 2005).

Reliability of the Digitizing Procedure

Fifteen trials were selected at random and the displacement trajectories of attackers and defenders (n = 45) were re-digitized after 1 month by the same experimenter. Intra-digitizer reliability values were assessed using technical error of measurement (TEM) and coefficient of reliability (R) statistics (for details see Goto and Mascie-Taylor, 2007). The intra-TEM yielded values of 0.235 m (2.25%) with a corresponding coefficient of reliability (R = 0.991).

Variables

According to our purposes, the interpersonal distance between the ball carrier and defender (ID) was calculated. Also, the interpersonal angles between (1) ball carrier, defender, and second attacker (IABDA) and (2) between the goal target (the center of the goal in order to maintain the reference fixed and allow a better understanding of the relationships between players and the goal), defender, and ball carrier (IAGDB) were calculated to investigate changes in interpersonal interactions between participants in the 2-vs-1 performance contexts (See **Figure 1**; Vilar et al., 2014a; Laakso et al., 2017).

Data Analysis

Descriptive statistics were reported for all performance measures recorded. Comparisons between field zones and participants' roles were assessed using standardized mean differences with 90% confidence intervals. The smallest worthwhile differences were estimated from the standardized units multiplied by 0.2 (Hopkins et al., 2009; Cumming, 2012). Effect size statistics were reported using the following ranges: trivial (0–0.19); small (0.2–0.59); moderate (0.6–1.19); large (1.2–1.99); and very large (≥2.0). Magnitudes of clear effects were considered at the following scale: 25–75%, possibly; 75–95%, likely; 95–99%, very likely; >99%, most likely (observed effects were represented by –ive and +ive directions) (Hopkins et al., 2009). Correlation values between variables were accessed through Pearson correlation using SPSS 22.0 software (IBM SPSS Inc., Chicago, USA). Thresholds for correlation coefficients (r) were: 0.30, small; 0.49, moderate; 0.69, large; 0.89, very large; and 1.00, near perfect (Hopkins et al., 2009).

RESULTS

Effects of Field Location

Analysis of ID revealed main effects for field zones. Small higher values were observed in comparisons of the left to middle zone (likely –ive). Moderate higher values were observed in comparisons of middle to right zone (very likely +ive). Unclear values were observed in comparisons of left to right zone (unclear). Generally, the middle zone revealed the lowest ID values, while the right zone revealed the highest ID values (see **Table 1** and **Figure 2**).

Analysis of IABDA revealed main effects for field zones. Moderate higher values were observed in comparisons of left to middle zone (very likely –ive). Small higher values were observed in comparisons of middle zone to right zone

TABLE 1 | Descriptive statistics and differences in means for field location and players' roles.

	(Mean ± SD)			Difference in means (d; 90% CL)		
			Field location			
Variables	**Left**	**Middle**	**Right**	**Left vs Middle**	**Left vs Right**	**Middle vs Right**
ID (meters)	3.21 ± 1.42	2.68 ± 1.49	3.67 ± 1.73	–0.35 [–0.7–0.01]	0.28 [–0.04 0.62]	0.60 [0.26 0.95]
IABDA (degrees)	121.34 ± 20.57	107.77 ± 22.28	115.94 ± 23.22	–0.63 [–0.98–0.27]	–0.24 [–0.57 0.608]	0.36 [0.01 0.07]
IAGDB (degrees)	122.9 ± 20.76	135.72 ± 23.87	140.40 ± 17.12	0.57 [0.22 0.92]	0.91 [0.58 1.24]	0.22 [–0.13 0.57]
			Players' role			
Variables	**Defenders**	**Midfielders**	**Attackers**	**Defenders vs Midfielders**	**Defenders vs Attackers**	**Midfielders vs Attackers**
ID (meters)	3.75 ± 1.81	3.30 ± 1.59	2.77 ± 1.13	–0.26 [–0.6 0.07]	–0.65 [–0.98–0.31]	–0.38 [–0.73–0.04]
IABDA (degrees)	120.83 ± 19.88	110.45 ± 19.22	114.74 ± 26.86	–0.52 [–4.7 3.62]	–0.25 [–3.69 3.18]	0.18 [–3.29 3.66]
IAGDB (degrees)	131.71 ± 20.55	136.77 ± 20.35	130.45 ± 24.07	0.24 [–3.72 4.21]	–0.06 [–3.67 3.57]	–0.28 [–3.92 3.36]

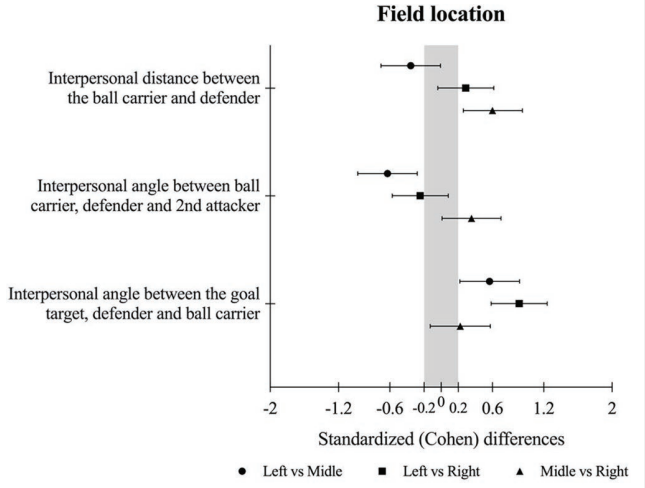

FIGURE 2 | Standardized (Cohen) differences of ID, IABDA, and IAGDB for field zones (left vs. middle vs. right).

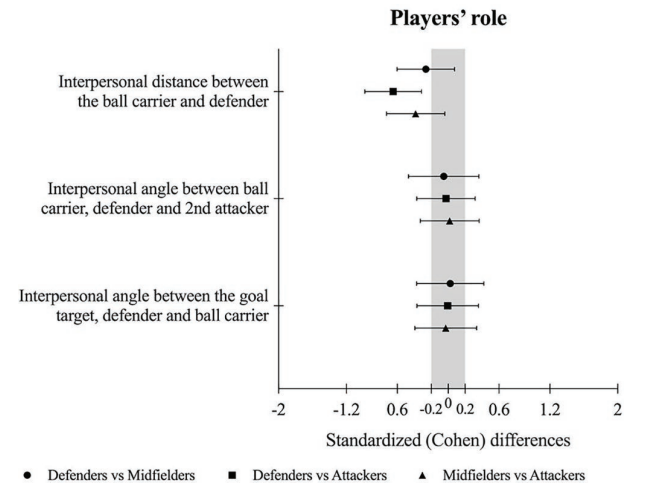

FIGURE 3 | Standardized (Cohen) differences of ID, IABDA, and IAGDB for players' role (defenders vs. midfielders vs. attackers).

(likely +ive). Unclear values were observed in comparisons of left to right zone (unclear). Generally, the left zone revealed higher values of IABDA, while the middle zone revealed lower values (see **Table 1** and **Figure 2**).

Analysis of IAGDB revealed main effects for field zones. Small lower values were observed in comparisons of left to middle zone (very likely +ive). Unclear values were observed in comparisons of middle to right zone (unclear). Moderate higher values were observed in comparisons of left to right zone (most likely +ive). Generally, the right zone revealed the higher values and the left zone revealed the lower values of IAGDB (see **Table 1** and **Figure 2**).

Analysis of relationships between ID, IABDA, and IAGDB for each field zone revealed interesting effects. In the left field zone, a large negative correlation was revealed between ID and IABDA values [$r = -0.76$, $R^2 = 0.57$ (90%CI: −0.84 to −0.64), most likely −ive], a large positive correlation between ID and IAGDB values [$r = 0.72$, $R^2 = 0.52$ (90%CI: 0.59–0.82), most likely +ive], and a moderate negative correlation between IABDA and IAGDB values [$r = -0.46$, $R^2 = 0.21$ (90%CI: −0.62 to −0.24), most likely −ive]. On the right, an unclear correlation was revealed between ID and IABDA values [$r = 0.08$, $R^2 = 0.01$ (90%CI: −0.16 to 0.31), unclear], a large negative correlation between ID and IAGDB values [$r = -0.70$, $R^2 = 0.48$ (90%CI: −0.8 to −0.55), most likely −ive], and a moderate negative correlation between IABDA and IAGDB values [$r = -0.56$, $R^2 = 0.31$ (90%CI: −0.7 to −0.37), most likely −ive]. In the middle zone, a near perfect positive correlation was revealed between ID and IABDA values [$r = 0.93$, $R^2 = 0.87$ (90%CI: 0.9 to 0.96), most likely +ive], and unclear correlations between ID and IAGDB [$r = 0.15$, $R^2 = 0.02$ (90%CI: −0.37 to 0.1), unclear] and IABDA and IAGDB values [$r = 0.10$, $R^2 = 0.02$ (90%CI: −0.14 to 0.33), unclear].

Effects of Players' Roles

Analysis of players' roles, as attacking players, revealed subtle changes in emergent interpersonal coordination tendencies (see **Table 1** and **Figure 3**). When defenders acted as attacking players, small higher values of ID were observed compared to midfielders (possibly −ive) and a moderate higher ID was observed compared to attackers (very likely −ive). Also, when midfielders acted as attacking players, small higher ID values were observed compared to attackers (possibly −ive). No other effects on IABDA and IAGDB were revealed in analysis of effects of players' roles when participants acted as attacking players (see **Table 1** and **Figure 3**). Analyses of relationships between ID, IABDA, and IAGDB for each player role were unclear.

DISCUSSION

The aim of the present study was to analyze the adaptive behaviors of players who sustained 2-vs-1 sub-phases in football at different field locations near the goal (left-, middle- and right- zones on field) and manipulate participants' team performance roles (i.e., divided into roles as attackers, midfielders, and defenders). As expected, results indicated a main effect of field location and a subtle effect of participants' roles on spatial-temporal coordination tendencies in the 2-vs-1 sub-phases. Generally, the findings reinforced effects noted in previous studies on performer interactions in football (Laakso et al., 2017).

Effect of Field Locations

Field location was confirmed as an important constraint on interpersonal coordination of players, not just in 1-vs-1 sub-phases (Headrick et al., 2011; Laakso et al., 2017) but also in 2-vs-1 sub-phases of football. As observed in performance context (Schulze et al., 2018), according to changes in field zones of performance, the relationship between values of interpersonal distances and relative angles between players and the goal revealed different relational dynamics. Analysis of interactions in the middle zone revealed lower values for ID

and IABDA (near 1–10°) and medium values (near 135°) for IAGDB. These findings contrasted with data reported in previous research on performance in 1-vs-1 sub phases, in which higher values of ID and greater relative angles between players and the goal were observed in the middle zone, compared to performance in the other zones. In 2-vs-1 sub-phases, the additional teammate increases the available affordances for the ball carrier (dribbling, shooting, passing), not allowing the defender to perform as conservatively. Thus, defenders tried to cope with the increase in affordances for attackers by dividing their efforts to occupy passing lines and inhibit the emergence of dribbling/shooting lines for the ball carrier (Vilar et al., 2012c). The near perfect correlation values observed in mid zone between ID and IABDA variables reinforced such an interpretation. Similar results have been observed in previous research (Travassos et al., 2014b; Vilar et al., 2014b).

When a defending team performing with a numerical disadvantage usually adopts a zonal defense to simultaneously occupy space and close down options for the ball carrier at the same time (Travassos et al., 2014a). That is, the defenders or even the defensive team seeks to co-position themselves to mark the opponents and the space at the same time, inhibiting the emergence of the most advantageous affordances for attackers. This strategy of defenders can be explained by an attempt to adapt to the emerging informational constraints of the 2-vs-1 sub-phase, increasing the time for ball carriers to interact, that is, explore, decide, and perform actions (van Andel et al., 2017).

Observations of performance in left and right field zones revealed contrasting findings. Analysis of performance in the left zone revealed mid values for ID, higher values for IABDA, and lower values for IAGDB. In opposition, analysis of performance in the right zone revealed higher values for ID, mid values for IABDA, and higher values for IAGDB. These performance observations may be related to the fact that all the players were right-footed, constraining possibilities for the ball carrier to explore affordances for shooting or passing, consequently allowing different affordances for defenders (Paterson et al., 2016). It is worth noting that the ball carriers' preferred foot was the "outside" foot on the right field zone, providing the ball carrier with affordances to typically pass the defender on the right side. This affordance typically constrained the interactions for the defending players so that they could focus more on their alignment with the goal (IAGDB). These adaptations allowed defenders to maintain a large ID to provide an affordance for the ball carrier to dribble to the right and shoot at goal from the "outside" (with a narrow angle to the goal). The negative correlations between ID and IAGDB values support the use of this functional defensive strategy. It suggests that when the defender presses the ball carrier, he is seeking to maintain symmetry of the system with the goal to ensure that he could not shoot at goal with the preferred foot.

In contrast, in the left field zone, the starting position of the second attacking player was on the right side of the area. In this case, the ball carrier tried to open space to explore a dribble to the middle or to open a passing line to the second attacker. While this was happening, the defender sought to constrain the ball carrier to drive to the left and use the preferred foot and, simultaneously, seeking to occupy the passing line to the second attacker. These interactions were driven by increases in IABDA and decreases in IAGDB values. The emergent negative correlations between ID and IABDA and the positive correlations between ID and IAGDB supported the use of this defensive strategy. When a defender presses the ball carrier, a major aim is to cut the passing line from the ball carrier to the second attacker, increasing the value of IABDA and temporarily decreasing alignment with the goal. These dynamical interactions suggest that the exploration of affordances by attackers and defenders, during performance, was context-dependent and forged by variations in spatial-temporal relations between players (Vilar et al., 2012b; Silva et al., 2013; Gesbert et al., 2017) and their own effectivities (Silva et al., 2013; Paterson et al., 2016). Also, the findings clearly revealed how the location of the scoring target acted as a powerful constraint on emergent interpersonal spatial-temporal interactions of players and teams in football (Headrick et al., 2011; Vilar et al., 2012c; Laakso et al., 2017).

Effect of Team Roles

As expected, the participants' main performance roles constrained interpersonal coordination tendencies in the 2-vs-1 sub-phases. However, only subtle changes were revealed, particularly for defenders, compared with midfielders and attackers (Laakso et al., 2017). Compared to midfielders and attackers, defenders usually displayed different technical and tactical abilities, which constrained the identification of affordances and consequently shaped the coordination tendencies during performance (Laakso et al., 2017; Baptista et al., 2018). In this study, results revealed higher ID values for defenders, acted as attacking, compared to participants with other main performance roles. Midfielders revealed higher ID values than attackers, when acting also as attacking players. The findings suggested that the familiarity and past experience of players, acting in their main performance role or other, may influence their interaction tendencies with other participants, especially in exploiting affordances. For instance, defenders, in attack, revealed generally higher ID values than midfielders and attackers. In competition, defenders typically do not have as many opportunities to face 2-vs-1 situations near the opposite goal to achieve scoring box opportunities, as do midfielders and attackers in their team roles. Due to their typically less effective skills in attacking situations to create scoring box opportunities, defenders seek to manipulate the ball when well away from attackers. That is, defenders usually face the 2-vs-1 situations with the aim of keeping the ball possession and achieving in-depth passing opportunities, and for that, it makes sense to play with high distance from opponents to ensure secure passing lines or other options for play. In 2-vs-1 sub-phases, this lack of skill and experience may lead defenders to seek more possibilities to pass the ball to the second attacker rather than to try to dribble the defending player with the ball. These findings in contrast with previous results in a study of 1-vs-1 sub-phases show that, when defenders attack and attackers defend, lower values in interpersonal distance emerged in comparison to performance of participants with other role combinations (Laakso et al., 2017).

Our data suggest that an individual's team role is an individual constraint that can be related to performance effectiveness (Varley et al., 2017). Due to differences in performance contexts and the requisite actions, players of different team roles exploited affordances and performed differently in competition condition (Travassos et al., 2013a; Silva et al., 2014; Araújo et al., 2017). The findings signified that participants revealed different levels of effectiveness, especially the defenders in comparison to participants with other team roles.

CONCLUSIONS

Our findings supported the general idea that field location is a key constraint on interpersonal coordination tendencies in 2-vs-1 sub-phases of association football, as also observed in previous work on 1-vs-1 sub-phases (Headrick et al., 2011; Laakso et al., 2017). Taken together, these findings imply how coaches can design practice environments for team sport athletes. These findings in 2-vs-1 sub-phases suggested the need to analyze interactional dynamics of attackers and defenders in different relevant sub-phases of team games (i.e., 3-vs-2, 3-vs-3, 4-vs-3, 5-vs-5) (Laakso et al., 2017). These observations are important to understand how manipulated constraints in team games practice can change interpersonal coordination tendencies and how players explore such variations. The results also suggested that the manipulation of different field playing locations should be promoted in practice. Further research is also required to understand the dynamics of this game sub-phase during training sessions or in the game environment. That is, what is really the transfer between such spatial-temporal coordination tendencies in training and competition and how it happens at different levels of relations (from individuals to teams).

The manipulation of the relative position of the goal could highlight the behavior of defenders to effectively manage the spatial-temporal relations with opponents and constrain affordances according to the current effectivities (capacities) of players (for instance use of a preferred foot). Such manipulations have implications for specificity of practice, highlighting the importance of conditioning for footwork and management of spatial-temporal relations with opponents, which can be best attained in sub-phase practices (rather than ladder drills) because of the perception of information for action (affordances).

Despite the obtained results, some limitations should be acknowledged. In this study, only U15 players from one team were considered for analysis. Further research should be developed using larger sample of players and considering diferent ages and levels of practice to identify variations or similarities between spatial-temporal coordination tendencies. Also, independently of the age and level of practice, further studies should evaluate the technical/tactical proficiency of players and their level of fitness and maturation in order to understand the impact of individual characteristics on the spatial-temporal coordination tendencies developed in 2-vs-1 sub-phases of association football.

At the end, it was clear that changes in contextual game constraints such as relative position of the goal promote adaptive behaviors of players to perform. In line with that, coaches should constantly promote changes in the field location of 2-vs-1 sub-phases of game in order to promote the creation of new possibilities for action of players. Also, the definition of different couples of attackers and defenders according to different levels of effectivities seems to be a good constraint to create new spatial-temporal information and promote new possibilities for action of players according to their effectivities. Further research is required to understand the contribution of such manipulations to the learning process.

ETHICS STATEMENT

The club and all parents of participants provided prior informed consent for participation in the study. The study was approved by the Local Ethics Committee according to the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

TL, KD, JL, and BT participated in study design. TL and JL participated in data collection. TL, KD and BT participated in data analysis and in the first draft manuscript. All the authors participated and approved the final version of the manuscript and agree with the order of the presentation of the authors.

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III

HOW FOOTBALL TEAM COMPOSITION CONSTRAINTS EMERGENT INDIVIDUAL AND COLLECTIVE TACTICAL BEHAVIOURS: EFFECTS OF PLAYER ROLES IN CREATING DIFFERENT LANDSCAPES FOR SHARED AFFORDANCES IN SMALL-SIDED AND CONDITIONED GAMES

by

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How football team composition constrains emergent individual and collective tactical behaviours: Effects of player roles in creating different landscapes for shared affordances in small-sided and conditioned games

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Abstract

The aim of the present study was to examine how team composition of players with different roles constrains individual and collective tactical behaviours, and ball possession effectiveness, during competitive 3 vs 3 small-sided and conditioned games (SSCGs) in youth soccer players. Fifteen male players (under 15 yrs, mean age 13.2 ± 1.03 years, mean years of practice: 4.2 ± 1.10 years) from the same club participated in this study. For analysis purposes, on advice from the coaching staff, participants were categorised according to their main team performance role, resulting in sub-samples of 5 defenders (centre-backs = 2 and full- backs = 3), 7 midfielders (central midfielders = 3 and wide midfielders = 4) and 3 attackers (forwards). In order to assess participant tactical behaviours, a notational analysis system was created with four categories: i) team behaviours, ii) individual players' offensive actions, iii) individual players' defensive actions, and iv), ball possession effectiveness. Analysis of players' offensive actions revealed that the team composed only of midfielders revealed a higher frequency of diagonal and vertical passes in relation to the attackers' team. In offensive individual actions, the attackers' team revealed more dribbles in relation to the teams of defenders and midfielders. Analysis of ball possession effectiveness revealed that the team of defenders achieved higher values of shots on goal compared to the team of midfielders. These findings exemplified how playing role constrains the emergence of different collective behaviours and individual actions in 3 vs 3 SSCGs.

Keywords

Ball possession, decision making, ecological dynamics, youth soccer

Introduction

In line with the ecological dynamics perspective, tactical behaviours of players and teams result from information exchanges that emerge among players, based on their action capabilities (physical, technical, and tactical).[1,2] Players and teams constantly interact to form synergies and create information, making decisions and organizing actions, according to collective *possibilities for action* of the team, known as affordances.[3,4]

Ecological dynamics views competitive performance behaviours in sports teams as emerging from the sharing of available affordances.[5] According to Gibson,[4] affordances are opportunities or possibilities for

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action that exist in a performance environment. In football, players are able to perceive the availability of space and time provided by the movements of teammates and opponents, which offers information about the possibilities for action (affordances) such as an open space for dribbling, a passing or a shooting gap. Affordances are not only dependent on changes in the contexts of play, but also dependent on individual players' capabilities and their intentions during performance (e.g., to attack to progress or to maintain ball possession).[5] Players' adaptations to changes in competitive performance environments are regulated by the environmental information surrounding each individual, that they perceive in order to interact with other individuals.[6] For each individual, and collective subunits of players (e.g., attackers, defenders, midfielders), previous research has revealed that affordances are available in the environment, but their utilisation is dependent on each individual's intentions, motivations, values and capabilities.[3] Not all individuals perceive and utilise the same affordances in a performance environment, due to differences in their situated intentions, skill levels and attunement to the information available to support the actions required by their roles.[7,8]

In the sport of football, the number of players involved, and the use of structured patterns of play, have promoted a greater specialization of players' roles. Each player's role (generally categorised as defenders, midfielders and attackers) has specific technical, tactical and physical playing demands, which may need to be adapted due to varying performance constraints.[9] For example, recent research has revealed some differences in the perceptual scanning frequency of players of different roles, with the central midfielders revealing the highest mean frequency (perhaps due to density of player numbers in that field location) and attackers the lowest mean frequency of emergent scanning behaviours (perhaps due to proximity to goal affording shots).[8]

The use of available affordances during performance is sustained by variations in space-time relations defined by co-positioning of teammates and opponents, as well as co-variations in their displacement trajectories and their movement velocities with respect to field markings and dimensions.[5,10] Players perceptually attune to information specifying affordances for action through, for example, visual exploratory actions, which entail eye, head and body movements, supporting the pick-up of visual information.[11] So, the capability of individuals to perceive and act upon affordances in a performance environment, should be continually influenced by each player's role, continually shaping their ability to pick up and use information from the competitive environment and functionally adjust their individual tactical behaviours.[12]

These ideas suggest that, in performance, players in different playing roles should use different sources of information to successfully regulate their competitive actions.[8] In fact, each player assumes a specific role on field according to the tactical system and principles defined by the coach to defend or exploit space and create/prevent scoring opportunities.[6,13] The exploitation of affordances by each player is influenced by the team's general patterns of play, but particularly by their surrounding information. That is, when a player is in a defensive area of the pitch (mostly populated by defenders), the majority of game-relevant information for that player is likely to be in front of them (i.e. in an attacking direction). In contrast, a player who is situated in a midfield area of the pitch (midfielders) is likely to be completely surrounded by game-relevant environmental information.[14] Accordingly, it is likely that each player's main role on the pitch influences, not only the perceptual scanning frequency,[8] but also the nature of the exploratory actions that are used to perceive the surrounding environment.[11] These important performance constraints on behaviour led us to expect to observe different individual and collective tactical behaviours for players, not only inside of the game dynamics, but also to accomplish the same performance goals.

Indeed, previous research has revealed that players with different roles (such as mainly attacking or defending) display different individual tactical behaviours to manage the spatial-temporal relations with teammates and opponents in 1 vs 1[7] and 2 vs 1 subphases of football.[15] Also, in the context of the manipulation of small-sided and conditioned games (SSCGs), Baptista, Travassos[16] revealed that variations in tactical systems of play and teams composition, according to the players' roles used in each team (i.e. defenders, midfielders or attackers), promoted changes in interpersonal dynamics during SSCGs.

Despite these findings, in the practice of SSCGs, particularly in teams of youth players (from 3×3 to 5×5), coaches usually mix players up into small teams without at all considering the impact of team composition (i.e. defenders, midfielders or attackers) on the emergent tactical behaviours of players and teams during practice. There is a need to understand how teams constituted by players of different roles influences the tactical exploration of possibilities for action during performance as well as their effectiveness percentages. These findings could inform sport practitioners on the need for players to be exposed to more specialised (i.e., role-based) and more general (varying roles) affordances from the design of small-sided and conditioned games. Thus, the aim of the present study was to examine how team composition of players with different roles constrains emergence of individual and

collective tactical behaviours, as well as effectiveness, during competitive SSCGs in youth soccer players. Due to the influence of their roles on performance dynamics, we expected to observe changes in emergence of collective and individual offensive and defensive tactical behaviours, according to the nature of each team's role composition (whether attackers, defenders, or midfielders).

Methods

Participants

Fifteen male players (under 15 yrs, mean age 13.2 ± 1.03 years, mean years of practice 4.2 ± 1.10 years, mean height 176.3 ± 7.46 cm and mean weight 66.9 ± 8.70 Kg), from the same club in a national level Finnish team, participated in this study (2016/2017 season). For purposes of analysis, participants were divided into three groups according to their main playing role on field (defenders, midfielders and attackers). On advice of the coaching staff, participants were categorised into their main team performance role, resulting in subsamples of 5 defenders (centre-backs = 2 and full-backs = 3), 7 midfielders (central midfielders = 3 and wide midfielders = 4) and 3 attackers (forwards). All players were right-foot dominant and were part of the U15s team of the club. All participants undertook five training sessions per week (90 minutes per session) and played one official GK + 11 v 11+GK competitive match at the weekend. The club, all parents and participants provided prior informed consent for participation in the study. The study was approved by the Ethics local Committee according to the Declaration of Helsinki.

Task and procedure

All small-sided games were played in one training session during the summer break of the competitive season (July) on an artificial grass pitch, with an ambient temperature of about 18–20°C. In the summer break, the team had no official competitive matches, only daily training sessions. Before data collection, all participants engaged in a thorough warm-up routine (15 mins of jogging, 10 mins of technical actions with ball and 10 mins of stretching). Each team played against each other (i.e. defenders vs midfielders, defenders vs attackers, attackers vs midfielders) in a playing area of 30×25 m (Owen et al. 2004). Three games were played in each training session in a random order over three different days, resulting in a total number of 9 games. A regulation ball size 5 was used in all games. The small-sided game constraints included a regular size goal (2.44 m×7.32 m) protected by a goalkeeper for both sides (Gk + 3 vs 3+Gk). Each game was timed for 5 minutes. All the players/teams had at least 10mins of rest between trials and played a maximum of two games each day, in order to avoid fatigue. The goalkeepers stayed guarding the same goals, but the team's direction of play was systematically changed. The Gk + 3 vs 3+Gk format was used to better capture the players' adaptations to the context of play according to players' specific roles.

The Gk + 3 vs 3+Gk sub-phase was played with official football rules, with some exceptions/modifications: i) the offside rule did not apply; ii) when the ball left the field or a goal was scored, the game was always restarted by the goalkeeper of team with ball possession, with both teams located in their own pitch half; and iii), as the goalkeeper opened the game and the first player touched the ball, both teams played without restrictions.

Before the small-sided games, all participants were informed about the rules and the goals of the task/exercise and encouraged to compete to win games. The goalkeepers were also instructed to perform as if in a competitive game. No coach feedback or encouragement was allowed during the games to avoid the potential biasing effects of feedback on individual participant performance. The aim of the participants in these games was to score and prevent goals and try to win each game.

Participant movements were captured by using a digital video camera (Sony HRX-MC50E) placed 7 m above the ground, forming an angle of approximately 45° with the longitudinal axis of the performance area to capture participant movements during the whole task (for more details see Fernandes et al., 2010). All the video recordings captured the displacement trajectories of all participants without moving the camera.

Instruments

In order to assess the tactical behaviours of teams and players, and based on variables recorded in previous studies see literature[17,18] a notational analysis system was created with four categories: i) team behaviours, ii) players' offensive individual actions, iii) players' defensive individual actions, and iv), ball possession effectiveness (see Table 1 for independent variables and their description). All data were collected by the first author. As a preliminary step, all the variables coded were discussed and described by the authors in line with recommendations in previous research see literature.[17,18] To check the reliability of measurements, the same sample of matches were coded after an interval of two weeks. Intra-observer reliability was calculated using the Cohen K index.[19] We found values of $K = 0.913$ ensuring an adequate reliability of data.

Table 1. Description of the independent variables.

Variables	Description
Team tactical behaviour	
Ball possession	The time a team has possession of the ball during one attack
Players involved	The number of players involved in that attack during ball possession
Participants' offensive actions	
Successful passes	Number of successful passes made by the team from one player to each other
Diagonal and vertical passes	Number of diagonal and vertical passes a team completed in one attack
Lateral and backward passes	Number of lateral and backward passes a team completed in one attack
Penetrative passes	A pass that split the last line of defence and plays a teammate through to shoot at the goal
Dribbles	Successfully completed dribbles made by a participant past layer an opponent
Players' defensive actions	
Ball recoveries	A player successfully wins the ball back for his own team
Interception	A player successfully intercepts an opponent's pass
Ball possession effectiveness	
Lost balls	A team loses the ball possession to an opponent or the ball goes out of play after an attempted interception or tackle
Shots	A team ends the ball possession with a missing shot, a shot resulting in a goal, or a shot saved by a goalkeeper.

Statistical analysis

A Shapiro-Wilks test was used to assess the normality of data distribution. Due to the existence of non-normal distribution of data, differences between performance variables were assessed using a non-parametric test. A Kruskall-Wallis test was conducted to evaluate differences between the values observed for teams composed of defenders, midfielders, and attackers. Observed significant effects were followed up using the Bonferroni post hoc test. All statistical analyses were performed using the Statistical Package for Social Sciences software V24.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.), and statistical significance levels were set at $p < .05$. Additionally, *Cohen's d* was calculated to obtain the magnitude of differences through an effect size calculator for non-parametric tests (www.psychometrica.de/effect_size.html), classifying values as very low (0–0.2), low (0.2–0.6), moderate (0.6–1.2), high (1.2–2.0) or very high (>2.0).[20]

Results

Regarding team tactical behaviours, no statistically significant differences were observed for the variables: ball possession and number of players involved in the attack, in teams composed of players with different roles ($p > 0.05$) (see Table 2).

Analysis of participants' offensive individual actions did not reveal significant differences between teams with players of different roles for the following variables: number of completed successful passes, lateral and backward passes and penetrative passes ($p > 0.05$). However, statistically significant between-team differences in performance variables were observed for the number of diagonal and vertical passes and dribbles completed ($p < 0.05$) (see Table 2). For diagonal and vertical passes, post hoc analysis revealed that the team of midfielders revealed the higher number of diagonal and vertical passes (1.22 ± 0.67) during performance, with significant differences in relation to values displayed by team of attackers (0.73 ± 0.59, $p < 0.05$, $d = 0.71$, moderate effect). No other differences were observed for diagonal and vertical passes between the teams ($p > 0.05$). Regarding the number of dribbles completed, post hoc analysis revealed that the team of attackers displayed the highest number of successfully completed dribbles (0.53 ± 0.78), with significant differences in relation to values displayed by teams of defenders (0.18 ± 0.39, $p < 0.05$, $d = 0.65$, moderate effect) and midfielders (0.16 ± 0.37, $p < 0.05$, $d = 0.66$, moderate effect). No differences in that performance variable were observed between the teams of defenders and midfielders ($p > 0.05$).

Analysis of participants' defensive individual actions did not reveal significant differences between teams for the variables of ball recoveries and balls intercepted ($p > 0.05$) (see Table 2). However, even without a statistically significant outcome, a tendency for the team of defenders to intercept a greater number of passes was recorded.

Finally, analysis of ball possession effectiveness, revealed significant differences for the variables lost possession and shots at goal between teams' roles ($p > 0.05$) (see Table 2). For lost possession, post hoc analysis revealed that the team of attackers displayed the highest number of lost balls (0.65 ± 0.74), with

Table 2. Inferences for the effects of the game scenarios comparisons on performance measures.

	Teams' constitution				p value d_{Cohen}					
Variables	Defenders	Midfielders	Attackers	χ^2	Def vs Mid		Def vs Att		Mid vs Att	
Team behaviour										
Ball possession	6.81 ± 4.73	6.94 ± 4.09	8.07 ± 5.11	1.72	–		–		–	
Players involved	1.82 ± 0.73	1.87 ± 0.70	1.78 ± 0.80	0.31	–		–		–	
Players' offensive actions										
Successful passes	0.86 ± 0.96	1.24 ± 1.34	0.98 ± 1.12	1.41	–		–		–	
Diagonal and vertical passes	0.98 ± 0.83	1.22 ± 0.67	0.73 ± 0.59	**8.75***	0.32	0.31	0.39	–0.35	**0.00****	0.71
Lateral and backward passes	0.31 ± 0.51	0.55 ± 0.76	0.38 ± 0.67	1.48	–		–		–	
Penetrative passes	0.12 ± 0.44	0.5 ± 1.08	0.48 ± 0.99	4.09	–		–		–	
Dribbles	0.18 ± 0.39	0.16 ± 0.37	0.53 ± 0.78	**7.57***	0.8	–0.05	**0.02***	0.65	**0.01***	0.66
Players' defensive actions										
Ball recoveries	0.12 ± 0.39	0.13 ± 0.34	0.10 ± 0.30	1.27	–		–		–	
Balls intercepted	0.22 ± 0.42	0.11 ± 0.31	0.13 ± 0.33	2.74	–		–		–	
Ball possession effectiveness										
Lost balls	0.28 ± 0.45	0.57 ± 0.64	0.65 ± 0.74	**7.62***	**0.03***	0.53	**0.01***	0.60	0.77	0.12
Shots at goal	1.28 ± 0.84	0.63 ± 0.78	0.95 ± 0.98	**11.51****	**0.00****	–0.80	0.19	–0.36	0.43	0.36

*$p < .05$; **$p < .001$.

significant differences in relation to values displayed by team of defenders (0.28 ± 0.45, $p < 0.01$, $d = 0.60$, moderate effect). Significant differences were also displayed between defenders (0.28 ± 0.45) and midfielders (0.57 ± 0.64, $p < 0.03$, $d = 0.53$, low effect) for this variable, although no differences were observed between the teams of midfielders and attackers ($p > 0.05$). Regarding the variable Shots at goal, post hoc analysis revealed that the team of defenders displayed the highest number of shots completed (1.28 ± 0.84), with significant differences in relation to values displayed by the teams of midfielders (0.63 ± 0.78, $p < 0.01$, $d = -0.80$, moderate effect). No differences in this performance variable were observed between the teams of defenders and midfielders and midfielders and attackers ($p > 0.05$).

Discussion

The aim of this study was to examine how team composition, composed of players with team differing roles, influenced the emergence of individual and collective tactical behaviours, as well as the ball possession effectiveness in youth soccer players. In line with our expectations, results revealed variations in individual offensive and defensive tactical behaviours according to teams' composition in the U15 yrs squad, as well as in the ball possession effectiveness of the composed teams. No differences were observed for team behaviors in analyses of time spent in ball possession and number of players involved in each attack. These results reinforced the co-adaptive behaviours of players of different roles, through the creation of particular game dynamics, and according to their role dispositions and capacities.

These findings support the idea that the current methods of player development in practice, performance and learning environments promote the development of role-specific skills and expertise, founded on motivations, values and capabilities of players. In particular current development methods shape the use of different individual affordances for players in similar game environments.[5] Thus, it can be assumed that playing roles in association football may not only be characterized by different anthropometrical or physiological differences of individuals,[21,22] but also by different technical-tactical capabilities required by specific roles in which players are specialising.[15] An ecological dynamics rationale for the current findings suggest that players' main team roles seem to impact on their perception-action systems (i.e. the way they use information to regulate their actions), changing their capabilities for action during these learning experiences (intrinsic effectivities or readiness for action).[9,23] Our findings show that players' roles are a key constraint on the nature of the individual tactical actions that they learn to perform. Our evidence, is well aligned with previous data, for example, evidencing role effects on players' spatial-temporal relations to perform[15] or on the exploratory movements used to perceive the specifying properties of the surrounding environment[8,11] that sustain affordances.

The lack of differences of role effects on team behaviors could be influenced by the numerical relations and the format of play used. Further research should be

developed to understand the impact of individual changes at team level, by changing the number of players involved in practice games. In this particular format, it mean that variations in players' roles may not promote adaptive behaviours at the team level, but only in the process of synergy formation at individual (i.e. organization of actions) and sub-group levels of performance (i.e. coordinated activities between players).[13] These findings emphasize that exploitation of available affordances in SSCGs, as key learning environments, by players is particularly sustained by increased capacity to attune to the nature of surrounding information. Further research is required to understand the impact of manipulating players' roles on emergent collective behaviors of SSCG teams in practice environments, using different metrics of analysis related to spatial-temporal relationships that emerge between players during performance.

Coaches' favoured designs and tendencies to maintain players in specialized roles during practice may impact their capacity to adapt and use available affordances in different locations of the field. This idea was supported by data from analyses of players' offensive individual actions, revealing that the team composed only of midfielders revealed a higher frequency of completed diagonal and vertical passes, compared to the team of attackers. Also, in performing individual offensive actions, the attackers' team displayed more dribbles in relation to teams of defenders and midfielders. Interestingly, analysis of ball possession effectiveness revealed that the team of defenders achieved a greater number of shots on goal, compared to the team of midfielders.

Defenders' team role

The role of defenders in 11-a side versions of football, when in possession of the ball is to initiate attacks by creating space to pass the ball to the midfield players and ensure the creation of space for supportive passes to maintain ball possession under pressure.[16] The lower number of dribbles completed by the team of defenders, which was statistically different to the number of dribbles completed by the attackers, highlighted that field location constrains the information and actions that players tend to explore to successfully progress up field. In fact, previous research[24] has revealed that the proximity to the goal constrains the spatial-temporal relations of players involved in 1v1 contexts. Also, evidence suggests that defenders tend to explore the affordances to progress upfield, based on the notion of risks of a change in ball possession in spaces nearer the goal.[25] Thus, supporting the notion of exploration and utilisation of available affordances during competitive performance, these findings signify how players act on affordances available in spatio-temporal properties of a performance environment, available for themselves according to their own roles and spaces of play.[16]

Consequently, in line with previous research, the team of defenders in this study, in comparison to teams of midfielders and attackers, revealed greater capability to control and manage available space relative to the opposition.[16] Since the main role of defenders during performance, is to protect their own goal, prevent use of free space in critical scoring areas by attackers, and recover ball possession, our findings suggest that players in defensive roles tend to develop greater awareness of affordances of space in front, between and behind themselves, than teammates with other roles.

Against our expectations, analysis of ball possession effectiveness revealed that teams of defenders also displayed a lower tendency to lose ball possession, which significantly differed to the team of attackers. The team of defenders also displayed a greater number of shots at goal in relation to the team of midfielders, an unexpected finding given their main team role. However, the explanation for this unexpected finding could be a result of the players being able to maintain team balance when involved counter-attacks, from defensive positions.[16] That is, even without statistical differences to performance behaviours of the teams of midfielders and attackers, the defenders revealed a tendency to recover the ball by interceptions, facilitating a great number of counterattacks and shots at goal. According to our previous research, teams of defenders tend to maintain higher values of interpersonal distances with opponents and play with lower levels of risk, than teams of midfielders and attackers.[15] Thus, the higher number of completed shots in 3v3 SSCGs may be a consequence of being able to perceive affordances for passes in opponents and, therefore, intercept more passes, as well as losing possession less often, allowing them to progress forward for shots at goal. However, more information is required to sustain this assumption and further research is required to analyse the origin of the ball re-possessions that ended in shots at goal by defenders, midfielders, and attackers. Also, there is a need for further research with SSCGs involving different numbers of players to understand whether the effectiveness obtained by the team of defending players in 3v3 transfers to other task constraints (e.g., 5v5 or 7v7).

Midfielders' team role

The midfielders' main role is to operate between attackers and defenders, creating variability in the exploration of possibilities for action of attackers to destabilize the defending team and score goals. It means that they constantly need to explore the relevant environmental

information during performance that support their positioning and actions to allow the team to progress up field.[26] In the analysis of individual attacking actions, team of midfielders tended to perform a greater number of diagonal and vertical passes, compared to the team of attackers. Such results are aligned with previous findings on passing frequency of midfielders. It has been observed that midfielders preferentially explore affordances for passing opportunities to progress up field, through the defensive lines, seeking to play penetrative passes to attackers in space.[27,28] In fact, midfielder players are usually the players with higher centrality of play (i.e., the players that receive and distribute more passes to other players) inside of the network of relations of a team, assuming the main responsibility to promote the flow of passes between different team sectors.[6]

In line with our previous findings, midfielders revealed, in ball possession effectiveness, a lower number of shots at goal, compared to teams of defenders. Due to their greater propensity to perform more passes and to explore opportunities for penetrative passes in progressing up field, the performance analysis of the midfielder teams highlighted how previous experience in their specific roles influenced participants to explore the affordances of the 3vs3 performance landscape.[26,29]

Attackers' team role

The attackers' main role is to perform in areas of the field outnumbered by defenders, with restrictions on space and time to receive the ball, dribble and create opportunities to assist or to shot at goal. Attackers should have good skills with the ball to win 1vs 1 contexts with immediate opponents and to dribble into critical scoring spaces. That is, they usually reveal versatile and creative technical actions that allow them to be more unpredictable in de-stabilising defensive formations and to create space to shoot at goal.[30] However, previous research has revealed that attackers display the lowest rate of perceptual scanning frequency for information during play.[8] Perhaps, because attackers have restrictions of space and time to receive the ball in dangerous areas of the field and to perform shots at goal, they tend to focus their attention on nearby surrounding information (i.e. goal location) in order to gain advantages in relation to immediate opponents.[26] In line with this role tendency, attackers displayed a higher number of dribbles in relation the teams of defenders and midfielders and, in general, a lower number of completed diagonal and vertical passes in comparison to the midfielders. Such observations are in line with data from previous studies that revealed that the lower perceptual scanning frequency of attackers could be associated with the fewer number of completed passes and higher number of completed dribbling actions.[11] This finding is also in line with outcomes of previous studies where attackers completed fewer forward passes, compared players in other roles, perhaps explained by attackers typically having their back to goal during build-up play.[31]

Analysis of ball possession effectiveness revealed differing results compared to previous studies,[32,33] where attackers performed more shots and scored more goals compared to players in other roles. However, such studies have reported differences in tactical performance behaviours emerging from performance in different playing roles, but within a single SSCG team composed of a mix of defenders, midfielders and attackers. Also, as previously stated, the use of the 3vs3 format cannot sample the perceptual-action task constraints that attackers face in 11vs11 competitive conditions. It is clear that players will use different perceptual information, available affordances and action requirements to constrain performance under different task constraints, for example, when shooting at goal. The attacking team also tended to lose the ball more often, compared to the team of defenders. One explanation for a greater frequency of lost ball possession is that the team of attackers were the group most focused on taking risks to go past opponents to win 1 vs 1 situations.

Practical implications

The obtained results allow coaches to understand how manipulating team composition through modifying players' roles in SSCGs can change the affordance landscape and the training session dynamics. The findings suggest that coaches should manipulate SSCGs situations for players to experience a variety of playing roles to increase opportunities for the players to explore synergy formation with teammates. These manipulations could help players to develop new effectivities (capabilities) to explore competitive performance environments from different perspectives, rather than just from the roles developed in an early specialization process.

Coaches could design SSCGs with a team of defenders against midfielders or attackers to promote specific skills and collective behaviours. For example, it may be useful to prepare the defenders to face a team based on possession play while developing the confidence to stay on the ball (fewer lost balls and more shots). Also, it allows the players to learn how to perform individually and collectively to regain spatial-temporal equilibrium relative to ball location, while exploring the possibility to recover it. Also, a SSCG with a team of midfielders against a team of attackers could be used to promote

spatial-temporal balance in defense, providing affordances for making or preventing diagonal and vertical passes and for recovering ball possession. The lower defensive coordination of attacking team seems to enhance the perception of space by the midfielders to progress on the field through passing actions and progress towards games against defenders in further phases of development. Finally, a SSCG with a team of attackers against of a team of defenders, may be useful to develop defensive ability of players against high skilled teams. It allows to improve players' defensive capability to face the dribbles of attackers and also practice recovering ball possession.

In summary, players' main team roles seem to have an impact on their current capabilities for action that can emerge during performance. In line with that finding, our data imply that coaches should constantly promote changes in the field dimensions and other properties of SSCGs, allowing players to explore different performance sub-phases or different playing roles, promoting opportunities for exploration of different possibilities for action, in different affordance landscapes.

In turn, facing a team of attackers may be useful to develop defensive ability against high skilled teams, mainly related to the dribbling. In addition, to prepare youth midfielders to perform frontal and diagonal passes, coaches may compose the opposing team with attackers, as their lower defensive coordination seems to enhance the perception of space by the midfielders, and progress towards games against defenders in further phases of development.

Conclusions

Our findings suggested how the main playing role of a performer may constrain and promote different emergent collective behaviours and individual actions in 3 vs 3 SSCGs. Due to differences in performance context, players with different playing roles seem to exploit affordances and perform differently in competitive conditions.[14] Some previous studies also observed similar results of effects of players roles in 1 vs 1 contexts[7,24] and 2 vs 1[15] sub-phases in football. Despite these obtained results, some limitations should be acknowledged. In this study, only U15 yrs players from one team were considered for analysis. Nevertheless, the findings suggest the need for further research for investigations with a larger sample and using different SSCGs formats (i.e. 4 v 4, 5 v 5, 6 v 6 or 7 v 7) in order to discover whether similar results may be observed with players of different ages and level of practice. In fact, the efectiveness of players, the teams' constitution or even the structure of play used seems influence the exploitation of possibilities for action and should be considered as a part of the formula of the design of training sessions to improve the learning and the performance development of players.

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