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ORIGINAL

TACTICAL DEMANDS OF SMALL-SIDED GAMES IN FOOTBALL: INFLUENCE OF TRACKING TECHNOLOGY

DEMANDAS TÁCTICAS DE JUEGOS REDUCIDOS EN FÚTBOL: INFLUENCIA DE LA TECNOLOGÍA UTILIZADA

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ABSTRACT

This article analyses tactical behaviour in Small-Sided Games (SSGs) over the geometrical centre and surface area according to: (1) Tracking technology: Global Positioning System (GPS) and Ultra-Wide Band (UWB); (2) playing phase (attack vs. defence); and (3) Objective of the SSGs. Sixteen semi-professional football players participated in this research (Age: 23.6±3.3 years

old; Weight: 78.1±5.2 kg; Height: 1.8±0.1 meters). WIMU PRO^{TM} inertial devices (RealTrack System, Almeria, Spain) were used for the recording process. The main results show significant differences: (1) between tracking technologies (GPS and UWB) on the surface area, (2) between playing phases; and (3) among all activities. In conclusion, the data obtained by both technologies cannot be compared due to the differences found, the analysis being very important in relation to the objective and the playing phase of the SSGs for their influence on tactical behaviour to achieve sport performance enhancement.

KEY WORDS: performance, geometrical centre, surface, GPS, UWB.

RESUMEN

Este estudio analiza el comportamiento táctico en Juegos Reducidos (JRs) a través de las variables área y centroide en función de: (1) tecnología empleada: Sistema de Posicionamiento Global (GPS) y Ultra-Banda Ancha (UWB); (2) fase de juego (ataque y defensa); y (3) objetivo del JRs. Dieciséis jugadores semiprofesionales de fútbol participaron en esta investigación (Edad: 23.6±3.3 años; Peso: 78.1±5.2 kg; Altura: 1.8±0.1 metros). Para el registro se utilizaron dispositivos inerciales WIMU PRO^{TM} (RealTrack System, Almería, España). Los principales resultados muestran diferencias significativas: (1) entre tecnologías de seguimiento (GPS y UWB) en la variable área, (2) entre fases de juego, y (3) en función del objetivo de los JRs. En conclusión, los datos obtenidos por ambas tecnologías no pueden compararse debido a las diferencias encontradas, siendo muy importante el análisis en función del objetivo y la fase de juego de los JRs por su influencia en la disposición táctica para conseguir una mejora en el rendimiento deportivo.

PALABRAS CLAVE: rendimiento, punto centroide, superficie, GPS, UWB.

1. INTRODUCTION

The search for new and effective training methods in football has been, for a long time, one of the main concerns for coaches and trainers who are dedicated to the teaching-training of this sport (Bangsbo, Mohr & Krustrup, 2006). In order to improve training methods it is necessary to expand scientific knowledge, and thus to have objective knowledge of the characteristics of the game in competitive situations (Carling, Williams and Reilly, 2005). This possibility is, to a large extent, dependent on technological development, and its use in competitive situations has the support of FIFA (International Federation of Associated Football). These studies are providing new evidence in the study of physical (Castellano & Casamichana, 2014) and tactical demands in team sports. Knowing the requirements of the competition makes it possible to guide training more effectively (Grehaigne, Godbout, & Zerai, 2011).

Small-Sided Games (SSGs), are sports-playful motor situations (Parlebas, 2008) which include most of the factors that intervene in the real game, are

extensively applied in the field of football training and facilitate that all the elements of the game interact in a flexible way (Casamichana & Castellano, 2010; Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Rowsell & Dawson, 2009; Impellizzeri et al., 2006). The physical, physiological and tactical demands of the game are reproduced by SSGs (Little & Williams, 2007).

There is a growing interest among researchers and coaches in the use of SSGs as a method to facilitate the learning of technical-tactical skills in players of all ages and categories (Davids, Araujo, Correia & Vilar, 2013). Therefore, a multitude of coaches and physical trainers commonly use this type of motor situations as their training method (Ford, Yates, & Williams, 2010), since it is effective (Hill-Haas et al., 2009; Impellizzeri et al., 2006; Chamari et al., 2005) and can be carried out regardless of age, sex, previous experience in practice or competitive level (Dellal et al., 2011). It is mainly used to develop physical condition (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011), technical-tactical skills (Jones & Drust, 2007), and tactical, strategic or psychological aims in an integrated way (Flanagan & Merrick, 2002; Gabbett & Mulvey, 2008), being applied in different team sports (Hill-Haas et al., 2011).

Compared with more traditional training methods, SSGs are perceived as specific, since they allow optimisation of training time because physical performance, technical skills and tactical perception develop simultaneously (Gabbett & Mulvey, 2008). In addition, SSGs provide a more specific training stimulus with respect to the demands in competition (Rampini et al., 2007) and induce physiological adaptations similar to short-term intermittent training (Dellal et al., 2008).

There are many variables to control which can influence the intensity of SSGs, so previous studies have investigated the impact of modifying and/or combining them. (Little & Williams, 2006; Owen, Twist, & Ford, 2004). Knowing the most relevant aspects of performance in each sport is a complicated task in that technique, tactics and even physical training are conditioned by such variables. The intensity of these types of tasks can be manipulated by altering factors such as: (a) size of the playing field (Casamichana & Castellano, 2010, Sassi, Reilly, & Impellizzeri, 2004), (b) orientation of the game space (Casamichana & Castellano , 2010), (c) number of players per team (Brandes, Heitmann & Müller, 2011, Dellal et al., 2011, Hill-Haas et al., 2011), (d) presence or absence of substitute players (Hill- Haas et al., 2011: Mallo & Navarro, 2007) or (e) of goalkeepers (Mallo & Navarro, 2007).

Advances in technology have helped the analysis and quantification of physical-technical-tactical requirements thanks to the incorporation of Global Positioning Systems (GPS) used outdoors (Dempsey, Gibson, Sykes, Pryjmachuk & Turner, 2017) and Ultra-Wide Band (UWB) technology in indoor conditions (Leser, Schleindlhuber, Lyons & Baca, 2014; Rhodes, Mason, Perrat, Smith & Goosey-Tolfrey, 2014). The use of these devices, both in training situations and in competition, has made it possible to analyse and / or measure all the efforts, both kinematic and tactical, that football requires in a valid and reliable way (Coutts & Duffield, 2010; Gray, Jenkins, Andrews, Taaffe, & Glover, 2010;

MacLeod, Morris, Nevill & Sunderland, 2009; Petersen, Pyne, Portus, & Dawson, 2009), increasing the use of these types of devices (Rogalski, Dawson, Heasman, & Gabbett, 2013).

Taking the position of each player as a reference (x-y coordinates in each half), several variables have been proposed to evaluate collective behaviour in team sports. These have been called compound positional variables because they integrate the individual positions of each team player into a meaningful description of a collective team pattern (Silva et al., 2014). These innovative variables reveal significant collective behaviours from a practical perspective and can be used to evaluate the idiosyncratic performance values of each team (Duarte & Frias, 2011). From a pragmatic point of view, one cannot understand the demands and requirements of football without having a perspective of tactical / strategic purpose. This is what makes a player stop or run somewhere, with more or less intensity of movement, at a specific moment, in relation to the configuration of the game (Carling, Bloomfield, Nelsen, & Reilly, 2008, Garganta, 2009, Sampaio & Maçãs, 2012). In this respect, several studies have shown the significant influence of collective tactics on physiological and kinematic demands in professional football (Bush, Barnes, Archer, Hogg, & Bradley, 2015, Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). Despite this, few studies have been carried out from this perspective of game analysis. So far there have been studies on: the dynamics of the distance to the team's own goal (Silva, Chung, et al., 2016, Silva, Vilar, Davids, Araújo, & Garganta, 2016), the centroid and surface areas covered by the teams (Frencken & Lemmink, 2008); the distance of the players to the team centroid (Sampaio & Maçãs, 2012) and the position and distribution of the team on the field (Voronoi diagrams) (Fonseca, Milho, Travassos, & Araújo, 2012). There is not a great deal of knowledge about the use of the different player tracking systems, and there is no analysis of their adequacy for application in tactical analysis.

Therefore, the objectives of this study were to analyse tactical behaviour through the area and centroid variables based on: (1) technology used: Global Positioning System (GPS) and Ultra-Broadband (UWB); (2) game phase (attack and defence); and (3) objective of the SSGs (1. keeping possession, 2. keeping possession and progressing, 3. keeping possession, progressing and finishing in multiple goals and 4. keeping possession, progressing and finishing in a real game situation with a goalkeeper).

2. METHOD

2.1. Subjects

Sixteen semi-professional football players (age: 23.6 ± 3.3 years old; body mass: 78.1 ± 5.2 kg; height: 1.8 ± 0.1 metres) competing in the category of the Third Division (Group XIII) participated voluntarily in the present research. The players included in the study met two basic criteria: (1) no injury during the season in progress and (2) completion of the whole past match.

The club was informed about the nature of the study and it gave its authorisation for the development of the research. Participants were informed about the research procedures and provided written informed consent. To ensure the team's and players' confidentiality, all performance data were anonymised before analysis.

The study followed the Ethics Code of the World Medical Association and the Recommendations Guiding Doctors in Clinical Research of the Declaration of Helsinki (2013) and the protocol was approved by the ethics committee of the University of Murcia.

2.2. Material

An inertial device called the WIMU PROTM (RealTrack Systems, Almeria, Spain) was used for data collection. This device has its own microprocessor, 8GB flash memory and a high speed USB interface with the purpose of recording, collecting and sending data for later analysis. The device is powered by an internal battery with 4 hours of autonomy, it weighs 70 grams and measures 81 x 45 x 16 millimetres. The WIMU PROTM device consists of different sensors (four accelerometers, one gyroscope, one magnetometer, GPS chip and UWB chip, among others).

Regarding location, this device consists of two technologies for recording the players' positioning, which can be done simultaneously: (1) outdoor, Global Positioning System, GPS; and (2) indoor, Ultra-Wide Band Technology, UWB. The GPS system determines the positioning and location (latitude and longitude) in any part of the world through a constellation of satellites which transmit in certain signal ranges. On the other hand, the UWB system uses a reference frame formed by different antennas and determines the positioning (coordinates) in relation to the time of emission and reception of the signal by radiofrequency technology in a bandwidth greater than 500 Mhz. The sampling rate of UWB technology is 20 Hz, while for GPS technology it is 10 Hz. The accuracy of both localisation technologies present in the WIMU PROTM inertial device has been previously studied in different publications (Bastida-Castillo et al., 2018a, Bastida-Castillo, Gómez-Carmona, Hernández-Belmonte, Pino-Ortega, 2018b, Muñoz-López, Granero-Gil, Pino-Ortega, & De Hoyo, 2017).

Figure 1 shows the layout of the antennas to determine the positioning using UWB technology.

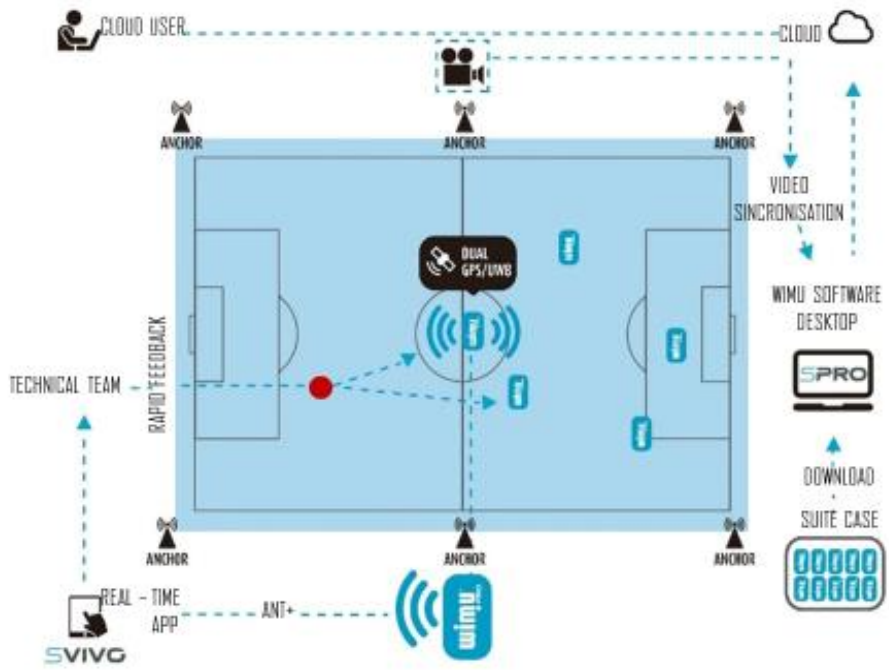

Figure 1 *Graphical representation of the UWB data recording and analysis system.*

To position the devices on the players, they were called 15 minutes before each training session. Prior to placement, the devices were calibrated and synchronised following the manufacturer's recommendations. The procedure was as follows: (i) to turn on the devices, (ii) to wait approximately 30 seconds after turning them on, (iii) once the device operating system was initialised, to press a button to start recording and (iv) to position the devices on each player. Specially designed vests were used for the placement of the devices which were located on the upper part of the torso, being anatomically adjusted to each participant. All the data obtained from the devices were analysed using SPROTM software (RealTrack Systems, Almeria, Spain).

2.3. Variables

Table 1 shows the tactical variables recorded in the present investigation obtained from the position of each player (x-y coordinates).

Table 1. *Tactical variables recorded in this investigation*

Variables	Description	Units
The surface area occupied by teams. Frencken, Lemmink, Delleman and Visscher (2011)	Represents the area of the field covered by the entire team in each fraction of time.	m^2
The geometrical centre of teams Lames, Ertmer and Walter (2010)	Represents the geometric centre of an area	m

2.4. Procedure

The study was carried out in training session number 46, during the competitive period of the 2016/2017 season, which was the second training session of the week, and took place 4 days before the official competitive game (MD-4). The participants were distributed in 2 teams (team 1 and team 2) of 8 players, without being assigned specific roles. The playing surface was artificial turf and the schedule was the one used throughout the season for every training session, between 7:00 p.m. and 9:00 p.m.

2.5. Small-Sided Games

4 SSGs were analysed with 4 different objectives in the attack phase, the objective always being the same in the defence phase, recovering possession of the ball. The four SSGs used in this investigation according to the objective in the attack phase were:

- Game 1. Keeping possession of the ball.
- Game 2. Keeping possession of the ball and progressing to the goal line of the opposing team.
- Game 3. Trying to score a goal in either of the two goals of the rival team.
- Game 4. Trying to score a goal in the goal defended by a goalkeeper.

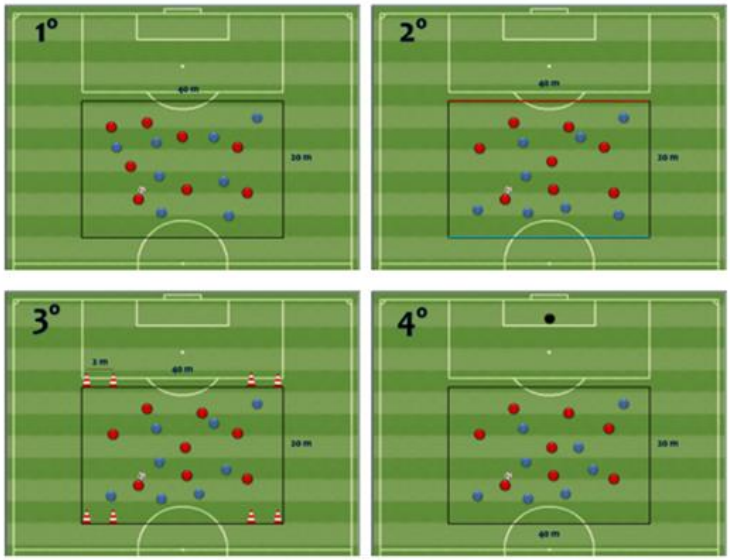

Figure 2 *Graphic representation of the four small-sided games formats*

The SSGs were carried out on a previously marked pitch, with dimensions of 20 metres wide and 40 metres long. Each small-sided game was played twice, with full possession in the attack phase for each team. Therefore, each time the defending team regained possession of the ball, they returned possession to the attacking team. Following the recommendations of Mallo (2013) and Verheijen (2014) each of the repetitions had a total duration of five minutes and between each of the series, a break of two minutes was taken.

2.6. Statistical Analysis.

Firstly, a descriptive analysis was carried out showing the data as averages and standard deviations (average ± SD) to describe all the requirements in the different SSGs analysed according to the tracking system used and the variables recorded. To determine the normality of the variables, the Kolmogorov-Smirnov test was performed, all of them reporting a normal distribution. Student's t-test for related samples was used to compare the differences in the variables depending on the game phase and the tracking system used in the pairwise comparison. An ANOVA was used for the comparison of the variables according to the objective of the different SSGs. The level of significance was established at $p<0.05$. The effect size was calculated using Cohen's d to calculate the magnitude of the differences in the analysed variables. This was classified as low effect (0-0.2), small effect (0.2-0.6), moderate effect (0.6-1.2), large effect (1.2-2.0) and very large effect (> 2.0) (Hopkins, Marshall, Batterham, & Hanin, 2009). Finally, the Pearson correlation test was performed for the relational analysis of the variables of tactical positioning according to the game phase. SPSS software version 24.0 (SPSS Inc., Chicago IL, USA) was used for the statistical analysis.

3. RESULTS

Table 2 shows the comparison between the tactical variables analysed, differentiating between defence and attack phases, depending on the tracking system used (GPS vs. UWB). Statistically significant differences were found in the variable area, both in attack ($p <0.01$, TE = -0.12) and defence ($p <0.01$, TE = -0.22), reporting a low effect size. No significant differences were found in the centroid variable between both tracking systems.

Table 2 Comparative analysis of the variables analysed according to the tracking system used

Game phase	Variable	UWB		GPS		p	ES
		Mean	SD	Mean	SD		
Attack	Area	238.95	73.68	248.18	79.87	<0.01	-0.12
	Centroid	0.51	0.33	0.51	0.35	0.11	0.00
Defence	Area	134.64	45.75	146.85	62.33	<0.01	-0.22
	Centroid	0.62	0.39	0.62	0.39	0.95	0.00

Note. *UWB: Radio frequency technology; GPS: Global Positioning System; SD: Standard deviation; p: p value; ES: Effect size.*

The comparative analysis of the tactical variables analysed, differentiating between the two tracking systems (GPS and UWB), depending on the game phase (attack vs. defence) is shown in Table 3. Statistically significant differences were found in both tactical variables, these being of a large effect size in the variable area (UWB: ES = 1.74, GPS: ES = 1.43, $p <0.01$), and higher in attack and of a low effect size in the centroid variable (UWB: ES = -0.30; GPS: ES = -0.30; $p <0.01$), and higher in defence.

Table 3 *Comparative analysis of the variables according to the game phase*

Tracking system	Variables	Attack		Defence		p	ES
		Mean	SD	Mean	SD		
UWB	Area	238.95	73.68	134.64	45.75	<0.01	1.74
	Centroid	0.51	0.33	0.62	0.39	<0.01	-0.30
GPS	Area	248.18	79.87	146.85	62.33	<0.01	1.43
	Centroid	0.51	0.35	0.62	0.39	<0.01	-0.30

Note. *UWB: Radio frequency technology; GPS: Global Positioning System; SD: Standard deviation; p: p value; ES: Effect size.*

Table 4 shows the comparative analysis of the tactical variables, differentiating between the two tracking systems (GPS and UWB) and the game phase (attack vs. defence), depending on the objective of the SSG. Statistically significant differences were found among all SSGs according to the objective. The largest occupation areas were found in SSG 4, both in the attack and defence phase in both tracking systems, whereas the lowest space occupation was in SSG 2. As for the centroid variable, the highest values could be found in SSG 1 in both phases of the game and with the recording of both tracking systems.

Table 4 *Comparative analysis of the variables according to the objective of the SSG*

Game phase	Tracking system	Variable	SSG 1		SSG 2		SSG 3		SSG 4		p
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Attack	UWB	Area	240.37	70.44	214.74	61.67	218.66	62.19	290.49	78.84	<0.01
		Centroid	0.57	0.33	0.52	0.33	0.46	0.32	0.45	0.33	<0.01
	GPS	Area	253.54	75.41	225.35	64.81	220.33	66.73	301.89	89.16	<0.01
		Centroid	0.57	0.34	0.52	0.33	0.46	0.27	0.48	0.47	<0.01
Defence	UWB	Area	120.82	38.16	109.37	32.04	150.54	36.87	163.78	55.52	<0.01
		Centroid	0.75	0.44	0.68	0.38	0.54	0.32	0.47	0.31	<0.01
	GPS	Area	39.88	111.36	31.52	145.20	35.31	218.42	84.98	39.88	<0.01
		Centroid	0.75	0.42	0.68	0.39	0.54	0.32	0.47	0.33	<0.01

Note. *UWB: Radio frequency technology; GPS: Global Positioning System; SD: Standard deviation; p: p value; ES: Effect size.*

Finally, Table 5 shows the relational analysis of the tactical variables recorded in terms of the game phase, using the average of the values of the two systems employed to track the players. The greatest relationships between attack and defence in the variable area were found in SSG 4 while in the centroid variable they were found in SSG 1. The worst values were found in the variable area and centroid in SSG 3.

Table 5 *Relational analysis of the variables according to the game phase*

SSG	Game Phase	Variable	Attack		Defence	
			Area	Centroid	Area	Centroid
1	Attack	Area		-0.02	0.23**	0.02
		Centroid			0.05	0.61**
	Defence	Area				0.06*
		Centroid				
2	Attack	Area		-0.15**	0.12*	-0.09*
		Centroid			-0.04	0.54**
	Defence	Area				-0.03
		Centroid				
3	Attack	Area		-0.02	0.04	0.05

		Centroid		0.04	0.30**
	Defence	Area			-0.07*
		Centroid			
4	Attack	Area	-0.02	0.66**	-0.11**
		Centroid		0.02	0.49**
	Defence	Area			-0.06
		Centroid			

** Significant correlation (p<.05); **Significant correlation (p<.01).*

4. DISCUSSION

Analysis of matches and training sessions is increasingly being used by coaches and researchers; however, there is less research that delves into the question from a more tactical perspective (Frencken and Lemmink, 2008). The objectives of this study were to analyse tactical behaviour through the area and centroid variables according to: (1) the tracking system used (GPS vs. UWB) (2) the game phase (attack vs. defence) and (3) the objective of four SSGs (1. keeping possession, 2. keeping possession and progressing, 3. keeping possession, progressing and finishing with multiple goals and 4. keeping possession, progressing and finishing in a real game situation with a goalkeeper).

Regarding the comparison between both types of technologies for the monitoring of players, in this study we found that there are significant differences between GPS and UWB in the area variable, both in defence ($p < 0.01$) and in attack ($p < 0.01$), but not for the centroid variable. This finding is interesting, since the centroid represents the distance from the geometric centre of a team over time, i.e. it expresses the distance (m) of that centre from one moment to another (in this case every 2 seconds) and, therefore, a linear distance. In this regard, these results are in line with the findings of Bastida-Castillo, Gómez-Carmona, De la Cruz Sánchez, & Pino-Ortega (2018) which showed that there were no significant differences in accuracy when measuring distance between UWB and GPS technology, especially in linear movements. However, given the limitations of GPS technology (Aughey, 2011, Larsson, 2003, Scott, Scott, & Kelly, 2015), it was hypothesised that the difference between the two systems would be greater when a more sophisticated analysis was required, such as the x, y coordinates of a position. This is the case of the covered area variable, which takes into account the position of several players. These results indicate that a comparison of the accuracy of both systems is necessary for their use in tactical analysis applications, in which the exact position of the player is taken into account.

Regarding the two phases of the game studied, attack and defence, we found significant differences in the tactical variables analysed ($p < 0.01$) with both systems, with the area in attack and the centroid in defence being greater. There is a relationship between the dynamics of the area and centroid variables, meaning that there is an adaptation of the tactical distribution of the defence depending on the tactical distribution of the attack in all the small-sided games, the relations of both variables being greater in the SSG 4 (real game

simulation). These data coincide with those published by Bartlett, Button, Robins, Dutt-Mazumder and Kennedy (2012) where they analyse 5 SSGs and find a relationship between the centroid of the attacking team and the defending team with a correlation on the x-axis of r = 0.93 and on the y axis of r = 0.76. In addition, as for the area variable, a larger size in the attack corresponds to an increase in the size of the defence; as opposed to the results obtained by Moura, Martins, Anido, De Barros and Cunha (2012). During the analysis, unstable moments are observed which are caused by disturbances (loss of possession or a bad pass, among others) that break the dynamics. Therefore, to achieve success in attack, players will seek to break down the attack-defence flow, through switching the direction of play, exploiting the space on the flanks, etc, in order to find spaces in defence.

According to Dellal et al. (2008), in spite of the fact that modification of certain rules is an important factor that can influence the demands of the exercises, only a small number of studies have consistently examined this question (Casamichana, San Roman, Calleja, & Castellano, 2015). In this study we have analysed how the modification of the main objective of the task significantly influences the tactical behaviour during the exercises. Thus, we found statistically significant differences between all SSGs ($p < 0.01$). In this respect, a previous investigation carried out by Frencken et al. (2011) analyses the tactical behaviour of 3 repetitions of a SSG (SSG 4 in the present investigation) finding that there is no variation in the relation of the area and centroid variables between defence and attack due to the non-modification of the objective. The SSGs, according to occupation of space from lowest to highest, are 2-3-1-4 in attack and 2-1-3-4 in defence. In game 4 we find the highest spatial occupation in both defence and attack and the lowest value of the centroid, which means that the inclusion of a regulated goal and a goalkeeper brings us closer to the tactical demands of the real game. These data are related to those obtained by Folgado, Lemmink, Frencken and Sampaio (2014) which find a lower value of the centroid in child athletes (younger than 13 years old) with respect to the youngest children (under 9 years old), suggesting that these results originate in the fact that older players more consistently apply the expansion game principles (avoiding being marked and creation of space) and tilt (defensive coverage), reflecting a higher level of collective tactical behaviour. Another influential fact is the self-assignment of specific positions oriented to the goal in order to guarantee a balanced occupation of the playing field (Silva, Aguiar, Davids, Araújo, & Garganta, 2014). Besides the objective, other variables have also been analysed to evaluate their influence on the tactical variables. Among these are the influence of the partial result and the game situation (inferiority vs. superiority) in the centroid variable, where significant differences have been found (Sampaio, Lago, Gonçalves, Maçãs, & Leite, 2014) and the level of the players, which shows a greater synchronisation in professional teams with respect to amateur teams (Folgado, Duarte, Fernandes and Sampaio, 2014). Therefore, the objective of the tasks, the partial result, the game situation and the level of the players are aspects to take into account when it comes to planning modified situations of small-sided games during training sessions due to their direct influence on tactical demands.

5. CONCLUSIONS

- The differences found between GPS technology and UWB indicate that the values obtained through both technologies cannot be compared in terms of their application in tactical analysis variables.

- The game phase and the objective of the SSGs have a direct influence on the variables of tactical analysis evaluated in the present investigation. Thus, a greater relationship is found in such a distribution when the objective is to score a goal in a regulated goal, due to the fact that there is a great similarity to the real game distribution.

6. LIMITATIONS

This study used a small sample (a single national division team) so the results obtained are specific to the analysed team and cannot be extended to the general population. In addition, this research project could be complemented by comparing the actual tactical demands in official competition with respect to the SSGs designed according to the different objectives analysed.

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