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Capturing and Quantifying Tactical Behaviors in Small-Sided and Conditioned Games in Soccer: A Systematic Review

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ABSTRACT

Purpose: To systematically describe and analyze the tracking systems, the variables, and the statistical methods used to evaluate the players and teams' tactical behavior in small-sided and conditioned games (SSCGs). **Methods**: A search was done in Web of Science, PubMed, Science Direct, and Scielo databases to identify manuscripts published between 2008 and 2019 that manipulated small-sided and conditioned games (SSCGs) and analyzed tactical behaviors of players and teams. **Results**: From 349 articles identified, 31 were selected for review. To collect positional data, the global positioning system (GPS), the local position measurement (LPM) system, and TACTO were identified as reliable tracking systems. Twenty-one positional variables were identified to evaluate tactical behaviors, grouped into five main categories: team balance, playing space, width and length of playing space, and interpersonal distance. Tactical behavior patterns were analyzed using approximate entropy, sample entropy, Shannon entropy, and patterns of coordination between players and teams were analyzed using relative phase and running correlation. **Discussion**: The tracking systems analyzed were reliable but revealed different advantages and disadvantages of their use. Authors should define the use of each tracking system based on their purpose and level of precision required for analysis. A great duplication was observed on the variables used with similar purposes of tactical analysis. The identification of the variables according to their purpose of analysis will allow a better understanding of their use in the future.

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Football; performance analysis; small-sided and conditioned games; tactical behaviors

Team sports, such as soccer, are open dynamic environments in which players are required to adjust their individual actions according to the constantly emerging dynamics in the spatial-temporal relations of teammates and opponents. That is, individual performances emerge from continuous interactions with other players to ensure a balance in team behaviors, based on their capabilities and collective performance, opportunities in competitive performance or training environments (Silva, Vilar et al., 2016). From these interactions, tactical behaviors emerge as players explore individual and collective possibilities for action when seeking functional performance behaviors in competitive games or practices (Araújo et al., 2010; Gréhaigne et al., 1997).

In line with this idea, small-sided and conditioned games (SSCGs) have been widely used in soccer practice aiming to develop physical, physiological, technical, and tactical behaviors at the same time (Ometto et al., 2018; Sarmento et al., 2018). These types of practice task designs seek to potentiate several performance factors, while maintaining the representativeness of training exercises, ensuring a greater specificity of transfer between training and competition (Davids et al., 2013). For example, previous research has emphasized the analyses of the effects on physical and technical actions of players when manipulating key task constraints in SSCGs such as playing area dimensions, number of players involved, type and number of target goals or the number of touches allowed when in possession of the ball (Silva et al., 2015; Silva, Vilar et al., 2016; Travassos, Gonçalves et al., 2014).

In recent years, there has also been a growing interest in understanding the effects of SSCGs manipulations on tactical behaviors of players and teams, using positional data to study the coordinated behaviors of players with and without the ball (Memmert et al., 2017; Sarmento et al., 2018; Travassos et al., 2013). To perform the tactical analysis, most of the studies used global positioning (GPS; Coutinho, Goncalves, Santos et al., 2019; Goncalves et al., 2016; Praça et al., 2016), local position measurement systems (LPM; Olthof et al., 2015, 2018, 2019), or manual tracking systems based on video analysis (TACTO; Duarte, Araújo, Freire et al., 2012; Vilar, Esteves et al., 2014). All of the systems revealed good reliability values in tracking players' trajectories. For

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example, Linke et al. (2018) revealed good reliability values registering player positioning on the field for LPM (23 cm), for manual tracking systems based on video analysis (TACTO; 56 cm) and for GPS (96 cm) with similar levels of error sensitivity with increases in players' speed during performance (Linke et al., 2018). The analysis of positional data to capture the effects of the manipulation of SSCGs in tactical behaviors of players and teams has reported several different variables (e.g., centroid position, surface area, effective area play, stretch play or the lpwratio), and used different methodologies (e.g., identification of patterns of coordination, spatial-temporal relations between players, analyzing behavioral variability; Ometto et al., 2018; Sarmento et al., 2018).

To summarize, due to a rapid increase in the volume of research studies on the different kinds of variables and methods used to measure the tactical behaviors of players during training, there is a need to systematically review the results obtained, as well as the variables assessed, and methodologies used that best fit the specific objectives of the academic research. Thus, the aim of this systematic review was to systematically describe and analyze the error margins of the systems, the variables recorded, and the statistical methods used to evaluate and monitor the players' and teams' tactical behavior in SSCGs.

Methods

Search strategy

This systematic review was conducted following the PRISMA protocol (Moher et al., 2009). The researchers examined the Web of Science, PubMed, Science direct and Scielo databases by using the following keywords "small sided soccer games" and "small sided football games," and by associating the terms "tactical," "behaviors," "tactical behaviors," and "effects of manipulations". Bibliography lists were also consulted in order to identify potential studies to be included in the review. All data were exported to the EndNote X6 software for further analysis.

The analysis selected experimental, descriptive, or review studies, that complied with the following inclusion criteria: 1) articles published between 2008 and 2019; 2) articles written in English; 3) took into account the positional data of individual players and teams in order to analyze tactical behaviors or 4) revealed effects of task constraints manipulations in SSGs with detailed statistical analyses, and 5), identified the tracking systems used with detailed descriptions of reliability levels.

The exclusion criteria were set for articles analyzing performance: 1) in formal (full-sided) games; 2) in sports other than soccer; 3) studies only reporting physiological data; 4) studies only reporting technical performance; and 5) systematic review; 6) studies focused on the manipulation of coaches' instructions; 7) articles only composed of abstracts.

Once the articles were selected they were analyzed and the data were related to sample characteristics, players' ages, the task constraints manipulated (e.g., changing playing area dimensions, the number of players involved, types of scoring targets used), the tracking systems used (GPS, LPM, Tacto Software), the variables measured (e.g., team balance, playing space, width and length playing space, interpersonal distances) and methodologies used for analysis. For the purpose of the study each article was categorized according to the tracking systems used, the positional variables studied, as well as the methods of analysis used.

Risk of bias

For the article evaluation, the Law scale was used (Law et al., 1998) consisting of 15 items, including: purpose of the study (item 1), literature relevance (item 2), study design (item 3), sample (items 4 and 5), results (items 6, 7, 11, 12 and 13), intervention (items 8, 9 and 10), dropouts description (item 14), and conclusions and implications (item 15). Articles reporting these items were classified with a value of 1 and those articles in which these items were not reported were given a value of 0. The final score is the sum of the items (1 to 15). Additionally, we estimated, on a percentage scale, the methodological quality of each specific study. The studies were classified as follows: low methodological quality ≤ 50% of items reported in an article, good methodological quality rated between 51% and 75%, and excellent methodological quality above 75% of items reported (Sarmento et al., 2018). Two independent evaluators (NC, MM) reviewed the selected studies and any discrepancy in article categorization was resolved by consensus. Only four studies required additional revision by the evaluators.

Results

Study selection and methodological quality

An initial survey identified 349 articles in the database. Figure 1 illustrates the selection process of the articles included for systematic review. In total, 31 articles were included in the study.

The average value of article methodological quality rating was 80,4%, with 21 articles rated above 75% and ten articles between 51% and 75% (see Table 1). In the 31 articles analyzed, possible gaps were identified in two items. None of the studies justified the sample size

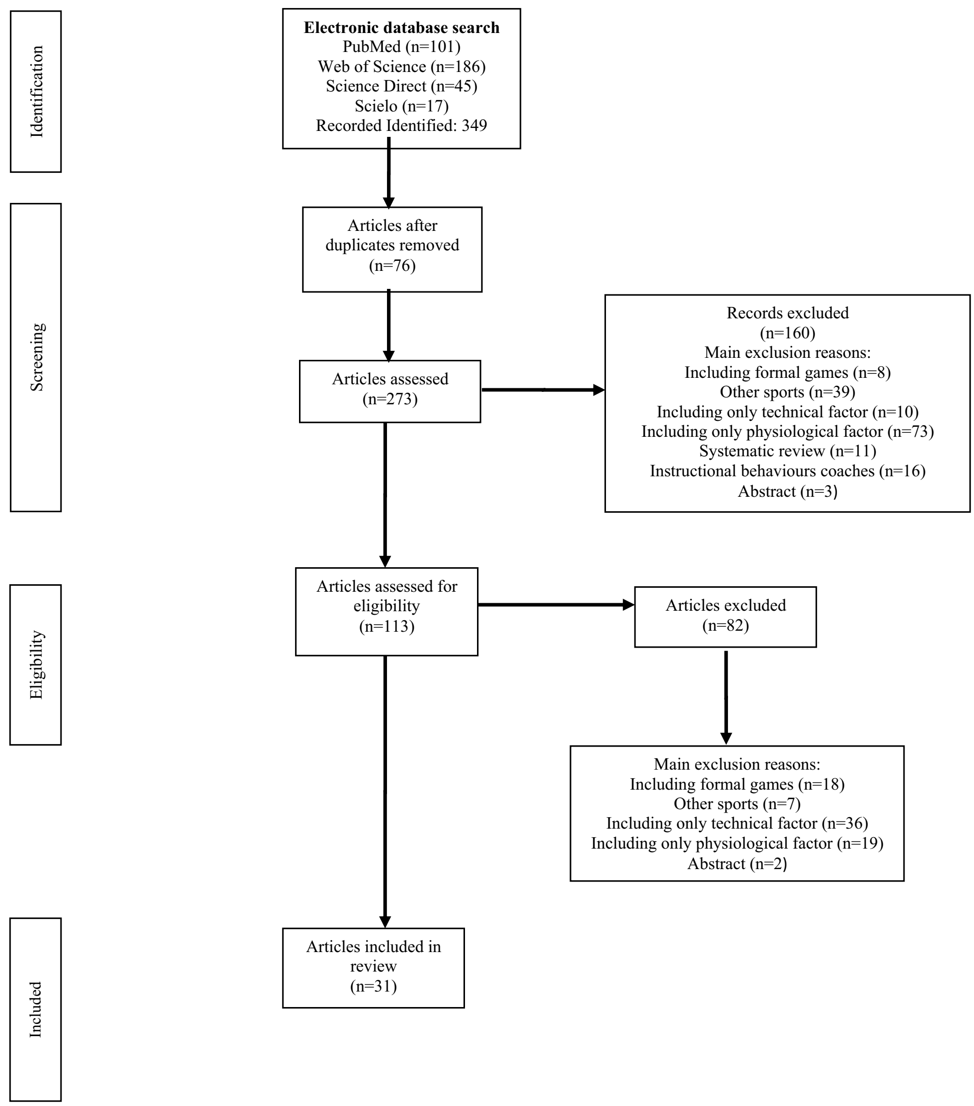

Figure 1. Article selection process flowchart.

selected, nor reported the number of players dropping out during data collection. The objectives and the design of each study were rated as "good quality" according to the "*Law scale*". The statistical methods were valid and in general were well described. Almost all of the conclusions revealed implications for coaching practice.

Analysis of tactical behaviors in SSCGs in soccer

Table 1 describes the main characteristics of the 31 articles considered for analysis. The studies were published between the years 2011 to 2019, involving a total of 1035 players.

According to the purposes of the studies, it was possible to organize the articles according to the tracking systems used, the positional variables studied, as well as the methods of analysis used (see Figure 2).

To collect positional data on participant movement, the global positioning system (GPS) was used in 21 studies. The SPI-Pro, GPSports (Canberra, ACT, Australia) was used in 17 studies, the minimax 4.0 Catapult Innovations in three studies and the Qstarz Model: BT-Q1000Ex in one. The local position measurement (LPM) system (Inmotio Object Tracking BV Amsterdam, The Netherlands) was used in five studies. At the end, the software package Tacto ("Tool for Applied and Contextual Time-series Observation; Fernandes et al., 2010) was used in five studies (see Table 2).

Regarding the variables considered for analysis, 21 positional variables were identified to evaluate tactical behaviors. The team centroid position was evaluated in 19 studies, the stretch index in ten studies, the surface area in nine, the width and length in eight, the lpwratio in five, effective playing space and distance between teammates

Table 1. Article characterization in the systematic review.

Studies	Tracking system	Measures	Methodologies	SSCGs constraints	Number	Field	Area per player	Quality score (%)
(Canton et al., 2019)	GPS 5 hz	Width Length Centroid Position Spread Rate Stretch Index	Mean SD Magnitude Based inference	Player number Age	Gk+4v4+ Gk Gk+5v4+ Gk Gk+6v4+ Gk	40x45 m	180 m^2 163,6 m^2 150 m^2	86,7
(Coutinho, Goncalves, Santos et al., 2019)	GPS 5 hz	Effective playing space Distance between teammates	Mean SD Magnitude Based inference Relative Phase	Age Pitch designs	Gk+5v5+ Gk	36x25 m	75 m^2 58 m^2 29 m^2	86,7
(Coutinho, Goncalves, Travassos et al., 2019)	GPS 5 hz	Stretch index Distance between teammates	Mean SD T-Test ApEn CV Relative Phase	With spatial references Without spatial references	Gk+6v6+ Gk	62x43 m	190,4 m^2	86,7
(Folgado et al., 2019)	GPS 10 hz	Width Length Centroid Position Gk- defender distance	Mean SD Magnitude Based inference Relative Phase	Field	Gk+4v4+ Gk	40x30 m 30x 40 m	120 m^2	86,7
(Olthof et al., 2019)	LPM 34–91 hz	Width Length Surface area	Mean SD Mixel model approach Pearson Correlations CV	Age Player number Field	Gk+4v4+ Gk Gk+6v6+ Gk Gk+8v8+ Gk	68x47 m 80x56 m 91x63 m	320 m^2	86,7
(Baptista et al., 2020)	GPS 5 hz	Width Length Centroid Position Surface area	Mean SD ApEn Magnitude Based Inference	Playing formation	Gk+7v7+ Gk	62x50 m	194 m^2	86,7
(Olthof et al., 2018)	LPM 42–100 hz	Centroid Position Lpwratio Surface Area Stretch index Gk- defender distance	Mean SD Manova CV	Age Field	Gk+4v4+ Gk	40x30 m 68x47 m	120 m^2 320 m^2	86,7
(Santos et al., 2018)	GPS 5 hz	Distance between teammates Distance team's own target Distance opponent team target	Mean SD Ancova ApEn	Age	Gk+5v5+ Gk	36x 25 m	75 m^2	86,7
(Castellano et al., 2017)	GPS 10 hz	Width Length Effective playing space Centroid Position Stretch index	Mean SD ApEn	Age Field	Gk+6v6+ Gk	60x40 m 50x40 m 40x40 m 30x40 m	200 m^2 166,7 m^2 133,3 m^2 100 m^2	80

(*Continued*)

Table 1. (Continued).

Studies	Tracking system	Measures	Methodologies	SSCGs constraints	Number	Field	Area per player	Quality score (%)
(Gonçalves et al., 2017)	GPS 5 hz	Spatial exploration index Distance between teammates	Mean SD Magnitude based inferences ApEn CV Relative Phase	Pitch designs	9x10+ Gr	58,5x64 m	187,2 m^2	86,7
(Barnabé et al., 2016)	GPS 15 hz	Surface area Stretch index Width Length	Mean SD SampEn Cross-sample entropy Anova	Age	Gk+6v6+ Gk	60x33 m	141, m^2	73,3 %
(Castellano et al., 2016)	GPS 10 hz	Width Length Lpwratio Team Separateness	Mean SD Magnitude based inferences	Goal	GK+4V4+ GK 2(7 G) GK+4V4 + 2+ GK (SG) GK+4V4+ GK (7 GF)	40x25 m	100 m^2	73,3%
(Barnabé et al., 2016)	GPS 5 hz	Centroid Position Effective playing space	Mean SD Magnitude based inferences ApEn	Player number	Gk+4v3+ Gk Gk+4v5+ Gk Gk+4v7+ Gk	40x30 m	133,3 m^2 109 m^2 92,3 m^2	86,7%
(Praça et al., 2016)	GPS 15 hz	Centroid Position Lpwratio	Kolmogoro-Smirnov test	Player number	Gk+3v3+ Gk Gk+4v3+ Gk Gk+3v3 + 2+ Gk	36x27 m	121,5 m^2 108 m^2 97,2 m^2	80%
(Barnabé et al., 2016)	GPS 15 hz	Centroid Position Stretch index	Mean SD ICC	Player number	3v3 4v4 5v5	36x28 m	168 m^2 126 m^2 100 m^2	73,3%
(Aguiar et al., 2015)	GPS 5 hz	Centroid Position	Mean SD ApEn	Player number Field	2v2 3v3 4v4 5v5	28x21 m 35x26 m 40x30 m 44x34 m	150 m^2	60%
(Olthof et al., 2015)	LPM 43 hz	Centroid Position Stretch index	Mean SD RC CV Pearson Correlations	Age	Gk+4v4+ Gk	40x30 m	120 m^2	86,7%
(Silva et al., 2015)	GPS 10 hz	Effective relative space per player Radius of free movement Players spatial distribution variability	Mean SD Magnitude based inference Shannon Entropy	Player number Field	6v6 7v7 8v8 9v9	52,9x34x4 m 49,5x32x2 m 46,7x30,3 m 57,3x37,1 m	152 m^2 133 m^2 118 m^2	73,3%
(Folgado et al., 2014)	Tacto Software	Centroid Position Lpwratio	Mean SD Repeated Measures	Player number	Gk+3v3+ Gk Gk+4v4+ Gk	30x20 m	75 m^2 60 m^2	86,7%
(Silva, Aguiar et al., 2014)	GPS 15 hz	Player to locus distance variability Spatial distribution variability	Mean SD Anova CV SampEn Shannon Entropy	Field	Gk+4v4+ Gk	36,8x23x8 m^2 47,3x30,6 m^2 57,8x37,4 m^2	216,2 m^2 144,7 m^2 87,5 m^2	86,7%

(*Continued*)

Table 1. (Continued).

Studies	Tracking system	Measures	Methodologies	SSCGs constraints	Number	Field	Area per player	Quality score (%)
(Silva, Duarte et al., 2014)	GPS 15 hz	Lpwratio Effective playing space Stretch index Team Separateness	Mean SD Anova CV SampEn	Field	Gk+4v4+ Gk	36,8x23x8 m^2 47,3x30,6 m^2 57,8x37,4 m^2	216,2 m^2 144,7 m^2 87,5 m^2	86,7%
(Silva, Travassos et al., 2014)	GPS 15 hz	Centroid Position Stretch index Surface area	Mean SD Anova	Player number Skill level	3 SG+5V5+ Gk 3 SG+5V4+ Gk 3 SG+5V3+ Gk	47,3x30,6 m	131,6 m^2 144,7 m^2 160,8 m^2	73,3%
(Travassos, Gonçalves et al. 2014)	GPS 15 hz	Stretch index Centroid Position Relative stretch index between teams (RelSTI)	Mean SD Pooled variance Magnitude effects	Goal	Gk+5v5+ Gk 3SG+5v5 + 3SG	30x25 m	75 m^2 62,5 m^2	86,7%
(Travassos, Vilar et al., 2014)	Tacto Software	Centroid Position Surface area	Anova Mauchly's test Paired T-Test Relative Phase	Player number	Gk+4v4+ Gk Gk+4v3+ Gk	40x20 m	80 m^2	86,7%
(Vilar, Duarte et al., 2014)	Tacto Software	Relative distance to intercept a shot Attacker-defender distance Relative distance to intercept a pass	Mean SD Anova CV	Field	5v5	28x14 m 40x20 m 52x26 m	39,2 m^2 80 m^2 135 m^2	86,7%
(Vilar, Esteves et al., 2014)	Tacto Software	Relative distance to intercept a shot Attacker-defender distance Relative distance to intercept a pass	Anova	Player number	5v5 5v4 5v3	40x20 m	100 m^2 89 m^2 80 m^2	86, 7%
(Sampaio et al., 2013)	GPS 5 hz	Centroid Position	Mean SD Anova ApEn	Player number	Gk+5v5+ Gk During the game a player was removed	60x40 m	200 m^2	73%
(Frencken et al., 2013)	LPM 100 HZ	Centroid Position Surface area Tean length Tean width	Mean SD Pearson correlation Manova RC	Field	Gk+4v4+ Gk	24x20 m 30x20 m 30x16 m 20x16 m	48 m^2 60 m^2 32 m^2	86,7%
(Duarte, Araújo, Friere et al., 2012)	Tacto Software	Centroid Position Surface Area	Anova Turkey's HSD test RC	Creation of scoring	Gk+3v3+ Gk	49x20 m	122,5 m^2	60%
(Sampaio & Maçãs et al., 2012)	GPS 5 hz	Centroid Position	Relative phase ApEn Paired-Test		Gk+5v5+ Gk	60x40 m	200 m^2	73,3%
(Frencken et al., 2011)	LPM 45 hz	Centroid Position Surface Area	Pearson Correlation		Gk+4v4+ Gk	36x28 m	100,8 m^2	53,3%

Approximate entropy (ApEn); Standard deviation (SD); Intraclass correlation analysis (ICC); Coefficients of variation (CV); Running correlations technique (RC); Samples Entropies(SampEn); Small goal (SG); 7G = 7-a-side goals; 7GF = Two floaters.

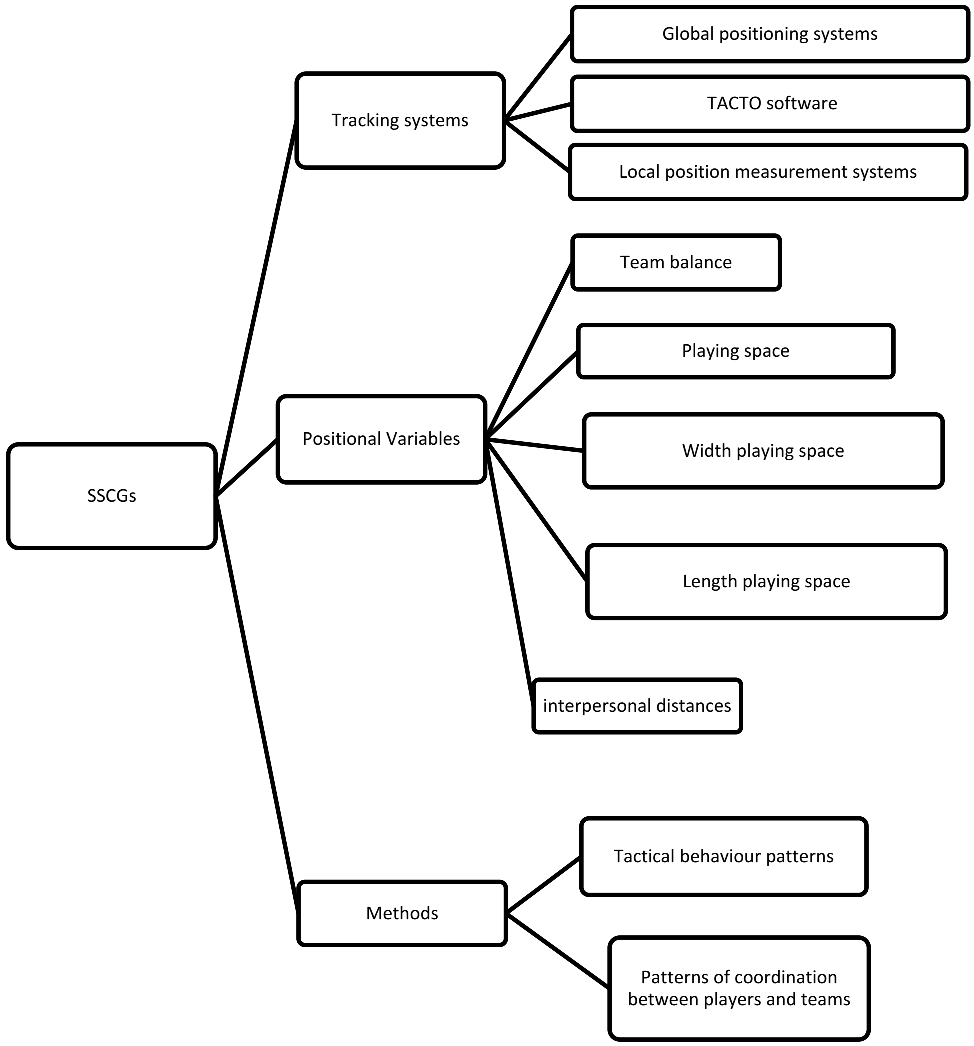

Figure 2. Study structure analysis.

were assessed in four studies. Relative distance to intercept a pass, distance to intercept a shot, attacker-defender distance, team separateness, goalkeeper defender distance were used twice. The following variables were also analyzed: effective relative space per player, radius of free movement, relative stretch index and player to locus. Spread rate, distance to team's own target, distance to opponent team's target, and spatial exploration index were considered just once each. All the variables were grouped into categories of variables according to their main purpose of analysis: Team balance (variables that allow to analyze the individual or team balance on the field in relation to opponent team for the exploration of possibilities for action), playing space (variables that allow to analyze the covered space of a team or the used space in relation to the field references), width and length of playing space (variables that allow to measure lateral and longitudinal spatial occupation and relations between teams), and interpersonal distance (variables that allow to measure player-to-play or player to ball distances; see Table 3).

The methods used for analysis of tactical behaviors in SSCGs can be grouped according to the purpose of the studies. With the purpose of describing and characterizing tactical behavior patterns using linear methods of analysis, identifying the dynamics of tactical behavior patterns or accessing the interpersonal patterns of coordination that sustain tactical behavior between players and teams using non-linear methods of analysis. In this section, more than to describe the linear methods of analysis generally used to characterize tactical behavior patterns, a focus on the non-linear methods of analysis was made. In line with that, to access the dynamics of tactical behavior patterns, approximate entropy (ApEn) was used in nine studies, sample entropy (SampEn) was used in three, and Shannon entropy was used in two studies. To access the interpersonal patterns of coordination that sustain tactical behavior between players and teams, relative phase was used in six studies, and the running correlation technique was used in three studies (see Table 4).

Table 2. Description of tracking systems.

Tracking systems	Study	Sampling rate	Reliability
GPS (SPI-Pro, GPSports, Canberra, ACT,Australia)	(Barnabé et al., 2016; Praça et al., 2016; Silva, Aguiar, 2014; Silva, Duarte, 2014; Silva, Travassos, 2014; Silva, Vilar, 2016; Travassos, Gonçalves, 2014)	15	5% (total distance covered)
	(Aguiar et al., 2015; Baptista et al., 2020; Canton et al., 2019; Coutinho, Goncalves, Santos, 2019; Coutinho, Goncalves, Travassos, 2019; Gonçalves et al., 2017; Goncalves et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012; Santos et al., 2018)	5	5 a 10% (peak speed
GPS (Minimax 4.0. Catapult Innovations)	(Castellano et al., 2017; Castellano et al., 2016; Folgado et al., 2019)	10	
GPS (Qstarz, Model:BT-Q1000Ex)	(Silva et al., 2015)		
Local position measurement (LPM) system	(Frencken et al., 2013)	100	1,6% (total distance covered)
	(Frencken et al., 2011)	45	
	(Olthof et al., 2015)	43	5% (average speed)
(Inmotio Object Tracking)	(Olthof et al., 2018)	42–100	
	(Olthof et al., 2019)	34–91	
Tacto Software	(Duarte, Araújo, Freire, 2012; Folgado et al., 2014; Travassos, Vilar, 2014; Vilar, Duarte, 2014; Vilar, Esteves, 2014)	25	< 5%

Table 3. Variables used for analysis of tactical behaviors in SSCGs.

Categories	Calculation	Study
Team balance		
Centroid position		(Aguiar et al., 2015; Baptista et al., 2020; Canton et al., 2019; Castellano et al., 2017; Duarte, Araújo, Freire, 2012; Folgado et al., 2019; Folgado et al., 2014; Frencken et al., 2011; Frencken et al., 2013; Goncalves et al., 2016; Olthof et al., 2015, Olthof et al., 2018; Praça et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012; Silva, Travassos, 2014; Silva, Vilar, 2016; Travassos, Gonçalves, 2014; Travassos, Vilar, 2014)
Team separateness		(Castellano et al., 2016; Silva, Duarte, 2014)
Stretch index		(Barnabé et al., 2016; Canton et al., 2019; Castellano et al., 2017; Coutinho, Goncalves, Travassos, 2019; Olthof et al., 2015, Olthof et al., 2018; Silva, Duarte, 2014; Silva, Travassos, 2014; Silva, Vilar, 2016; Travassos, Gonçalves, 2014)
Relative stretch index		(Travassos, Gonçalves, 2014)
Spread rate		(Canton et al., 2019)
Playing space		
Surface area		(Baptista et al., 2020; Barnabé et al., 2016; Duarte, Araújo, Freire, 2012; Frencken et al., 2011; Frencken et al., 2013; Olthof et al., 2018, Olthof et al., 2019; Silva, Travassos, 2014; Travassos, Vilar, 2014)
Effective playing space		(Castellano et al., 2017; Coutinho, Goncalves, Santos, 2019; Goncalves et al., 2016; Silva, Duarte, 2014)
Distance team's own target		(Santos et al., 2018)
Distance opponent team's target		(Santos et al., 2018)
Width and length playing space		
Length		(Baptista et al., 2020; Barnabé et al., 2016; Canton et al., 2019; Castellano et al., 2017; Castellano et al., 2016; Folgado et al., 2019; Frencken et al., 2013; Olthof et al., 2019)
Width		(Baptista et al., 2020; Barnabé et al., 2016; Canton et al., 2019; Castellano et al., 2017; Castellano et al., 2016; Folgado et al., 2019; Frencken et al., 2013; Olthof et al., 2019)
Lpwratio		(Castellano et al., 2016; Folgado et al., 2014; Olthof et al., 2018; Praça et al., 2016; Silva, Duarte, 2014)
Interpersonal distances		
Distance to intercept a pass		(Vilar, Duarte, 2014; Vilar, Esteves, 2014)
Distance to intercept a shot		(Vilar, Duarte, 2014; Vilar, Esteves, 2014)
Attackers-defenders distance		(Vilar, Duarte, 2014; Vilar, Esteves, 2014)
Goalkeeper defender distance		(Folgado et al., 2019; Olthof et al., 2018)
Distance between teammates		(Coutinho, Goncalves, Santos, 2019; Coutinho, Goncalves, Travassos, 2019; Gonçalves et al., 2017; Santos et al., 2018)
Effective space per player		(Silva et al., 2015)
Radius of free movement		(Silva et al., 2015)
Player to locus distance		(Silva, Aguiar, 2014)
Spatial exploration index		(Gonçalves et al., 2017)

Discussion

Tracking systems

The Global Position System (GPS) was the most frequently used system to collect the positional data of players. Players wear a vest in which a sensor can be placed located in the upper back between the shoulder blades. Regarding the different GPSs used, the SPI-Pro, GPSports (Canberra, ACT, Australia) uses a sampling rate between 5 and 15 hz, while the minimax 4.0 Catapult Innovations and Qstarz Model:BT-Q1000Ex used a sampling rate of data collection of 10 hz. In general the **systems** reveal a margin of error less than 5% (in measuring total distance covered), which can increase to about 10% in high-intensity actions

Table 4. Non-linear methods used for analysis of tactical behaviors in SSCGs.

Methods	Study
Dynamics of tactical behaviors patterns	
Approximate entropy	(Aguiar et al., 2015; Baptista et al., 2020; Castellano et al., 2017; Coutinho, Goncalves, Travassos, 2019; Gonçalves et al., 2017; Goncalves et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012; Santos et al., 2018)
Sample entropy	(Barnabé et al., 2016; Silva, Aguiar, 2014; Silva, Duarte, 2014)
Shannon entropy	(Silva, Aguiar, 2014; Silva et al., 2015)
Interpersonal patterns of coordination	
Relative phase	(Coutinho, Goncalves, Santos, 2019; Coutinho, Goncalves, Travassos, 2019; Folgado et al., 2019; Gonçalves et al., 2017; Sampaio & Maçãs, 2012; Travassos, Vilar, 2014)
Running correlation	(Duarte, Araújo, Freire, 2012; Frencken et al., 2013; Olthof et al., 2015)

(Johnston et al., 2012; see Table 2). The 10 hz GPS was up to six times more reliable in measuring the instantaneous speed, than systems operating at 5 hz (Varley et al., 2012).

The local position measurement (LPM) is a system that uses radio frequency technology to record players' positioning through triangulation between the device and at least 10 fixed stations placed around the field (Frencken et al., 2011, 2013; Olthof et al., 2019). The sampling rate values ranged from 34 to 100 hz considering the reciprocal relationship between the sampling frequency and the number of devices (e.g., 10 players, the sampling frequency is 100 Hz (1000/10; see Table 2), with an estimation error of less than 1,6% (distance covered) and 5% (relative average speed; Frencken et al., 2010).

The Tacto software is a video-based system that collects players' positions through manual digitization, with a sampling rate of data collection of 25 hz. Through manual scanning, using a mouse, virtual coordinate data (pixel units) were collected and later transformed into real coordinates (metric units), using the two-dimensional Direct Linear Transformation Method DLT-2D (Serrano et al., 2014). The TACTO software revealed a reliability of more than 95% (Fernandes et al., 2010).

In comparing the three types of tracking systems used, the advantages of GPS are that system is portable, reliable, simple to use and to extract data live or in a short period of time. The disadvantage is that the precision and reliability of the system depend on the number of satellites detected (Colino et al., 2019). The LPM is also reliable, simple to use and to extract data from in a short period of time. The disadvantage is that the LPM system is a fixed system that can only be used in one field. TACTO software is also a reliable system to collect positional data and is the unique system identified to track the position of players and the ball. The disadvantage is that it is a very time-consuming method.

Despite the reported decrease in the reliability of GPS and LPM position data in high-intensity actions, no study was developed to understand the impact of such variations in the reliability of tactical variables. Further research is required on this issue to clearly identify possible errors of measurement in different tactical variables. Any decrease in reliability of measurement was reported in TACTO software according to intensity of actions.

Variables for tactical behavior analysis

Team balance

To analyze team balance, different variables were identified: centroid position (CP), team separateness (TS), stretch index (SI), relative stretch index (RSI) and spread rate (SR). A great number of studies considered had analyzed centroid position (CP). CP represents the (gravitational) midpoint of the team of players and is calculated by recording the mean position of the outfield players for each time stamp in which all team players were considered (Frencken et al., 2011). The CP is a useful measure to evaluate the dynamics of a team in relation to the opponent team or to a specific location on the field. Indeed, the isolated analysis of CP cannot contribute to a deeper understanding of team balance due to the lack of references for comparison. The CP revealed to be sensitive to the manipulation of the number of players and the numerical relation between teams, the manipulation of the number and position of goals, and even the age of the players. Particularly, differences in the distance between teams (Duarte, Araújo, Freire et al., 2012; Frencken et al., 2011), on the distance of each team from the goal (Frencken et al., 2011) were observed between manipulations. CP can also be used to analyze the balance of attacking and defending teams in relation to the attacking and defending goal. The distance between the teams' CPs can also be used to understand the balance or the proximity between teams in different game moments or spaces on the field (Frencken et al., 2013). In addition, it seems that the CP can be used to capture the adaptive behaviors of teams according to the manipulations of the numerical unbalance between teams, number of players, field space, number of targets. Thus, the CP seems to be a relevant positional variable that facilitates reductions in game complexity and a characterization of the dynamic interactions between competing teams over the games (Frencken et al., 2011; Silva, Vilar et al., 2016; Vilar et al., 2012).

Similarly, the team separateness measure (TS) has units of meters and can be interpreted as the overall radius of action free of opponents. TS is calculated by recording the sum of distances between each team player and the closest opponent (Castellano et al., 2016). A measure of TS was preferred to other metrics, such as the centroids' distance, to measure the closeness of the team's players since the latter does not account for the teams' dispersion differences which may impact on the players' radius of free movement. A value of TS close to 0 indicates that all players are closely marked, while a high value indicates more freedom of movement. Thus, while the CP allows to understand the general balance between teams, the TS captures the individual balance on space occupation between attacker-defender players for the exploration of tactical behavior. TS significantly increased with pitch size regardless of players and team's level (Silva, Duarte et al., 2014).

The SI expresses the dispersion of the team players during a game, by considering the distance of each player to the CP. SI is calculated by computing the mean of the distances between each player and the CP for that team. The SI proved to be sensitive to the effects of players' ages and skill level, with the older and more skilled practitioners revealing higher SI and more variable values (Barnabé et al., 2016; Canton et al., 2019; Olthof et al., 2015). When the game is played by teams with high levels of practice, there is a tendency for higher values of dispersion in the lateral rather than the longitudinal axis (Olthof et al., 2015).

Relative stretch index (RSI) is a relational variable that results from the analysis of the relationship of the SI of both teams. It seems that RSI is a useful variable to pick up information about the free-space between attacker and defender teams. It reveals sensibility to measure variations in the available space between teams according to the position of the ball in the field (Travassos, Gonçalves et al., 2014). Higher RSI values were observed in SSCGs with two scoring targets in comparison with six scoring targets (Travassos, Gonçalves et al., 2014).

The Spread Rate is also a derivative variable from SI that analyzes the rate of change of the stretch index of teams over time. This variable is calculated as the rate of change of SI and expresses the speed of contraction and expansion of the teams over time and could be related to the rate of exploration and adaptation of teams to the game environment (Canton et al., 2019). Changes were observed on the Spread Rate according to changes in numerical relationship between teams. It seems that numerical unbalance promoted higher spread rate, and consequently more variability in patterns of play explored by players. However, further research is required to improve the understanding of the use of this variable to explain game dynamics.

Playing space

To analyze the playing space, the following variables were identified: surface area, the effective playing space, distance team's own and opponent target.

The surface area is the total space covered by a team, and is calculated as the perimeter of the space occupied by the outermost players or the greater area containing players from one or two teams (Frencken et al., 2011; Goncalves et al., 2016; Olthof et al., 2018), and also defined as the area within the convex hull of the team or the teams (Frencken & Lemmink, 2008; Moura et al., 2013). The surface area measurement can be used to improve understanding about the area of play of each team or the effective area of play between both teams (Frencken et al., 2011; Goncalves et al., 2016). It is important to note that the surface area behavior is dependent on the number of players involved. That is, the increase in the number of players involved increases its predictability and distance in surface area, inhibiting the successful description of teams playing space dynamics (Goncalves et al., 2016; Olthof et al., 2019). Also, it was reported that the surface area provides an evaluation of the space occupation of the teams, but it did not reveal the sensitivity to discriminate instabilities in the relations between sub-groups of players (Duarte, Araújo, Freire et al., 2012).

The effective playing space variable is also frequently used to measure the smallest space that contains all outfield players of a team (Goncalves et al., 2016). Indeed, the method of calculation and the results were quite broad across the studies. It is not clear why the same variable was defined with different names in different studies.

The variables, distance team's own target, and distance team's opponent target were calculated as variables that represent the spatial occupation of teams in relation to specific spatial references such as the goal or the goalkeeper position. Such variables were calculated as the Euclidean distance between a player and each target. Due to the reference to the targets, based on the changes in results observed due to the manipulation of small-sided and conditioned games, the authors considered that these variables help to understand the effectiveness of adaptations of team's tactical behavior to specific game demands (Folgado et al., 2019; Olthof et al., 2018; Santos et al., 2018).

Length and width playing space

To analyze the length and width playing space three related variables were identified: team length, team width and the length per width ratio (lpwratio).

The length and width of a team represent the longitudinal and lateral dispersion of players in a team and are calculated as the longitudinal or lateral distance between the most distant players of a team. The lpwratio represents the balance between longitudinal and lateral positioning of players (Folgado et al., 2014) and is calculated as a ratio between lateral and longitudinal values of a team. Values between 0 and 1 of lpwratio indicate superior positioning in width. Values greater than

1 suggests the prevalence of longitudinal occupation. The length and width playing space, but especially the lpwratio revealed sensitivity to the influence of players' ages (Folgado et al., 2014; Olthof et al., 2015). The low variation in the lpwratio variable tends to reflect the positional stability of players (Folgado et al., 2014), while the larger variations in lpwratio seem to represent a more individualized attacking game, with great variations in players' actions (Folgado et al., 2014; Praça et al., 2016). Also, the increase in space occupied in length and a reduction in width seem to promote large variability in lpwratio (Olthof et al., 2018).

Interpersonal distances

Regarding the analysis of interpersonal distances, nine different variables were identified: distance to intercept a pass, distance to intercept a shot, attacker-defender distance, goalkeeper defender distance, distance between teammates, effective space per player, radius of free movement, player to locus distance, spatial exploration index. Such variables represent the spatial-temporal relationships between players (attacker-attacker, defender-defender or attacker-defender) to perform, in opposition to previous categories of variables that capture the collective dimension of the game. Interestingly it is the category that revealed a higher number of variables. However, with some differences in the methods of calculation, some of them were used with similar purposes.

The distance to intercept a pass or a shot represents the shortest distance of defenders to the passing or shooting lines (Vilar, Duarte et al., 2014) and allows for an understanding of how the manipulation of SSCGs constrains the possibilities of defenders to intercept the ball or the attacker to ensure a pass or a shot. Such variables proved to be of a good informative value for coaches' understanding of the manipulation of the numerical relationship between players on passing and shooting actions, or on defending the defenders' behavior (Vilar, Esteves et al., 2014). Both variables revealed significantly higher values in numerical unbalance between teams in comparison with numerical balance (Vilar, Esteves et al., 2014).

In line with previous variables, the attacker-defender distance variable represents, in the attack, the space available for the attacker to maintain ball possession or to define passing lines, and in the defense the capability of defenders to close spaces for attackers' action, to pressure the ball or to recover ball possession (Vilar, Duarte et al., 2014). Goalkeeper defender distance represents the space between goalkeeper and defending line. Older players revealed higher values on a large pitch (Olthof et al., 2018).

The analysis of distance between teammates revealed how a pair of teammates share and create playing space. Interestingly, it seems that the distance between teammates tends to reveal differences between attacking and defending moments, but reveal similarities between such moments even in different SSCGs (Gonçalves et al., 2017; Santos et al., 2018). Also, Coutinho et al. (2019) advocated that distance between teammates is one of the key information variables that regulate sub-units and team behavior.

The variables effective space per player and radius of free movement revealed the amount of free space that each player has at each moment over the game. While effective space per player measures the amount of free space available for each player by dividing the area of the effective playing space delimited by the smallest rectangle encompassing all the players, the radius of free movement evaluated the space free of opponents for each player by calculating the smallest distance to opponents at each instant (Silva et al., 2015). Similar tendencies on the results were observed for these variables. However, the effective space per player revealed higher values than radius of free movement.

Finally, the variables, players to locus distance and spatial exploration index revealed the space covered by each player in relation to their mean pitch position. Allowing for the identification of the predominant space covered by each player and its variability over the game (Gonçalves et al., 2017).

Methodologies of analysis

Dynamics of tactical behavior patterns

The analysis of tactical behavior patterns through non-linear methods made it possible to evaluate the degree of regularity and unpredictability of spatial-temporal variables assessing performance at an individual and team level (Santos et al., 2018; Silva, Duarte et al., 2016). ApEn and SampEn were used to measure the randomness of the series of data (Delgado-Bonal & Marshak, 2019) and to evaluate the variability in spatial-temporal relations of players and teams in SSCGs. ApEn numbers range from 0 to 2, while SampEn numbers range from zero to infinity (Silva, Duarte et al., 2016). Low numbers indicate regularity, while high numbers indicate irregularities in time series (Sampaio et al., 2013; Silva, Aguiar et al., 2014). ApEn can be used with signals of equal length, preferably with at least 50 data points (Yentes et al., 2012). SampEn could be used in short time-series (that is less than 50 data points) and consequently is considered more robust to calculate the variability of shorter time series than ApEn (Richman & Moorman, 2000). Duarte et al. (2013) revealed three differences between ApEn and SampEn: 1) ApEn allows self-matches while SampEn does not; 2) ApEn showed less consistency about choices of input parameters; 3) ApEn revealed to be more sensitive to the length of the data series. SampEn showed a higher consistency and ability to discriminate differences between groups than ApEn (Montesinos et al., 2018). For example, they were used to evaluate the dynamics of the distances between each player to the nearest opponent (Silva, Duarte et al., 2014), the dynamics of surface area, stretch index, team length, team width and centroid position (Duarte, Araújo, Folgado et al., 2012) or variability in distance between players (Coutinho, Goncalves, Travassos et al., 2019; Gonçalves et al., 2017; Santos et al., 2018).

In addition, Shannon entropy is another nonlinear method that was used to measure the regularity of the spatial distribution of players in the field (Silva, Duarte et al., 2014; Silva et al., 2015). A low entropy number (near 0) indicates that the player's position can be easily predicted. A high number (near 1) indicates that the distribution is irregular and that the player's position is highly unpredictable (Sampaio & Maçãs, 2012; Silva et al., 2015). That is, the values near 1 reveal irregularity in players' behavior related to performance in attacking phases of performance. The values near 0 revealed regularity in the players who really spend more time in their positions in the defensive phase (Silva et al., 2015).

Shannon entropy was used to analyze the variability of the player behaviors during the manipulation of space (small, intermediate, large playing areas). Results showed that the increase in playing space provides players with greater stability in occupying their specific positions (defender, midfielders and forward; Silva, Aguiar et al., 2014). Also, the manipulation of space and number of players in small-sided games revealed changes in players' spatial distribution variability. That is, higher irregularity was registered when low numbers of players and small spaces were used (Silva et al., 2015). Authors considered that a more irregular spatial distribution is related to a higher tactical adaptability of players and teams to different game moments and dynamics.

Patterns of coordination between players and teams

Relative Phase is a non-linear statistical method that allows for the processing of signals and describes synchronization between, for example, players displacements or teams' spatial-temporal relations, providing a quantitative measure of the coordination between the players or teams under analysis. The modes of coordination are expressed in angles (Galgon & Shewokis, 2016), and while the in-phase (0° and 360°) represents a periodic symmetrical relationship between components, the anti-phase (180°) coordination represents a periodical anti-symmetrical relationship (Travassos, Vilar et al., 2014). This method evolves throughout the movement, promoting a detailed description of the emerging pattern coordination and the level of coupling between players and teams and the transition between the most prevalent stages of coordination (Lamb & Stockl, 2014). For example, previous research compared interpersonal coordination between players in SSCGs with different numerical relations (Travassos, Vilar et al., 2014) or in different practice tasks (Folgado et al., 2019).

The method of running correlations (RC) is a useful technique to explore the linear relationship between, for example, players displacements or between spatial-temporal relations of player movements in teams. The correlation coefficient at each instant represents the normalized sample covariance of data (Elias & de Artigas, 2006). The results of RC identify three types of coordination trends: i) a strong positive correlation, that represent a symmetrical relationship between variables, when results are positive and near 1; ii) a strong negative correlation, that represent an anti-symmetrical relationship between variables, when results are negative and near −1; iii) an irregular pattern of coordination, when results do not show any preferable pattern of coordination (Corbetta & Thelen, 1996; Duarte, Araújo, Freire et al., 2012). RC method was used in a small number of studies.

Conclusions

The aim of this systematic review was to describe the tracking systems, positional variables and statistical methods used to characterize the tactical behaviors of players and teams in SSCGs (Small sided and conditioned games). In general, the studies that used small-sided and conditioned games should improve their design in the future. Particularly, it is suggested the inclusion of a rationale for the chosen sample size and players' drop-out in order to improve the article's methodological quality for comparison purposes.

In this study it is possible to identify the most appropriate tracking systems, variables and methods of analysis that best fit the needs of further research. The tracking systems analyzed were reliable but revealed different advantages and disadvantages of its use. Authors should define the use of each tracking system based on their purpose and level of precision required for analysis. Twenty-one positional variables were identified to evaluate tactical behaviors, grouped into five main categories: Team balance, playing space, width and length of playing space, and interpersonal distance. However, a great duplication was observed on the variables used with similar purposes of tactical analysis. Further comparisons are required to understand the similarity between them. Also, further research should be developed to compare the dynamics of each variable in small-sided and conditioned games and official games.

Tactical behaviors patterns were analyzed using approximate entropy, sample entropy, Shannon entropy. Patterns of coordination between players and teams were analyzed using relative phase and running correlations. Further research is required to improve the understanding of the changes on tactical behaviors patterns and patterns of coordination between players in the performance of players and teams.

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