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

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Abstract

Purpose: Small sided and conditioned games (SSCGs) are characterized by involvement of a reduced number of players, varied field dimensions, and different rules to maintain the representativeness of training activities. The aim of this systematic review was to analyze the error margins of the tracking systems, positional variables and methods used to monitor player behaviors in SSCG training. Methods: Web of Science and reference list databases were searched using the following keywords: “small sided soccer games” and “small sided football games”, and by associating the terms “tactical”, “behaviour”, “tactical behaviour”; “Effects of manipulations”. Results From 346 articles, 21 were selected for review. The tracking system (Global Positioning system (GPS)), was used in 13 studies. For measuring the tactical behaviors of players and teams 19 positional variables were used in the sample of published papers. The centroid position was used in 14 studies, surface area analysed in 6 studies, stretch índex and lpwratio were used in 5 studies. The methods used to evaluate tactical behaviour included variability analyses using approximate entropy, sample entropy, shannon entropy and intraclass correlation, and identification of patterns of coordination using relative phase and running correlation. Conclusions: GPS was considered the most suitable technology to monitor players' performance, revealing high values for reliability and validity for measuring performance over short distances at high intensity. The selected positional variables allowed the SSCGs to characterize the behavior of teams in the attacking and defensive phases of play, although, the lpwratio should be used with other positional variables. The most frequently implemented methods for measuring patterns of tactical behaviours that

emerged in SSCGs were approximate entropy, sample entropy, shannon entropy measures, relative phase and running correlation.

Keywords: small-sided and conditioned games, football, tactical behaviours, methods

Introduction

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 behaviours, based on their capabilities and collective performance opportunities in competitive performance or training environments (Silva, Vilar, Davids, Araújo, & Garganta, 2016). From these interactions, tactical behaviours emerge as players explore individual and collective possibilities for action when seeking functional performance behaviours in competitive games or practices (Araújo, Travassos, & Vilar, 2010; Gréhaigne, Bouthier, & David, 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 behaviours 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 (e.g., the maintenance of information sources from the competitive environment that support the learning of players and teams in practice contexts), ensuring a greater specificity of transfer between training and competition (Davids, Araújo, Correia, & Vilar, 2013). For example, previous research has emphasized 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(e.g., Dellal, Drust, & Lago-Penas, 2012; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Owen, Wong, McKenna, & Dellal, 2011; Rampinini, Impellizzeri, & Castagna, 2007). For that purpose, time- motion measures of player performance have been used.

However, in recent years, there was a growing interest in understanding the effects of SSCGs manipulations on tactical behaviours of players and teams, using positional data to investigate the coordinated behaviours of players with and without the ball (e.g., Memmert, Lemmink, & Sampaio, 2017; Sarmento et al., 2018; Travassos, Davids, Araújo, & Esteves, 2013). For undertaking tactical analysis, most of the studies used global positioning (GPS) (Coutinho et al., 2019; Gonçalves, Marcelino, Ronda, Torrents, & Sampaio, 2016; Praça, Folgado, Andrade, & Greco, 2016), local position measurement systems (LPM)(Olthof, Frencken, & Lemmink, 2015, 2018, 2019), or manual tracking systems based on video analysis (TACTO) (Duarte, Araújo, Freire, et al., 2012; Vilar, Esteves, et al., 2014). All systems revealed good values of reliability in tracking players trajectories. For example, Linke et al. (2018) revealed good reliability values registering player positioning on 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, Link, & Lames, 2018).

To summarise, in order to analyze positional data during performance, many current studies on effects of SSCG manipulations in soccer have used a range of different methodologies (e.g., identification of patterns of coordination, spatial-temporal relations between players, analysing behavioural variability) and reported several different measures (e.g., centroid position, surface area, effective area play, stretch play or the lpwratio), revealing variations in outcomes (Ometto et al., 2018; Sarmento et al., 2018). Due to a rapid increase in the volume of research studies on the different kind of variables and methods used to measure tactical behaviours of players during training, there is a need to systematically review the results obtained, as well as variables assessed, and methodologies used that best fit specific goals of academic research. Thus, the aim of this systematic review was to systematically describe and analyse the error margins of the systems, the variables recorded and the statistical methods used to evaluate and monitor the players' tactical performance in SSCGs.

Methods

Search Strategy

This systematic review was conducted following the PRISMA protocol (Moher, Liberati, Tetzlaff, Altman, & Grp, 2009). The researchers examined the Web of Science database by using the following keywords "small sided soccer games" and "small sided football games", and by associating the terms "tactical", "behaviours", "tactical behaviours" and "effects of manipulations". Bibliography lists were also consulted in order to identify potential studies to be included in the review.

An initial survey identified 345 articles in the database, with an additional 117 studies included after consulting the bibliography lists of the articles. All data were exported to the software EndNote X6 for further analysis.

The analysis selected experimental, descriptive, or review studies, that complied with the following inclusion criteria: 1) articles published between 2008 to 2016; 2) articles written in English; 3) reviewed the effects of different task constraints in SSGs on emergent collective and individual tactical behaviours; 4) took into account the positional data of individual players and teams in order to analyse tactical behaviours, 5) revealed effects of task constraints manipulations in SSGs with detailed statistical analyses, and 6), identified the tracking systems used with detailed descriptions of reliability levels.

The exclusion criteria included articles analysing 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), articles only composed of abstracts.

Once the articles were selected they were analysed and data 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 8.0 software), the variables measured (e.g., centroid position, surface area, effective playing area, stretch index, lpwratio) and methodologies used for analysis (see table 1).

***** Insert Table 1 near here *****

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 to 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 categorisation was resolved by consensus. Only 3 studies required additional revision by the evaluators.

Results

Study selection and methodological quality

An initial survey identified 345 articles in the database, with an additional study included after consulting the bibliography lists of the articles. Figure 1 illustrates the selection process of the articles included for systematic review. In total, twenty-one articles were included in the study.

The average value of article methodological quality rating was 76 %, with eleven articles rated above 75 % and ten articles between 51 and 75 %. In the twenty-one articles analysed, possible gaps were identified in two items. None of the studies justified the sample size selected, nor reported the number of players dropping out during data collection. The goals 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. The conclusions revealed implications for practice.

**** Insert Figure 1 near here****

Analysis of tactical behaviours in SSCGs in soccer

Table 1 describes the main characteristics of the twenty-one articles considered for analysis. The studies were published between the years 2011 to 2016, involving a total of 408 players. According to the purposes of the studies, it was possible to organize the articles according to the tracking systems used, the positional variables investigated, as well as the methods of analysis used (see Figure 2).

***** Insert Figure 2 near here*****

To collect positional data on participant movement, the global positioning system (GPS) was used in thirteen studies, with the SPI-Pro, GPSports (Canberra, ACT, Australia) being used in eleven studies, the minimax 4.0 Catapult Innovations in one study and the Qstarz Model: BT-Q1000Ex in one study and two more tracking systems were used. The local position measurement (LPM) system (Inmotio Object Tracking BV Amesterdam, The Netherlands) was used in three studies. At the end, the software package Tacto 8.0 ("Tool for Applied and Contextual Time-series Observation") was used in five studies (see Table 2).

***** Insert Table 2 near here *****

Regarding the variables considered for analysis (see Table 1), nineteen positional variables were used to evaluate tactical behaviours. The team centroid position was evaluated in fourteen studies, six examined the surface area, five analysed the stretch index, and five calculated the lpwratio. Relative distance to intercept a pass, distance to intercept a shot, distance between all attackers and all immediate defenders, team separateness, width, length, players' spatial distribution variability and effective playing space were used twice. The following variables were also analysed: effective relative space player, radius of free movement, numerical relations inside each player´s relative space per player, and team shape. Spatial distribution variability, longitudinal and lateral inter team distance were used just once each.

The methods used for analysis of tactical behaviours in SSCGs can be grouped according to the purpose of the studies. With the purpose of identifying tactical behaviour patterns, approximate entropy (ApEn) was used in four studies, sample entropy (SampEn) was used in three, and Shannon entropy was used in two studies with the goal. Relative phase was used in two studies, and the running correlation technique was used in three studies with the goal of accessing the interpersonal patterns of coordination that sustain tactical behaviour between players and teams (see Table 3).

***** Insert Table 3 near here *****

Discussion

Tracking systems

The GPS was the most frequently used system to collect positional data of players, with a sensor typically located in a vest placed on players' upper back. Regarding the different GPS system used the SPI-Pro, GPSports (Canberra, ACT, Australia) (Aguiar, Gonçalves, Botelho, Lemmink, & Sampaio, 2015; Barnabé, Volossovitch, Duarte, Ferreira, & Davids, 2016; Gonçalves et al., 2016; Praça et al., 2016; Sampaio, Lago, Gonçalves, Macãs, & Leite, 2013; Sampaio & Maçãs, 2012; Silva, Aguiar, et al., 2014; Silva, Duarte, et al., 2014; Silva, Travassos, et al., 2014; Silva, Vilar, et al., 2016; Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio, 2014) using a frequency between 5 and 15 hz. The SPI-

Pro, GPSports presented a margin of error less than 5% (in measuring total distance covered), which can increase to about 10% in high intensity actions (Johnston et al., 2012). The minimax 4.0 Catapult Innovations (Castellano, Silva, Usabiaga, & Barreira, 2016) and Qstarz Model:BT-Q1000Ex (Silva et al., 2015) were other models of GPS reported with a frequency of data collection of 10 hz. The 10 hz GPS were up to six times more reliable to measure the instantaneous speed than systems operating at 5 hz (Varley, Fairweather, & Aughey, 2012).

In addition to GPS, the Tacto 8.0 software (Duarte, Araújo, Freire, et al., 2012; Folgado, Lemmink, Frencken, & Sampaio, 2014; Travassos, Vilar, Araujo, & McGarry, 2014; Vilar, Duarte, Silva, Chow, & Davids, 2014; Vilar, Esteves, et al., 2014) uses images obtained from a video camera so that, 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, Shahidian, & Fernandes, 2014). The TACTO 8.0 software revealed a reliability of more than 95% (Fernandes, Folgado, Duarte, & Malta, 2010). However, it was reported as a very time-consuming method.

The local position measurement (LPM) is a system that uses radio frequency technology for recording players' positioning through triangulation between the device and 10 fixed stations placed around the field (Frencken, Lemmink, Dellemam, & Visscher, 2011; Frencken, Van der Plaats, Visscher, & Lemmink, 2013; Olthof et al., 2015). The frequency values ranged from 43 to 100 hz (see Table 2), with an estimation error of less than 1,6 % (distance covered) and 5% (relative average speed) (Frencken, Lemmink, & Delleman, 2010).

GPS is the best system to monitor performance in SSCGs on outdoor playing spaces, being a simple and reliable system to use in these locations. The unique issue is that researchers and performance analysts need to ensure that the number of satellites detected are sufficient to maintain the precision of data according to the manufacturers' recommendations (Colino et al., 2019). The GPS is the most useful tracking system to monitor short displacements at high-intensity and players' workload (Linke et al., 2018; Vickery et al., 2014).

Variables for tactical behaviour analysis

Centroid position

The centroid position (CP) represents the (gravitational) midpoint of the team of players and is calculated by recording the mean position of the outfield players (Frencken et al., 2011). To calculate the CP, the formula used in several studies was CP=(X_n,Y_n) for each time stamp (Duarte, Araújo, Freire, et al., 2012; Frencken & Lemmink, 2008; Frencken et al., 2011; Sampaio & Maçãs, 2012) in which all team players (n) were considered.

The CP measure can be used to improve the understanding about: (a) the distance of each team from the goal (Frencken et al., 2011); (b) the distance between teams (Duarte, Araújo, Freire, et al., 2012; Frencken et al., 2011); (c) or even the dispersion of the players on field, measuring the distance from the players to the CP (Sampaio & Maçãs, 2012). That is, the CP of the attacking team moves towards the opponent team goal with as the ball approaches to opponent team goal, while the CP of defending team was always between its goal and the CP of attacking team (Frencken et al., 2013). The distance between the teams' CPs decreases when the attacking team gets closer to the opposition's goal (Frencken et al., 2011). In addition, it seems that the numerical unbalance between teams (e.g., Goalkeeper(GK)+4v3+GK) promoted dispersion of the players on the field, with the distance from the players to the CP increasing for both teams (Praça et al., 2016). 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, Araújo, Davids, & Bar-Yam, 2012).

Surface area/Effective area play

The surface area is the total space covered by a team, based on 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; Gonçalves et al., 2016). The surface area, has also been described as the area within the convex hull, describing the players' distribution on field at each instant in time (Frencken & Lemmink, 2008; Moura et al., 2013). The surface area of teams is calculated considering the player with lowest values in coordinate y (Width) and the player with highest values in coordinate x (length). After determining these 2 points, the pivot angle for each player is calculated. Thus, the surface area is determined by adding the triangles and the CP (Moura et al., 2013). This variable may also appear in some studies as an effective area of play being calculated in square meters. In one of the studies analysed, the surface area was determined as a triangle, taking into account the number of players on field (Gk+3v3+Gk), using the following formula according to the Cartesian coordinates (Duarte, Araújo, Freire, et al., 2012): $Area = (x1\ y2 - y1\ x2) + (x2\ y3 - y2\ x3) .... + (xn\ y1 - yn\ x1) / 2$. Also, some of the studies mentioned the use of previous routines for the calculation of convex hull (convhull) in MATLAB to measure surface area (Frencken et al., 2011; Gonçalves et al., 2016). Such calculation is dependent of the number of the players in the analysis.

The surface area measure can be used to improve understanding about the area of play of each team or the effective area of play of both teams. Based on the calculation of the area of play of each team, it is possible to improve understanding about the equilibrium in the balance of play contributed by both teams (Frencken et al., 2011; Gonçalves et al., 2016). The variable surface area revealing independent tactical behaviours between attacking and defending teams, it was clear that attacking teams increased team space at the three defined moments. This finding signified that when transitioning to the scoring zone, attacking teams tended to increase the area of play to prevent defenders to intercept passing and shooting lines and exaggerate the defensive imbalance of the opposition (Duarte, Araújo, Freire, et al., 2012; Frencken et al., 2011; Frencken et al., 2013; Gréhaigne & Godbour, 2013). Such tactical behaviours seem to emerge as a need to gain space-time advantages to successfully achieve a shot at goal. In another study, that manipulated the number of competing players per team (2v2, 3v3, 4v4, 5v5), it was observed that the increase in the number of players involved in SSCGs promoted higher values of surface area (Aguiar et al., 2015). These results concurred with similar data reported in another study with SSCGs teams involving a greater number of players (6v6, 7v7, 8v8 e 9v9) (Silva et al., 2015). However, results from a study by Gonçalves et al. (2016) suggested that, with an increase in the number of players involved, analysis of the surface area becomes more predictable, inhibiting the successful description of the effects of task constraint manipulations (Gonçalves et al., 2016).

In general, analysis of the surface area between teams revealed that there was a linear correlation between the space covered by the playing area of each team and the difference between the surface areas of both teams (Frencken et al., 2013). That is, the decrease in the areas of play of each team decreased the difference between the areas of attacking and defending teams and contributes to promote higher equilibrium in the areas of play between teams. Also, the surface area was analysed to identify moments of instability in spatial-temporal relations between teams when rupture passes occur (i.e., when a passed ball penetrates a defensive line and facilitates a shot at goal by a teammate). However, results did not discriminate the perturbations that characterize such moments of instability (Duarte, Araújo, Freire, et al., 2012). Clearly, the surface area provides an evaluation of the general equilibrium between teams and did not reveal the capability of discriminating instabilities in the relations between sub-groups of players.

Stretch index

The stretch índex (SI) expresses the dispersion of the players in a team during a game. The SI is calculated as the average (not summation) of the distance of each player to the centroid position of the team and can be calculated either in the longitudinal and lateral direction, as well as a radial distance at each instant (Bartlett, Button, Robins, Dutt-Mazumder, & Kennedy, 2012). This calculation is carried out by adding the values of each player's distance in relation to a team's midpoint and determines a team's dispersion value on field (Olthof et al., 2015). Results indicate the increase of the SI of about one meter for each player added in each team (3v3, 4v4, 5v5), keeping the playing area dimensions constant (36x28m). The range of the players' dispersion values varied from 5-6 meters (3v3) to 7-8 meters (5v5) in 30-40% of game time (Silva, Vilar, et al., 2016). The SI proved to be sensitive to effects of players' ages and skill level. There is a tendency for older and more skilled practitioners to display higher SI values (Barnabé et al., 2016; Olthof et al., 2015).

Travassos, Gonçalves, et al. (2014) sought to evaluate the effect of changing the number of scoring targets (goals) on team tactical behaviours in SSCGs. Analysing the SI and the relative SI between the teams (RelSI), they observed that both generally decrease with an increase in the number of goal scoring targets. Attacking teams tend to display higher SI values compared to defensive team. When the game is played by teams with high levels of practice, there is a tendency for dispersion values to be greater in the lateral axis than the longitudinal axis (Olthof et al., 2015). The results of the analysis of the SI seems to be similar to the results of the surface area analysis. However, in SSCGs with fewer players (Gk+3x3+Gk and Gk+4x4+Gk) the results of SI analyses seem to better discriminate variations in the players' dispersion on field (Duarte, Araújo, Freire, et al., 2012; Frencken et al., 2011). Accordingly, Bartlett et al. (2012) suggested the use of the surface area preferentially when player positioning is more stable (e.g., full-sized games). In contrast, the use of the SI seems to be preferable to the surface area variable in small-sided games because it is more sensitive to variations in player positioning. In general, it seems that the SI is more sensitive to identify the attacking/defending teams' contraction/expansion behaviours at each instant, compared to the surface area (Bartlett et al., 2012).

Lpwratio

The lpwratio represents the ratio between a team's length and width values. It is calculated by the team's maximum and minimum values in the x (length) and y (width) axes at each instant, according to the individual player's position on field (Folgado et al., 2014). The lpwratio calculation formula is: length per width ratio (Folgado et al., 2014; Praça et al., 2016). Values between 0 and 1 indicate superior positioning in width. Values greater than 1 suggest the prevalence of players' positioning in the x axis.

Results indicate that low variation in the lpwratio variable tends to reflect offensive and defensive patterns of play with greater positional stability of players (Folgado et al., 2014). Players maintaining disciplined positions in key locations on field may indicate more functional collective, tactical behaviours (Barnabé et al., 2016; Olthof et al., 2015). On the other hand, larger variations in lpwratio represent a more individualized attacking game, with great variations in defensive and offensive behaviours (Folgado et al., 2014; Praça et al., 2016). Also, large variability of lpwratio reflects the tendency for an increase in space occupied in depth (length) and a reduction of space occupied in width.

As with the SI, the lpwratio is sensitive to the influence of players' ages (Folgado et al., 2014; Olthof et al., 2015). In the “Gk+3v3+Gk” format, it was noted that younger players (under-9, under-11 and under-13 yrs) displayed higher values of field spatial occupation longitudinally than laterally (Folgado et al., 2014). Similar results were observed in the “Gk+4v4+Gk” format in the under-17 and under-19 yrs age groups (Olthof et al., 2015). This result suggests a wider dispersion by the older age groups. It was also confirmed that older players were more elaborate in exploring the playing area width on field, in contrast to the direct (longitudinally-based) game typically preferred by less skilled players. To support this view, the lpwratio values observed were lower in older, compared to younger teams (Aguiar et al., 2015; Folgado et al., 2014). However, recently there have been some contradictory findings, with some younger teams revealing higher values for exploration of width on field, relative to depth (Silva, Duarte, et al., 2014). Olthof et al. (2018) suggested that changes in the skill level of players and in pitch size may explain these contradictory results. Thus, additional measures should be added to analyses to improve understanding of such manipulations on tactical behaviours of teams**.** For example, the combination of lpwratio with CP allows the evaluation of space-time interactions between players in different configurations, namely, the game "style" exhibited by teams (Folgado et al., 2014; Praça et al., 2016).

Methodologies of analysis

Tactical behaviour patterns

Analysis of tactical behaviour patterns through variability analysis allowed us to evaluate the degree of regularity and unpredictability of spatial-temporal variables assessing performance at an individual and team level (Silva, Duarte, Esteves, Travassos, & Vilar, 2016). Mathematical algorithms for ApEn and SampEn were used to measure the randomness of series of data (Delgado-Bonal & Marshak, 2019) and to evaluate variability in spatial-temporal relations of players and teams in SSCGs. For example, they were used to evaluate the distances between each player to the nearest opponent (Silva, Duarte, et al., 2014), field direction (longitudinal/lateral) (Duarte et al., 2013), surface area, stretch index, team length, team width and centroid position (Duarte, Araújo, Folgado, et al., 2012). These algorithms are extremely sensitive to their input parameters and considered the following variables: "m" (data segment lengths being compared), "r" (similarity criterion) and "n" (data length) (Yentes, Hunt, Schmid, & Stergiou, 2012). The ApEn and SampEn measures are defined as the natural negative logarithm that evaluates the conditional probability of two similar sequences for m points (length the vector to be compared) remaining similar at the next point $m+1$ (Silva, Duarte, et al., 2016). 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, Castaldo, & Pecchia, 2018).

ApEn has been used to analyse nonlinear time series data in football (Aguiar et al., 2015), measuring the regularity of centroid position of teams (Aguiar et al., 2015; Gonçalves et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012). SampEn has been used to evaluate the uncertainty of the interpersonal distance values in the SSCGs (Silva, Duarte, et al., 2014), player-to-locus distances (Silva, Aguiar, et al., 2014) or teams' contraction/expansion patterns through stretch index (Barnabé et al., 2016; Silva, Duarte, et al., 2014).

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). The playing area was divided into bins for calibration purposes, and the amount of time spent by each player in each bin was assessed by the sampling frequency of the GPS acquisition system. Maps of spatial distributions were normalized to the total time of play to produce spatial probability distributions (2D). The size the bins was the same magnitude for all areas of the field to balance between high spatial resolution and high range of measured values. Each bin corresponds to an area of 1 m^2, which allows large spatial variability in the counting of bins (>100xdt). Considering a performance area partition of the area with N bins and defining "pi" as the measured probability of finding the player in bin "i". The entropy S of the spatial distribution is S=$-\sum_{i=0}^{N}$1pi logpi (Silva, Duarte, et al., 2014; Silva et al., 2015).

The entropy data were normalized to place the results within the range 0 and 1. 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 (more irregular) reveal irregularity in players' behaviour related to performance in attacking phases of performance. The values near 0 (more regular) capture when the behaviours of players who really spend more time in their positions in the defensive phase (Silva et al., 2015). Shannon entropy was used to analyse the variability of the player behaviours 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)

Table 3 shows ten studies that analysed the variability analysis between practice tasks. Aguiar et al. (2015), Gonçalves et al. (2016), Sampaio & Maçãs (2012) and Sampaio et al. (2013) used ApEn to evaluate effects of the manipulation of space, number of players and skill, on the centroid position and the effective game area. The increase in the number of players in SSCGs promotes more movement regularity due to the increase in the distance between the teams' centroid positions (Aguiar et al., 2015; Gonçalves et al., 2016). The regularity of effective playing space increases with the number of players (Gk+4x3+Gk, Gk+4x5+Gk, Gk+4x7+Gk) in teams with different levels of skill, although amateur teams display lower ApEn values (Gonçalves et al., 2016). The irregularity of the position of the centroid increases when a team has fewer players than the opposition and loses the game (Sampaio et al., 2013). Sampaio and Maças (2012), showed that the increase in players' skill levels promoted lower ApEn values in the post-test situation than in the pre-test, using player's distance from CP team.

Barnabé et al. (2016) and Silva et al. (2014) used the SampEn measure to evaluate the manipulation of age, space and skill. The results suggested that younger players (under 16 yrs) covered less space on field, compared to older ones (under 17 and under 19 yrs,) and the stretch index displayed higher values in the under 19 yrs age group (Barnabé et al., 2016). The values of the effective game area and the distance to the nearest opponent are variables that tend to increase with the size of the playing area designed in practice tasks (Silva, Duarte, et al., 2014).

Sample entropy and Shannon Entropy have been used to evaluate the manipulation of space and skill. Results revealed that, with increases in playing area dimensions, the distance between the competing players increases, increasing the specific zones occupied by each player (Silva, Aguiar, et al., 2014).It was verified that higher skilled players have a greater ability to adapt to the variations of the playing area dimensions, assessed by the variability of the occupied space on field, regardless of variations in playing area, compared to players of lower skill level (regional) (Gonçalves et al., 2016; Silva, Aguiar, et al., 2014; Silva, Travassos, et al., 2014). Shannon Entropy allows investigators to evaluate how different constraints can enhance specific patterns in player performance behaviours. These data suggest that the application of entropy in the identification of talents in young football players is adequate (Silva, Duarte, et al., 2014).

Silva et al. (2015) used Shannon entropy to evaluate the manipulation of the number of players and space, and the results revealed that with increasing of the players and the playing area, game variability of performance is reduced. Another study (Silva, Vilar, et al., 2016), using intraclass correlation (ICC), and manipulating the number of players involved, indicated a consistent regularity in the direction of the centroid position (in depth and width) and an increase in the value of the stretch index, when increasing numbers of players were involved in the SSCGs.

Patterns of coordination between players and teams

Relative Phase is a non-linear statistical method that allows 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. For example, previous research compared interpersonal coordination between players when using two defensive strategies (deep defending vs high press) (Low et al., 2018) or compared the dyadic relations between defenders, defenders and attackers or between attackers in SSCGs with different numerical relations (Travassos, Vilar, et al., 2014). 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).

Table 3 shows the studies that analysed the identification of patterns of coordination between practice tasks. Sampaio and Maçãs (2012) and Travassos et al. (2014) used relative phase measures to evaluate effects of manipulating the number of players involved SSCGs. Sampaio and Maçãs (2012) used relative phase to evaluate the interpersonal patterns of coordination between players through the distance between players and between the centroid position of the teams in a pre and post-test design. Results did not reveal clear relational patterns of coordination between players and teams. However, the results of the post-test showed frequent periods with a tendency to anti-phase, in which the players' distance to the geometric centre of the team revealed an asynchronous behaviour. The investigators argued that the emergent patterns of asynchronous coordination between players' distances to the geometrical centre was a consequence of the learning process that emerged between pre and post-test. Travassos et al. (2014) revealed that different coordination processes between defenders emerge according to the use of equal or unequal numbers of players involved in SSCGs on field. Accordingly, when there was a greater number of defenders involved, the interaction patterns between the defenders became stronger in the in-phase mode of coordination.

According to the data, it seems that relative phase seems to be an appropriate method to identify preferential spatial-temporal coordination patterns that characterize the behaviour of players and teams in specific competitive game environments (Sampaio & Maçãs, 2012; Siegle & Lames, 2013).

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 is calculated in a window of the first *n* observations, then the window is moved by one position, and the correlation recalculated. This is repeated until correlations are calculated for the whole data series. This procedure is analogous to the calculation of a running mean (also known as a moving average). The running correlation curve RC(t) is the time course of correlation coefficients obtained from a sliding rectangular window of wave form data centred. 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).

Using the RC method, Duarte et al. (2012) revealed a strong positive correlation between a team's CP and the distance to the scoring areas, i. e. a team's CP distance decreases as they get closer to the opposition goal. In contrast, the surface area didn't reveal any clear linear relationship with the distance to the opponent team. Frencken (2013) revealed higher correlations between a team's CP along the longitudinal axis, rather than on the lateral axis, when the playing areas are small. The surface area reveal any clear linear relationship. In Olthof et al. (2015) in the analysis of the impact of age on interpersonal relationships between players using RC didn't identified any clear linear relationship.

Conclusions

The aim of this systematic review was to describe the tracking systems, positional variables and statistical methods used to characterize the tactical behaviours of players and teams in SSCGs (Small sided and conditioned games).

GPS devices were the most used equipment for recording the positional data of players in SSCGs and it is the simpler and more reliable for using outdoors. However, more studies are needed to compare the validity and reliability of 5, 10 and 15 Hz frequencies. Centroid position, surface area, stretch index and lpwratio were the most robust positional variables for the analysis of the tactical behaviour. Stretch índex is the most sensible variable for identifying the team's contracting/expanding behaviour on offensive and defensive phases. Regarding the non-linear methods suitable for measuring tactical behaviours between players and teams, ApEn and SampEn were the most used. However, SampEn shows greater consistency for identifying differences between groups and is more suited than the ApEn for shorter time-series. Shannon Entropy was also used for assessing the regularity of the player's spatial occupation on the field. Relative phase and running correlation methods were used to assess the interpersonal patterns of coordination between players or teams. While the Relative phase can assess the interpersonal coordination between two oscillatory signals (e.g. centroid position and stretch index) in space and time, running correlation expresses the linear correlation between variables.

References

Aguiar, M., Gonçalves, B., Botelho, G., Lemmink, K., & Sampaio, J. (2015). Footballers' movement behaviour during 2-, 3-, 4- and 5-a-side small-sided games. *Journal of Sports Sciences*. doi: 10.1080/02640414.2015.1022571

Araújo, D., Travassos, B., & Vilar, L. (2010). Tactical Skills are not verbal skills: A comment on kannekens and colleagues. *Perceptual and Motor Skills: Exercise & Sport, 110 (3)*, 1086-1088.

Barnabé, L., Volossovitch, A., Duarte, R., Ferreira, A., & Davids, K. (2016). Age-related effects of practice experience on collective behaviours of football players in small-sided games. *Human Movement Science, 48*, 74-81.

Bartlett, R., Button, C., Robins, M., Dutt-Mazumder, A., & Kennedy, G. (2012). Analysing team coordination patterns from player movement trajectories in soccer: methodological considerations. *International Journal of Performance Analysis in Sport, 12 (2)*, 398-424.

Castellano, J., Silva, P., Usabiaga, O., & Barreira, D. (2016). The Influence of Scoring Targets and Outer-Floaters on Attacking and Defending Team Dispersion, Shape and Creation of Space During Small-Sided Soccer Games. *Journal of Human Kinetics, 51*(1), 153-163. doi: 10.1515/hukin-2015-0178

Colino, E., Garcia-Unanue, J., Sanchez-Sanchez, J., Calvo-Monera, J., Leon, M., Carvalho, M. J., . . . Navandar, A. (2019). Validity and Reliability of a Commercially Available Indoor Tracking System to Assess Distance and Time in Court-Based Sports. *Frontiers in Psychology, 10*. doi: 10.3389/fpsyg.2019.02076

Corbetta, D., & Thelen, E. (1996). The developmental origins of bimanual coordination: A dynamic perspective *Journal of Experimental Psychology: Human perception and Performance, 22*, 502-522.

Coutinho, D., Goncalves, B., Santos, S., Travassos, B., Wong, D. P., & Sampaio, J. (2019). Effects of the pitch configuration design on players' physical performance and movement behaviour during soccer small-sided games. *Research in Sports Medicine, 27*(3), 298-313. doi: 10.1080/15438627.2018.1544133

Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How Small-Sided and Conditioned Games Enhance Acquisition of Movement and Decision-Making Skills. *Exercise and Sport Sciences Reviews, 41 (3)*.

Delgado-Bonal, A., & Marshak, A. (2019). Approximate Entropy and Sample Entropy: A Comprehensive Tutorial. *Entropy, 21*(6). doi: 10.3390/e21060541

Dellal, A., Drust, B., & Lago-Penas, C. (2012). Variation of Activity Demands in Small-Sided Soccer Games. *Int J Sports Med, 33*, 370-375. doi: http://dx.doi.org/10.1055/s-0031-1295476

Duarte, R., Araujo, D., Correia, V., Davids, K., Marques, P., & Richardson, M. J. (2013). Competing together: Assessing the dynamics of team-team and player-team synchrony in professional association football. *Human Movement Science, 32*(4), 555-566. doi: 10.1016/j.humov.2013.01.011

Duarte, R., Araújo, D., Folgado, H., Esteves, P., Marques, P., & Davids, K. (2012). Capturing Complex, Non-Linear Team Behaviours During Competitive Football Performance. *J Syst Sci Complex* 1-11.

Duarte, R., Araújo, D., Freire, L., Folgado, H., Fernandes, O., & Davids, K. (2012). Intra- and inter-group coordination patterns reveal collective behaviors of football players near the scoring zone. *Human Movement Science 31*, 1639-1651.

Elias, A. G., & de Artigas, M. Z. (2006). The quasi-decadal modulation of running correlations involving the QBO. *Journal of Atmospheric and Solar-Terrestrial Physics, 68*(17), 1980-1986. doi: 10.1016/j.jastp.2006.08.003

Fernandes, O., Folgado, H., Duarte, R., & Malta, P. (2010). Validation of the tool for applied and contextual time-series observation. *International Journal of Sport Psychology, 41*, 63-64.

Folgado, H., Lemmink, K., Frencken, W. , & Sampaio, J. (2014). Length, width and centroid distance as measures of teams tactical performance in youth football. *European Journal of Sport Science*. doi: http://dx.doi.org/10.1080/17461391.2012.730060

Frencken, W., & Lemmink, K. (2008). Team kinematics of small-sided soccer games: a systematic approach.

Frencken, W., Lemmink, K., Dellemam, N., & Visscher, C. (2011). Oscillations of centroid position and surface area of soccer teams in small-sided games. *European Journal of Sport Science, 11 (4)*, 215-223.

Frencken, W., Lemmink, K., & Delleman, N. (2010). Soccer-specific accuracy and validity of the local position measurement (LPM) system. *Science and Medicine in Sport, 13*(6), 641-645. doi: https://doi.org/10.1016/j.jsams.2010.04.003

Frencken, W., Van der Plaats, J. , Visscher, C., & Lemmink, K. (2013). Size Matters: Pitch Dimensions Constrain Interactive Team Behaviour In Soccer. *Journal Of Systems Science and Complexity, 26*, 1-9.

Galgon, A., & Shewokis, P. (2016). Using Mean Absolute Relative Phase, Deviation Phase and Point-Estimation Relative Phase to Measure Postural Coordination in a Serial Reaching Task. *Journal of Sports Science and Medicine, 15*, 131-141.

Gonçalves, B., Marcelino, R., Ronda, L., Torrents, C., & Sampaio, . J. (2016). Effects of emphasising opposition and cooperation on collective movement behaviour during football small-sided games. *Journal of Sports Sciences 34 (14)*, 1346-1354. doi: 10.1080/02640414.2016.1143111

Gréhaigne, J., Bouthier, D., & David, B. (1997). Dynamic-system analysis of opponent relationships in collective actions in soccer. *Journal Sports Sciences 15*, 137-149.

Gréhaigne, J., & Godbour, P. (2013). Colective variables for analysing performance in team sports. *In T. McGarry, P. O' Donoghue, & J.Sampaio (Eds.). Routledge handbook of sports performance analysis,* , 101-114.

Hill-Haas, S., Dawson, B., Impellizzeri, F., & Coutts, A. (2011). Physiology of Small-Sided Games Training in Football: A Systematic Review. *Sports Med, 41 (3)*, 199-220. doi: 0112-1642/11/0003-0199/$49.95/0

Johnston, R. J., Watsford, M. L., Pine, M. J., Spurrs, R. W., Murphy, A. J., & Pruyn, E. C. (2012). THE VALIDITY AND RELIABILITY OF 5-HZ GLOBAL POSITIONING SYSTEM UNITS TO MEASURE TEAM SPORT MOVEMENT DEMANDS. *Journal of Strength and Conditioning Research, 26*(3), 758-765. doi: 10.1519/JSC.0b013e318225f161

Lamb, P. F., & Stockl, M. (2014). On the use of continuous relative phase: Review of current approaches and outline for a new standard. *Clinical Biomechanics, 29*(5), 484-493. doi: 10.1016/j.clinbiomech.2014.03.008

Law, M., Stewart, D., Pollock, N., Letts, L., Bosch, J., & Westmorland, M. (1998). *Critical review form-quantitative studies* (Vol. Hamilton:Mac-Master University).

Linke, D., Link, D., & Lames, M. (2018). Validation of electronic performance and tracking systems EPTS under field conditions. *Plos One, 13*(7). doi: 10.1371/journal.pone.0199519

Low, B., Vilas Boas, G., Meyer, L., Lizaso, E., Hoitz, F., Leite, N., & Gonçalves, B. (2018). Exploring the effects of deep-defending vs high-press on footballers' tactical behaviour, physical and physiological performance: A pilot study. *Motriz. The Journal of Physical Education. UNESP. Rio Claro,SP,Brazil, 24, n.2*. doi: 10.1590/S1980-6574201800020009

Memmert, D., Lemmink, Kapm, & Sampaio, J. (2017). Current Approaches to Tactical Performance Analyses in Soccer Using Position Data. *Sports Medicine, 47*(1), 1-10. doi: 10.1007/s40279-016-0562-5

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Grp, Prisma. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Journal of Clinical Epidemiology, 62*(10), 1006-1012. doi: 10.1016/j.jclinepi.2009.06.005

Montesinos, L., Castaldo, R., & Pecchia, L. (2018). On the use of approximate entropy and sample entropy with centre of pressure time-series. *Journal of Neuroengineering and Rehabilitation, 15*. doi: 10.1186/s12984-018-0465-9

Moura, Felipe Arruda, Barreto Martins, Luiz Eduardo, Anido, Ricardo O., Ruffino, Paulo Regis C., Barros, Ricardo M. L., & Cunha, Sergio Augusto. (2013). A spectral analysis of team dynamics and tactics in Brazilian football. *Journal of Sports Sciences, 31*(14), 1568-1577. doi: 10.1080/02640414.2013.789920

Olthof, S., Frencken, W., & Lemmink, K. (2015). The older, the wider: On-field tactical behavior of elite-standard youth soccer players in small-sided games. *Human Movement Science 41*, 92-102. doi: http://dx.doi.org/10.1016/j.humov.2015.02.004

Olthof, S., Frencken, W., & Lemmink, K. (2018). Match-derived relative pitch area changes the physical and team tactical performance of elite soccer players in small-sided soccer games. *Journal of Sports Sciences, 36*(14), 1557-1563. doi: 10.1080/02640414.2017.1403412

Olthof, S., Frencken, W., & Lemmink, K. (2019). A MATCH-DERIVED RELATIVE PITCH AREA FACILITATES THE TACTICAL REPRESENTATIVENESS OF SMALL-SIDED GAMES FOR THE OFFICIAL SOCCER MATCH. *Journal of Strength and Conditioning Research, 33*(2), 523-530. doi: 10.1519/jsc.0000000000002978

Ometto, L., Vasconcellos, F. V. A., Cunha, F. A., Teoldo, I., Souza, C. R. B., Dutra, M. B., . . . Davids, K. (2018). How manipulating task constraints in small-sided and conditioned games shapes emergence of individual and collective tactical behaviours in football: A systematic review. *International Journal of Sports Science & Coaching, 13*(6), 1200-1214. doi: 10.1177/1747954118769183

Owen, A., Wong, D.P., McKenna, M., & Dellal, A. (2011). Heart Rate Responses and Technical Comparison Between Small vs Large Sided Games in Elite Professional Soccer. *Journal of Strength and Conditioning Research, 25 (8)*, 2104-2110. doi: 10.1519/JSC.0b013e3181f0a8a3

Praça, G., Folgado, H., Andrade, A., & Greco, P. (2016). Influence of additional players on collective tactical behavior in small-sided soccer games. *Revista Brasileira de Cineantropometria e Desempenho Humano*.

Rampinini, E., Impellizzeri, M., & Castagna, C. (2007). Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences, 25 (6)*, 659-666.

Richman, J.S., & Moorman, J.R. (2000). Physiological time-series analysis using approximate entropy and sample entropy *American Journal of Physiology-Heart and Circulatory Physiology, 278 (6)*, 2039-2049.

Sampaio, J., Lago, C., Gonçalves, B., Macãs, V., & Leite, N. (2013). Effects of pacing, status and unbalance in time motion variables, heart rate and tactical behaviour when playing 5-a-side football small-sided games. *Journal of Science and Medicine in Sport*. doi: 10.1016/j.jsams.2013.04.005

Sampaio, J., & Maçãs, V. (2012). Measuring Tactical Behaviour in Football. *Int J Sports Med 33*, 395-401. doi: http://dx.doi.org/10.1055/s-0031-1301320

Sarmento, H., Clemente, F. M., Harper, L. D., da Costa, I. T., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer - a systematic review. *International Journal of Performance Analysis in Sport, 18*(5), 693-749. doi: 10.1080/24748668.2018.1517288

Serrano, J., Shahidian, S., & Fernandes, O. (2014). Validation of a Manual Position Tracking Software (TACTO) to Quantify the Football Movements. *International Journal of Sports Science, 4 (6A)*, 28-34. doi: 10.5923/s.sports.201401.04

Siegle, M., & Lames, M. (2013). Modeling soccer by means of relative phase. *Journal of Systems Science & Complexity, 26*(1), 14-20. doi: 10.1007/s11424-013-2283-2

Silva, P., Aguiar, P., Duarte, R., Davids, K., Araújo, D., & Garganta, J. (2014). Effects of Pitch Size and Skill Level on Tactical Behaviours of Association Football Players During Small-Sided and Conditioned Games. *International Journal of Sports Science & Coaching 9*.

Silva, P., Duarte, R., Esteves, P., Travassos, B., & Vilar, L. (2016). Application of entropy measures to analysis of performance in team sports. *International Journal of Performance Analysis in Sport, 16*(2), 753-768.

Silva, P., Duarte, R., Sampaio, J., Aguiar, P., Davids, K., Araújo, D., & Garganta, J. (2014). Field dimension and skill level constrain team tactical behaviours in small-sided and conditioned games in football. *Journal of Sports Sciences*. doi: 10.1080/02640414.2014.961950

Silva, P., Esteves, P., Correia, V., Davids, K., Araujo, D., & Garganta, J. (2015). Effects of manipulations of player numbers vs. field dimensions on inter-individual coordination during small-sided games in youth football. *International Journal of Performance Analysis in Sport, 15*(2), 641-659.

Silva, P., Travassos, B., Vilar, L., Aguiar, P. , Davids, K, Araújo, D., & Garganta, J. (2014). Numerical Relations and Skill Level Constrain Co-Adaptive Behaviors of Agents in Sports Teams. *PLoS One, 9 (9)*. doi: 10.1371/journal.pone.0107112

Silva, P., Vilar, L., Davids, K., Araújo, D., & Garganta, J. (2016). Sports teams as complex adaptive systems: manipulating player numbers shapes behaviours during football small-sides games. *SpringerPlus, 5:191*. doi: 10.1186/s40064-016-1813-5

Travassos, B., Davids, K., Araújo, D., & Esteves, P. (2013). Performance analysis in team sports: Advances from an Ecological Dynamics approach. *International Journal of Performance Analysis in Sport, 13*, 83-95.

Travassos, B., Gonçalves, B., Marcelino, R., Monteiro, R., & Sampaio, J. (2014). How perceiving additional targets modifies teams' tactical behavior during football small-sided games. *Human Movement Science 38*, 241–250.

Travassos, B., Vilar, L., Araujo, D., & McGarry, T. (2014). Tactical performance changes with equal vs unequal numbers of players in small-sided football games. *International Journal of Performance Analysis in Sport, 14*(2), 594-605.

Varley, M., Fairweather, I., & Aughey, R. (2012). Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *Sports Medicine, 30:2*, 121-127. doi: https://doi.org/10.1080/02640414.2011.627941

Vickery, W. M., Dascombe, B., Baker, J. D., Higham, D. G., Spratford, W. A., & Duffield, R. (2014). ACCURACY AND RELIABILITY OF GPS DEVICES FOR MEASUREMENT OF SPORTS-SPECIFIC MOVEMENT PATTERNS RELATED TO CRICKET, TENNIS, AND FIELD-BASED TEAM SPORTS. *Journal of Strength and Conditioning Research, 28*(6), 1697-1705. doi: 10.1519/jsc.0000000000000285

Vilar, L., Araújo, D., Davids, K., & Bar-Yam, Y. (2012). SCIENCE OF WINNING SOCCER: EMERGENT PATTERN-FORMING DYNAMICS IN ASSOCIATION FOOTBALL. *J Syst Sci Complex, 1 (13)*.

Vilar, L., Duarte, R., Silva, P. , Chow, J., & Davids, K. (2014). The influence of pitch dimensions on performance during small-sided and conditioned soccer games. *Journal of Sports Sciences*. doi: 10.1080/02640414.2014.918640

Vilar, L., Esteves, P., Travassos, B., Passos, P., Lago-Peñas, C., & Davids, K. (2014). Varying Numbers of Players in Small-Sided Soccer Games Modifies Action Opportunities During Training. *International Journal of Sports Science & Coaching, 9 (5)*.

Yentes, J., Hunt, N., Schmid, K., & Stergiou, N. (2012). The Appropriate Use of Approximate Entropy and Sample Entropy with Short Data Sets. *Annals of Biomedical Engineering, 41 (2)*. doi: 10.1007/s10439-012-0668-3

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Table

Table 1. Article characterization in the systematic review

Study	Tracking system	Measures	Methodologies	SSCG constraints	Number	Field	Area per player	Quality Score (%)
(Folgado et al., 2014)	Tacto 8.0. Software	Centroid Position Ipwratio	Mean SD Repeated measures	Player number	Gk+3v3+Gk Gk+4v4+Gk	30x20 m	75 m^2 60 m^2	86,7 %
(Silva, Vilar, 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%
(Silva et al., 2015)	GPS 10 hz	Effective relative space per player Radius of free movement Numerical relations inside each player's relative space per player Players spatial distribution variability	Mean SD Magnitude based inference Shannon Entropy	Player number Field	6v6 7v7 8v8 9v9	52,9x34,4m 49,5x32,2m 46,7x30,3m 57,3x37,1m	152 m^2 133 m^2 118 m^2	73,3%
(Olthof et al., 2015)	LPM 43 hz	Centroid Position Stretch index Ipwratio	Mean SD RC CV Pearson Correlation coefficients	Age	Gk+4v4+Gk	40x30 m	120 m^2	86,7%
(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%

(Frencken et al., 2011)	LPM 45 hz	Centroid Position Surface area	Pearson Correlation coefficients		Gk+4v4+Gk	36x28 m	100,8 m^2	53,3%
(Duarte, Araújo, Freire, et al., 2012)	Tacto.8.0. software	Centroid Position Surface area	Anova Turkey´s HSD test RC		Gk+3v3+Gk	49x20 m	122,5 m^2	60%
(Praça et al., 2016)	GPS 15 hz	Centroid Position Ipwratio	Kolmogorov-Smirnov test	Player number	Gk+3v3+Gk Gk+4v3+Gk Gk+3v3+2+Gk	36x 27 m	121,5 m^2 108 m^2 97,2 m^2	80%
(Gonçalves et al., 2016)	GPS 5 hz	Effective playing space Centroid position	Mean SD Magnitude based inferences ApEn	Player number	Gk+4v3+Gk Gk+4v5+Gk Gk+4v7+Gk	40x 30 m	133,3 m^2 109 m^2 92,3 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%
(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%
(Travassos, Vilar, et al., 2014)	Tacto.8.0. software	Centroid Position Surface area	Anova Mauchly's test Paired T-Tests Relative Phase	Player number	Gk+4v4+Gk Gk+4v3+Gk	40x20 m	80 m^2 88,,9 m^2	86,7%
(Vilar, Esteves, et al., 2014)	Tacto.8.0. software	Distance between an attacker and nearest defender	Anova	Player number	5v5 5v4 5v3	40x20 m	100 m^2 89 m^2 80 m^2	86,7%

		Relative distance of a defender needed to intercept the trajectory of a shot Relative distance of a defender needed to intercept the trajectory of a pass						
(Silva, Duarte, et al., 2014)	GPS 15 hz	Ipwratio Effective playing space Stretch index Team Separateness	Mean SD Anova CV SampEn	Field	Gk+4v4+Gk	36,8x23,8 m 47,3x30,6 m 57,8 x37,4 m	216,2 m^2 144,7 m^2 87,5 m^2	86,7%
(Vilar, Duarte, et al., 2014)	Tacto software	Relative distance to intercept a shot Distance between all attackers and immediate defenders Relative distance to intercept a pass	Mean SD Anova CV	Field	5v5	28x14 m 40x20 m 52x26 m	135 m^2 80 m^2 39,2 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	36,8x23,8 m 47, 3x30,6 m 57,8x37,4 m	216,2 m^2 144,7 m^2 87,5 m^2	86,7%
(Frencken et al., 2013)	LPM 100 hz	Surface area Centroid Position Longitudinal inter-team distance Lateral inter-team distance	Mean SD Pearson Correlation Manova RC	Field	Gk+4v4+Gk	24x20 m 30x20 m 30x 16 m 20x16 m	48 m^2 60 m^2 32 m^2	86,7%
(Castellano et al., 2016)	GPS 10 hz	Width Length Team Shape Ipwratio Team Separateness	Mean SD Magnitude based inferences	Goal	Gk+4v4+Gk 2(7G) SG+4v4+2 SG (SG) Gk+4v4+Gk (7GF)	40x25 m	100 m^2	73,3%
(Travassos,	GPS 15 hz	Centroid Position	Mean	Goal	Gk+5v5+Gk	30x25 m	75 m^2	86,7%

Gonçalves, et al., 2014)		Stretch index (STI) Stretch index between teams (RelSTI)	SD Pooled variance Magnitude effects		3SG+5v5+3 SG		62,5 m^2	
(Barnabé et al., 2016)	GPS 15 hz	Surface area Stretch index Width Length	Mean SD Sample Entropy Cross-sample entropy Anova	Age	Gk+6v6+Gk	60x33 m	165 m^2	73,3%
(Sampaio & Maçãs, 2012)	GPS 5 hz	Centroid Position	Relative phase ApEn Paired-Test		Gk+5v5+Gk	60x40 m	200 m^2	73,3%

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

Table 2. Description of tracking systems

Tracking systems	Study	Frequency	Reliability
GPS (SPI-Pro, GPSports, Canberra, ACT, Australia)	(Barnabé et al., 2016; Praça et al., 2016; Silva, Aguiar, et al., 2014; Silva, Duarte, et al., 2014; Silva, Travassos, et al., 2014; Silva, Vilar, et al., 2016; Travassos, Gonçalves, et al., 2014)	15	5% (total distance covered) 5 a 10 % (peak speed)
	(Aguiar et al., 2015; Gonçalves et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012)	5	
GPS (Minimax 4.0. Catapult Innovations)	(Castellano et al., 2016)	10	
GPS (Qstarz, Model:BT-Q1000Ex)	(Silva et al., 2015)		
Tacto 8.0 Software	(Duarte, Araújo, Freire, et al., 2012; Folgado et al., 2014; Travassos, Vilar, et al., 2014; Vilar, Duarte, et al., 2014; Vilar, Esteves, et al., 2014).	25	< 5%
Local position measurement (LPM) system (Inmotio Object Tracking)	(Frencken et al., 2013)	100	1,6% (total distance covered)
	(Frencken et al., 2011)	45	
	(Olthof et al., 2015)	43	5% (average speed)

Table 3. Methods used for analysis of tactical behaviour

Study	Methods
Tactical behaviour patterns	
(Aguiar et al., 2015; Gonçalves et al., 2016; Sampaio et al., 2013; Sampaio & Maçãs, 2012)	Approximate Entropy
(Barnabé et al., 2016; Silva, Aguiar, et al., 2014; Silva, Duarte, et al., 2014)	Sample Entropy
(Silva, Vilar, et al., 2016)	Intraclass Correlation (ICC)
(Silva, Aguiar, et al., 2014; Silva et al., 2015)	Shannon Entropy
Interpersonal patterns of coordination	
(Sampaio & Maçãs, 2012; Travassos, Vilar, et al., 2014)	Relative phase
(Duarte, Araújo, Freire, et al., 2012; Frencken et al., 2013; Olthof et al., 2015)	Running correlation

Figure 1. Article selection process flowchart

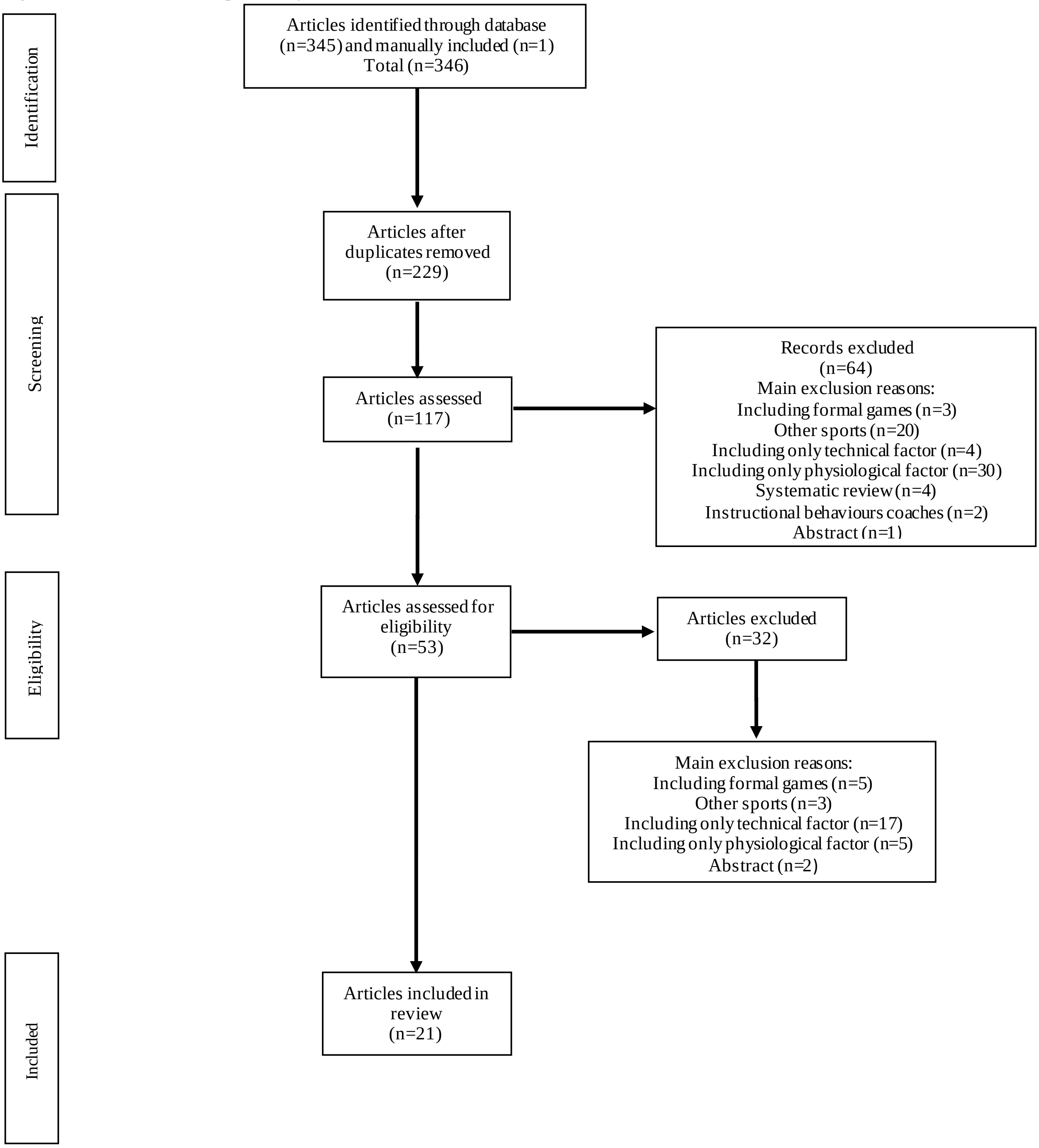

Figure 2. Study structure analysis