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Automatic Tools of Match Analysis: Inspecting Soccer Team's Dispersion

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Abstract

The contracting-expanding soccer teams' relationship is one of the most important dynamic behaviors of the game. Therefore, a soccer game was analyzed using the centroid and stretch index method, while recording the team's ball possession status (with or without ball possession). The correlation test suggest an inverse relationship between opposing teams ($r_{(1508)}$=- 0.054) during all game. When considering ball possession by the teams, the results of the stretch index confirm that there are statistical differences with a small effect between the moments with and without possession of the ball for team B ($F_{(1;\ 1506)}$=22.777; *p-value*$\leq$0.001; η^2=0.015; *Power*=0.998). Therefore, it was possible to confirm that the contracting -expanding relationship is an intrinsic behaviour of a soccer game in relation to ball possession.

Key words: Performance, Match analysis, Tactics, Team sports, Soccer

Introduction

Sport performance consists of a complex series of interrelationships between a wide varietyof performance variables (Borrie et al., 2002). Therefore, structures and configurations of play should be considered as a whole rather than analyzed individually (Passos, 2008). Systems with dynamic interacting elements can produce rich and varied patterns of behavior that are clearly different from the behaviour of individual players (Clemente et al., 2012a). In this line of thought, McGarry et al. (2002) considered that the rich and varied patterns that arise in team sports are the result of self-organization among many coupled oscillators (*e.g.*, players).

Some team sportsuse specific methods and metrics to analyze and evaluate dynamic collective behaviour. However, according to Neville, Atkinson and Hughes (2008), the results from various analytical techniques have been disappointing, despite the large quantity of research methods and techniques to model performance in sport, Simple frequency data cannot always capture the full complexity of the game performance (Borrie et al., 2002). Therefore, it is necessary to gather quantitative and qualitative information for further identification and interpretation of substantial game behaviour (Garganta, 2009). Consequently, it is necessary to develop novel concepts and tools, from the systems approach and computer science, to handle such complexity (Balagué & Torrents, 2005). One of the most recent methods is the stretch index which provides information about a team's dispersion. Compared to other analytical methods, (*e.g.,* surface area, effective area of play), the dispersion index is substantially different and only provides, information about the team

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players' dispersion in relation to their centroid (cf. Bourbousson et al., 2010). Thus, the stretch index (*SI*) equation depends directly on the centroid (x_c) and not all of the player positions (x_i):

$$SI = \frac{1}{n} \times \sum_{i=1}^{n} |x_i - x_c|, \qquad (1)$$

The stretch index measures the expansion and contraction of the space occupied by players in the longitudinal and lateral axis (Bourbousson et al., 2010) and can also provide a radial measure (Bartlett et al., 2012). The pioneering study of the stretch index metric (*cf.* Bourbousson et al., 2010) was developed from a systemic analysis of two professional basketball teams competing in the French championship in a 5-a-side game. The study sample was based on six play sequences with intermittence of ball possession from observing a single game. Through the relative stretch index calculation, *i.e.*, difference between the stretch index of both teams, it was possible to analyze the intermittent alterations between the positive and negative values in the longitudinal and lateral axes.

Bourbousson et al. (2010) observed intermittent switching evidenced by the bi-stability in both directions, which resulted in the expansion and contraction quantities between two teams. This bi-stability distribution in both directions can be explained by referencing the man-to-man markings used by both teams (Bourbousson et al., 2010). However, this argument is moot within the soccer community where the game space is larger and the movements are also different. Thus, considering the fundamental principles of defensive concentration and offensive width and length (Costa et al., 2009), an inverse relationship between the teams'stretch index is expected. This relationship has been shown to correspond to fundamental soccer tactical principles.

Bartlett et al. (2012) used the stretch index metric (excluding the goalkeepers), to analyze 5 professional soccer matches, which resulted in 305 offensive sequences of play. The sample composed of 4 groups of open attacking plays: *i)* those leading to goals, *ii)* those leading to a shot or header-shot that did not score a goal; *iii)* those that resulted in an active loss of possession; and *iv)* other attacks in which possession was lost passively. The results of this study indicate that the average correlation coefficients for the dispersion measures was positive, i.e., the contraction -expanding relationship between teams was simultaneous and not inverse (Bartlett et al., 2012). These results contrast with those observed by Moura et al. (2012), as well as the fundamental tactical principles of play, in particular, the defensive concentration and the offensive width and length. Nevertheless, in their study, Bartlett et al. (2012) provide examples in which the longitudinal teams' stretching rates are inversely related and, therefore, should be considered for further investigation that may provide an understanding of the relationship between the teams' dispersions.

Statement of Contribution

In summary, the stretch index is a valid metric for the identification of the teams' dispersion values throughout a match (Bartlett et al., 2012). However, it should be noted that the studies analyzed (Bourb ousson et al., 2010; Bartlett et al., 2012) only applied the metrics post match, *i.e.*, not testing their potential in real time in order to enhance the intervention team. Thus, similarl to the centroid, the stretch index is analyzed in a prominently systemic viewpoint, without considering the capability of increasing the quality of the match analysis and, as a result, the coaches' intervention. Furthermore, the centroid position used in the stretch index equation does not take into consideration the weight of the players' position in relation to the ball. Thus, one of the purposes of this work is to consider the weight of the players in the centroid position in relation to the ball.

In addition, it is important to analyze the inverse relationship of the stretch index values, to observe the inverse contraction-expanding relationship, which

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correspond to the fundamental tactical principles of play. This relationship is a key component of the principles of play in soccer. Thus, the aim of this study is to analyze the stretch index relationship between opposing teams, to try and find an inverse relation, i.e., a contracting-expanding relationship. Furthermore, the team's stretch index, with regard to ball possession status (*i.e.*, with or without ball possession), will be analyzed, and the expectation is a contraction when out of possession and expansion when gaining possession of the ball.

Methods

This study was conducted within the guidelines of the American Psychological Association and the protocol received approval from a local university ethics committee. All players' parents signed the Free and Clarified Consent Form respecting the Helsinki Declaration. All participants of this study did not have any kind of physical or psychological diseases.

Data Collection

Data were recorded from an official football match of an under-13 district final in the Portuguese league. The format of the match was a 7-a-side game, which is in accordance with rules of the Federação Portuguesa de Futebol.[1)] Teams' actions were captured using a digital camera (GoPro Hero with 1280×960 resolution), with the capacity to process images at 30 Hz (i.e., 30 frames per second). The camera was placed above the ground in order to capture the whole game. After capturing the football match through the camera, the physical space was calibrated using direct linear transformation (i.e., DLT), which transforms elements' position (i.e., players and ball) to the metric space (Duarte et al., 2010). After calibration, the tracking of players was accomplished, which resulted in the Cartesian positioning of players and the ball over time. At the same time, the ball possession status of both teams at every instant was recorded. The entire process inherent to this approach, such as the detection and identification of players' trajectories, the space transformation and the computation of metrics, was handled using the high-level calculation tool MatLab.

Data Analysis

Position data were used to calculate two variables: longitudinal and lateral team' player's position. These measures were able to calculated the centroid position while considering the ball position and players' position, as well as the stretch index of the players in function to the centroid position

Team's Centroid Position

For the soccer game, the centroid can be calculated through the geometric mean position $(\bar{x},\bar{y})$ of all players (x_n, y_n) for each team. According to Frencken et al. (2011), the team's centroid of both teams can provide three measures: i) the *x*-distance (*m*) represented forward-backward displacement (i.e., length of the field); ii) *y*-distance (*m*) represented lateral displacement (i.e., width of the field); and iii) radial distance (*m*), comprising both forward-backward and lateral displacement. Nevertheless, the centroid position and the weight of each player needs to be attributed to the function and proximity of the ball, which has not been considered in previous studies (e.g., Frencken et al., 2011; Bartlett et al., 2012)

The measures are obtained based on the centroid position relative to the origin *O*, i.e., (0,0), defined at the centre of the field (Fig 1).

$$\begin{bmatrix}\bar{x}\\ \bar{y}\end{bmatrix} = \frac{1}{\sum_{i=1}^{N} w_i}\begin{bmatrix}\sum_{i=1}^{11} w_i x_i\\ \sum_{i=1}^{11} w_i y_i\end{bmatrix} \quad (2)$$

1)http://www.fpf.pt/portal/page/portal/PORTAL_FUTEBOL/DOCS/REGULAMENTOS/leis_fut_7.pdf.

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The position of the i^{th} player is defined as (x_i, y_i). The relevance of each player to the team's centroid, i.e., w_i weight, is based on the Euclidean distance from each player to the ball as:

$$w_i = 1 - \frac{\sqrt{(x_i - x_b)^2 + (y_i - y_b)^2}}{d_{max}}, \qquad (3)$$

where (x_b, y_b) corresponds to the position of the ball and d_{max} is the Euclidean distance of the farthest player to the ball at each iteration (*cf.* Fig 1).

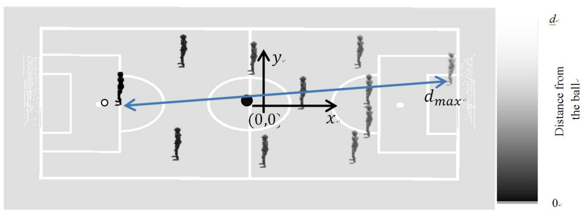

Fig 1. *Spatial Referential of the Field.*

Nevertheless, the team's centroid does not provide an understanding of the strategic distribution of players aroundthe field. Therefore, it is important to propose a tactical metric that provides an accurate representation of a teams' dispersion.

Team's Stretch Index Metric

The stretch index measures the space expansion or contraction of the team on the longitudinal and lateral directions (Bourbousson et al., 2010). Similarly to the team's centroid, a weighted team's stretch index metric may then be calculated as:

$$S_{ind} = \frac{\sum_{i=1}^{N} w_i d_i}{\sum_{i=1}^{N} w_i}, \qquad (4)$$

where d_i is the Euclidean distance between player and the team's centroid, i.e.,

$$d_i = \sqrt{(x_i - \bar{x})^2 + (y_i - \bar{y})^2}, \qquad (5)$$

Within this context, the stretch index can be obtained by computing the mean of the distances between each player and the centroid of the team. Thus, this metric represents the mean deviation of each player on a team from its centroid.

Statistical Procedures

A one-way ANOVA was used to analyze the statistical significant differences between teams with and without ball possession. The assumption of normality of distribution for a one-way ANOVA in the two conditions (i.e., with or without ball possession), was assessed using the Kolmogorov-Smirnov test by Lilliefors. Although the distributions are not normal in the dependent variable, since $n>30$ and using the Central Limit Theorem (Maroco and Bispo, 2003), we assumed the assumption of normality (Akritas & Papadatos, 2004). The analysis of homogeneity was carried out using the Levene' stest. It was found that there is no uniformity of practice under the previously mentioned conditions. However, despite the lack of homogeneity, the F test (ANOVA) is robustto homogeneity violations when the number of observations in each group is equal or approximately equal (Vicent, 1999), which is the case for this study.. As with the assumption of normality, violation of this assumption does not radically change the F value (Vicent, 1999). The classification of the effect size (i.e., measure of the proportion of the total variation in the dependent variable explained by the independent variable) was done according to Pallant (2011). To compute the correlations between tactical metrics and teams the r-pearson test was used. These analyses were per formed using the IBM SPSS program (version 19) with a significance level of 5%.

Results

The dispersion of players according to the centroid can be understood as the collective behaviour of the

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team. Globally, the stretch index gives an average of 8.611 *m* for Team B and 8.229 *m* for Team A. Indeed, Team B presents a higher dispersion, thus resulting in a collective strategy that explores the forward players without a higher level of collective involvement during the offensive process.

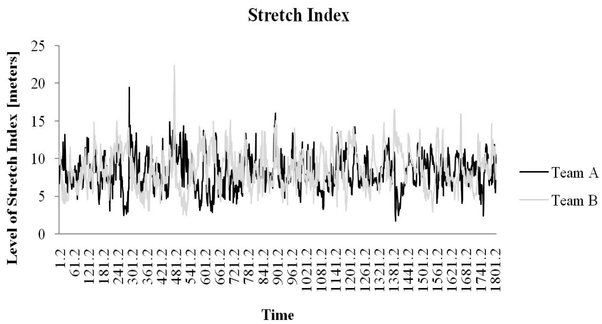

Fig 2. Stretch index over time.

The correlation test suggest an inverse relationship between opposite teams with statistical significance (p = 0.035). In fact it appears that there is an inverse relationship between opposite stretch index (since the linear correlation coefficient $r_{(1508)}$ = - 0.054). The inverse relationship can also be verified, i.e., the forward players do not closely participate in the defensive phase of the game.

Table 1. Mean results of the stretch index by each team

Team	Ball Possession [BP]	Stretch Index [m]
Team A	With BP	8.19 ± 2.27
	Without BP	8.29 ± 2.22
Team B	With BP	9.01 ± 2.42
	Without BP	8.36 ± 2.68
General	With BP	8.60 ± 2.35
	Without BP	8.32 ± 2.45

As a result, the stretch index metric provides an indication of whether a team is expanding or contracting at any instant (Bourbousson et al., 2010). Nevertheless, it is important to analyze the stretch index of each team with regard to ball possession status, i.e., intra-team analysis (*cf.* Fig 3).

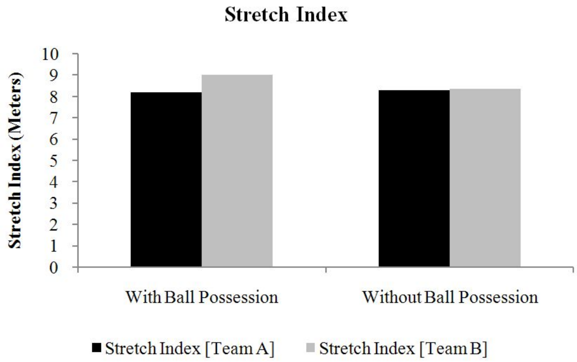

Fig 3. Mean of the stretch index of both teams.

With regard to the stretch index results and considering the status of ball possession, it is possible to confirm statistical differences with a small effect between the moments with and without ball possession in team B ($F_{(1;1506)}$=22.777; *p-value* $\leq$ 0.001; η^2 = 0.015; *Power*=0.998). In the case of team A, the results are not statistically different ($F_{(1;1506)}$=0.595; *p-value*= 0.441; η^2 =0.001; *Power*=0.120).

Discussion

The expanding-contracting relationship is one of the main theoretical behaviours of soccer teams. Nevertheless, recent studies (e.g., Bartlett et al., 2012) using dispersion analysis methods have not confirmed this assumption. In contrast, the outcomes provided by Bartlett et al. (2012) did not, in general, give consistent negative correlations for any given attack analyzed. Nevertheless, the contracting behaviour in the defensive phase and the offensive expanding behaviour are two main tactical fundamentals of play. Thus the first goal of this work was to analyze the relationship between teams' stretch indexes.

Through the weighted centroid it was possible to include the goalkeeper position, which has typically been excluded in previous studies that used the centroid method (e.g., Frencken et al., 2011; Lames et al., 2010; Bartlett et al., 2012). The centroid metric

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calculation without weight (e.g., Frencken et al., 2011; Lames et al., 2010; Bartlett et al., 2012) considers that player farthest is equally crucial than the closest player to the ball, compromising a clear understanding of the influence of the player closer to the ball, i.e., their influence in the game center (Costa et al., 2009). The centroid calculation takes into consideration the positioning of the ball, which increases the efficacy of the formula, incorporating all players in the game as well as their importance in function of the ball positioning.,This demonstrates that if the ball is closer to the goalkeeper their influence will be substantially higher than other forward players.

The relationship between opposite teams that was analyzed in this work showed inverse and small correlation values. Nevertheless, this outcome suggests a tendency to a contracting-expanding relationship (Moura et al., 2012). Fundamental tactical principles in a soccer game are strongly related with the ball possession status, i.e., defending without ball posse ssion and attacking with. This status constrains the collective behaviour and allows new coordination's ways. The collective behaviour of teams in reaction to the state of ball possession may be substantially different during the match depending on the ball possession (Hughes & Franks, 2005). Therefore, the tactical behaviour will be necessarily different depending on which team has ball possession.

In offensive phase the level of the stretch index it should be higher when compared to the defensive phase, according to the principles of width and length (expanding in offensive phase) and concentration (contracting in defensive phase) (*cf.* Costa et al., 2010). According to the present study, the principles of attacking and defending those principles are more evident in team B. When not in possession of the ball, the stretch index is statistically lower in comparison to the offensive phase. In the defensive phase (i.e., without ball possession) players arrange their positions around the centroid and try to reduce the likelihood of the opposing team from entering the scoring zone. Respectively, in the offensive phase (i.e., with ball possession) the team explores the width and length of the field and tries to unbalance the focus and unit of the opposing team. In the case of team A, there were similar results for the stretch index between having possession and not having possession of the ball, which might be related to the team's strategy. For example, in the defensive phase, the team can choose to maintain one or two players in the offensive zone, thus reducing the effective number of players participating in the defensive phase. This kind of strategic option is applied when the team has its better players in the defensive phase, which makes it possible to keep the opponent's defensive players in their defensive zone. This strategy ensures that none of the attackers from the opposing team retreat to the defensive zone.

The outcomes from this study indicate that a team's stretch index can provide information about the dispersion of the team in relation to the centroid (Bartlett et al., 2012). This information is important to the team coach/manager so they can improve their players' knowledge and understanding of the relation between players and the centrality of the game. Increasing the players' knowledge allows the team to organize the game as a function of such dispersion (Clemente et al., 2012b). Moreover, a coach may organize the team in order to reduce or increase the distance between players to the centroid based on a specific tactical definition. For instance, it may be a team strategy to allow a player more distance from the centroid to entice an opponent away from the central play. However, the stretch index may give erroneous information to the coach, i.e., although teams have a great dispersion, the rational occupation of the team may be dysfunctional and inefficient. Therefore, it is important to complement this tactical metric with relevant information of the rational occupation of players and the effective area of the team. further research should be conducted to improve anunder-standing about rational placement of the players on the

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field. It may be important to contemplate the effective area of a team (Clemente et al., 2012b), i.e., the real area that a team covers without intercepting the effective area of the opposing team. In fact, players need to be aware that the effective area needs to considered as pace that a team can efficiently cover. Therefore, soccer tactics can be geometrically analysed to provide greater understanding of how a team behaves.

According to Lucchesi (2001 the geometric figure that allow the most successful play on the field is a triangle. The author suggests that the ability of a team to "draw up" such triangles on the field will provide the team an effective offensive play. With regard to defensive organization, triangles pointing toward the ball, known as defensive triangles, are typically formed in an attempt to create a “defensive shadow”, i.e., the space through which the opponent cannot pass or dibble owing to the triangular-shaped positioning of players (Dooley & Titz, 2011). Thus, further investigation should consider the number of effective triangles formed by each team at any instant as that proposed by Clemente et al. (2012b). It is through this update that more robust results about expansion -contraction relationship can be detected, as well as novel ways to measure the team’s tactical performance.

Conclusion

The aim of this study was to analyze the contracting-expanding tactical relationship within a soccer team. Using the stretch index method, it was possible to identify the dispersion of the soccer players in relation to their team’s centroid. The main results suggested an inverse relationship between teams’ stretch index with regard to their ball possession status. It was also determined that when a team is in possession of the ball, the dispersion increases and when a team is out of possession of the ball the dispersion decreases. As a result, the tactical principles related to a team contracting in the defensive phase and expanding in the offensive phase was confirmed. However, it is possible that the stretch index is not enough to analyze a team’s overall collective performance. It is suggested that future studies analyze the collective tactical performance of soccer games through new match analysis methods, e.g., the effective area of play.

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