QUANTITATIVE ANALYSIS OF FUTSAL PLAYERS' ORGANIZATION ON THE COURT

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The purpose of this study was to quantify and analyze professional Futsal teams' organization on the court in shots to goal and tackles situations. Two-dimensional coordinates of 22 players' positions were obtained during a match between Brazil and Paraguay using a computational tracking system. Team organization in 58 specific situations of shots to goal and 120 tackles were analysed. The variables quantified were teams' coverage area and distance between teams' centroids. Results showed that defending team coverage area was greater ($p < 0.01$) when tackles were performed (47.7 ± 37.8 m^2) than when the team suffered shots to goal (30.7 ± 28.0 m^2). The average distance between centroids was greater ($p < 0.01$) in shots to goal (5.2 ± 2.7 m) than in tackles situations. These results can provide valuable insights for coaches.

KEY WORDS: Computational tracking, tactics, team coverage area and centroid.

INTRODUCTION: A considerable amount of researches have been devoted to establishing the need for objective forms of analysis and their importance in the coaching process (Hughes, 1996). Using automatic tracking systems, researchers have evaluated players' physical efforts during soccer and futsal matches, such as distance covered and high-intensity running (Barbero-Alvarez, Soto, Barbero-Alvarez & Granda-Vera, 2008; Barros et al., 2007; Bradley et al., 2009; Castagna, D'Ottavio, Granda Vera & Barbero Alvarez, 2009). However, there is a lack of studies about the tactical features of futsal teams, as it relates to players' organization on the court.

Futsal is an invasion game, to score a goal it is fundamental to advance on the pitch. Therefore, players should organize their positions collectively to increase shots to goal opportunities when attacking and to increase tackles chances when defending. Frencken and Lemmink (2009) evaluated players' organization in nine attacks of two four-a-side games, considering teams' surface areas and the distance between the centre of the teams (calculated as the mean coordinate (x, y) of all players of the same team). The authors affirmed that the variables analyzed changes as a result of a perturbation, such as loss of possession or a goal. Therefore, an analysis of teams' organization during tackle and shots to goal situations can provide valuable tactical information that can be used during specific training sessions.

However, no studies were found with this kind of analysis during professional futsal matches. Small sided games, as analyzed by Frencken and Lemmink (2009), are similar to futsal game but may not represent the real situation of a high level competitive match. Thus, the purpose of this study was to analyze professional futsal players' organization on the court, by quantifying teams' coverage areas and the distance between teams' centroids in shots to goal and tackles situations. Specifically, we were interested in evaluate if defending team has a different organization when performs a tackle than when suffers a shot to goal. Additionally, we analyzed if attacking team also has a different organization on the court when performs a shot to goal than when suffers a tackle.

METHODS: Images from an International Futsal Challenge match between Brazilian and Paraguayan teams in 2010 were recorded. The entire match had 22 different players' participating. Four high definition cameras (JVC GZ-HD6), with a 30 Hz sample frequency, registered the images. These cameras were positioned in high places of the gymnasium and

stayed fixed during the whole match. Each camera covered a half of the court, in a way that they could cover the court area completely. The television broadcast who detained players' images rights authorized the recordings.

The images were then transferred to a computer and were synchronized using an audio band method (Barros, Russomanno, Brenzikofer & Figueroa, 2006). The 2D players positions as function of time were obtained using DVideo® software, by its specific interface developed to track football players (Figueroa, Leite & Barros, 2006a; Figueroa, Leite & Barros, 2006b). Cameras calibration and 2D images reconstruction were performed through the Direct Linear Transformation (DLT), proposed by Abdel-Aziz and Karara (1971), which is already implemented on DVideo®. To calibrate the cameras, each one of them had information about points inside the court (side lines, halfway line, substitution zones indication, penalty spot, etc.) with known distances. This software permitted an automatic tracking rate of approximately 56% of the processed frames. Players' coordinates were then filtered by a Butterworth 3rd order low-pass digital filter with a cut-off frequency of 0.4 Hz, available on Matlab®.

Teams' organization in the exact frame of 58 specific situations of shots to goal and 120 tackles were analyzed. The variables quantified were a) team coverage area of the defending team (i.e., team which performed the tackle or suffered the shot to goal) and attacking team (i.e., team which performed the shot to goal or suffered the tackle) and b) distance between teams' centroids. Team coverage area was defined by the area of the convex hull formed by the teammates' positions. The convex hull of a set of points S on a plane (in our case, represented by each player's position on the same team excluding goalkeeper, in each instant of time t) is the smallest convex set containing S; if S is finite, the convex hull is always a polygon whose vertices are a subset of S (Preparata & Shamos, 1985). Thus, team centroid coordinates was calculated as the centroid of the geometric form of the team convex hull and then Euclidian distance between teams' centroids was determined. Figure 1 illustrates the variables analyzed.
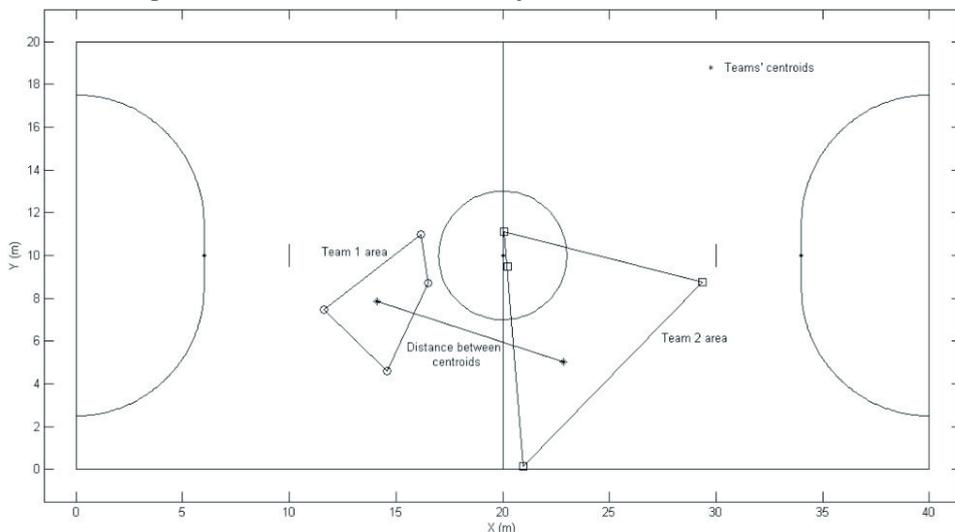
Figure 1: Teams coverage area and distance between teams' centroids.

Specifically, we were interested in the comparison between defending team area when tackles were performed and when the team suffered shots to the goal. Similarly, attacking team coverage area was compared when team performed shots to the goal and when the team suffered a tackle. Furthermore, in both situations (shots to the goal and tackles) the distance between teams' centroids was compared. Therefore, a Wilcoxon rank-sum test was

performed to each comparison, once all distributions were not normal. We adopted $\alpha = 0.05$ for all statistical analyses.

RESULTS: Teams coverage areas (mean ± standard deviation) in situations of tackles and shots to the goal are shown in Table 1. Wilcoxon rank-sum test showed that defending team presents a lower coverage area (p<0.01) when suffered a shot to goal. No statistical differences were found for attacking team area in these situations (p ≈ 0.18). However, distance between teams' centroids was smaller (p < 0.01) when tackles were performed.

Table 1
Teams coverage area (mean ± standard deviation) and distance between centroids in specific match situations.

Situation	Coverage Area (m^2)		Distance between centroids (m)
	Defending team	Attacking team	
Tackle (n=58)	47.7 ± 37.8 *	87.3 ± 68.4	3.5 ± 2.0*
Shot to goal (n=120)	30.7 ± 28.0	88.5 ± 42.5	5.2 ± 2.7

* p < 0.01

DISCUSSION: The results of this study suggest that defending and attacking futsal teams have different organization on the court, verified by team areas. This kind of behaviour was already reported for football matches (Okihara et al., 2004; Yue, Broich, Seifriz & Mester, 2008) but was not for futsal matches. Nevertheless, our purpose with this study was to answer the following questions: a) Do futsal teams have a different organization on the court, as a defensive strategy, that may determine their success in performing a tackle and do not suffer a shot to the goal? b) Do futsal teams have a different organization on the court, as an attacking strategy, that determines their success in performing a shot to the goal and do not suffer a tackle?

Results showed that there are no differences between attacking team area when a shot to the goal was performed and when a tackle was suffered. However, the distance between teams' centroids is an important variable to be analysed in this situation. According to Frencken and Lemmink (2009) this variable represents 'pressure'. Thus, the shorter the distance between the two centroids, the higher is the pressure. As a result, the likelihood of player mistakes increases. Based on this, it could be seen that when a shot to the goal was performed, the distance between the centroids was greater, i.e., the defensive team failed in pressuring the opponent or did not perform pressure enough.

Besides, defending team coverage area was smaller when it suffered a shot to the goal than when a tackle was performed, suggesting that, in futsal matches, a very compact defensive strategy (i.e. with a small coverage area) can be inefficient. However, futures studies with greater samples are necessary to verify if this behaviour is not a particular case of the match analyzed in the present study.

Teams coverage area and distance between centroids were also analyzed in a previous study (Frencken & Lemmink, 2009). However, a comparison with our results is impracticable due to methodological differences: the authors analyzed a four-a-side game (which can not represent a high level futsal match) and did not provide the court or field dimensions.

Data presented are promising, once it provided important information about team organization on the court in specific situations of shots to goal and tackles. This kind of analysis can be also extended to football matches, although the greater implementation complexity (e.g. field has a greater dimension and there are more players).

CONCLUSION: This study provided information about futsal players' organization on the court during specific situations of the match. The results allowed concluding that defending team has a greater coverage area when performed a tackle compared to its area when suffered a shot to the goal. Besides, the distance between teams' centroids is greater when a

shot to the goal happens. These data are valuable information for coaches and can be used to identify possible mistakes during the match and to enhance tactical performance during training and, consequently, during competition.

REFERENCES:

Abdel-Aziz, Y. I., & Karara, H. M. (1971). *Direct linear transformation from comparator coordinates into object space coordinates in close-range photogrammetry.* Paper presented at the Proceedings of the Symposium on Close-Range Photogrammetry Illinois.

Barbero-Alvarez, J. C., Soto, V. M., Barbero-Alvarez, V., & Granda-Vera, J. (2008). Match analysis and heart rate of futsal players during competition. *J Sports Sci, 26*(1), 63-73.

Barros, R. M., Misuta, M. S., Menezes, R. P., Figueroa, P. J., Moura, F. A., Cunha, S. A., et al. (2007). Analysis of the distances covered by first division Brazilian soccer players obtained with an automatic tracking method. *Journal of Sports Science and Medicine, 6*, 10.

Barros, R. M. L., Russomanno, T. G., Brenzikofer, R., & Figueroa, P. J. (2006). A method to synchronise video cameras using the audio band. *J Biomech, 39*(4), 776-780.

Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *J Sports Sci, 27*(2), 159-168.

Castagna, C., D'Ottavio, S., Granda Vera, J., & Barbero Alvarez, J. C. (2009). Match demands of professional Futsal: a case study. *J Sci Med Sport, 12*(4), 490-494.

Figueroa, P. J., Leite, N. J., & Barros, R. M. L. (2006a). Background recovering in outdoor image sequences: An example of soccer players segmentation. *Image and Vision Computing, 24*(4), 363-374.

Figueroa, P. J., Leite, N. J., & Barros, R. M. L. (2006b). Tracking soccer players aiming their kinematical motion analysis. *Computer Vision and Image Understanding, 101*(2), 122-135.

Frencken, W. G. P., & Lemmink, K. A. P. M. (2009). Team kinematics of small-sided soccer games. In T. Reilly & F. Korkusuz (Eds.), *Sience and Football VI*. New York: Routledge.

Hughes, M. (1996). Notational analysis. In T. Reilly (Ed.), *Science and Soccer* (pp. 343 - 361). Great Britain: E & FN Spon.

Okihara, K., Kan, A., Shiokawa, M., Choi, C. S., Deguchi, T., Matsumoto, M., et al. (2004). Compactness as a strategy in a soccer match in relation to a change in offence and defense. *Journal of Sports Sciences, 22*(6), 515. Communications to the Fifth World Congress on Science and Football.

Preparata, F. P., & Shamos, M. I. (1985). *Computational geometry : an introduction*. New York: Springer-Verlag.

Yue, Z., Broich, H., Seifriz, F., & Mester, J. (2008). Mathematical Analysis of a Soccer Game. Part I: Individual and Collective Behaviors. *Studies in Applied Mathematics, 121*(3), 223-243.