Sports Science

Combined effects of home advantage and match result on interactions performed by Brazilian handball players

Lucas N. Trindade[1], Marek Popowczak[2], Matheus de O. Jaime[1], Priscila G. Marques[1], Juliano F. da Silva[3], Lucas S.C. Ueda[3], Dourivaldo Teixeira[1], Paulo H. Borges[3]

[1]*Universidade Estadual de Maringá, Departamento de Educação Física, Maringá, PR, Brazil;* [2]*Wroclaw University of Health and Sport Sciences, Wroclaw, Poland;* [3]*Universidade Federal de Santa Catarina, Departamento de Educação Física, Florianópolis, SC, Brazil.*

Associate Editor: Eduardo Lusa Cadore, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil. E-mail: edcadore@yahoo.com.br.

Abstract - Aim: This study verified the combined effects of game result and match location on centrality measures based on the interactions of Brazilian handball players. **Methods:** The sample consisted of 3435 interactions performed by 15 players during 7 official Brazilian Regional Championship matches. Social network analysis was applied to investigate the following network properties: degree of centrality, closeness centrality, degree of prestige, proximity prestige, and network density. **Results:** Results revealed that playing at home increases closeness centrality ($\eta^2 = 0.99$; $p = 0.01$), and network density ($\eta^2 = 1.00$; $p = 0.01$). When the handball team lost the game, an increment in the network density in relation to the draw and win scenario was observed ($\eta^2 = 1.00$; $p = 0.01$). It was observed that closeness centrality and network density increased when the team had lost and played at home, while when the team was playing away from home and losing, closeness centrality decreased ($\eta^2 = 0.99$; $p = 0.01$). **Conclusions:** In conclusion, contextual variables impact the way that handball players interact during a match.

Keywords: handball, network, performance.

Introduction

Handball is a team sport game characterized by the great changeability of events on the court[1]. Additionally, several researchers and coaches from different handball schools have shared information about different training methods, which allow the development of the sport, improve the process of prospecting and training sporting talents and the development of more evolved game models[2,3].

In addition to substantial evolutions evidenced in the game and training processes, studies carried out in the field of handball have sought to support coaches and physical trainers, considering information from different morphofunctional[4], motor[5,6], psychological[7,8] and tactical indicators[2]. Nevertheless, most investigations are based on one-dimensional tests, neglecting the multidimensional characteristic of the game[9].

Comprehending team dynamics requires adopting a multidimensional view since handball is characterized by the interrelationships among physical, technical, tactical, and psychological dimensions, which are presented by the interaction among players[10,11]. In this sense, team sports can be understood as complex dynamic systems[12], and the actions of players have a certain degree of independence at the level of infrastructure (direct 1 × 1) and microsystems (partial confrontations between players of both teams) but are aimed at building a collective sense and respond to a common goal of the team subsystem[10,13].

In handball, the main interactions between players are manifested from the movement of the ball and the exchange of passes[14]. In this sense, a methodological alternative recently pointed out in literature for the evaluation of interactions is the social network analysis (SNA), a method derived from graph theory that considers each graph agent (player) as a vertex, while edges connect vertices from a previously established interaction criterion, usually a pass between two players[15,16]. Using SNA, interactions during a match provide information related to the player's measures of centrality or prominence in the network (microanalysis), the degree of interrelationship between small groups of players (mesoanalysis), and they also reveal global properties of this network (macroanalysis)[17].

In handball, Korte and Lames[14] investigated the network properties from different offensive formations and reported that center backcourt is the players who structure the main interactions within the match and that pivots are more prominent when the opposing team is with an excluded player (6 vs. 5 formations).

With the increase in studies developed seeking to investigate behaviors in team sports from network proper-

ties, it is evident that factors influence and are influenced by interactions between players. From the analysis of interactions and their relationship with the result, the work of Grund[18] stands out, who attributed the improvement in goals scored in football to the increase in the total number of passes. Studies that verify the influence of game moments, tactical behaviors, and player positioning based on interactions carried out throughout the game are also highlighted[19-21].

Castellano et al.[22] expand the perspectives by analyzing those interactions that are also susceptible to changes according to the distances covered, which makes us think about the physiological demands, also inherent to the sport. From the analysis of social networks, it could be observed that the placement of players in regions of the network that collaborate with the movement of the ball is less exposed to fatigue situations[17].

Despite this information, studies involving handball players have not yet systematically considered whether environmental constraints related to the place of the match and the result of the game impact the interaction patterns of handball players. It is supposed that playing away from home can impact interactions as the trip to the match location directly affects the rest and recovery of players[23], in addition to motivational factors arising from the presence of fans supporting the opponent team. Moreover, the game score can also affect network properties, as players need to make more or less proactive decisions depending on the tactical-strategic goals for that game.

However, to the best of our knowledge, in handball, this information is unknown. Therefore, this study aimed to verify the combined effects of game result and match location on centrality measures based on the interactions of Brazilian handball players. We hypothesized to find different behavior interactions between handball players according to the effect of contextual variables and their combination.

Methods

Participants

The sample was intentionally composed and included 15 handball players belonging to one professional team, named Maringá Handball Association, participating in the 2019 Paraná Handball Championship. The following inclusion criteria were adopted: I) being registered as an athlete of the analyzed team; II) participating in official team games. As exclusion criteria, the following stood out: I) having musculoskeletal injuries; II) refusing to participate in the study. The study was approved by the local ethics committee (No. 3442914).

Procedures

In total, 7 official matches and 3435 interactions (passes) were analyzed during the 2019 Paraná Handball Championship. To record games, two camcorders were installed at locations of official games, in a high plane relative to the game surface in order to capture the entire length of the court. After filming, videos were transferred to a computer to analyze the interactions performed by players, using the Ultimate Performance Analysis Tool (upato.it.ubi.pt).

Statistical analysis

For the analysis of social networks, an observational protocol was used to investigate network properties in official games. The classical structure of observational drawings is defined by the crossing of dimensions: observed units, temporality, and dimensionality[19]. Thus, this study is characterized by the specific taxonomy of the area as ideographic (an observed unit), with dynamic temporality (tracking), and heterogeneity of possibilities (multidimensional)[24].

Players were classified for analysis based on their role in the game, as follows: center backcourt, right flank, left flank, right winger, left winger, and pivot.

The successful pass was adopted as a criterion for interaction between two players, as recommended in literature[25]. The sequence of passes was counted and from it, adjacency matrices were created for each offensive sequence (Figure 1).

The zero-value assigned to the adjacency matrix indicates the absence of the observed attribute, while value 1 indicates the presence of the pre-established criterion. From adjacency matrices, the following metrics were obtained with scores ranging from 0 to 1: (I) degree of centrality, which in the sporting context can be understood as the amount of interactions a player establishes with others, with high values indicating greater connectivity with teammates; (II) closeness centrality, measure of geodesic distance between nodes (teammates) during the attack, where high values indicate greater proximity in offensive actions; (III) degree of prestige, which in sport context may be understood as the amount of passes that the player receives from other teammates, where higher degrees of prestige suggest that the player has greater preference from peers when making a call; (IV) proximity prestige, expresses how far teammates are from a certain player, where high values suggest that the other teammates tend to pass the ball to another player in case of a situation involving the pass; (V) network density, which expresses the ratio between the number of calls made and the number of possible calls within an attack, where high density indicates greater exchange of passes during offensive plays[17].

Data normality was obtained using the Kolmogorov-Smirnov test, while the assumption of homo-

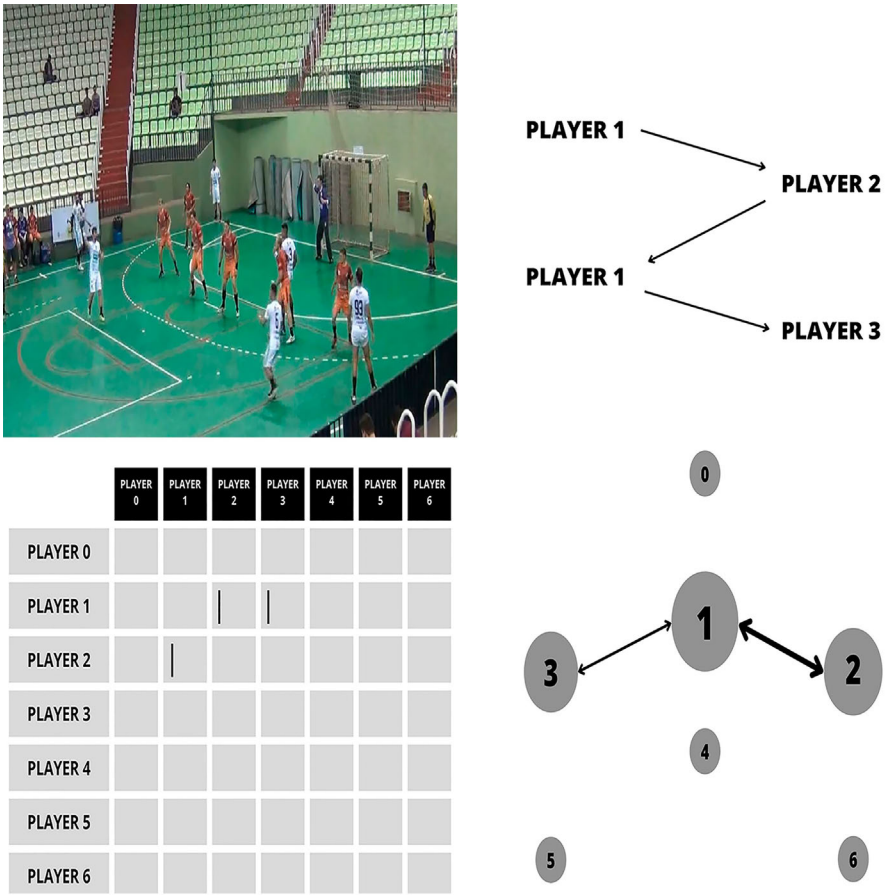

Figure 1 - Graph representation, indicating interactions among players.

geneity of variances was validated using the Levene test. Two-way MANOVA was used to identify the effects of match location and match outcome factors on the net properties of handball players. Subsequently, the t-test for dependent samples was used to compare teams that played at home and away from home on the metrics with a significant effect on the two-way MANOVA. Similarly, One-Way ANOVA was used to compare the victory, draw and defeat outcomes for the network measures that showed the effect of the match result factor. The data were analyzed considering the effect size obtained through the eta squared measure (η^2). For all analyses, the SPSS 23.0 software was used, considering a 5% significance level.

Result

Table 1 presents the effects of match location and match results on network properties between different handball players. The results revealed that playing at home contributes to greater closeness centrality ($t = 2.34$; $p = 0.02$), and network density ($t = 4.29$; $p = 0.01$). One-Way ANOVA revealed the effect of the match result on density ($F_{2.95} = 15.18$; $p = 0.001$), and losing teams showed increased network density in relation to draws and wins.

The effect of match location on closeness centrality and network density was influenced by the match result. Playing at home increases the closeness centrality when the team is losing, as well as the network density. Conversely, when the team is playing away from home and losing, the closeness centrality decreases.

Discussion

The present study identified that playing at home and losing in their own domains, made players get closer (considering geodesic distance in the graphs) and exchange a greater number of passes during offensive plays (increasing mutual help), corroborating the findings of Taylor et al.[26] in soccer. Despite the differences between modalities, Praça et al.[27] also identified that soccer teams in a defeat situation increased the centrality in their offensive sequences, bringing players closer together and opting for an indirect offensive construction style.

It is possible that when losing a match within its own domains, the team feels the need to develop a collective

Table 1 - Descriptive statistics represented by mean (standard deviation) of the network properties performed by handball players, and the effects of the match location, match result, and respective interactions between factors on interactions performed.

	Match location (ML)		Match result (MR)			ML effect			MR effect			ML x MR interaction		
	Home	Outside	Win	Draw	Lose	F	P	η^2	F	P	η^2	F	P	η^2
DC (%)	0.14 (0.10)	0.14 (0.12)	0.14 (0.12)	0.14 (0.14)	0.14 (0.09)	0.01	0.98	0.05	0.01	1.00	0.01	0.01	0.98	0.05
CC (d)	0.17 (0.09)	0.12 (0.08)	0.13 (0.08)	0.10 (0.04)	0.17 (0.13)	21.42	**0.01***	0.99	1.63	0.20	0.34	22.16	**0.01***	0.99
DP (%)	0.14 (0.12)	0.14 (0.14)	0.14 (0.13)	0.14 (0.16)	0.14 (0.11)	0.01	0.96	0.05	0.01	1.00	0.05	0.01	0.97	0.05
PP (d)	0.14 (0.08)	0.11 (0.07)	0.12 (0.07)	0.08 (0.05)	0.15 (0.08)	3.57	0.06	0.46	1.42	0.24	0.30	1.58	0.21	0.24
D (pass performed/pass possible)	0.15 (0.03)	0.13 (0.01)	0.13 (0.02)	0.12 (0.01)	0.16 (0.03)	66.51	**0.01***	1.00	17.21	**0.01***	1.00	31.13	**0.01***	1.00

Note: DC = Degree of centrality; CC = Closeness centrality; DP = Degree of Prestige; PP = Proximity prestige; D = Density.
*Significant difference ($p < 0.05$). d = geodesic distance.

behavior of approximation, and mutual help, to overcome the adversities of the match. Furthermore, it is also possible that the opponent, when winning away from home, decides to compact, lowering the marking blocks and preventing free space, since throwing with the greatest chance of success are those made in areas close to the goalkeeper[28], thus forcing the opponent to articulate more the plays to unbalance the opponent's defensive block, or to finish from a medium-long distance (9 meters zone). This behavior makes sense especially when we consider that attacks based on collective play, predominantly indirect, are more frequent, but less efficient than direct attacks based on individual actions, which depend on more space and are closer to the opponent's goal[29].

In defeat situations and far from their own domains, it was identified in this study that the adversities made teammates become more distant and consequently perform lower network density, indicating less collective and more direct plays. According to Oliveira et al.[30], in handball, when losing a match, the team becomes more vulnerable and affected by psychological crises, while, conversely, winning teams increase confidence and the number of goals scored, pointing to the effect generated by the game context on the psychological control and performance of players. In sports such as soccer, goals are less frequent than in handball; however, studies also indicate greater difficulty in creating and scoring goals in most teams after being at disadvantage on the scoreboard[4,26].

The study represents an advance as it can be applied to understand behaviours and trends about factors that influence interactions in the handball game and facilitate them to be trained and corrected. However, the number of studies on the subject needs to be expanded, since one of the limitations of the study refers to the competition feature (state level), requiring investigations at the national and international levels.

Conclusions

It is concluded that both the result of the game and the place of the match influence the central measures of interactions within the observed modality and context. There is evidence that losing within their domains causes a greater approximation of the teammates and with that, they seek mutual help by increasing the interactions through the exchange of passes in the offensive actions to seek to reverse the score of the team match. On the other hand, there is a distance and a decrease in interactions when the team plays away from their domains.

Acknowledgments

We gratefully acknowledge the contribution of all participating of the present study. Moreover, we acknowledge the Programa Institucional de Apoio à Inclusão Social, Pesquisa e Extensão Universitária - FA-SETI/PIBIS UEM, and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the grants conceded to L.N.T. and M.O.J., respectively.

References

1. Menezes RP, Morato MP, Marques RFR. Estratégias de transição ofensiva e defensiva no handebol na perspectiva de treinadores experientes. J Phys Educ. 2016;27(1):e2753.
2. Hassan A, Schrapf N, Ramadan W, Tilp M. Evaluation of tactical training in team handball using artificial neural networks. J Sports Sci. 2017;35(7):642-47.
3. Menezes RP, Marques RFR, Nunomura M. Teaching handball to players under-12: the perspective of Brazilian coaches. Motriz: J Phys Educ. 2020;23(4):e101792.
4. Machado JC, Barreira D, Garganta J. Eficácia ofensiva e variabilidade de padrões de jogo em futebol. Rev Bras Educ Fís Esporte. 2013;27(4):667-77.
5. Barros JD, Marques PG, Borges PH, Teixeira D, Corrêa UC. The effect of freedom of relevant choice on the 7-m throw

in university students practicing handball. Adapt Behav. 2021;30(3):237-43.
6. Michalsik LB, Aagaard P, Madsen K. Technical activity profile and influence of body anthropometry on playing performance in female elite team handball. J Strength Cond Res. 2015;29(4):1126-38.
7. Ferrari SF, Borges PH, Teixeira D, Marques PG. Impact of verbal instruction and demonstration methods on self-efficacy and motor learning in inexperienced handball players. J Phys Educ Sport. 2018;18(2):816-20.
8. Reigal RE, Vázquez-Diz JA, Morillo-Baro JP, Hernández-Mendo A, Morales-Sánchez V. Psychological profile, competitive anxiety, moods and self-efficacy in beach handball players. Int J Environ Res Public Health. 2020;17(1):241.
9. Araújo D, Davids K. Team synergies in sport: theory and measures. Front Psychol. 2016;7(21):1449.
10. Silva P, Vilar L, Davids K, Araújo D, Garganta J. Sports teams as complex adaptive systems: manipulating player numbers of shapes behaviours during football small-sided games. Springerplus. 2016;5(1):1-10.
11. Travassos B, Davids K, Araújo D, Esteves TP. Performance analysis in team sports: advances from an ecological dynamics approach. Int J Perform Anal Sport. 2013;13 (1):83-95
12. Glazier PS, Davids K. Constraints on the complete optimization of human motion. Sports Med. 2009;39(1):15-28.
13. Grehaigne JF, Godbout P, Bouthier D. Performance assessment in team sports. J Teach Phys Educ. 1997;16(4):500-16.
14. Korte F, Lames M. Passing network analysis of positional attack formations in handball. J Hum Kinet. 2019;70 (1):209-21.
15. Barnes JA, Harary F. Graph theory in network analysis. Soc Netw. 1983;5(2):235-44.
16. Clemente FM, Martins FML, Wong DP, Kalamaras D, Mendes RS. Midfielder as the prominent participant in the building attack: a network analysis of national teams in FIFA World Cup 2014. Int J Perform Anal Sport. 2015;15 (2):704-22.
17. Clemente FM, Martins FML, Mendes RS. Social network analysis applied to team sports analysis. Dordrecht, Ed. Springer International Publishing; 2016.
18. Grund TU. Network structure and team performance: the case of English Premier League soccer teams. Soc Netw. 2012;34(4):682-90.
19. Cotta C, Mora AM, Merelo JJ, Merelo-Molina C. A network analysis of the 2010 FIFA world cup champion team play. J Syst Sci Complex, 2013;26(1):21-42.
20. Clemente FM, Couceiro MS, Martins FML, Mendes RS. Using network metrics to investigate football team player's connections: a pilot study. Motriz: J Phys Educ. 2014;20 (3):262-71
21. Clemente FM, Silva F, Martins FML, Kalamaras D, Mendes RS. Performance Analysis Tool for network analysis on team sports: A case study of FIFA Soccer World Cup 2014. Proc. Inst. Mech. Eng. P: J. Sports Eng. Technol. 2015;230 (3):1-13.
22. Castellano J, Echeazarra I. Network-based centrality measures and physical demands in football regarding player position: is there a connection? A preliminary study. J Sports Sci. 2019;37(23):2631-8.
23. Nevill AM, Holder RL, Baxter-Jones A, Round JM, Jones DA. Modeling developmental changes in strength and aerobic power in children. J Appl Physiol. 1998;84(3):963-70.
24. Anguera MT, Camerino O, Castañer M, Sanchez-Algarra P, Onwuegbuzie AJ. The specificity of observational studies in physical activity and sports sciences: moving forward in mixed methods research and proposals for achieving quantitative and qualitative symmetry. Front Psychol. 2017;19 (8):e2196.
25. Taylor JB, Mellalieu SD, James N, Shearer DA. The influence of match location, quality of opposition, and match status on technical performance in professional association football. J Sports Sci. 2008;26(9):885-95.
26. Praça GM, Lima BB, Bredt SDGT, Sousa RBE, Clemente FM, Andrade AGP. Influence of match status on players' prominence and teams' network properties during 2018 FIFA World Cup. Front Psychol. 2019;28(10):1-8.
27. Pic M. Performance and home Advantage in handball. J Hum Kinet. 2018;63(1):61-71.
28. Rogulj N, Vuleta D, Milanovic D, Cavala M, Foretic N. The efficiency of elements of collective attack tactics in handball. Kinesiol Slov. 2011;17(1):5.
29. Oliveira T, Gómez M, Sampaio J. Effects of game location, period, and quality of opposition in elite handball performances. Percept Mot Skill. 2012;114(3):783-94.
30. Lago-Peñas C, Gómez MA, Viaño J, González-García I, Fernández-Villarino MA. Home advantage in elite handball: the impact of the quality of opposition on team performance. Int J Perform Anal Sport. 2013;13(3):724-33.
31. Meletakos P, Bayios I. General trends in European men's handball: a longitudinal study. Int J Perform Anal Sport. 2010;10(3):221-28.
32. Pollard R, Gómez MA. Reassessment of home advantage in Spanish handball: comment on Gutiérrez, et al. (2012). Percept Mot Skill. 2012;115(3):937-43.

Corresponding author

Lucas Shoiti Carvalho Ueda, Universidade Federal de Santa Catarina, Departamento de Educação Física, Florianópolis, SC, Brazil.
E-mail: lucashoiti@hotmail.com.

Manuscript received on February 17, 2022
Manuscript accepted on June 29, 2022