Journal of Physical Education and Sport ® (JPES), 17(2), Art 104, pp. 692 - 697, 2017
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Network process of children: influence of gender and type of game during cooperative-opposition games

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Published online: June 30, 2017
(Accepted for publication June 15, 2017)
DOI:10.7752/jpes.2017.02104

Abstract:
The children, when playing, are communicating, since this is one of the forms of disinhibition and interaction with the group in which they are inserted (Lima, 2014). Ten children, five boys (n = 5; 5.8 ± 0.4 years old of age) and five girls (n = 5; 5.6 ± 0.5 years old of age) from a elementar school were observed during classes of motor expression. These classes took place once a week for a month, lasting one hour for each session. The interactions were observed with two cameras. It was counted as an interaction when a child passed one ball to another. The results suggest that it was in the "Free Game" that there were significant diferences between the type of game, since it was found in this one that it was easier for a player to be connected with his colleagues, being later the most requested, at the moment they had to pass the ball. Between the type of game and the gender, no significant interactions were found, as children who were the ones most requested by their classmates when they had to pass the ball were not verified. However, children who were crucial to maintaining cross-pass connections were also not checked. With regard to gender, no significant differences were found because no child, both male and female, has become important in sustaining the connections between the passes and the fact that no boys and / or girls were the most requested to make the passes with the ball. Finally, among the game types, no significant differences were found, since the children did not become essential to maintain the connection of passes between colleagues, in any of the matches played. The main objective of this study is to compare the interaction between female and male children in the type of cooperative-opposition games through Social Network Analysis.
Key words: adjacency matrices - graph theory - network - children - cooperation-oposition - type of game.

Introduction

Nowadays, although there are great changes, the game presents timeless brands. Children have always played and will continue to do so, even in different ways. These changes, caused by the digital world and the internet, triggered several changes that, to date, had not occurred (Silva, 2008). Play is essential in the lives of children, being recognized by the United Nations as an exclusive right (UNICEF, 2004). This importance and its characteristics make the game an instrument of learning and communication for cognitive, motor development, moral, affective and development of the child's personality (Serrão, 2009).

The child, when playing, is communicating, since it is one of the forms of disinhibition and interaction with the group in which he/she is inserted (Lima, 2014), providing moments where the child experiences, exposes, invents, creates and learns skills which stimulate various aspects such as curiosity, self-confidence, autonomy, language, concentration, cooperation, thought and attention. The game is also able to integrate cognitive and affective aspects that are necessary and important in the development of the child (Oliveira & Hackbart, 2013). The ability to be in oposition to others begins to manifest itself around the age of 5 and 6 years, and this capacity can contribute to the development of the child, because it elaborates and complies with rules, thinks actively and motivates itself (Riccetti, 2001). Facing opposition situations, several strategic and social processes are activated (Roque, 2015), being these games seen as something positive, where children must be educated and they must be able to compete, maintaining all the values they have acquired and were transmitted (Roque, 2015).

However, the child has for a long time adopted an active behavior that was facilitated "by the freedom of movement in an open, free and safe environment" (Pinho & Petroski, 1997, p.68). On the other hand, the children of the present world have a sedentary behavior. Behavior that is characterized by a limit of effort in the actions exercised in their daily lives, adopting a lifestyle that jeopardizes their motor development (Pinho &

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Petroski, 1997). So, electronic devices become increasingly attractive, making it difficult for children to participate in physical activities (Pinho & Petroski, 1997), thus leading to an increase in the rates of overweight and child obesity and overweight.

However, play activities arise as activities that develop qualities necessary for the child to live in a healthy way, both physiologically and psychologically, such as self-knowledge, self-respect, self-esteem and self-confidence (Almeida & Shigunov, 2000).

A study was developed in Portugal with 10 children, 5 boys and 5 girls, from a preschool institution. This study focused on the interactions that occurred in the playground. The children were tested three times, in which each observation had 15 minutes. The children had complete freedom to make the decisions of how they wanted to pass the time. In this study, researchers used the metrics outdegree, indegree and betweenness centralities. The results obtained through the social network analysis showed that: (1) Boys can be more sought at play time; (2) Boys tend to be more social during free activities; (3) Boys tend to bond more with their peers than girls, which can be explained, according to the researchers, because girls have more intimate relationships with their friends and spend more time alone (Oliveira, Clemente & Martins, 2016).

Another study was developed with 72 children, 44 boys and 28 girls, aged between 53 and 77 months, from a kindergarten in Portugal. The main purpose of this study was to "characterize the patterns of interaction established in outdoor recreation in terms of average times in interaction, preference for interactions by gender of pair and preference for dyad or group interactions" (Veiga, Cachucho, Neto & Rieffe, 2015, p.44). Interactions were measured using proximity sensors based on radio frequency identification devices. The results of this study were as follows: (1) The male children established more interactions and a longer duration than the female sex; (2) Boys have been more often involved with children of the same gender than girls; (3) Girls deal more often with girls; (4) Boys were more involved in group interactions than girls and, finally, (5) Girls became more involved in dyads than boys (Veiga et al., 2015).

Regarding the limitations of the studies already carried out, these are due to the fact that a small sample is used and because proximity sensors are used, because although they consider an interaction between the contacts between children that are prolonged for at least 5 seconds, They are not sure that the child was interacting with the one that was closest to them, since they did not have a video recording to be able to verify that aspect.

The present study has as main purpose to compare the interaction between the female and male children in the type of cooperative-oposition games, through Social Network Analysis.

Material & methods

Participants

The study was carried out with 10 children (5 boys and 5 girls) (boys: n = 5, 5.8 ± 0.4 years old of age, 117.8 ± 6.1 cm of height, 21.6 ± 4.8 kg of body mass index) (girls: n = 5, 5.6 ± 0.5 years old of age, 116.8 ± 3.1 cm in height, 19.3 ± 2.1 kg of body mass index).

Prior to the study, all parents were informed and signed an informed consent about what was to be done in the study. The study followed the international recommendations for the study in humans in accordance with the Declaration of Helsinki.

Procedure

This study aimed to measure the interactions that occur between children in cooperative-oposition games, in the motor expression classes held at the Coimbra Education School. To collect data, we used one session per week for a month, since the children's lesson was conducted weekly. Initially, we used a session where we recorded the data of the children regarding the date of birth, weight, height and the dominant side. It should be noted that both the weighing (SECA DELTA model 707 scale) and the heightness (ADE MZ10038 stadiometer) were performed twice, so that it was possible to verify their accuracy.

After the data collection session, we held a familiarization session with the games and the material used - camcorders and accelerometers - so that the children knew them and felt comfortable with their presence at the time of collection, thus not influencing the study. In the month in which we conducted the data collection, only two cooperative-oposition games per session were performed, since two sets of cooperation and two cooperation-oposition games were held in each session. The games were filmed for later coding of the interaction network.

Game Description

The cooperative-oposition games were timed so that its accomplishment was exact in all the games, having the duration of 5 minutes. Each game was made with a group of 5 and a group of 10 elements. The following games were performed: "Monkey in the middle", "Easy Goal", "Ball Possession" and "Free Game". It is important to note that for a better distinction of children, each had a different colored sweater.

In "Monkey in the middle", the children were divided into two teams (team A and team B) and the playing area was divided by a circle-shaped tape. Thus, team A was out of the circle and team B was inside the circle. In the

group of 5 elements, team A (with 3 elements) was outside the circle, while team B (team with 2 elements) was within the circle. The team with 3 elements (team A) had to make passes between themselves without the 2 elements of the opposing team could get the ball. If an element of team B get the ball out of an element of team A, they had to change positions. On the other hand, in group of 10 elements, team A was composed of 7 elements, while team B comprised 3 elements, repeating the process and the rules previously explained.

In the game "Easy Goal", the children were divided in two teams (team A and team B) and they were positioned in a similar way of a football game. In the group of 5 elements, since the number of children was odd, the two teams had two elements, since the third element was a neutral element. The neutral element was part of the two teams, thus belonging to the one who had possession of the ball at the time. The main objective of the game was to score goals on the opposing team's goal. Should the ball leave the playing area, the responsables for the game would pick it up and deliver it to the child who was part of the opposing team of the child who sent the ball off the field. In that way, the team would be able to score the most goals against the opposing team win the game. It is important to note that the children, to pass the ball between them, could use their hand or foot, but to score goals they could only do it by hand. In turn, it should be noted that the children who were in the beacon did not belong to the study, so that it was possible to verify, in a better way, the cooperation between the elements of the experimental group. In the group of 10 elements, since the teams were already uniform, it was not necessary the neutral element, thus constituting the team A with 5 elements and the team B with 5 elements, also repeating the process and the rules previously explained.

In the "Ball Possession", the children were divided into two teams - Team A and Team B, and they were circulating freely through space. In the group of 5 elements, as in the game "Easy Goal", was necessary to use a neutral element, since the number of children was odd, thus two teams with two elements, the third being the neutral element that belonged to the team who had possession of the ball. The main objective of the game was that one of the teams made 10 passes, without the elements of the opposing team could get the ball. If team B was able to get the ball out of the A team, it was in possession of the ball and began counting the 10 passes again. In the group of 10 elements, the development of the game was the same, but the teams already became uniform, since both had 5 elements.

In the "Free Game", the children were moving freely through space. In this game, although there was a division between the group of 5 and the group of 10 elements, the teams were not divided and there was no neutral element. Since it was a free game, there were 3 balls in the field and the children had to create a game of cooperation-oposition, where they used these balls, in the way they understood, since they were the ones who created their own rules.

Network Analysis

We recorded in weighted adjacency matrices the interactions between colleagues, codified as number of passes. The network measurements have been processed with the Social Network Visualizer (SocNetV, version 1.9.) that is a software that allow to visualize the graphs and compute the network measurements (Kalamaras, 2014; Oliveira, Clemente, Martins, 2016). Closeness centrality was used to check the proximity of how close is such player to its peers. The betweenness centrality quantifies how often each player lies between other nodes of the network. All the games in this study are analysed with weighted digraph formulas.

Standardized Closeness Centrality

Closeness centrality quantifies how close a player is to his or her colleagues. Players who have a high closeness value can reach more players in a smaller number of passes than players who have a lower value (Clemente, Martins & Mendes, 2016). Thus, closeness indicates the facility of a player to be connected with his peers being later the most requested at the moment that they had to pass the ball.

Definition 1. (Opsahl et al., 2010; Clemente, Martins & Mendes, 2016) Given two vertices n_i and n_j of the weighted graph G with n vertices. The geodesic distance between n_i and n_j is obtained by:

$$d^w(n_i, n_j) = \min_{ijh}\left(\frac{1}{a_{ih}}+\dots+\frac{1}{a_{hj}}\right),$$

where h are intermediary vertices on paths between vertices n_i and n_j, and a_{uv} are the elements of the weighted adjacency matrix of the G.

Remark: The geodesic distance between n_i and n_j in weighted digraphs is determined in the similar form that weighted graphs.

Definition 2. (Opsahl et al., 2010; Clemente, Martins & Mendes, 2016) Given a weighted graph G with n vertices. The closeness index of the n_i, $C_{(C)}^{w}(n_i)$, is determined by:

$$C_{(C)}^{w}(n_i) = \left[\sum_{\substack{j=1 \\ i \neq j}}^{n} d^{w}(n_i, n_j)\right]^{-1},$$

where $d^{w}(n_i, n_j)$ is a geodesic distance between n_i and n_j.

Remark: The closeness of one vertex n_i of weighted digraph is determined in the similar form that weighted graph.

Definition 3. (Rubinov & Sporns, 2010; Opsahl et al., 2010; Clemente, Martins & Mendes, 2016) Given a weighted graph G with n vertices. The standardized closeness index of the vertex n_i is obtained by:

$$C'^{w}_{(C)}(n_i) = (n-1) \times \left[\sum_{\substack{j=1 \\ i \neq j}}^{n} d^{w}(n_i, n_j)\right]^{-1},$$

where $d^{w}(n_i, n_j)$ is a geodesic distance between n_i and n_j.

Remark: The standardized closeness of one vertex n_i of weighted digraph is determined in the similar form that weighted graph.

Standardized Betweenness centrality

Betweenness centrality quantifies how many times each player ir among his peers, acting as a "bridge". Players with a high level of betweenness are often assumed to be the ones most likely to exert control among colleagues (Clemente, Martins & Mendes, 2016). Players who have a high level of betweenness are those who are most often among their peers. Thus, the betweenness indicates the children who presented themselves crucial to maintain links between the passes.

Definition 4. (Rubinov & Sporns, 2010; Clemente, Martins & Mendes, 2016)
Given an unweighted graph $G = (V, E)$, with $n_i, n_j, n_k \in V$, $i, j, k = 1, \ldots, n$. The standardized betweeness centrality index is calculated by:

$$C'_b(n_k) = \frac{1}{(n-1)(n-2)} \sum_{\substack{n_i, n_j \in V \\ i \neq nj \neq k}} \frac{g_{ij}(n_k)}{g_{ij}},$$

where $g_{ij}(n_k)$ is the number of shortest paths between n_i and n_j that pass trought n_k and g_{ij} is the number of shortest paths between n_i and n_j.

Remark: The betweenness centrality and standardized betweeness centrality in weighted and/or direct graphs, is determined the similar form that unweighted graphs shut that the path lengths are obtained on respective weighted or direct paths (Rubinov & Sporns, 2010; Clemente, Martins & Mendes, 2016).

Data collection and analysis

In the video observation process, the inter-observer validation was performed, in order to verify that the videos were analyzed properly. The observers' training was done with 15% of the full data with a 20-days of interval to ensure the intra- and inter-reliability. The inter-observer validation was tested using Cohen's Kappa, this being one of the most commonly used agreement indices (Fonseca, Silva & Silva, 2007). The inter-observer agreement index was 83%. Once the analysis was started, we assigned a number to each child so that later the data was entered already encoded in the Social Network Analysis software, thus verifying the interactions that occurred in the games. In cooperative-oposition games, since games require the use of a ball, it is considered

interaction when a child passes the ball to another. Subsequent to the video observation phase, adjacency matrices were constructed, where all the interactions observed in them were recorded. The matrices were later imported into the ultimate Performance Analysis Tool software to calculate the measures of network: closeness and betweenneess centralities.

Statistical procedures

The normality and homogeneity of the sample were tested and verified before the inferential tests. The two-way ANOVA tested the variance of betweenness and closeness centralities between the factors of gender (male and female) and type of game ("Monkey in the middle", "Easy Goal", "Ball Possession" and "Free Game"). The effect size (ES) of the two-way ANOVA was tested with the partial eta squared. The classification used to partial eta squared was: no effect ($\eta^2 < 0.04$), minimum effect ($0.04 < \eta^2 < 0.25$), moderate effect ($0.25 < \eta^2 < 0.64$) and strong effect ($\eta^2 > 0.64$) (Ferguson, 2009). In the case of no-interaction between factors, the analysis of variance for the gender was made with the independent t test followed by the Cohen D to test the effect size. The following classification was used to characterize the effect of Cohen D (Ferguson, 2009): no effect ($d < 0.41$) minimum effect ($0.41 < d < 1.15$); moderate effect ($1.15 < d < 2.70$) and strong effect ($d > 2.70$). The one-way ANOVA followed by the post hoc of Tukey HSD and the partial eta squared assessed the variance between types of game. All data sets were tested for each statistical technique and corresponding assumptions and performed using Statistical Package for Social Sciences (SPSS) software (version 23.0, Chicago, Illinois, USA). Statistical significance was set at $p \leq 0.05$.

Results

Descriptive statistics of betweenness and closeness centralities obtained by male and female children in different type of games can be observed in table 1. The two-way ANOVA tested the variance of closeness and betweenness centralities between gender and type of game. No significant interactions were found between factors for the variable of closeness ($p = 0.981$; ES = 0.002, *no effect*) and betweenness ($p = 0.302$; ES = 0.824, *no effect*).

Table 1. Descriptive statistics (mean and standard deviation) of both centralities.

	Betweenness M ± SD		**Closeness** M ± SD	
Type of Game	Male	Female	Male	Female
"Monkey in the middle"	0.13 ± 0.14	0.10 ± 0.14	1.11 ± 0.49	0.88 ± 0.36
"Easy Goal"	0.15 ± 0.17	0.08 ± 0.12	3.45 ± 5.76	0.90 ± 0.42
"Ball Possession"	0.16 ± 0.13	0.10 ± 0.10	0.90 ± 0.50	0.85 ± 0.50
"Free Game"	0.05 ± 0.10	0.04 ± 0.06	17.69 ± 26.55	14.85 ± 26.89

The independent t test analysed the variance of dependent variables between genders. No significant differences were found between genders in the betweenness ($t = 0.434$; $p = 0.665$; Cohen D = 0.097) and closeness ($t = 1.497$; $p = 0.139$; Cohen D = 0.408).

The one-way ANOVA tested the variance of dependent variables between type of game. Significant differences were found between games in the variable of closeness ($p = 0.001$; ES = 0.203, *minimum effect*). Free game had significant greater values of closeness centrality in comparison with monkey in the middle ($p = 0.003$), easy goal ($p = 0.007$) and ball possession ($p = 0.003$). No significant differences between games were found in betweenness ($p = 0.153$; ES = 0.067).

Dicussion

The results obtained through the Social Network Analysis showed that there were only significant differences between the type of game, at the level of closenness centrality, in which the game "Free Game" obtained better results, compared to "Monkey in the middle", "Easy Goal" and "Ball Possession". These differences could be identified in the "Free Game", since it was found that it was easier for a player to be connected with his colleagues, and he was later, the most requested, when they had to pass the ball. Thus, it is to reinforce that it was in this game that the significant differences were found, because there were children who were more requested by their colleagues, at the time of passing the ball. Between the game type and the gender, no significant interactions were found at both the closenness level and the betweenness centrality level. This means that, between the type of game and the gender, children who were the most requested by their colleagues were not checked at the time of the pass. Also, no children were found that were crucial to maintaining the connections between passes. Regarding gender, no significant differences were found in closeness or in betweenness centrality, due to the fact that no child, both male and female, has become important to sustain the

connections between the passes and the fact that no boy and/or girl was the most requested to make the passes with the ball. However, among the game type, no significant differences were found in the level of betweenness centrality, since children did not become essential to maintain the connection of passes between colleagues in any of the games performed.

Conclusions

The present study revealed that no significant interactions between the factors at the level of closeness ($p = 0.981$; ES = 0.002, *no effect*) and betweenness centrality ($p = 0.302$; ES = 0.824, *no effect*) were found. There were no significant differences between genders, either at the closeness level ($t = 1.497$, $p = 0.139$, Cohen D = 0.408) or betweenness centrality ($t = 0.434$, $p = 0.665$, Cohen D = 0.097). At the level of closeness centrality ($p = 0.001$; ES = 0.203, *minimum effect*), significant differences between games were found. The "Free Game" obtained better values of closeness centrality, compared to "Monkey in the middle" ($p = 0.003$), "Easy Goal" ($p = 0.007$) and "Ball Possession" ($p = 0.003$). Regarding the level of betweenness centrality ($p = 0.153$; ES = 0.067), no significant differences between games were found. Future studies should consider analyzing these interactions with a larger number of children, that is, with a larger sample and with different types of games.

Acknowledgments

This study was carried out within the scope of R&D Unit 50008, financed by UID/EEA/50008/2013. This study was conducted in the aim of the granted project: uPATO from Instituto de Telecomunicações. We would like also to thank to Quoc Trong Nguyen for his contribution during the data processing.

References

Almeida, A., & Shigunov, V. (2000).The children's play activity and its possibilities. *Journal of Physical Education/UEM*, 11(1), 69-76.

Clemente, F., Martins, F., & Mendes, R. (2016). *Social Network Analysis Applied to Team Sports Analysis*. Netherlands: Springer International Publishing.

Ferguson, C. (2009). An Effect Size Primer: A Guide for Clinicians and Researchers. *Professional Psychology: Research and Practice*, 40(5), 532-538.

Fonseca, R., Silva, P., & Silva, R. (2007). Inter-judges agreement: The case of the kappa coefficient. *Laboratory of Psychology*, 5(1), 81-90.

Kalamaras, D. (2014). The SocNetV Manual Social Networks Visualizer (2014).

Lima, M. (2014). *The role of the game in the learning and cooperation of children in school – Evolution of Pre-school education for 1st Cycle Education* (Masters dissertation). University of the Azores.

Oliveira, P., Clemente, F., & Martins, F. (2016). Assessment of interactions in children's playground by using network measures: An exploratory study based on graph theory. *Journal of Physical Education and Sport*, 16(4), 1-5.

Oliveira, C., & Hackbart, J. (2013). Games and Play in Early Childhood Education. *Castelo Branco Scientific Magazine*, (4), 1-15.

Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node Centrality in Weighted Networks: Generalizing Degree and Shortest Paths. *Social Networks*, 32(3), 245-251.

Pinho, R., & Petroski, E. (1997). Level of physical activity in children. *Brazilian jornal of physical activity and health*, 2(3), 67-79.

Riccetti, V. (2001). Group games for early childhood education. *Educação Matemática em Revista*, 11, 19-25.

Roque, J. (2015). I need an opponent to learn how to live – Role of the opposition in the emotional experience of Physical Education. In A. Ferreira, A. Jaqueira & P. Araújo (Org.), *Games and Physical Activity in Contemporary Society: Bodies, Education and Emotion* (pp. 63-81). Santo Tirso: De Facto Editores.

Rubinov, M., & Sporns, O. (2010). Complex network measures of brain connectivity: Uses and interpretations. *NeuroImage*, 52(3), 1059-1069.

Serrão, E. (2009). *The child educator and the child development game* (Masters dissertation). University of Lisbon.

Silva, A. (2008). Games, Toys and Games, Intergenerational trajectories (Outlines of a doctoral study). In *VI Congress of the Portuguese Association of Sociology of Lisbon, Portugal*, 25-28 June 2008 (pp. 1-12).

UNICEF. (2004). *Convention on the rights of the child.* Available in: http://www.unicef.pt/docs/pdf_publicacoes/convencao_direitos_crianca2004.pdf

Veiga, G., Cachucho, R., Neto, C., & Rieffe, C. (2015). Innovations in the study of children's behavior with proximity sensors. In V. Lopes & C. Gonçalves (Eds.), *Child motor development studies VIII* (pp. 44-59). Bragança: ESE-IPB/CIDESD.