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Complex system theory in team sports. example in 5 on 5 basketball contest

Javier García*, Sergio J. Ibáñez*, María Cañadas and Antonio Antúnez***

COMPLEX SYSTEM THEORY IN TEAM SPORTS. EXAMPLE IN 5 ON 5 BASKETBALL CONTEST

KEYWORDS: Complex systems, Basketball, Offensive rating.

ABSTRACT: The purpose of the study was to analyze basketball contest under complex systems framework. Control and order parameters were defined as time and offensive rating. The data was composed by 73 games from the ACB league during the 2007-08 season. Relative phase of confronting teams was calculated through Hilbert Transform. Results show stability, instability and transition periods, with coordination in-phase and anti-phase. Perturbations were found in the development of the game. These perturbations move the systems from stable to instable states. Findings of the study guarantee the dynamics analysis of basketball contest. Coaches should prepare their teams to be able of analyze environmental information and find new solutions for game constraints.

Performance analysis in team sports has identified performance indicators associated with success (Ibáñez, García, Feu, Lorenzo, and Sampaio, 2009; Sampedro and Prieto, 2012). Recently, researches have embraced the ecological framework to explain performance behaviors at individual and team level (Araújo, Davids, and Hristovski, 2006). Complex systems theory explains that these systems exhibit a non-lineal behavior, with many degrees of freedom and, interact with the environment in a constant flux of changes at systems and subsystems level (Glazier, 2010). Team sports dynamics can be explained throw concepts as order and control parameters, instabilities, perturbations, phase transitions, attractor or constraints (Glazier, 2010). Interactions in team sports can occur in physical (when players fight for a rebound) and non-physical ways (Glazier, 2010). Available literature established that non-physical coordination appear when players adapt their movements trajectories and velocity to create space and time (Duarte, Araujo, Davids, Trasvassos, Gazimba and Sampaio, 2012).

Coordination in team sports has been analyzed in interpersonal dyads. Several studies had investigated the interpersonal coordination tendencies in attacker-defender dyads in different sports like basketball (Bourbousson, Séve and McGarry, 2010a), soccer (Duarte et al., 2012) or futsal (Vilar, Araujo, Davids and Trasvassos, 2012). Moreover, other researchers analyze confronting teams as a dyad itself. In fact, Bourbousson, Sevé, and McGarry (2010b) suggest that the highest level of game performance is the interaction of team-team dyad. Lames (2006), studied the interaction between two teams in handball, measuring as order parameter the score development and probability of score a goal. Bourbousson et al. (2010b), focused their efforts in basketball and analyzed spatial centre and dispersion (stretch index) to examine the coordination dynamics of two teams during competition.

Thus, the aim of this study was to improve the basketball knowledge at teams level trough dynamic analysis of confronting teams in basketball. To this purpose, offensive rating was used as order parameter, and time as control parameter.

Method

Sample and variables

Data were obtained from official statistics service of A.C.B. league, Spanish first division, of the 2007-2008 season (n = 306). Game-related statistics recorded were successful and unsuccessful free-throws, and 2 and 3 point field-goals, defensive and offensive rebounds, assist, steals, turnovers and received and committed blocks and fouls (coefficient of agreement *kappa* > .92 (Ibáñez, et al., 2009). Variables were normalized to 100 possessions due the game rhythm effect. Ball possessions were calculated by the procedure of Oliver (2004). Prior to the principal analysis, discriminant analysis was carrying out to identify games correctly unclassified. There were 73 games unable to describe by the quantitative modeling technique.

Dynamic System is defined using order and control parameters. In this study, control parameter was time, and Offensive Rating was defined as order parameter. Offensive rating (OR) were calculated by Oliver's equation (2004):

Offensive rating = (points produced)/(ball possessions) x 100.

Correspondence: Javier García, Facultad de Ciencias del Deporte. Universidad de Extremadura. AVD. de la Universidad s/n, 1007, Cáceres (Extremadura).
E-mail: jagaru@unex.es
* Universidad de Extremadura.
** Universidad de Murcia
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Procedure

The relative phase has to be calculated to identity perturbations, stabilities and instabilities period between opposite teams. This relative phase was calculated as a result of confronting teams' interaction. First, OR of each team was calculated in every minute of game using Basquetadistica 1.0 software (Sampaio, Lorenzo and Ribeiro, 2006). All data were smoothed trough double mean mobile of 4 records (Lames, 2006). Because of that, final data of games begin in minute 8. The relative phase was calculated with the difference in OR between one minute and the following one.

The data signal achieved allows calculating the relative phase of confronting teams. Through Hilbert transform (Duarte et al., 2012) the evolution of a basketball game as a system was calculated in *MATLAB* 2008a software (*The MathWorks Inc*.).

The results of analysis were put into groups with the purpose of facilitate the examination of relative phase. *K-means* analysis was used to grouping games and 7 different groups were established. Results have been analyzed trough visual inspection (Bourbousson et al. 2010 a, b), trying to identify periods of stability and instability in relative phase.

Results

Three different tendencies can be identified in the relative phase: i) when tendency is stable along the time: *Stability periods* (in-phase, anti-phase and transition); ii) when tendency is not clear, is called *Instability periods*; and iii) the change from one state to another in a stable way, *transition*. Furthermore, relative phase is expressed in degrees. The relative phase of confronting teams are synchronized, or in-phase, the values are around 0º or 360º and multiples. Teams collective efficacies are desynchronized, or in anti-phase, when values or relative phase are around 180º and multiples. In the panels, relative phase, expressed in degrees, was represented in abscissa. The timeline was represented in the ordinate.

The results show the relative phase of the closer game to the relative phase of each cluster. In game a (Figure 1), relative phase had negative values. This means that the offensive rating initiative was displayed by the away team. Game b shows negative values in relative phase since the beginning of the game. In the middle of the third quarter the tendency change and stop decreasing until the last part of the game. In game c, relative phase shows the superiority of home teams in offensive rating. The phase relation demonstrates an anti-phase coordination between teams during the game until the last minute, when relative phase shows a transition to in-phase relation. The upper right (d) and middle right games (e) have the same tendency in relative phase during the 3 first periods, where the teams show in-phase coordination. Relative phase in game d, in last quarter, increases to positive values. Whereas, game e, since the middle of the third period, decrease to negative values. The relative phase behavior´s shows opposite development of the game. Bottom right panel (game f), relative phase shows two different behaviors. In first period the coordination is in-phase. In the second period, the tendency changes to an anti-phase state.

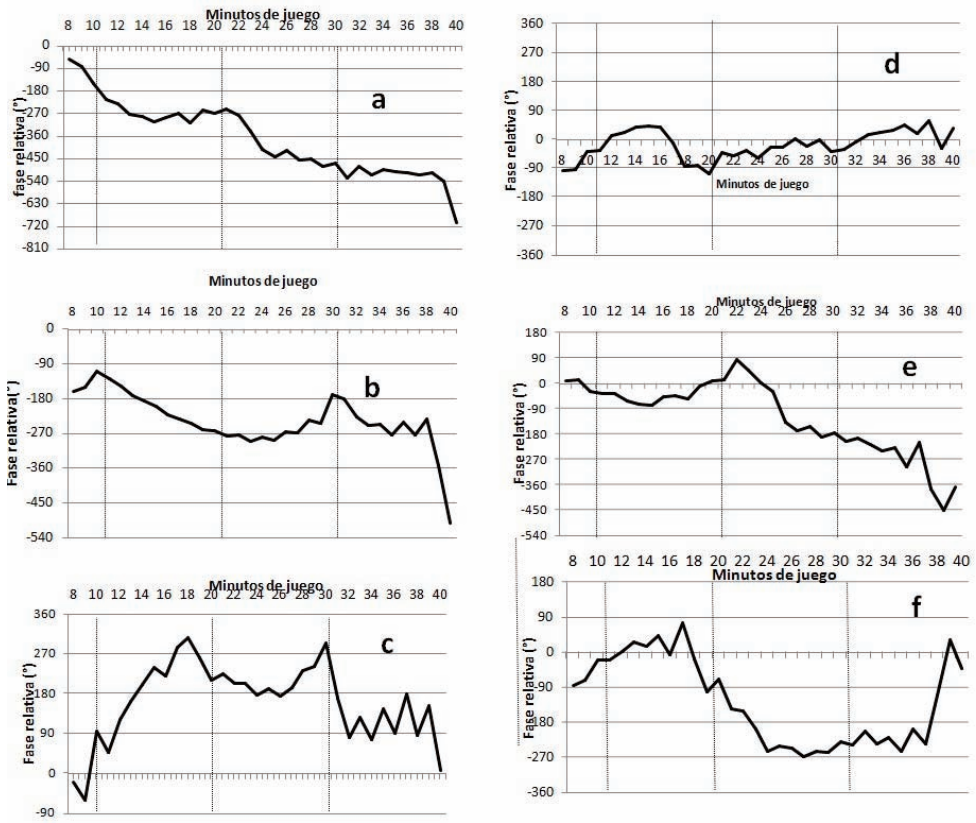

Figure 1. Relative phase of games (a) (b) (c) (d) (e) and (f). Longitudinal line represents relative phase. Discontinuous line represent games' quarters.

Figure 2 displays game g relative phase and offensive ratings development in the game. Relative phase is always in positive values and increasing during the match. Is a stable period of transition, trying to achieve in-phase coordination. In the bottom panel, offensive rating in each minute of the game showed collective efficacy of confronting teams. When these offensive rating cross o move away (minute 12 to 18), mean that relative phase is in anti-phase coordination. On the contrary, when relative phases are stables (minute 35 to 40), the relative phase achieve in-phase coordination.

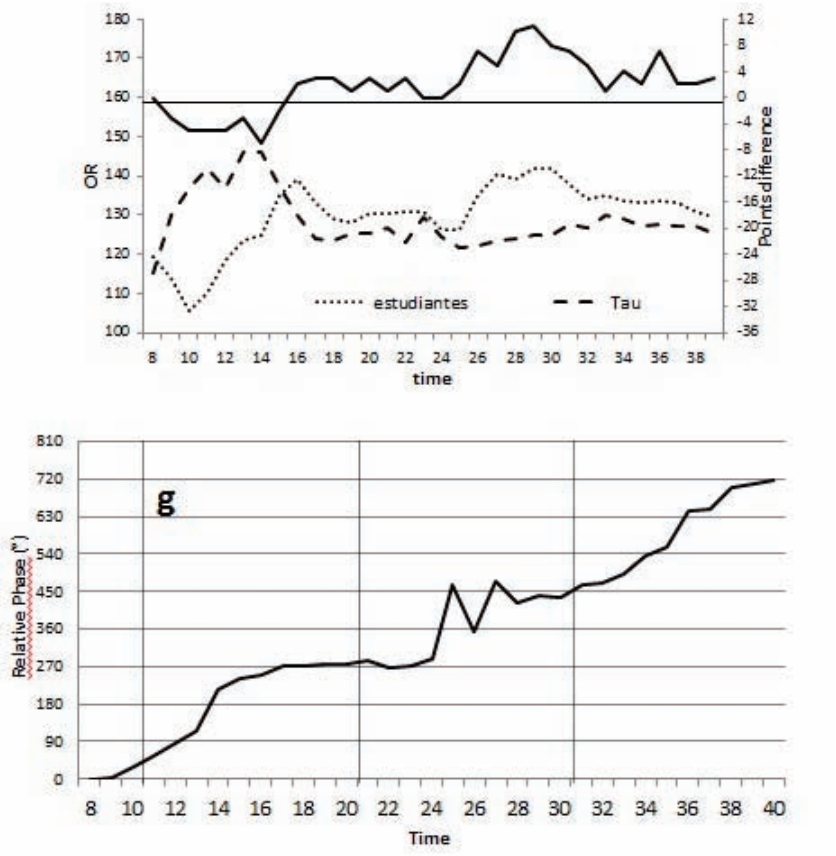

Figure 2. Coordination tendencies of basketball game. Upper panel show relative phase offensive ratings time series of game (g). Bottom panel displays offensive rating in each minute and points difference. Discontinuous line represent games' quarters.

Discussion

The primary goal of this work was to analyze basketball contest as a dynamic system, identifying time and offensive rating as control and order parameters. Scientific literature in coordination dynamics applied to sports contest is poor. In basketball, the work of Bourbousson, et al., (2010b) is the only one available. Basketball games show commons characteristics with systems theory. Stabilities and instabilities periods, perturbation and in-phase and anti-phase states have been identified. The offensive rating of a minute is not independent of the prior minute thanks to the smooth method (Lames, 2006).

The discussion will start in the game example in Figure 2. The match coordination begins with both teams in-phase (0°-90°). Since this period, relative phase increases gradually, going trought differents in-phase and anti-phase states according to ofensive rating of competitive teams. These collective efficacy evolved in differents ways during the game, with away team being more effective at the beginning, meanwhile home team will be more effective during the rest of the game. This change in ofensive rating is reflected in relative phase, that changes from a in-phase state to an anti-phase state (14´-24´). The score difference changes from away to home leads. This changes, have been identified as game pertubations (Bourbousson, et al., 2010b). Hughes, Howells, and Hughes (2006), stablished that instability periods have been created by perturbations, until the systems re-organize itself. This pertubation can lead teams to create and advantage in the game. This is a critical aspect of sport (Bourbousson et al., 2010b). Time outs and break between quarters are examples of them. In this time, coaches have assessed teams' performance and

adjust strategies. Gréhaigne, Bouthier and David (1997), suggest that team's opposition creates unexpected, and need to adjust every subsystem.

In first period of game, the system shows an in-phase attractor. This seems logic because of the nature of the game, with a constant exchange of ball possession. Teams try to search the better plays for that game, without taking risks. At this stage of the macth, time is not determinant as in the end of the game, and teams take advantage of it. Lames and McGarry (2007) explain the sport contest as an interaction of two teams in function of time. Second periods, when games go near the end, are attracted to victory. This attractor make teams more proactive looking for perturbations to destabilize the dyad and win the confrontation (Vilar et al., 2012). Constraints based approach stablish that pattern formation emerges from information received by the system (Glazier, 2010). Score development is an important source of information (enviromental constraint). Teams interacting in function of the contrary, and stability of systems depends on the information that the systems can achieve from the environment (Richardson, Marsh, Isenhower, Goodman and Schmidt, 2007). Point´s difference and time to the end of the game makes changes in performance and style of plays of confronting teams. Coaches desing differents rhytmths according to match status. This lead to systems that involve several perturbations that take teams through stable to instable state.

Constraints based approach is a potential pedagogical tool to develop players to a higher performance (Glazier, 2010). This framework changes task constraints with the purpose of improve qualitative information and decision-making (Gréhaigne, Godbout and Zerai, 2011). These principles can be applied in basketball. Creating different game scenarios (time, score development…) that forced the teams, as a system, to learn optimal solutions. Coaches have to design training situations that demand the use of sources of information from performance environment to solve game problems (Vilar et al., 2012). Coaches cannot predict the unexpected, but they have to prepare their teams to achieve solutions that emerge through team self-organization (Glazier, 2010; Ortega, Jiménez and Olmedilla, 2008).

In conclusion, the findings identified order parameter (offensive rating) and control parameter (time) that allowed capturing basketball contest in terms of dynamical systems theory. Stabilities, instabilities and transitions periods, as well as perturbations were identified. And indeed the ACB basketball league showed different game dynamics.

Agradecimientos

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TEORÍA DE SISTEMAS COMPLEJOS EN DEPORTES DE EQUIPO. APLICACIÓN AL 5 CONTRA 5 EN BALONCESTO

PALABRAS CLAVE: Sistemas complejos, Baloncesto, Eficacia ofensiva.

RESUMEN: El objetivo del siguiente estudio fue analizar la competición de baloncesto como un sistema complejo, utilizando como parámetros de orden y control la eficacia ofensiva y el tiempo. Se analizaron los partidos de la liga A.C.B. de baloncesto en la temporada 2007-08, seleccionado para el estudio dinámico los 73 partidos que no se consiguen explicar mediante el análisis dinámico. A través de la transformada de Hilbert se halló la fase relativa de los equipos en competición. Los resultados muestran periodos de estabilidad, inestabilidad y transición, tanto en fase como en anti fase. También se encontraron perturbaciones en el desarrollo del juego que llevan al sistema desde un estado estable a otro inestable. Los resultados del estudio avalan el análisis de los partidos de baloncesto a través de la teoría de sistemas. Los entrenadores deben preparar a sus equipos para ser capaces de obtener la información del entorno de competición y buscar nuevas soluciones a los problemas emergentes del juego.

TEORIA DE SISTEMAS COMPLEXOS EM DESPORTOS DE EQUIPA. APLICAÇÃO AO 5 CONTRA 5 NO BASQUEBOL

PALAVRAS-CHAVE: Sistemas complexos, Basquetebol, Eficácia ofensiva.

RESUMO: O objetivo deste estudo foi analisar a competição de basquetebol como um sistema complexo, utilizando como parâmetros de ordem e controlo a eficácia ofensiva e do tempo. Analisaram-se os jogos da liga A.C.B. de basquetebol na temporada 2007-08, selecionado para o estudo dinâmico os 73 jogos que não se conseguem explicar através da análise dinâmica. Através da transformação de Hilbert analisou-se a fase relativa das equipas em competição. Os resultados mostram períodos de estabilidade, instabilidade e transição tanto na fase como na anti-fase. Também se verificaram perturbações no desenvolvimento do jogo que conduz ao sistema a partir de um estado estável para outro instável. Os resultados do estudo suportam a análise dos jogos de basquetebol a partir da teoria de sistemas. Os treinadores devem preparar as suas equipas de forma a obter a informação sobre o contexto de competição e procurar novas soluções para os problemas emergentes do jogo.

References

Araújo, D., Davids, K. and Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise*, 7(6), 653-676.

Bourbousson, J., Sève, C. and McGarry, T. (2010a). Space-Time coordination dynamics in basketball: Part 1. Intra- and inter-couplings among player dyads. *Journal of Sports Sciences, 28*(3), 339-347

Bourbousson, J., Sève, C. and McGarry, T. (2010b). Space-Time coordination dynamics in basketball: Part 2. The interaction between the two teams. *Journal of Sports Sciences, 28*(3), 349-358.

Davids, K., Araújo, D. and Shuttleworth, R. (2005). Applications of dynamical systems theory to football. *In Science and Football V: The Proceedings of the 5th World Congress on Sports Science and Football*. T. Reilly, J. Capri and D. Araújo (Eds.). London: Routledge.

Duarte, R., Araújo, D., Davids, K., Trasvassos, B., Gazimba, V. and Sampaio, J. (2012). Interpersonal coordination tendencies shape 1-vs-1 sub-phase performance outcomes in youth soccer. *Journal of Sports Sciences*, *30*(9), 871-877.

Glazier, P. S. (2010). Game, Set and Match? Substantive Issues and Future Directions in Performance Analysis. *Sports Medicine*, *40*(8), 625-634.

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

Grehaigne, J., Godbout, P. and Zerai, Z. (2011). How the "rapport de forces" evolves in a soccer match: the dynamics of collective decision in a complex system. *Revista de Psicología del Deporte, 20*(2), 747-765.

Hughes, M. T., Howells, M. and Hughes, M. (2006). Using perturbations in elite men's squash to generate performance profiles. *Cultura, Ciencia y Deporte*. *Congreso mundial deportes de raqueta, 2,* s30.

Ibáñez, S. J., García, J., Feu, S., Lorenzo, A. and Sampaio, J. (2009). Effect of consecutive basketball games on the game-related statistics that discriminate winner and losing teams. *Journal of Sports Science and Medicine, 8*, 458-462.

Lames, M. (2006). Modelling the interaction in game sports – relative phase and moving correlations. *Journal of Sports Science and Medicine, 5*, 556-560.

Lames, M. and McGarry, T. (2007). On the search for the reliable performance indicators in game sports. *International Journal of Performance Analysis in Sport, 7*(1), 62-79.

Oliver, D. (2004). *Basketball on paper. Rules and Tools for Performance Analysis*. Washington, DC: Brassey's Inc.

Ortega, E., Jiménez, J. M. and Olmedilla, A. (2008). Utilización del vídeo para la mejora de la percepción subjetiva de la eficacia competitiva y del rendimiento en jugadores de baloncesto. *Revista de Psicología del Deporte, 17*(2), 279-290

Richardson, M. J., Marsh, K. L., Isenhower, R. W., Goodman, J. R. L. and Schmidt, R. C. (2007). Rocking together: dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science, 26,* 867-891.

Rosenblum, M. G., Pikovsky, A. S. and Kurths, J. (1996). Phase synchronization of chaotic oscillators. *Physical Review Letters, 76* (11), 1804-1807.

Sampaio, J., Lorenzo, A. and Ribeiro, C. (2006). Momentos críticos en los partidos de baloncesto: metodología para identificación y análisis de los acontecimientos precedentes. *Cultura, Ciencia y Deporte, 5*(2), 83-88.

Sampedro, J. and Prieto, J. (2012). El efecto de marcar primero y la ventaja de jugar en casa en la liga de fútbol y en la liga de fútbol sala de España. *Revista de Psicología del Deporte, 21*(2), 301-308.

Thomas, J., Nelson, J. and Silverman, S. (2006). *Research Methods for Physical Education and Sport*. Champaign, IL: Human Kinetics.

Trasvassos, B., Araújo, D., Vilar, L. and McGarry, T. (2011). Interpersonal Coordination and ball dynamics in futsal (indoor football). *Human Movement Science*, *30*, 1245-1259.

Vilar, L., Araújo, D., Davids, K. and Trasvassos, B. (2012). Constrsints on competitive performance of attacker-defender dyads in team sports. *Journal of Sports Sciences, 30*(5), 459-469.