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Identifying individuality and variability in team tactics by means of statistical shape analysis and multilayer perceptrons

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A B S T R A C T

Offensive and defensive systems of play represent important aspects of team sports. They include the players' positions at certain situations during a match, i.e., when players have to be on specific positions on the court. Patterns of play emerge based on the formations of the players on the court. Recognition of these patterns is important to react adequately and to adjust own strategies to the opponent. Furthermore, the ability to apply variable patterns of play seems to be promising since they make it harder for the opponent to adjust.

The purpose of this study is to identify different team tactical patterns in volleyball and to analyze differences in variability. Overall 120 standard situations of six national teams in women's volleyball are analyzed during a world championship tournament. Twenty situations from each national team are chosen, including the base defence position (start configuration) and the two players block with middle back deep (end configuration). The shapes of the defence formations at the start and end configurations during the defence of each national team as well as the variability of these defence formations are statistically analyzed. Furthermore these shapes data are used to train multilayer perceptrons in order to test whether artificial neural networks can recognize the teams by their tactical patterns.

Results show significant differences between the national teams in both the base defence position at the start and the two players block with middle back deep at the end of the standard defence situation. Furthermore, the national teams show significant

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differences in variability of the defence systems and start-positions are more variable than the end-positions. Multilayer perceptrons are able to recognize the teams at an average of 98.5%.

It is concluded that defence systems in team sports are highly individual at a competitive level and variable even in standard situations. Artificial neural networks can be used to recognize teams by the shapes of the players' configurations. These findings support the concept that tactics and strategy have to be adapted for the team and need to be flexible in order to be successful.

1. Introduction

Team sports are important fields of application in sport science. Many influencing factors occur during a match while two teams compete with each other. Just as well there is a broad variety of approaches to analyze such complex phenomena in sports.

One major goal of these approaches is the analysis of performance that has strong practical value for optimizing training processes in competitive sports. Usually, through notational analysis (see Hughes & Franks, 2004 for a review) coaches can identify good and bad performances based on well-chosen performance indicators and thus facilitate comparative analysis of individuals, teams and players (Hughes & Bartlett, 2008). Performance indicators are a selection, or combination, of action variables that aim to define some or all aspects of performance (Hughes & Bartlett, 2002). For instance, time-motion analysis may be used in team games to determine movement profiles of players during competition or training. They give information about the frequency, duration and distribution of match time among different classes of stationary and locomotive movement in many team sports (O'Donoghue, 2008). However, notational analysis is not only applied in team sports like basketball or soccer, there are also notational systems for individual sports like tennis and boxing (Hughes, 2008).

Analysis systems in general may use different underlying models of sports contests (McGarry & Perl, 2004). Whether Markov chains (Eom, 1988; McGarry & Franks, 1994, 1995), dynamical systems theory (McGarry, Anderson, Wallace, Hughes, & Franks, 2002) or artificial neural networks models (Perl, 2002), each model of sports contests has common methods for analysis purposes. For instance, the interaction of two players in squash may be investigated by the phase relation between them (McGarry, Khan, & Franks, 1999) or the interaction of two handball teams by random walk analysis of the scoring process (Lames, 2006).

An expanding area of game analysis uses artificial neural networks for the recognition of patterns. Such patterns of play, which involve the players' positions for instance, are notably important since the ability to recall and recognize an evolving pattern of play is a strong predictor of anticipatory skill (Williams, 2002). Such patterns of play and the process of their changes within a game or rally are usually analyzed by self-organizing maps (SOM) (Perl & Dauscher, 2006). Recently, a further development of SOM, the dynamically controlled network concept (DyCoN) (Perl, 2002), has been applied to assess game intelligence and creativity in team sports (Memmert & Perl, 2004, 2006). However, patterns of players' configurations do not only occur in processes during a match but also at certain situations in team sports as a hierarchical cluster analysis shows (Jäger & Schöllhorn, 2007). Thus, two different approaches may be distinguished depending on the focus and the aim of a study: a more situation-oriented (time discrete) approach that deals with particular moments during a match or a rally and a more process-oriented (time continuous) approach that takes changes of certain situations into consideration.

The application of a SOM/DyCoN concept in volleyball shows that these kinds of artificial neural nets are able to classify patterns of configurations and patterns concerning their change during games (Jäger, Perl, & Schöllhorn, 2007). However, neither the neural network approach with SOM/DyCoN nor the hierarchical cluster analyses of team tactics usually include statistical tests of significant differences in typical configurations. Both the SOM/DyCoN with its unsupervised learning