FOOTBALL (SOCCER) PLAYERS KINEMATICS AT DIFFERENT DEVELOPMENT LEVELS. PART ONE: ACQUISITION AND PROCESSING OF DATA

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The paper presents description of different, but mostly image, technological approaches to obtain kinematic data of football players. Authors' technology was presented for acquiring and processing data of soccer players at different development levels.

KEY WORDS: football, soccer, kinematics, research method

INTRODUCTION: There are different national styles of playing and there are also many different approaches to the tactics of play. The most impressive tactics were those called *"arte football"* played by Brazilians*, "total football"* played by the Dutch *"catenacio"* played by Italians, who mastered defensive play, or *"organization football"* played by Germans*.* (Eisenberg et al., 2004).
Also different tactics of a play refers to the players of different age and level of development. The overall aim of this research work was investigation of kinematic data of a play of football players at different level of development. The aim of this particular paper was a presentation of different approaches by several researchers and by the authors to the acquisition and processing of football kinematic data.

TECHNOLOGICAL APPROACH TO KINEMATIC INVESTIGATIONS OF GAMES

Analysis of games for many years has been based on 'observation sheets' filled in during the match and chalk and board. Then maps of the pitch were utilized sometimes joined with the use of audio recording for more detailed description of intensity of movement (e.g. Reilly and Thomas, 1976). A technology which used film for recording a match was expensive and rarely used for longer time of playing. Introduction of television technology, and especially video, opened very broad possibilities of recording and analyzing tactics of players.
Ohashi et al. (1988) in Japan used two television cameras mounted on tripods. Between a camera and a tripod potentiometer was installed. Every rotational movement of a camera was acquired and sent to the computer. Since a camera was aimed all the time onto the one particular player his position on the pitch and then displacement versus time was calculated .
Erdmann (1987, 1993) in Poland proposed recording of a match using stationary video camera equipped with a wide-angle (130^{O}) lens. Camera was situated at an elevated level and at far distance from the pitch. In a viewfinder of a camera the whole pitch was seen. In this way it was possible to obtain data on a position of every player, at every place of a pitch, and at every second of a match – Figure 1.

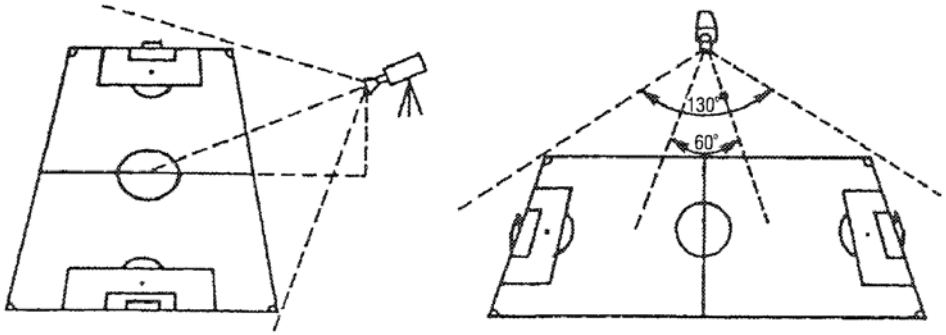


Figure 1: Recording of data (Erdmann, 1987, 1993).

Church and Hughes (1987) and Hughes et al. (1988) in England and Dufour in Belgium (1993) presented systems were one had to observe a game on the monitor's screen and also

touched a digital panel with a stylus. On a panel there was a pitch's map. At the same time the first operator commented on the actions he saw on the screen so that the second operator could input necessary data on a keyboard with 127 sensors. According to Dufour this system is used since 1966.
In 1990 Sušanka in Czechoslovakia offered another system for computerization of sport games (Drobny, 1990). In the United States Friedman and Kotas (ah, 1995) used a laptop on-line during the game. One of the authors observed a match and second author input data to the computer through a keyboard. During a brake of a match they were ready to back a coach with their data to improve his decisions.
At the end of the XXth century and at the beginning of the XXIst century next technological and research works appeared devoted to semi-automatic and automatic tracking of players in the pitch. For example Soto Hermoso (2002) from Spain presented a system where two video cameras were used and an operator has to track manually the position of a player on the screen during playback. Barros et al. (2001) from Brazil presented a system which used 4 video cameras, each recording another part of a pitch. Computerized system enabled automatic tracking of all players' positions at the same time. Only longer mutual occlusion of players needed intervention by the operator.
There are few other technologies used for tracking players during the game. They are used in different disciplines. Those which went the furthest for automatic tracking are used in American football and in ice hockey. Except using image methods global positioning system (GPS) and sensors mounted on a player or on a hockey stick are used.

MATERIAL AND METHOD: The paper presents investigations on three groups of players belonging to different levels of development. The groups were as follow:

A. International players playing at "A" level matches.
B. International players playing at Olympic level matches.
C. International players playing at U-16 level matches.

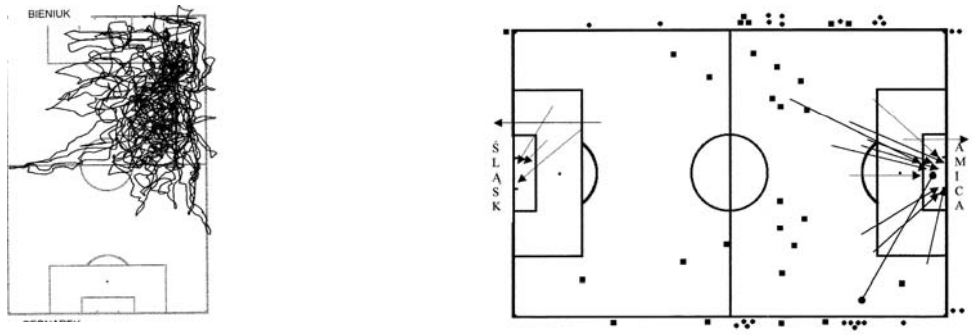
In this paper the following matches were analysed: 1) Poland – England (A level), 2) Poland – Italy (A level), 3) Poland – Norway (Olympic level), 4) Poland – Germany (U-16 level).
The acquisition of data was obtained using Erdmann's EMRA method (see Figure 1 B). Also processing of data was done according to that method (Erdmann, 1995). All kinematic data were calculated according to individual players, group of players, and the whole team. The following kinematic data were obtained: a) position (according to side lines of a pitch), b) displacement (m), c) time (s), d) velocity (m/s), e) acceleration (m/s^2). The above quantities were calculated based on 1/10 of a second. Since a match lasts 90 min = 5400 s, so for one player there were 54000 × 2 = 108000 lines representing position (X and Y) of a player on the pitch during the whole match.
For biomechanical and physiological evaluation additional data were obtained (Dargiewicz 2005). For every player a distance covered with velocity above anaerobic threshold was presented. Also special indexes /1/ and /2/ were calculated:

$$IKP = (TD \times |aD|) / (Tt \times st) \qquad /1/$$

where: IKP – Index of kinematics of play, TD – total distance covered, aD – distance covered with acceleration counted for metabolism above anaerobic threshold, Tt – total time of play, st – standing time.

$$IAM = (D+ / TD) \times 100 \qquad /2/$$

where: IAM – Index of anaerobic metabolism, D+ - distance covered with a velocity above anaerobic threshold, TD – total distance covered.
The data processing of recorded games was done using computer program BANAL (Kuzora 1996, Kuzora and Erdmann, 1998) – Figures 2 and 3.



A **B**

Figure 2: Analysis of a match (Dargiewicz et al., 2005): A – displacement of a left defender for 45 min., B – shots to the goal, throw-ins, and free kicks.

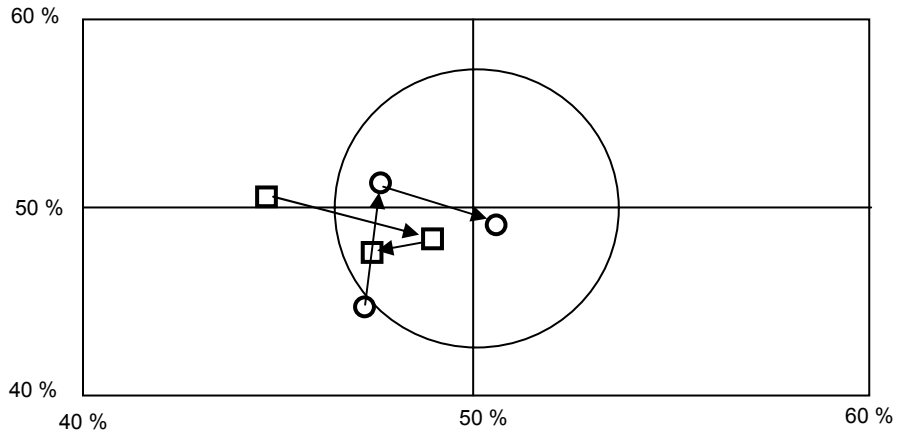


Figure 3: Positions for every 15 min. intervals of the match time of Polish team points (circles – I half, squares – II half). Abscissa – distance from own goal. At the same time English team had data from 51 to 56 %. English team won the match 2:0 (from: Dargiewicz, 2005).

The BANAL program enables semi-automatic tracking of an object. In this paper playback of a match and digitized tablet for input of player's position during the entire match were used.

DISCUSSION: Half a century ago football players ran during the entire match no more than 3-5 km. Now the best players run more than 10-12 km, and sometimes more than 15 km. Also important to know is how they utilize their running, how it is effective. Specific analyses of the play give the possibility to answer the questions.

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