

SPORT PERFORMANCE PROFILE IN MEN'S EUROPEAN MODERN HANDBALL: DISCRIMINANT ANALYSIS BETWEEN WINNERS AND LOSERS

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ABSTRACT

Research background and hypothesis. Europeans have won Olympic and world gold medals since modern indoor men's handball became an international sport (1938) and an Olympic sport (1972) (www.ihf.com). Nevertheless, no research has been carried out in order to find out the tendencies in European modern men's handball.

Research aim of this study was to illustrate discriminant indicators of sport performance between winners and losers in European men's modern handball match activities.

Research methods. Data sets were gathered from the European Handball Federation (EHF) website (<http://www.eurohandball.com>) covering the five European Men's Handball Championships (EMHC): 2002, 2004, 2006, 2008 and 2010 ($n = 239$ matches). Each match was classified as successful and non-successful for each team, and then the number of analysed matches doubled to 478. We examined 28 variables of sport performance, but only 15 key indicators where significant discriminant between winners and losers at least in one EMHC was shown.

Research results. Winners scored more goals ($p < 0.01$, $p < 0.001$), were better in total attack ($p < 0.001$) and positional attack ($p < 0.01$, $p < 0.001$), performed more efficiently in shooting total ($p < 0.001$) and shooting from long distance ($p < 0.01$, $p < 0.05$), and goalkeepers saved more throws ($p < 0.05$, $p < 0.001$).

Discussion and conclusions. Winning and losing teams played in the same pattern ($p > 0.05$). In many cases the separate match-play was determined by using temporal model of playing style. The phenomenon is that teams scored more goals in the second half than in the first one despite the fact that players' activities decreased in the second half. Sport performance profile in European modern handball can generate a useful database.

Keywords: sports games, performance analysis, elite athletes.

INTRODUCTION

Europeans have won Olympic and world gold medals since modern indoor men's handball became an international sport (1938) and an Olympic sport (1972) (www.ihf.com). Whilst European men were leaders in world handball, they did not compete in continental championships until the European Handball Federation (EHF) was founded (1991). European championships (EC) have been organised every two years since 1994. In the beginning of the EC (1994–2000), 12 teams competed in the final stage. However, the rapid popularity of the game convinced the EHF to enlarge the number of teams to 16 in 2002

(www.eurohandball.com). This fact determined the need to carry out a sport performance analysis of European men's modern handball.

Sport performance requires an athlete to integrate many factors (Smith, 2003). Evaluation is an essential component because it provides the coach with a means of establishing norms from the model. Moreover, the development of a database is a crucial element. If the database is large enough to formulate predictive models as an aid to the analysis of sports, it will, subsequently, enhance future training and performance (Hughes, Bartlett, 2002; Hughes, Franks, 2006).

The main method of objectifying the process in sports games is the use of notational analysis. One of the main purposes of notation is statistical compilation (Franks, 2006). Notational analysis can be used to determine the key indicators of performance (Taylor et al., 2007). Full and objective interpretation of the data from the analysis of a performance and comparison of data are vital (Hughes, Franks, 2006). The existence of structure in sport competition is implicated in the widespread practice of using the information gathered from a past contest to prepare for a future contest (McGarry et al., 2002). If a large number of players are observed, mean values yield important information about activity and fitness profiles and how these might vary with different team configurations. Fitness profiling can generate a useful database (Reilly et al., 2000). Performance indicators should relate to successful performance or outcome. Analysts and coaches use performance indicators to assess the performance of an individual, a team or elements of a team, using in a comparative way, with opponents, other athletes or peer groups of athletes or teams, but often they are used in isolation as a measure of the performance of a team or individual alone. Notational analysts have focused on general match indicators (Hughes, Barlett, 2002; James et al., 2005).

Typically, indicators of team performance are provided from the comparison of winning and losing teams (Jones et al., 2004). There are different aspects of performance profiles, assessing, for example, positive and negative aspects of attacking and defensive play (Ortega et al., 2009). However, comparing winning and losing indicators may result in a potential loss of any meaningful information due to each team possessing different styles of play and diverse performance profiles (Taylor et al., 2005). Some studies (Jones et al., 2004) considered the winning and losing performances of a single team and found a number of significant statistical differences. Nevertheless, studies comparing successful teams have been popular as they can identify the reasons why certain individuals or teams dominate a particular sport (Hughes, Franks, 2006). In order to enable a full and objective interpretation of the data from the analysis of a performance, it is necessary to compare the collected data with the aggregated data of a peer group of teams, or individuals, which compete at an appropriate standard (Hughes, Barlett, 2002).

Any quantitative analysis must be logically structured of the game itself, defining the possible actions and the possible outcomes (Hughes, Franks, 2006 a). The research related to identifying the efficiency indicators in a game, which have the power to discriminate between winning and losing teams, was conducted in sports such as basketball (Mendes, Janeira, 2001), but not in handball. Feedback is a concept that originated in control theory for close-loop systems designed to keep homeostasis or equilibrium around a reference value a priori set. Feedback may change the attitude of players in their thinking about and analysis of personal performance (Franks, 2006).

The increasing demand for ever higher top-level achievements in sport in general (Hughes, Bartlett, 2002), including handball, has meant greater interest and research into the factors which influence performance and sporting achievements (Gómez et al., 2008). Discriminant analysis between elite and non-elite players reveals that height, running speed and agility are important parameters for talent identification in youth handball (Mohamed et al., 2009).

Handball is a complex sport whereby performance can be analysed and presented in a variety of ways. Variables of sport performance in handball are obtained from the trained staff of observers, who follow all matches of the Olympics and World Championships (IHF), and in the European Championships (EHF). Match statistics are given directly after the match in digital version and can be seen on the websites of the IHF (www.ihf-info.com) or the EHF (www.eurohandball.com). Trend analysis after the end of each EC is provided by the EHF handball experts (Mocsai, 2002; Sevim, Taborsky, 2004; Pollany, 2006, 2010; Hergeirsson, 2008). Performance and success in team handball depend on many factors, and efficacy models are different with each team and almost each match. Analysis of women's handball WC'2003 results showed that the performance of the teams in each group might be described by different performance factors (Ohnjec et al., 2008).

Y. Sevim and M. Bilge (2004) analysed sport performance in Athens OG, EC'2004 and WC'2005 men's handball. For the analysis, they selected variables of attacks, goal throws and goalkeeper. The authors concluded that handball was now being played quickly and dynamically, with attractive and fast individual and group combinations. Goalkeepers were also seen as crucial for winning

a game. F. Taborsky (2008) suggested that attacks and shooting efficiency, mistakes were the key indicators for winning at the Beijing OG men and women tournament, but not goalkeepers' efficacy in the men's game.

M. Wiemeyer (2008) analysed the difference between winners and losers in the EC 2002–2006. They suggested that some variables might be specific to one or two championships and thus considered as 'short-term fashion' in the development of handball tactics. They concluded that in the EC'2000 variables of defensive tactics dominated, whereas offensive tactics were more important in the EC'2002 and 2004, and steals in the EC'2006.

It is unclear how European men's modern handball has developed over the last decade in general. A review article by G. Ziv and R. Lidor (2009) indicated that longitudinal studies were lacking in handball research.

The aim of this study was to use a combination of notational analysis and historical records to illustrate discriminate indicators of sport performance between winners and losers in European men's modern handball match activities in the last decade.

We hypothesized that winners played more dynamic handball, used greater ratio of counterattacks, and played more efficiently in this pattern.

RESEARCH METHODS

The data sets gathered from the EHF website (<http://www.eurohandball.com>) cover the five European Men's Handball Championships (EMHC) held in 2002 (Sweden), 2004 (Slovenia), 2006 (Switzerland), 2008 (Norway) and 2010 (Austria). The same number of 16 teams, and the same competition system, except the number of matches played for the ranking, were used in the years 2002–2010 of the EMHC. Both mentioned factors determined selection of the particularly EMHC for the analysis. We used data from all 239 matches (Table 1). Ethics approval was not required as the data sets are publically available at the EHF website (<http://eurohandball.com./activitiesnew/analysis>). No interventions were required for data gathering.

Data collection. The indices of each match of sport performance were analysed using 'Match Team Statistics' from the EHF site (<http://eurohandball.com./activitiesnew/analysis>). According to the EMHC regulations, winners of a match are awarded 2 points, 1 point for a draw, and losers get 0 points. Each match was classified as successful (won match and draw – for both teams) and non-successful for each team. Then, the number of analysed matches doubled to 478.

Sport performance indicators. Sport performance indicators were determined by the given match statistics on the EHF website. Later

Table 1. Number of matches, players and competition system design of the EMHC in 2002–2010

European Men's Championships	2002	2004	2006	2008	2010	Total
Matches analysed, n	50	48	47	47	47	239
Champions	Sweden	Germany	France	Denmark	France	
Competition system, matches played and maximum points earned by one team						
Places 1–4	8 matches – maximum 16 points					
Placement matches	Places 7–12	Places 5–8	Places 5–6	Places 5–6	Places 5–6	
	7 matches – maximum 14 points					
Non-holding of placement matches	Places 9–12	Places 7–12	Places 7–12	Places 7–12	Places 7–12	
Places 13 to 16	6 matches – maximum 12 points					
	3 matches – maximum 6 points					
Winners & Losers						
Matches won + (draw*2)	43+(7*2) = 57	41+(7*2) = 55	44+(3*2) = 50	43+(4*2) = 51	40+(7*2) = 54	267
Matches lost	43	41	44	43	40	211
Cases analysed	100	96	94	94	94	478

circumstance was limitation factor to choose key indicators of sport performance: goals, attacks, shots, goalkeeper's playing efficacy, positive actions (steals, 7 metres throw earned, shots blocked) and negative actions (2 minutes suspension, turnovers). For the purpose of determining the features of playing style (ratio of positional and counterattacks) we used the formula:

$$R_p = (P / A) * 100,$$

where R_p is the ratio of positional attacks, P is the number of positional attacks and A is the number of total attacks. Rest percentage ratio of attacks were considered as the counterattacks ($R_c = 100 - R_p$). The ratio of individual and team counterattacks from overall counterattacks, goals from positions and durations and goalkeeper's playing efficacy were calculated similar to attacks.

Data analysis. A discriminant analysis was employed to identify a subset of game-related statistics that discriminated between winning and losing teams in each of the five EMHC. In the final discriminant model were included the variables with significant inequality of group means (the Wilks' Lambda Statistic) and with highest absolute values of the correlation coefficient between discriminating variables and standardised canonical discriminant functions. The indicators of champions, teams of 1–4, 5–12 and 13–16, were compared across EMHC'2002–2010, using a general linear model analysis of variance (ANOVA), with Tukey Post Hoc test using PASW 18.0 statistical package. The ANOVA was evaluated as significant when there was a < 5% chance of making a type I error ($p < 0.05$).

RESEARCH RESULTS

Game-related statistics that discriminate between winners and losers. The results allowed discrimination between winning and losing team performances through the following game-related statistics. In all events, i. e. EMHC'2002–EMHC'2010, the discriminant models are as a whole significant; Wilks' lambda is significant at the level below 0.001, the canonical correlation, where the squared canonical correlation is the per cent of variation in the dependent discriminated by the independents in discriminant analysis, and is in the range 0.943–0.999. The Box's M test validates the homogeneity of covariance matrices between

groups and the discriminant function obtained correctly classified 100% of the cases.

We analysed 28 variables of sport performance, but only 15 key indicators with significant discriminant between winners and losers at least in one EMHC. This is presented in Table 2. Winners were better ($p < 0.05$, $p < 0.01$, $p < 0.001$) than losers in 6 indicators throughout EMHC'2002–2010. Winners scored more goals ($p < 0.01$, $p < 0.001$), were better in *total attacks* ($p < 0.001$) and *positional attacks* ($p < 0.01$, $p < 0.001$), performed more efficiently in *shooting total* ($p < 0.001$) and shooting from *long distance* ($p < 0.01$, $p < 0.05$), and *goalkeepers saved* more throws ($p < 0.05$, $p < 0.001$).

Attack structure and efficacy. Besides the data presented in Table 2, we analysed the ratio of positional and counter-attacks, the efficacy of the latter and the efficacy of individual counter-attacks and team counter-attacks. No statistically significant differences were found in the mentioned indices except individual counter-attacks at the EMHC'2010 ($p < 0.05$). Winners played more efficiently in the majority especially at the EMHC'2002 ($p < 0.01$), 2004 ($p < 0.05$), 2006, 2008 ($p < 0.001$), but more efficiently in the minority at the EMHC'2010 ($p < 0.05$, $p < 0.01$, $p < 0.001$).

Shots. We analysed shots efficiency and goalkeeper's playing efficiency total as well as from long distance, 6 metres, 7 metres, wing positions and counter-attacks. Winners performed total shots better throughout EMHC'2002–2010 ($p < 0.001$), and from long distance ($p < 0.01$, $p < 0.001$). Wing players of winning teams performed better than the players of losing teams at the EMHC'2004 ($p < 0.01$); from 6 metres at the EMHC'2002, 2004 ($p < 0.05$); and 7 metres penalties at the EMHC'2004, 2006 ($p < 0.001$, $p < 0.01$ respectively).

Goalkeepers of winning teams saved throws better: in total throughout EMHC'2002–2010 more than goalkeepers from losing teams ($p < 0.05$, $p < 0.001$), and shots from long distances ($p < 0.05$, $p < 0.01$), except EMHC'2002.

Positive and negative indices. We analysed three positive (earned 7 metres penalties, steals, blocked shots) and two negative (turnovers, 2 minute penalties) actions. Winning teams were better than losing teams in blocked shots at the EMHC'2002–2008 ($p < 0.05$, $p < 0.01$, $p < 0.001$), except the last, EMHC'2010. Winners did not exceed losers in the other mentioned positive or negative indices throughout the analysed EMHC'2002–2010.

Table 2. Sport performance indicators of winners and losers in EMHC (mean \pm s)

Sport performance indicators	2002		2004		2006		2008		2010	
	Winners	Losers	Winners	Losers	Winners	Losers	Winners	Losers	Winners	Losers
Goals scored	28.7 \pm 2.6	23.7 \pm 1.9***	29.5 \pm 1.9	25.0 \pm 1.4***	32.3 \pm 2.6	26.9 \pm 2.6***	30.2 \pm 2.8	25.4 \pm 4.1***	30.8 \pm 2.7	26.6 \pm 3.7**
Goals missed	24.7 \pm 3.8	28.9 \pm 1.7***	25.7 \pm 1.5	28.0 \pm 2.1**	28.1 \pm 2.4	31.6 \pm 2.5***	25.9 \pm 1.5	29.8 \pm 4.1**		
Attacks efficiency, %	53.2 \pm 3.5	44.0 \pm 3.3***	52.1 \pm 1.9	44.9 \pm 1.9***	54.8 \pm 4.2	46.6 \pm 4.4***	51.9 \pm 2.1	43.0 \pm 5.8***	54.2 \pm 4.1	46.6 \pm 4.2***
Efficiency of positional attacks	50.9 \pm 4.3	43.1 \pm 4.2***	50.5 \pm 2.3	42.9 \pm 2.8***	52.4 \pm 4.9	42.8 \pm 5.6***	48.8 \pm 4.9	42.6 \pm 6.8**	52.3 \pm 4.2	43.8 \pm 3.6***
Efficiency of individual counter-attacks									77.5 \pm 31.5	45.3 \pm 40.5*
Number of players	66.2 \pm 16.1	51.6 \pm 13.3**	57.3 \pm 5.3	51.9 \pm 5.0*	65.2 \pm 11.3	51.6 \pm 8.3***	66.9 \pm 10.9	48.6 \pm 12.8***		
Efficiency of shots, %									47.6 \pm 12.5	35.1 \pm 14.1*
Total	58.8 \pm 4.5	48.3 \pm 5.8***	58.3 \pm 4.5	48.5 \pm 3.2***	60.3 \pm 3.3	51.9 \pm 5.9***	59.4 \pm 2.2	49.2 \pm 6.4***	59.7 \pm 4.1	53.3 \pm 4.1***
Long distance	43.4 \pm 7.8	33.7 \pm 7.2**	43.3 \pm 1.9	28.8 \pm 3.5***	45.9 \pm 7.2	36.5 \pm 7.1***	44.2 \pm 6.1	36.4 \pm 8.5**	44.1 \pm 5.3	37.6 \pm 6.9**
Wings			55.5 \pm 8.7	46.7 \pm 4.2**						
6 m	68.8 \pm 7.9	58.6 \pm 14.4*	69.2 \pm 12.4	78.5 \pm 7.9*						
7 m			75.2 \pm 11.0	59.9 \pm 6.1***	78.5 \pm 14.5	63.3 \pm 15.2**				
Total	37.3 \pm 5.5	29.9 \pm 4.6***	36.1 \pm 2.3	32.6 \pm 5.0*	35.7 \pm 4.3	28.4 \pm 3.9***	36.1 \pm 62.7	29.8 \pm 4.3***	33.6 \pm 4.1	29.4 \pm 4.9*
Long distance	49.7 \pm 7.4	38.3 \pm 9.7**			44.0 \pm 8.7	37.9 \pm 7.9*	48.4 \pm 5.7	39.5 \pm 8.4**	45.4 \pm 5.3	38.9 \pm 8.3*
Blocked shots	4.2 \pm 2.7	3.1 \pm 1.7*	5.1 \pm 1.1	2.5 \pm 1.1***	3.9 \pm 1.4	2.4 \pm 1.1**	3.7 \pm 1.6	2.6 \pm 1.1*		

Note: Data presented as means of means.

* – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$ between winners and losers of the same championship.

Dynamics of handball. Controversy results between indices of *attacks* by one team and goals scored by both teams per match were found (Figure 1). Despite variation of attacks and goals scored during EMHC'2002–2010, teams performed more attacks across all EMHC'2004–2006–2008–2010 compared to EMHC'2002 (53.6 ± 4.6). Attacks increased until the EMHC'2004 (59.1 ± 4.6 attacks), and to the EMHC'2006 (59.0 ± 4.2) ($p < 0.001$, $OP = 1.000$). Then, the number of attacks decreased at the EMHC'2008 (57.0 ± 5.5), but was still more than in 2002 ($p < 0.001$, $OP = 1.000$). In the last, EMHC'2010 (55.2 ± 9.1), attacks decreased, but were still 1.6 attacks more than in the EMHC'2002.

Goals scored by both teams per match increased across all EMHC ($p = 0.000001$, $OP =$

0.999) compared to EMHC'2002. Teams scored more goals until the EMHC'2006 (59.0 ± 6.2) – similar to increasing attacks. Furthermore, the number of goals scored by both teams decreased in the EMHC'2008 (55.8 ± 6.2) and increased again in the EMHC'2010 (56.5 ± 9.6).

Teams scored more goals in the second half than in the first (Figure 2) in all EMHC (EMHC'2002 – 27.2 ± 4.5 and 24.8 ± 4.1 , $p < 0.01$; EMHC'2004 – 30.2 ± 4.4 and 28.1 ± 3.7 , $p < 0.02$; EMHC'2006 – 30.2 ± 4.4 and 28.8 ± 4.0 , $p < 0.05$; EMHC'2008 – 28.1 ± 4.7 and 27.7 ± 4.3 , $p > 0.05$, respectively), but not in the EMHC'2010 (28.3 ± 7.8 and 28.2 ± 5.1 , $p > 0.05$ respectively). Difference between goals scored and goals missed slightly fluctuated from 4.3 to 4.9 goals during the last decade.

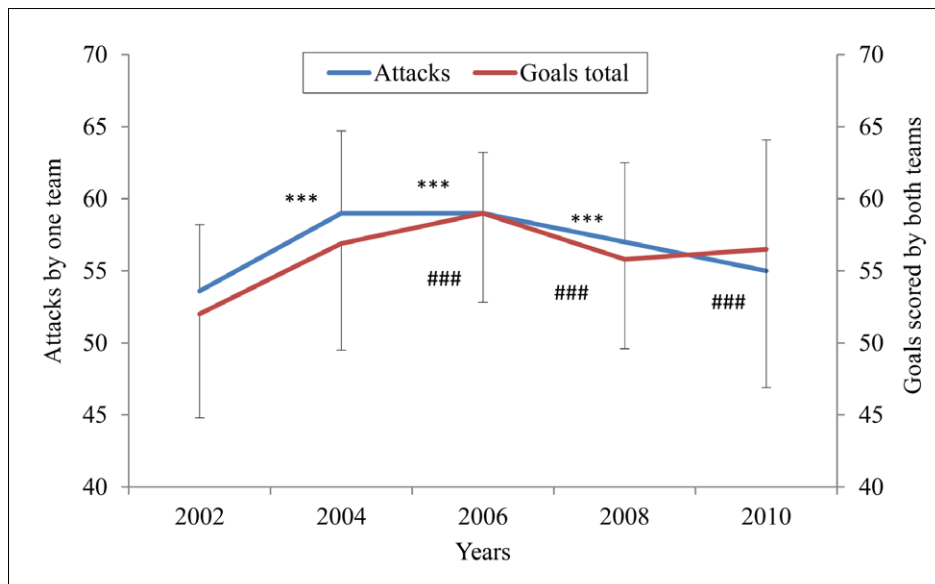


Figure 1. Attacks, goals scored in the years 2002–2010 of the EMHC (mean ± s)

Note. *** – $p < 0.001$ number of attacks compared to the EMHC'2002.
– $p < 0.001$ goals scored by both teams compared to the EMHC'2002.

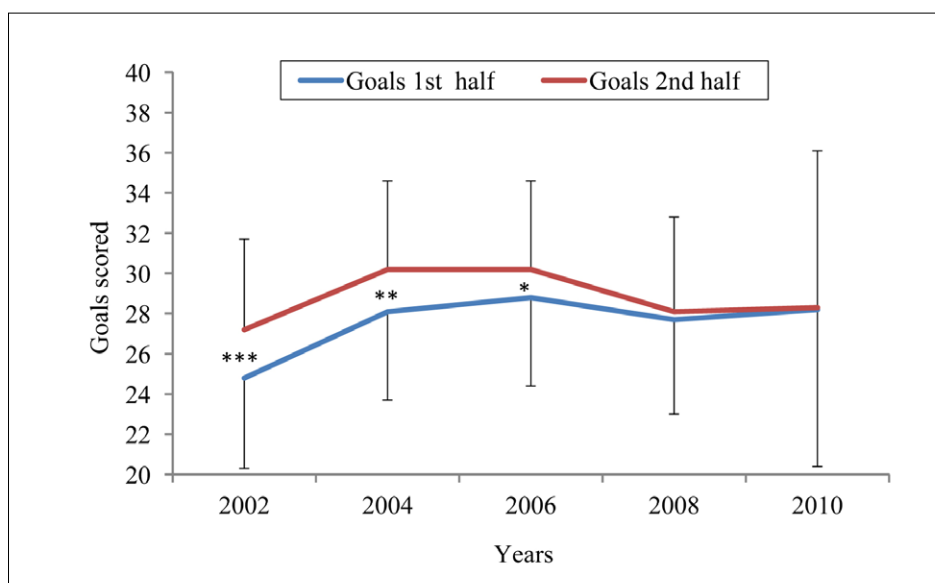


Figure 2. Goals scored in the halves in the years 2002–2010 of the EMHC (mean ± s)

Note: * – $p < 0.05$, ** – $p < 0.01$, *** – $p < 0.001$ between halves.

DISCUSSION

Pattern of European modern handball.

Attacks and goals. Changes in handball match activities are defined by the number of attacks and goals scored per match (Mocsai, 2002; Skarbalius, 2002, 2006, 2010; Sevim, Taborsky, 2004; Polany, 2006, 2010; Hergeirsson, 2008; Taborsky, 2008). Europeans performed the same numbers of attacks in the EMHC'2002–2010 as the teams in the last three Olympic Games handball tournaments. Teams performed 38.8 ± 5.9 attacks at Munich OG and $32.3, s = 9.7$ goals were scored per match only by both teams (Skarbalius, 2002, 2010). During four decades between the years 1972–2008 Olympic handball (OH) became more dynamic (Skarbalius, 2002, 2010): number of attacks increased ($p < 0.001$) by 17.2 attacks (Beijing OG, 56 ± 4.4) and goals scored by both teams increased ($p < 0.001$) by 22.3 goals (Beijing OG, 54.6 ± 6.9), but this was still 2.1 goals less compared to the EMHC'2010. Later findings suggest that the competitive level of European teams was higher in EMHC than that of the teams at the modern OG. However, no significant differences were found in attacks efficacy between OH at Beijing OG ($48.7 \pm 7.4\%$) and the EMHC'2010 ($48.3 \pm 7.3\%$). The fact that 50% of the matches at the EMHC'2010 were as close as 2 or less goal difference in the final score (Pollany, 2010) is evidence of equal ability (Mocsai, 2002; Pori et al., 2008). Our results are in line with general research on this subject and allow for the proposition that individual skills of European handball players are better and team actions in offence and defence are more balanced than OH. That said, there is no information on how playing faster or slower affects game performance. The activity profiles can also vary from game to game (Quarrie, Hopkins, 2007) depending on the strength of the opposition, the fitness of players, the consequences of previous games and a myriad of other factors (Drust et al., 2007).

Types of attacks. Empirical research investigating performance analysis in handball has been limited to studies exploring, for example, the patterns of team play. To date, there has been no performance analysis of elite men's handball, assessing team performance via the evaluation of team playing pattern indicators. Winning and losing teams in the EMHC'2002–2010 played in the same pattern ($p > 0.05$) because the ratio of positional attacks as well as counterattacks varied

slightly. The ratio of positional attacks for winners varied between 84.5–90.9% from total attacks, and between 86.4–90.4% for losing teams. The same ratio of positional attacks was found at the Beijing OG'2008 ($86.6 \pm 6.9\%$), but less as in the beginning of OH (Munich OG'1972 – $91.4 \pm 5.7\%$) (Skarbalius, 2002, 2010). The phenomenon of EMHC'2002–2010 is that winners exceed ($p < 0.01, p < 0.001$) losers throughout all the championships in efficacy of positional attacks, but moderate value of efficacy of positional attacks of European handball and the last three at the OH is the same (44–46%). Whilst these changes (Pyne et al., 2004) appear small in size (less than 1%), they have a substantial effect on the outcome of competition (Trewin et al., 2004).

Team counterattack is a considerable feature of modern handball (Sevim, Taborsky, 2004; Pollany, 2006, 2010; Hergeirsson, 2008). No significant difference of efficacy of team counterattacks were found in the EMHC'2002–2010 between winners and losers: i. e. they varied between 63–75% for winners and 59–66% for losers. Efficiency of individual attacks varied between 56.8–83.9% for winners and 45–82.3% for losers, but there was no significant difference between winners and losers, except EMHC'2010. This suggests that, within the international matches, individual events were more often part of larger temporal patterns and that more consistency in temporal structure exists within international matches (Borrie et al., 2002).

Majority. According to handball rules, players are allowed to play tough game and so they need to have excellent fitness. Players who commit fouls are punished by suspension of 2 minutes. Then opponents have superiority in terms of number. Winners and losers at the EMHC'2002–2010 performed the same 2 minutes faults (8–10 minutes per match), but winners played more efficiently than losers ($p < 0.05, p < 0.01, p < 0.001$) at the EMHC'2002–2008. The phenomenon is that winners performed losers better ($p < 0.05$) at the EMHC'2010 in minority. The latter findings are in line with OH where the teams who achieved higher placing performed more vigorous and aggressive actions, did not take risks and made more rules violations, but most frequently won the match (Skarbalius, 2002, 2010).

Goals after halftime. In the men's tournament the scores became closer in the second half, but the gap widened in women's handball (Pollany, 2010). Whilst the two standards of competition place similar physical and game-specific skill demands

on players during matches, variations do exist within a match between the two playing standards (Sirotic et al., 2009). Contrary findings have been obtained of match activities in rugby (Sirotic et al., 2009) and football (Reilly, 2005). Handball teams at the EMHC'2002–2006 ($p < 0.05$, $p < 0.01$, $p < 0.001$) scored more goals in the second half than in the first. These findings allow consideration of the excellent fitness of European handball players. However, controversy results have been shown at the EMHC'2006, where Scandinavian teams tend to be stronger offensively in the second half, but French teams perform less effectively (Pollany, 2006). Success at the EMHC'2010 was based upon the first half performance (Pollany, 2010).

Individual indices. *Shots* as the main action for scoring goals have a variety of attention in research (Bayios et al., 2001; Gorostiaga et al., 2005; Marques et al., 2007; van der Tillaar, Ettema, 2007; Wagner, Müller, 2008). The phenomenon of modern European men's handball is that the winners at EMHC'2002–2010 exceed ($p < 0.001$) the losers in total shooting performance and long distance ($p < 0.01$, $p < 0.001$) indicators. Winners performed shots better from 6 m at the EMHC'2002, 2004 ($p < 0.05$), and from 7 m penalties at the EMHC'2004, 2006 ($p < 0.01$, $p < 0.001$). Shots efficacy varied between 53–57% ($p > 0.05$) throughout EMHC'2002–2010, whilst OH during four decades increased by 18.3% ($p < 0.001$). The efficacy of shots at the EMHC were similar to the last three (Skarbalius, 2002, 2010) OG (2000 – $50.6 \pm 15.2\%$; 2004 – $54.0 \pm 19.2\%$; 2008 – $55.3 \pm 9.0\%$). Handball expert L. Mocsai (2002) asserted that defensive play was the result of the decline in the shot efficiency of the attacking teams at the EMHC'2002, but it didn't prove on the basis of handball sport performance indicators.

Goalkeepers. Winners differed significantly throughout EMHC'2000–2006: i. e. saves of positional attacks and goals from long distance (Wiemeyer, Heinz, 2008), the average number of shots from 9 m and the wing position in the EMHC'2004, 2006; the number of goalkeeper saves (Pori et al., 2008) remained at the same level (2002 – 31.6%; 2004 – 32.6%; 2006 – 32.0%). T. Hergeirsson (2008) argued that the goalkeepers saved more shots in general and from 6 metres, and there was especially better cooperation between goalkeeper and defence at the EMHC'2008. However, no data was provided for evidence of the latter attitude. M. Taiysir (2008) stated that goalkeepers of Arab

teams (34%), compared to Europeans (44.8%) in the 2007 World Handball Championship, were weaker saving long shots from the backward. He made the assumption that this may be ascribed to the weakness of the defence of Arab teams, which permitted the opposition to shoot freely, compared to the European teams, which had a powerful and effective defensive system (6:0; the German, Polish and Danish teams) and, as a result, gained the top three places. These findings are in line with our research showing that goalkeepers of winning teams exceed losers throughout EMHC'2002–2010 and from long distance in fourth analysed EMHC'2002, 2006, 2008, 2010. We can conclude that both saved indices (total saved shots and long distance) might be used as the key indicators of men's handball sport performance.

Positive and negative actions. Winners did not exceed losers in none of the indices of positive (earned 7 meters penalties, steals, blocked shots) and negative (turnovers, 2 minutes faults) indices throughout EMHC'2002–2010, but they outperformed losers ($p < 0.05$, $p < 0.01$, $p < 0.001$) in blocked shots (moderate 3.1–4.1 blocks) at the fourth EMHC'2002–2008. M. Wiemeyer (2008) suggested that due to the development of the game, in the EMHC'2006 steals became more important and this feature indicated the fast switch from defence to offense, which played a decisive role. Our research did not show that winning teams were superior at stealing the ball and the ratio of counterattacks. On the other hand, M. Wiemeyer (2008) and N. Rogulj (2000) concluded that there were variables specific to one or two championships, which may be considered as 'short-term fashion' in the development of handball tactics. The authors stressed that in the EMHC'2000 variables of defensive tactics dominated the game, whereas offensive tactics were more important in the EMHC'2002 and 2004. Our analysis, based on statistics given on the website of the EHF, does not permit making such a conclusion. A. Borrie with co-authors (2002) suggested that the temporal configuration of play events was due to synchronisation and cooperation between players (including interaction with opponents), their actions and movements, rather than being a simple consequence of the number of data points in a complex performance. L. Nadeau et al. (2008) argued that statistics focused on the end results of various aspects of sport performance. However, it was impossible to determine whether

these statistics reflected the technical aspects of players' performance, tactical aspects, or both. Throughout EMHC'2002–2010 teams on average earned a 7 m penalty 4.3–4.8 times per match, performed steals 3.1–5.1 times and made 11.2–12.5 mistakes. In contrast to our research, F. Taborsky (2008) pointed out that mistakes at the Beijing OG (12.9 mistakes in offence) were the key indicators of sport performance in men's handball.

CONCLUSIONS AND PERSPECTIVES

The aim of this investigation was to determine the key indicators of discrimination between winning and losing teams in European men's handball throughout the last decade. Phenomenon is that no difference was found in playing style (ratio of positional and counterattacks) between winners and losers. Findings indicate that six indicators – goals scored, efficiency of total attacks and positional attacks, efficiency of total shots, from long distance, and shots saved by goalkeepers – are the key indicators of discriminating winners at the EMHC'2002–2010. Five indicators amongst those mentioned (except saved shots by goalkeepers) are characteristic of actions in offence and playing

patterns of team actions. The next three indicators (goals missed, blocked shots, saved long distance shots) among four (the other being efficiency of majority), which discriminate winners from losers at the fourth EMHC in the years 2002–2010, characterise defensive actions and individual fitness of players as having the second level of importance in order to win. Performance indicators such as efficiency of individual attacks, shots from wings and 7 m penalties, and efficiency in minority might be considered as the key indicators of temporal pattern at the EMHC'2002–2010. Detailed quantitative analyses can enhance performance through the improvement of performer feedback. The normative profile of winners identified can help coaches and players to create performance profiles according to team quality (O'Donoghue, 2005; Sampaio et al., 2010). Therefore, handball coaches will benefit from awareness of these results, particularly when designing game strategies and making tactical decisions.

Limitation and future research. The EHF data do not include information about the team actions in the 6–9 metres zone and efficiency in defensive actions, in order to separate team and individual actions. Handball as other sports is a complex game whereby performance can be analysed and presented in a variety of ways.

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EUROPOS VYRŲ RANKINIO ŽAIDIMO POŽYMIAI: LAIMĖTOJŲ IR PRALAIMĖTOJŲ VARŽYBINĖS VEIKLOS SKIRTYBĖS

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SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Nors Europos vyrų rankinio rinktinės nuolat tampa olimpinių žaidynių ir pasaulio čempionėmis, iki šiol nėra ištirtos europiečių žaidimo tendencijos. Keliama hipotezė, kad šiuolaikinio vyrų rankinio rungtynės laimėjusios Europos šalių rinktinės žaidžia dinamiškiau ir veiksmingiau taiko kontrataką.

Tikslas – nustatyti šiuolaikinio Europos vyrų rankinio čempionatų laimėtojų ir pralaimėtojų varžybinės veiklos skirtumus.

Metodai. Duomenys apie varžybinę veiklą buvo paimti iš Europos rankinio federacijos (EHF) svetainės (<http://www.eurohandball.com>) analizuojant penkis Europos vyrų rankinio čempionatus: 2002, 2004, 2006, 2008 ir 2010 m. (n = 239 rungtynės). Kiekvienos rungtynės buvo traktuojamos kaip sėkmingos ir nesėkmingos atskirai komandai, todėl tiriamų rungtynių skaičius padvigubėjo iki 478. Išnagrinėti 28 varžybinės veiklos rodikliai, tačiau teiktini tik penkiolika, kurių statistinis reikšmingumo lygmuo patikimas.

Rezultatai. Nugalėtojai įmetė daugiau įvarčių ($p < 0,01$; $p < 0,001$), veiksmingiau atakavo ($p < 0,001$) ir taikė pozicinio puolimo veiksmus ($p < 0,01$; $p < 0,001$), veiksmingiau metė į vartus ($p < 0,001$), ypač iš toli ($p < 0,01$; $p < 0,05$), vartininkai atrėmė daugiau metimų ($p < 0,05$; $p < 0,001$).

Aptarimas ir išvados. Laimėtojų ir pralaimėtojų rinktinių žaidimo pobūdis nesiskyrė ($p > 0,05$). Atskirų rungtynių nugalėtojams būdingas tik toms rungtynėms taikytinas žaidimo modelis. Fenomenalu, kad komandos antrą kėlinį pelnė daugiau įvarčių negu pirmą, nors tyrimai rodo žaidėjų veiklos intensyvumo sumažėjimą antro kėlinio metu. Nustatytos Europos šiuolaikinio vyrų rankinio varžybinės veiklos rodiklių reikšmės leis rankinio ekspertams vertinti treniruojamos komandos parengtumą.

Raktažodžiai: sportiniai žaidimai, parengtumo analizė, elito sportininkai.

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