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Handball game-related statistics in men at Olympic Games (2004-2016): Differences and discriminatory power

Estadísticas de juego en balonmano masculino en los Juegos Olímpicos (2004-2016): Diferencias y poder discriminatorio

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Abstract. Handball can be considered a complex game. Sports performance analysis is a relevant topic for scientists and coaches. The objectives of the present study were: (i) to compare handball game-related statistics by match outcome (winning and losing teams) and (ii) to identify characteristics that discriminate the performance in elite men´s handball. The game-related statistics of the 324 games played in the last four Olympic Games (Athens, Greece, 2004; Beijing, China, 2008; London, United Kingdom, 2012; and Rio de Janeiro, Brazil, 2016) were analyzed. Differences between match outcomes (winning or losing teams) were determined by using the chi-squared statistic, and by calculating the effect sizes of the differences. A discriminant analysis was then performed applying the sample-splitting method according to match outcomes. The results showed that the differences between winning and losing teams were shots, 9 m shots, assists, goalkeeper-blocked shots fast break. Also, discriminant analysis selected four variables (shots, goalkeeper-blocked shots, technical foul, and attacks) that classified correctly 82% of matches (Wilks's lambda=0.575; canonical correlation index 0.652). The selected variables included offensive and defensive predictors: Shots, goalkeeper-blocked shots, technical foul, attacks. Coaches and players can use these results as a reference against which to assess their performance and plan their team's training.
Keywords: notational analysis, performance, match, shot, goalkeeper.

Resumen. El balonmano puede considerarse un juego complejo. El análisis del rendimiento deportivo es un tópico relevante para los científicos y entrenadores. Los objetivos del presente estudio fueron: (i) comparar las estadísticas de juego en balonmano en función del contexto (equipos ganadores y perdedores) e (ii) identificar las estadísticas que discriminan el rendimiento en el balonmano masculino de élite. Se analizaron las estadísticas de juego de los 324 partidos disputados en los últimos cuatro Juegos Olímpicos (Atenas, Grecia, 2004, Beijing, China, 2008, Londres, Reino Unido, 2012 y Río de Janeiro, Brasil, 2016). Las diferencias entre los equipos ganadores y perdedores) se determinaron usando el estadístico chi-cuadrado y calculando los tamaños del efecto de las diferencias. A continuación, se realizó un análisis discriminante aplicando el método de por pasos. Los resultados mostraron que las diferencias entre los equipos vencedores y perdedores se presentaron en las variables lanzamientos de 9 m, asistencias, lanzamientos bloqueados por el portero en situación de contraataque. Además, el análisis discriminante seleccionó cuatro variables (lanzamientos, lanzamientos bloqueados por el portero, falta técnica y número de ataques) que clasificaron correctamente el 82% de los partidos (Lambda de Wilks=0,575; índice de correlación canónica=0,652). Las variables seleccionadas incluyeron predictores ofensivos y defensivos: lanzamientos, paradas del portero, faltas técnicas y ataques. Los entrenadores y los jugadores pueden utilizar estos resultados como referencia para evaluar su rendimiento y planificar el entrenamiento del equipo.
Palabras clave: análisis notacional, rendimiento, partido, lanzamiento, portero.

Introduction

Handball or Team-Handball is a popular indoor sport played at all levels from recreational to fully professional with origins in Scandinavia from the early 19th century. Handball has been an Olympic sport for men since 1972. This sport is a full body contact sport with 7-a-side teams. The aim is to throw the ball into the opponents goal, past the goalkeeper and 6 players defence formed around the «D-zone» which is in 7m radius around the goal itself (on a 20x40m court size). Handball is known for its intermittent tempo, i.e. fast pace and rapid change between defence and offence, basing performance on multiple factors such as endurance, coordination and strength. In this way, the relatively small court size and rules of the game provide opportunities for frequent displays of shooting, hitting, pushing, blocking, jumping and running (Milanese, Piscitelli, Lampis & Zancanaro, 2012). In addition, handball can be considered a complex game influenced by several factors: somatic physiological, technical, psychological, nutritional, and tactical, among others (adapted from Wagner, Finkenzeller, Würth, S. & von Duvillard, 2014).

Since the final result of a match in team sport is decided by goals scored, coaches and sport scientists have conducted studies in order to gain knowledge and improve training and thus competitive outcome (Carling, Williams & Reilly, 2005). Sports performance analysis could be developed in several context (elite players, coaches, referees, etc.) (Gómez-Ruano, 2017). Over the last year, such performance analysis has been used in many studies. Between 1991 and 2015, 8.1% articles among sports performance analysis topic included the term «sport» as the keywords (Gómez-Ruano, 2017). However, most of the handball studies have frequently focused on injuries, physical and physiological capacities (Prieto, Gómez & Sampaio, 2015a).

On the other hand, game-related statistics in performance analysis is a very popular method used in handball. This method analyses the game-related statistics in function (among others) game situation (fast break, static attack...) or player position (goalkeeper, pivot, wings -right and left-, backs -right and left-, and centre). A study that investigated nine major tournaments, including Olympic Games, World Championship and European Championship between 2004 and 2010 reported that the efficiency of fast break, pivot position and back court players were strongly associated with the high ranking of the European teams in the international tournaments (Bilge, 2012). Another study carried out in 1999 World Championships concluded that variables of frequency of shooting from particular position had no significant influence on the final result (Srhoj, Rogulj & Katic, 2001). At the same line, one study done in the preliminary phase (four groups with six teams each) of the World Championships (2003) showed results not conclusive (Gruic, Vuleta & Milanovic, 2006). On the contrary, the analysis for the 2013 World Championships found several variables were different by the ranking order (1st to 8th, 9th to 16th and 17th to 24th) including yellow card, blocked-shots, assist, technical fouls, wing shots, penalties, fastbreak shots, breakthroughs shots and total shots (score and percentage) (Hassan, 2014). Another work studied the trends in three World Championships (2005, 2007 and 2009), revealing more shot attempts from 9m in 2007 than 2009, parallel with decrease in 6m shots made (Melekatos, Vagenas & Bayios, 2011). In regards to the European Championship, a study reported that the match outcome discriminant variables were: goals (scored and attempted successful goal), positional attacks (number), shooting from long distance and goalkeepers blocked-shots (Skarbalius & Pukenas, 2012). From the analysis regarding «league system», the teams who reached the finals and came out victorious have a wide and well-defined range of offensive actions enabling them to

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involve all aspects of the game (Ferrari, dos Santos & Simoes Vaz, 2014). In the Croatian League, the attack variables that discriminated winning and losing team were: number of multiple interruption attacks, number of attacks done by pivot and number of attacks in left side court (Rogulj, Srhoj & Srhoj, 2004). Other variables that are often used in game statistics are home advantage, period and team quality (Oliveira, Gómez & Sampaio, 2012; Lago-Penas, Gomez, Viaño, González-Garcia &Fernández-Villarino, 2013; Gómez, Lago-Peñas, Viaño & González-García, 2014), the influence of player exclusions (Prieto, Gómez & Sampaio, 2015b) and timeouts (Prieto, Gómez, Volossovitch & Sampaio, 2016).

As summary, it is possible to say that previous studies have analyzed the game-related statistics in several whole or only finals in International Championship (Olympic Games, World Championship and European Championship) doing comparison between them (Bilge, 2012¸ Jimenez-Olmedo, Espina-Agullo & Manchado, 2017), another works have analyzed only World Championship (Gruic et al., 2006; Melekatos et al., 201; Hassan, 2014) or European Championship (Skarbalius & Pukenas, 2012). In addition, several studies have analyzed the game-related statistics in «League System» competitions (Rogulj et al., 2004; Oliveira et al. 2012; Lago-Penas et al., 2013; Ferrari et al., 2014; Gómez et al., 2014; Prieto et al., 2015b; Prieto et al., 2016) In this context, the current study analyzed the most relevant competition in the world, the Olympic Games between 2004 to 2016. The objectives of this present study were: (i) to compare handball game-related statistics by match outcome (winning and losing teams) and (ii) to identify characteristics that discriminate the performance in elite men´s handball.

Material and methods

Study items

Data included the results and game-related statistics of 324 men's matches played in the last four Olympic Games (Athens, Greece, 2004; Beijing, China, 2008; London, United Kingdom, 2012 and, Rio de Janeiro, Brazil, 2016).

Procedures

Data was retrieved from the Official Website of International Handball Federation (http://www.ihf.info/IHFCompetitions/OlympicGames/). A technician (see acknowledgement) retrieved each data from the published website and manually entered constructed the data file. Then, another author [JMS] performed data cleaning process with random checking methods to detect data input errors. Informed consent was not necessary since the information was publically available from the official website. Data published in official website is frequently used for the analysis in handball (Calin, 2010, Meletakos et al., 2011, Yamada, Aida & Nakagawa, 2011; Pollard & Gomez, 2012).

In this study, the independent variable was match outcome (winning and losing teams) and the dependent variables were the game-related statistics: shots (percentage of converted shots relative to the number of shots made), 6 m shots (percentage of converted shots at 6 m relative to the number of shots made. The area is from a zone outside the 45°angle from the left and right), 7 m shots (percentage of penalties -7m- converted relative to the number of penalties taken, 9 m shots (percentage of converted shots at 9 m relative to the number of shots made. The area from a backcourt player either –a- over or through the defense, and –b- after a breakthrough but with another defense player in front), wing shots (percentage of converted shots at wing area relative to the number of shots made. The area is from within an angle of 45° left and right without a defense player in front), fast break shots (percentage of shots converted in a situation of fast break – rapid switch from defense to attack without the defense organized – relative to the number of shots made in this situation), breakthroughs shots (percentage of shots converted in a situation of breakthroughs – (a) from the backcourt players after breakthrough in the 9 m zone without a defense player in front, (b) of the pivot after 1:1 situation, (c) from the left or right back after breaking through 1:1 situations – relative to the number of shots made in this situation), yellow card (yellow cards received by each player and/or coaching staff), red card (red cards received by each player or coaching staff), 2-minutes exclusions (2-minute suspension received by each player or coaching staff), assists (number of passes from one offensive player to another leading directly to a goal score), technical fouls (number of turnovers made by the offensive team where the ball is awarded to the defense due to offensive fouls), steals (number of turnovers in favour of the defense due to actions of anticipation and snatching the ball), goalkeeper-blocked (G.B.) shots (percentage of shots stopped relative to the number of shots made by the attackers), G.B. 6 m shots (percentage of shots stopped at 6 m relative to the number of shots made by the attackers), G.B. 7 m shots (percentage of penalties -7 m- stopped relative to the number of penalties taken by the attackers), G.B. 9 m shots (percentage of shots stopped at 9 m relative to the number of shots made by the attackers), G.B. wing shot (percentage of shots stopped at wing area relative to the number of shots made by the attackers), G.B. fast break (percentage of shots stopped at fast break situation relative to the number of shots made by the attackers), G.B. breakthroughs (percentage of shots stopped at breakthroughs situation relative to the number of shots made by the attackers), These game-related statistics are already of general use amongst men handball coaches and technicians, and are those that have been used in earlier studies (Meletakos et al., 2011).

Data analysis

Basic statistical descriptors (mean and standard deviation) were calculated by match outcome (winning and losing teams). The significance of the descriptors distinguishing between winning and losing teams was determined by means of a chi-squared test, the recommended technique when the descriptors are discrete frequency response variables (Nevill, Balmer & Williams, 1999; Nevill, Atkinson, Hughes & Cooper, 2002). The effect sizes of the differences were calculated (Cohen, 1988). The values of this statistic were interpreted in terms of size following recommendations in the literature (Hopkins, Marshall, Betterham & Hanin, 2009): >0.1 small, >0.3 moderate, >0.5 large, >0.7 very large, and >0.9 nearly perfect. Also a discriminant analysis, using the sample-splitting method according to match outcome (winning and losing teams) was performed. The criterion used to determine whether or not a variable was discriminatory, was the Wilks's lambda test, which measures the deviations within each group with respect to the total deviations. The sample-splitting method included initially the variable that best minimized the value of lambda, provided that the value of F was greater than a certain critical value (F=3.84, «include»). From that point on, the method combines the variables pairwise. The new variable is selected if l is greater than the value of the input F. However, before introducing a variable one tries to eliminate some of those already selected, as long as the increase in the minimized l is below a critical threshold (F=2.71, «remove»). We thus calculated l, the canonical correlation index (deviations of the between-group discriminant scores relative to the total deviations), and the percentage of correctly classified matches (winning and losing teams). A p-value <0.05 was considered to be statistically significant. The statistical analysis was performed using the software package SPSS version 15.0 (SPSS Inc., Chicago, IL, USA).

Results

Table 1 presents the basic descriptors of the variables by match outcome (winning/losing teams). Four variables (shots, 9 m shots, assists, goalkeeper-blocked shots) were different between winning and losing teams.

Table 2 presents the results of the discriminant analysis (Wilks's lambda, the canonical correlation index, and the percentage of teams correctly classified) for match outcome. The predictive models classified correctly 81.9% of matches using four variables: Shots, goalkeeper-blocked shots, technical foul, and attacks.

Table 1.
Basic descriptors (mean and standard deviation), chi-squared statistic, p-value, and the effect sizes of the differences (Cohen's d) for each variable according to the context.

	Winners M ± SD	**Losers** M ± SD	**X²**	**p**	**ES**
Shots (%)[a]	61.7 ± 8.7	51.6 ± 8.7	**439.97**	**0.018**	**0.50**
6 m shots (%)[a]	68.4 ± 17.7	64.1 ± 19.3	109.77	0.330	**0.16**
7 m shots (%)[a]	78.1 ± 25.3	68.4 ± 30.6	27.60	0.841	**0.17**
9 m shots (%)[a]	45.3 ± 14.4	35.1 ± 12.1	296.63	**0.019**	**0.36**
Wing shots (%)[a]	58.3 ±21.0	55.8 ± 25.1	81.96	0.661	**0.54**
Fast break shots (%)[a]	77.2 ± 19.1	72.2 ± 25.1	83.07	0.326	**0.11**
Breakthroughs shots (%)[a]	71.0 ± 32.1	70.4 ± 33.2	74.91	0.900	**0.01**
Yellow card (n)	3.0 ± 0.7	3.1 ± 0.8	5.37	0.497	**-0.07**
Red card (n)	0.1 ± 0.3	0.2 ± 0.4	3.91	0.419	**-0.14**
2 min (n)	4.2 ± 2.1	4.1 ± 2.0	14.85	0.869	**0.02**
Assists (n)	14.1 ± 4.4	10.8 ± 3.8	81.03	**<0.001**	**0.37**
Technical fouls (n)	11.5 ± 3.6	13.6 ± 4.5	40.65	0.616	**-0.25**
Steals (n)	4.8 ± 2.9	4.3 ± 9.0	39.40	0.173	**0.05**
Attacks (n)	55.5 ± 5.2	55.4 ± 5.3	53.80	0.405	**0.01**
G.B. shots (%)[b]	37.7 ± 8.1	28.4 ± 8.0	372.30	0.096	**0.31**
G.B. 6 m shots (%)[b]	29.3 ± 19.1	25.9 ± 17.0	88.87	0.514	**0.09**
G.B. 7 m shots (%)[b]	20.3 ± 24.7	15.7 ± 22.8	15.85	0.968	**0.09**
G.B. 9 m shots (%)[b]	49.2 ± 14.0	39.5 ± 16.0	185.66	0.294	**0.31**
G.B. wing shot (%)[b]	34.1 ± 24.1	32.3 ± 21.9	89.13	0.083	**0.04**
G.B. fast break (%)[b]	19.2 ± 20.9	16.1 ± 15.7	75.66	**0.041**	**0.08**
G.B. breakthroughs (%)[b]	17.9 ± 26.3	16.9 ± 23.0	35.15	0.165	**0.02**

[a] number of shots converted/number of shots; [b] number of shots saved/number of shots; G.B. = goalkeeper-blocked, ES = Effect sizes

Table 2.
Discriminant analysis models by match outcome (winning and losing teams), giving the percentage correctly classified, Wilks's lambda, canonical correlation index, and variables included in the model by order of selection.

Percentage correctly classified	Wilks's lambda	Canonical correlation index	Variables selected by order		
			Name	Wilks's lambda	Standardized canonical discriminant function coefficients
81.9	0.575	0.652	Shots	0.749	0.792
			Goalkeeper-blocked shots	0.612	0.648
			Technical fouls	0.582	-0.427
			Attacks	0.575	0.201

Discussion

The current study analyzed 324 men's matches played in four last Olympic Games (2008, Athens, Greece; 2008 Beijing, China; 2012, London, United Kingdom and 2016, Rio de Janeiro, Brazil). The analysis of game-related statistics in championships (excluding League System) has been previously performed in European championships (2002-2010) (Skarbalius and Pukenas, 2012) and World championships (2003) (Srhoj et al. 2001; Gruic et al. 2006; Hassan, 2014) (2005 to 2009) (Melekatos et al., 2011) and combination of different championships (2004 to 2010) (Bilge, 2012). To the best of our knowledge, this has been the first study to report the influence of game-related statistics in four Olympic Games (the most relevant event in sport).

Differences by match outcome (winning/losing teams)

In the current study, four variables differentiate winning and losing teams: shots, 9 m shots, assists, goalkeeper-blocked shots fast break. In shots the difference between winning and losing teams was large (winners=61.7 ± 8.7 –mean and standard deviation-, losers=51.6 ± 8.7-mean and standard deviation-, X^2=439.97, p=0.018, ES=0.50). These results are similar to the previous studies in EHF´s [European Handball Federation] Champions League (season 2011/12) (Ferrari et al., 2014). In addition, teams ranked from 1st to 8th place in 2013 World Championship were more efficient (total shots) than teams ranked from 9th to 16th and 17th to 24th (Hassan, 2014). Although shooting efficiency in the current study was similar to the report from the EHF´s Champion League (Ferrari et al., 2014), it was lower than the reported shooting efficiency from World Championship (Melekatos et al., 2011). However, shooting efficiency in the current data from the four recent Olympic matches was higher than the report from the previous Olympic Games (2004= 47.38%; 2008=52.88%) (Bilge, 2012), It suggests that shooting efficiency varies between championships. For the 9m shots the winners were more efficient that losers (winners=45.3 ± 14.1 – mean and standard deviation-, losers=35.1 ± 12.1-mean and standard deviation-, X^2=296.63, p=0.019, ES=0.36). This is in accordance with previous studies done in Champion League (Ferrari et al., 2014). However, if the teams were classified by rank (1st to 8th place, 9th to 16th and 17th to 24th) no differences were observed (Hassan, 2014). On the other hand, the percentage of successful (goals/shots) in winners was higher than previous studies where there was no differences between the 2005, 2007 and 2009 World Championship (Melekatos et al., 2011). In this last study the efficiency in 6 m shot increased through time, this could indicate a change in the team´s tactical. According to previous results it may be preferable to play defensively to reduce opponents shooting efficiency from 9 meters giving less opportunities to opponents to throw 6 m shot. We found that assists were also significantly different by match outcome (winners=14.1 ± 4.4 –mean and standard deviation-, losers=10.8 ± 3.8-mean and standard deviation-, X^2=81.03, p<0.001, ES=0.37). Previous studies showed that teams ranked 1st to 8th place had more assists than teams ranked between 9th to 24th (Hassan, 2014). The differences in assists suggest that winning teams are more effective in the selection of shoot that the players look for others options while they have chances to shoot. This also could partly explain why winning teams have better shot efficiency from 9 meters compared with the losing team. Finally, goalkeeper-blocked shots and fast break were also different between winning and losing teams (winners=19.2 ± 20.9 –mean and standard deviation-, losers=16.1 ± 15.7-mean and standard deviation-, X^2=75.66, p<0.041, ES=0.08). The finding indicates that a highly relevant role of goalkeeper in fast break situations which may lead to have positive psychological effects among team members.

Discriminatory power

Discriminatory power analysis showed that four variables (shots, goalkeeper-blocked shots, technical foul, attacks) classified correctly to 83% of the teams (winning and losing). It reflects how important it is to create more offensive situations, which then would link to increased chances for players to shoot and make a score. There are several factors that may have been involved with the current findings: (i) an appropriate decision making of the players for effective shots increased the likelihood of shot effective, (ii) forcing opponents into as difficult situation as possible to make shots which maximize the chances of blocks or saving and (iii) minimize the technical fouls for example by playing the game at a pace that the team can handle but the same time, try to maximize the number of attacks. In previous studies (Skarbalius and Pukenas, 2012) that used the same type analysis, the winners in European Handball Championship had better shooting efficiency and more saves from goalkeepers than losers do. Also, the technical fouls discriminated between winning and losing teams. This could indicate that the winners has a best control about technical rules. Results of the study on the 2013 World Championship (Hassan, 2014) were similar with our findings that the higher ranking teams (1st to 8th place) had lower number of technical fouls compared with lower ranking teams (9th to 24th place) . It is important to notice that a technical foul usually carries a fast break situation of the opponent team to facilitate advantage of successful shot since the efficiency of fast break shot has the highest (Melekatos et al., 2011; Bilge, 2012).

This study has some limitations. First, the discriminant analysis used post hoc prediction. In interpreting the results, it needs to be borne in mind that this type of prediction usually gives higher values for the classification than a priori predictions. Second, only top-level championships were analysed (Olympic Games), so these findings should be carefully interpreted in the context of national and local handball game statistics. Third, this study has a static perspective. The game-related statistics were «the final result» without attention paid to what happened at each moment of the match (dynamic perspective) (Prieto, Gómez & Sampaio, 2015c). Forth, the rules have changed between Oympics Games and this affect to dynamic game.

Conclusions

This study compared hand ball game-related statistics by match outcome (winning and losing teams) and identified characteristics that discriminate the performance in elite men's handball. The main conclusions were: (i) the variables differentiating winning and losing

teams were shots, 9 m shots, assists, goalkeeper-blocked shots fast breaks and (ii) the variables discriminating the teams were shots, goalkeeper-blocked shots, technical foul and attacks. The selected variables included offensive and defensive predictors. Findings in the current study may help coaches to prepare of games and tournaments in advance and to make tactical decisions during the course of the game. Coaches should put emphasis on maximize the shooting efficiency (especially from 9 m), increase of number of assists that is given in each game, increase the likelihood that goalkeepers saves shots (especially from fast breaks) and minimize technical fouls as much as possible. Finally, it is necessary to do more research in the topic, to take decisions in the match based on scientific knowledge.

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