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ORIGINAL ARTICLE

Differences in situational power performance between playing positions in top level handball

Diferenças na performance entre distintas posições no handebol, no desempenho de potência situacional

Las diferencias en el rendimiento de la potencia situacional entre posiciones de juego en el balonmano de alto nivel

Nikola Foretić[a]*, Šime Veršić[a], Ognjen Uljević[a], Vladimir Pavlinović[a], Toni Modrić[a]

Keywords:
Jump;
Sprint;
Shot;
Player.

ABSTRACT
This study aimed to determine the differences in situational power performance between playing positions in handball. The following variables were analyzed: body height and weight, fastest shot, fastest sprint, highest jump, and average game time. The study sample comprised 412 handball players who participated at European championships. Backcourt players had the fastest shots and wing players presented the slowest shots among all playing positions. Wing players presented the fastest sprinting (29.09 km/h). Jumping performance showed the most diversity between the playing positions, and backcourt players jumped significantly higher than other players (16.76 cm).

Palavras-chave:
Salto;
Sprint;
Remate;
Jogadores.

RESUMO
O objetivo do estudo foi determinar diferenças na performance entre diversas posições no handebol em potência situacional. As variáveis incluem; estatura, massa corporal; o remate mais rápido, o sprint mais rápido, o salto mais alto, e o tempo médio de jogo. Os jogadores que ocupam as posições de armador possuem os remates mais rápidos e as pontas por sua vez possuem os remates mais lentos. Os sprints mais rápidos foram registados na posição dos pontas. A performance no salto foi a variável que mostrou mais diversidade entre as posições – os armadores saltam significamente mais alto do que as restantes posições.

Palabras-clave:
Salto;
Esprint;
Disparo;
Jugador.

RESUMEN
El objetivo del estudio fue determinar las diferencias de la potencia situacional entre las posiciones de juego en el balonmano. Variables incluidas: altura y peso corporal, disparo más rápido, esprint más rápido, salto más alto y tiempo promedio en el juego. Los jugadores laterales tienen disparos más rápidos mientras extremos más lentos entre todas las posiciones de juego. La velocidad más rápida se registró para las posiciones extremos. El rendimiento de salto mostró la mayor diversidad entre las posiciones de juego: los jugadores laterales saltan significativamente más alto que los jugadores de otras posiciones.

[a]University of Split, Faculty of Kinesiology, Split, Croatia.

***Corresponding author:**
Nikola Foretić
E-mail: nikolaforetic@gmail.com

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INTRODUCTION

Handball is a strenuous intermittent team sport with specific requirements for anthropometric characteristics, technical skills, tactical understanding, and physical performance. Understanding the physical demands of the game is essential for modelling a rational conditioning program that will allow transfer from gym training to court performance. Physical demands of elite handball are primarily related to high-intensity actions, impacts, and rapid recovery during the game (Barbero et al. 2014). Analysis of handball technical activity reveals that power abilities are most important for efficient performance (Hespanhol et al., 2012, Póvoas et al., 2012). Power in handball is manifested through jumps, shots, and sprinting (Alvarenga et al. 2014; Michalsik and Aagaard, 2015; Bělka et al. 2016).

Handball jumps are performed in different attack and defense situations, can be executed with one or two legs, and with enhancing vertical or horizontal jumping dimension (long or high jump). Two-leg jumps occur mostly during defensive blocking actions, while one-leg jumps are the basis of every jump shot technique (Srhoj et al., 2012). Shots in handball can be performed with and without jumping. Jump shots are more common, while ground shots have significantly faster ball speed (Šibila et al., 2003; Saavedra et al., 2019). According to some authors, shooting velocity is one of the determining scoring elements in handball (Sarvestan et al., 2019). Running in handball presents different intensities. Fastest running, or sprinting, occurs during transitional game phases, especially during individual fast breaks and collective counterattacks (Srhoj et al., 2001).

Each playing position has its specific demands and profile for physical conditioning. Hence, power manifestations are specific for each playing position and the situations in which the players find themselves can influence maximal power performance. Except for game situations, a specific playing position morphology can also be an important factor of power actions in handball (Massuça and Fragoso 2013; Gümüş and Gençoğlu 2020).

Obviously, recognition of player load during a match is very important for designing training programs and recovery interventions. Recently, few studies have examined handball player load using GPS systems (Luteberget and Spencer, 2017; Wik et al., 2017). Luteberget and Spencer (2017) found that high intensity events are related to a playing position specific role in female handball players (Luteberget and Spencer, 2017).

Nevertheless, a literature review shows lack of scientific evidence of situational power activities during handball games. Most of the studies were conducted under controlled conditions and assessed only basic, and very rarely, specific power performance in handball. Thus, the main goal of this research was to determine the differences in situational power performance between the six playing positions in top level male handball.

METHODS

The study sample comprised 412 male handball players who participated at European handball championships held in Austria, Norway, and Sweden in 2020. Variables included basic anthropometrics: body height (BH) and body weight (BW), fastest shot (FS), fastest sprint (FSP), highest jump (HJ), and average game time (AGT). Data on situational power present the best results in the given variables for each player during the tournaments. All the data were collected from the championship official website of European handball federation.

Shot and sprinting speed and jump performance were collected using the iBall (SELECT, Denmark) and Player Tracking System (Kinexon, Germany). LPS is an ultra-wideband (UWB) local positioning system that assesses specific movements in handball (Fleureau et al., 2020). The system used in this study consisted of 14 antennas positioned around the handball court at three different heights. The tag was placed in the center of the players' upper back using the manufacturer's harness. The data were collected at 20 Hz and processed via the specific Kinexon Software. The signals were transmitted to the antennas using the UWB technology at a frequency range of 4.25–7.25 GHz. The field position of the tag is calculated by a proprietary algorithm based on a combination of different methods, such as Time Difference of Arrival, Two-Way Ranging, and Angle of Arrival (Blauberger et al., 2021). A 12-camera Vicon motion analysis system (Vicon Nexus T40, Vicon Motion Systems, Oxford Metrics, UK) is implemented in the two configurations. Data were collected at 250 Hz. Only one 14 mm reflective marker (B&L Engineering, Santa Ana, USA) is placed on the Kinexon tag. The data obtained from the three-dimensional marker position are used for further analysis. The loss of the marker signal is never longer than 25 successive images (i.e., 0.1 s), and is automatically extrapolated with the Vicon 3D software using the marker position immediately before and after the loss. The average Vicon calibration errors (Image and World Error, respectively) are 0.09 and 0.17 mm for data collected in the center of the court, and 0.08 and 0.16 mm for those collected on the side of the court. The original datasets from Kinexon were oversampled from 20 to 250 Hz for subsequent fine synchronization with the Vicon data. Signals from both systems are filtered using a 3rd-order zero-phase shifting low-pass Butterworth filter with a 10 Hz cut-off. Each pair of Kinexon and Vicon data sets for each movement repetition is manually synchronized to determine a common start and end. The distance travelled is then calculated as the sum of the instantaneous positions in the horizontal plane (x, y). Velocity and acceleration data are obtained by successive derivation and low-pass filtering (10 Hz, 3rd-order zero-phase shifting Butterworth filter). Peaks in speed, acceleration, and deceleration are calculated from the raw data and utilized for the analysis. They are respectively computed as the maximum mean speed, acceleration, and deceleration over a 500 ms window (Aughey, 2011; Buchheit and Simpson, 2017).

All offense players were divided into six playing positions; left wing (LW), right wing (RW), pivot (P), center backcourt (CB), left backcourt (LB) and right backcourt (RB). The ethics board of the authors' institution provided approval of the research experiment.

Statistical analyses included the calculation of descriptive statistical parameters (arithmetic means and standard deviations) and analysis of variance with *post-hoc* Scheffe test to determine differences between playing positions in the observed variables. For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a *p*-level of 95% was adopted.

RESULTS

Analysis of variance showed significant differences between the playing positions in all tested variables, except for AGT. Playing time span ranged from 24.22 (RB) to 30.90 (LW) min per game. As no differences were observed between the playing positions in AGT, it was concluded that all playing positions spent approximately the same time in the game.

Table 1 show the results of descriptive statistics and the differences between playing positions calculated by the Scheffe test. The greatest differences were observed in anthropometrical characteristics. CB differed significantly from all other positions in BH and BW, except for BW from RB. LB and RB presented BH and BW similar to P and different from those of the other positions. P was taller than CB, LW, and RW and heavier than the other positions. On the other hand, wing players were significantly lighter and shorter than backcourt and pivot players.

Significant differences in shot speed were noticed only between all backcourt positions (CB, LB, and RB) and RW. The best results in sprinting performance were recorded in wing players, with significant difference between LW and CB, LB, RB, and P. LW and RW did not differ significantly in FSP. Analysis of specific jump performance show that backcourt players jump higher than line players. At the same time, wings and P showed quite similar results in jumping performance; they jumped lower than backcourt players, 16.86 cm on average.

DISCUSSION

Although the main aim of this study was to explore the specific explosiveness in handball playing positions, basic anthropometry was considered for better understanding of possible differences. The results showed significant differences between backcourt and pivot players and wing players. This is not a new observation, since similar anthropometrical differences between playing positions have previously been reported in many studies.

All these studies agreed that emphasized body dimensions, especially the length dimensions, are selective criteria for backcourt players and pivots in modern handball (Ilić et al. 2011; Ghobadi et al. 2013). Oxyzoglou et al. (2014) found that backcourt players were taller and heavier than wing players. Moreover, they presented larger hands and more ectomorphic somatotype characteristics than wing players (Oxyzoglou et al., 2014; Burger et al. 2015). In most of

Table 1. Descriptive statistics and differences between playing positions (post hoc Scheffe test).

VAR	ALL (N=359) X±SD	CB (N=56) X±SD	LB (N=77) X±SD	RB (N=53) X±SD	P (N=78) X±SD	LW (N=44) X±SD	RW (N=51) X±SD
BH cm	192.19±6.96	189.76±5.82 LB, RB, LW, RW, P	196.14±4.51 CB, LW, RW	194.42±5.7 CB, LW, RW	196.78±4.66 CB, LW, RW	186.14±5.32 CB, LB, RB, P	184.76±5.44 CB, LB, RB, P
BW kg	94.25±10.93	90.67±6.62 LB, LW, RW, P	97.45±6.59 CB, LW, RW, P	95.32±8.97 LW, RW, P	106.06±8.22 CB, LB, RB, LW, RW	83.55±7.05 CB, LB, RB, P	83.37±6.31 CB, LB, RB, P
FS km/h	105.68±36.24	108.82±39.9	113.12±40.01 RW	113.96±35.32 RW	98.58±29.59	108.98±15.24	90.43±43.36 LB, RB
FSP km/h	25.56±4.93	24.32±6.56 LW	24.69±4.68 LW	25.32±4.08 LW	24.45±3.03 LW	29.09±1.34 CB, LB, RB, P	27.12±6.51
HJ cm	49.54±21.98	54.23±24.75 P	58.69±18.54 LW, RW, P	60.81±16.91 LW, RW, P	38.17±17.47 CB, LB, RB	43.50±17.64 LB, RB	41.49±25.28 LB, RB
AGT min	26.00±18.44	25.16±33.01	24.57±12.89	24.22±13.33	25.28±13.62	30.90±13.89	27.79±17.75

Legend: **ALL** – all payers, **CB** – center backcourt player, **LB** – left backcourt player, **RB** – right backcourt player, **P** – pivot player, **LW** – left wing player, **RW** – right wing player, **BH** – body height, **BW** – body weight, **FS** – fastest shot, **FSP** – fastest sprint, **HJ** – highest jump, **AGT** – average gaem time. "N" represents number of entities / subjects for the given category (playing position).

these studies, wing players are described as lighter and shorter. This observation is probably related to the fact that these players need to be more flexible and agile because they usually start and finish the counterattack (Karcher and Buchheit, 2014). In other words, they need to be faster and more reactive than players in other positions, and these demands somehow condition the somatotype for the wing positions.

Results show that backcourt players had the fastest shot and wing players presented the slowest shots among all playing positions (Figure 1). Fast shooting in backcourt positions is not a novelty, and has been detected in previous studies. In outfield shot, backcourt players have to perform the shots as explosive as possible. The biggest obstacle in 9 m shooting are the defenders, who constantly interfere the shooters, either through physical contact or blocking actions (Foretić et al., 2010; Rivilla-Garcia et al., 2011; Karcher and Buchheit, 2014). Hence, backcourt players cannot deceive or trick goalkeepers like wing players or pivots do. Their only option for scoring, when shooting from outfield, is a strong and fast shot (Shalfawi et al., 2014; Haugen et al., 2016). An additional factor of faster shooting is the differences in morphology – backcourt players are significantly heavier and taller than wing players. The positive influence of BH and BW on ball shooting/throwing velocity has been well documented in the scientific literature (Gorostiaga et al., 2005; Zapartidis et al., 2009; Debanne and Laffaye, 2011; Sarvestan et al., 2019). An unexpected finding was that shots by LWs and RWs differed in almost 18 km/h, with LWs shooting faster. This should be commented in two ways: (i) LWs are little taller (1.38 cm) and their length features contribute to faster shooting, (ii) in this study, only the fastest shots that ended in goals were monitored, meaning that it is possible that the fastest shots by RWs were not included in our data matrix.

Fastest sprinting was recorded for wing positions, specifically for LWs, who were significantly faster (29.09 km/h) than all backcourt (LB, RB, and CB) and pivot positions (Figure 2). Similar results were reported in a study conducted by Haugen et al. (2019), who found that wing players differed from the other positions, with superior 10-m and 40-m sprinting times (Haugen et al., 2019). In a review study, Karcher and Buchheit (2014) stated that wing players perform largely more sprints than backcourt and pivot players (Karcher and Buchheit, 2014). When considering sprinting distance, pivots cover sprints over 5–7 m, backcourt players over 8 m, and wing players over 15–18 m (Luig et al. 2008). Longer distance gives wing players more opportunity for developing speed. Obviously, sprinting skills are particularly crucial for wing players, as they are more involved in fast breaks and counterattacks during a game than the other playing positions (Rogulj et al., 2011; Foreti et al., 2013).

Although jumping is a very important facet of handball players' activity, no studies have addressed on-court jumping performance so far (Figure 2). This is the first research that analyzed situational jumping performance between playing positions in top level male handball. When compared with sprinting and shooting, jumping performance showed the most diversity between playing positions. Obviously, backcourt players jump significantly higher than the other positions (16,76 cm higher). Without deeper insight, this could be noticed as a controversy, since past studies defined wing players as the most "explosive jumpers" or, at least, at the same level as backcourt players (Chaouachi et al., 2009; Krüger et al., 2014). A more detailed analysis of technical activity is needed to understand this phenomenon. It is connected with roles and game situations that are typical of each playing position. Another feature is the occurrence of jumps in all phases of the game - defense and offense

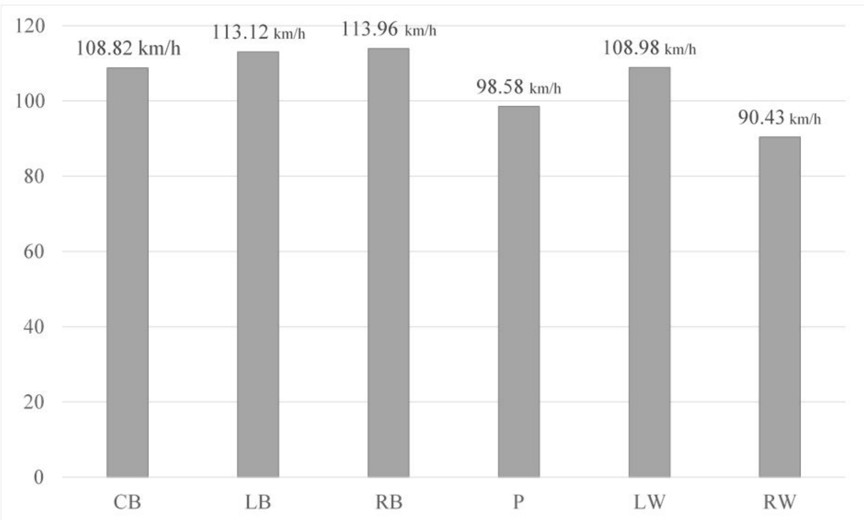

Figure 1. Distribution of fastest shots (FS) between playing positions.
Legend: **CB** – center backcourt player, **LB** – left backcourt player, **RB** – right backcourt player, **P** – pivot player, **LW** – left wing player, **RW** – right wing player.

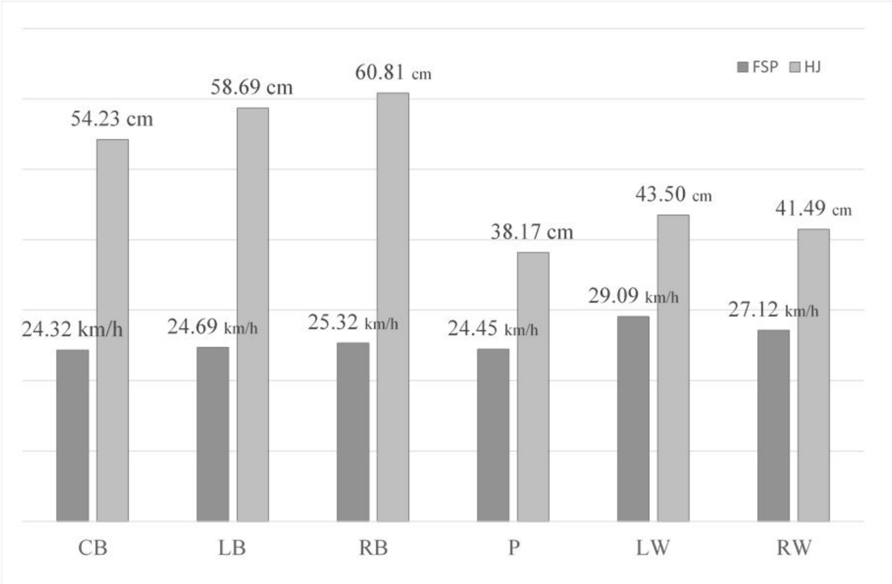

Figure 2. Distribution of fastest sprint (FSP) and highest jump (HJ) between playing positions
Legend: **CB** – center backcourt player, **LB** – left backcourt player, **RB** – right backcourt player, **P** – pivot player, **LW** – left wing player, **RW** – right wing player, **FSP** – fastest sprint, **HJ** – highest jump.

(Póvoas et al., 2012; Michalsik and Aagaard, 2015). According to Karcher and Buchheit (2014), backcourt players perform significantly more, while wing players perform significantly less jumps than the other playing positions (Karcher and Buchheit, 2014). Yet, no data on maximal jumping height was found in our literature review. Highest jumps from backcourt players may be associated with their need to shoot from over the defense, especially in its middle segment, where the tallest players are defending (Foreti et al., 2013). On the other hand, wing players and pivots are more focused on "angle opening", since their shooting positions are rarely interfered with defender blocking actions. Simplifying, back court players dominantly shoot with vertical jumps, while line players shoot with a combination of vertical and horizontal jump. This study monitored only the vertical dimension, and it concluded that backcourt players dominate the vertical features of situational jumping performance.

CONCLUSION

This is the first study in handball that analyzed situational explosiveness/power. The results show significant differences between playing positions in all assessed variables. The greatest differences were observed in jumping performance where backcourt players jump significantly higher than the other positions. All differences have foundation in position role and typical game situations. The biggest limitation to this study is that it only analyzed the best performance in given variables (shooting, sprinting, and jumping). There would be better insight into specific handball explosiveness if all shoots, sprints and jumps had been analyzed. Nevertheless, data from this research could assist coaches in better understanding situational power demands, since power activities should always be performed as high and as fast as possible. As training of elite handball players should be specific and similar to the actions performed during the game, the results of this study can assist handball and conditioning coaches in modelling more efficient power training for different playing positions.

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CONFLICTS OF INTEREST

The authors declare having no conflicts of interest.

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