DIFFERENCES IN AEROBIC AND ANAEROBIC PARAMETERS BETWEEN HANDBALL PLAYERS ON DIFFERENT PLAYING POSITIONS

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Original scientific paper

Abstract

The aim of this study was directed to analysing the differences in functional ability parameters of top handball players on different playing positions. The subject sample consisted of 70 handball players (25 wing players, 25 backcourt players, and 20 pivots) from the Croatian Division I Handball League. Statistically significant differences were found between handball players on different playing positions in parameters for the measurement of aerobic capabilities, while the analysis of the differences in anaerobic capacities showed no statistically significant differences. Significant differences in aerobic abilities could be explained by the morphologic differences of players on different playing positions and by different tasks that the players on different playing positions have during the match. Probably, it would be important to further examine the playing positions in handball in more detail and to use specific tests for the measurement of motor and functional abilities with a view to getting a deeper insight into the specific requirements of each playing position in handball.

Key words: *handball, top players, functional tests, playing positions, differences*

Introduction

In every team sport, there are differences in competition demands of different playing positions. This is related to the optimum functioning of the body as a whole and of different organ systems, such as the transport (cardiovascular and respiratory) and neuromuscular systems. An adequate level of functional abilities is a requirement for good performance in a handball match. Under short-term, medium-term and long-term loads, specific energy processes are activated, which is even more pronounced when the activity is performed at a maximum intensity level in situation-specific conditions. When analysing the covered distance, it is important to emphasize that there is a number of specific movements that considerably affect the energy consumption. These are jumping, throwing, stopping, direction changes, etc. Furthermore, the contact play, which places an increased demand both on motor and functional abilities, has a significant role in the total energy consumption in handball. These parameters offer an insight into physical demands of a handball game and provide useful information for the analysis of the differences in functional parameters of different playing positions. According to the previous studies, the frequency of different movements (standing, walking, running forward or backward, sprinting, jumping, moving sideways, etc.) is approximately 900 during a handball match (Mihalsik 2004; Thorlund et al., 2008). According to Michalsik (2004), a handball player runs an average of 3600 m during the 50 minutes of a match, of which 11% is performed at a high-intensity level. These results were confirmed by Šibila et al. (2004), who showed that12-17% of the total distance of 3250-3850 m is covered at a high or maximum intensity level. According to the results of other notation studies, even longer distances are covered during a handball match. According to Perš et al. (2002), 32% of the total distance of 4800 m is covered in sprint and fast running, and according to Kotzamanidis et al. (1999), the total distance covered in running during a match is 7000 m. An analysis of the duration of the offence play in big competitions showed that the average duration of the offence ranges between 22 and 31 seconds and that115-160 offence plays are played during a match (Seco, 2008).

With respect to the differences between playing positions, according to Šibila et al.(2004), there are significant differences in the percentage of the time spent in maximum intensity activities, which is 4% for wings, 3% for backcourt players, and 2% for pivots. According to Konzak and Schacke (in Cuesta, 1991), a player performs an average of 190 changes of the movement rhythm, 279 changes of direction, and 16 jumps. Many studies have confirmed that the average intensity in team sports is in high intensity aerobic zone, or 70-80% of the maximum oxygen uptake (VO_{2max}) and 80-90% of the maximum heart rate (HR_{max}) (Bangsbo, 1994; Reilly et al., 1996; Helgerud et al., 2001; Mohr et al., 2003; Bangsbo et al., 2006). The ratio between the high- and low-intensity activities in handball is between1:3 and1:5 (Šibila et al., 2004, according to Bon, 2001). During a handball match, the average intensity is around 70% of VO_{2max}, and the average heart rate is 157 BPM (Thorlund et al., 2008). According to Cardinale and Manzi (2008) and Loftin et al. (1996), the average HR is 86% of HR_{max}, 78% of the time HR is above 80% of HR_{max}, and 36% of the time HR is between 90 and 100% of $HR_{max.}$ Cuesta (1991) determined the lactate peak of 10 mmol/L (Figure 8)during a handball match, which is similar to the findings of Delamarche et al.from1987 (4-9 mmol/L), and Bolek and Liska from 1981 (7-10 mmol/L).

The main objective of this study was to analyse the differences in functional indicators of top handball players on different playing positions. With respect to the main objective of the study, it is possible to expect statistically significant differences in aerobic parameters of players on different playing positions and also statistically significant differences in anaerobic parameters of players on different playing positions. Findings of the studies examining the differences between players in different team sports can be used to improve the definition of the criteria for the selection of potential top handball players, as well as the improvement of the planning, programming and training control processes.

Methods

Subjects

The study was conducted on the Croatian Division I handball players who were tested at the Faculty of Kinesiology, University of Zagreb. The sample comprised 70 handball players (age 24.07±4.77, 188.4±8.0cm, 91.0±10.4kg), of which 25 wing players (age 24.53 ±5.69, 181.2 ±5.6cm, 82.4 ±9.5kg), 25 backcourt players (age 24.90±4.23, 193.3±6.5cm, 94.6±6.7kg) and 20 pivots (age 22.68±4.38, 191.3±5.9cm, 96.9±9.7kg).

Variables

For the diagnostics of functional abilities, 6 variables divided in 2 groups representing the parameters of aerobic abilities and anaerobic capacities were used. For the measurement of aerobic abilities, the following variables were used: 1) Maximum absolute oxygen uptake (VO_{2max}); 2) Maximum relative oxygen uptake (RVO_{2max}); 3) Max. running speed on the treadmill (v_{max}); 4) Running speed at the ventilation anaerobic threshold (v_{AnP}). For the measurement of anaerobic capacities, the following variables were used: 1) Time in the anaerobic zone (t_{an}); 2) Distance covered in the anaerobic zone (ds_{uk}). The spiroergometry test on a treadmill was conducted with subjects in good healthat the SportsDiagnostics Centre of the Faculty of Kinesiology, University of Zagreb. The treadmill test is a progressive test-to-failure which consists of resting in the first minute, followed by walking at the speed of 3 km/h for the next two minutes. After that, the treadmill is accelerated by 0.5 km/h every half a minute, until the moment in which the subject is not able to reach the next speed level. When treadmill speed reaches 7 km/h, the subject begins to run.

Statistical analysis

The results were analysed using package Statistica for Windows, version 7.0., and the following methods were used: * Basic descriptive parameters for creating the profiles of handball players on different playing positions; * Univariate analysis of variance for the analysis of the differences between the handball players on different playing positions in variables measuring functional abilities, while Bonferroni *post-hoc* test was used for additional analysis of the differences between groups.

Results and Discussion

Table 1 - Descriptive values of aerobic and anaerobic parameters of handball players

Test	Mean	Min	Max	SD	Skewness	Kurtosis
VO_{2max} l/min)	5.10	3.91	6.26	0.55	-0.13	-0.42
RVO_{2max} (ml/kg/min)	55.88	43.93	68.94	5.40	0.00	0.04
v_{max} (km/h)	17.29	14.50	19.50	1.21	-0.15	-0.72
v_{AnP} (km/h)	12.91	10.50	17.50	1.10	1.06	3.80
t_{an} (s)	262.37	30.00	420.00	54.65	-0.65	4.36
ds_{uk}(m)	1120.77	149.99	1837.43	263.40	-0.33	1.97

Table 2 - Central and dispersive parameters of the variables and significance of differences between wing, backcourt and pivot players in handball

Test	Wing (n=25) Mean±SD Min-max	Backcourt=25) Mean±SD Min-max	Pivot (n=20) Mean±SD Min-max	P
VO_{2max} (l/min)	4.82±0.51 3.91-5.67	5.25±0.47 4.69-6.26	5.26±0.56 4.01-6.02	$€
RVO_{2max} (ml/kg/min)	58.54±4.71 46.10-68.94	55.44±5.14 46.20-68.90	53.10±5.17 43.93-63.00	€
v_{max} (km/h)	17.86±1.01 16.00-19.50	17.22±1.12 14.50-19.00	16.65±1.27 15.00-19.50	€
v_{AnP} (km/h)	13.42±1.17 12.00-17.50	12.62±0.96 10.50-15.00	12.65±0.98 11.00-15.00	$
t_{an} (s)	266.40±69.97 30.00-420.00	276.24±38.71 210.00-378.00	240.00±44.35 180.00-360.00	ns
ds_{uk}(m)	1172.93±319.23 149.99-1837.43	1166.53±199.05 849.97-1690.43	998.39±225.99 687.47-1574.94	ns

VO_{2max} – maximum absolute oxygen uptake; RVO_{2max}– maximum relative oxygen uptake; v_{max} – maximum speed on the treadmill; $v_{AnP}t_{an}ds_{uk}$ ANOVA - $ significant wing-backcourt p<.05; € significant wing-pivot p<.05; £ significant backcourt-pivot p<.05; ns not significant.

Table 1 contains descriptive parameters of tests for the measurement of functional abilities of handball players. The obtained results, VO_{2max} of 5.10 l/min, RVO_{2max} of 55.9 ml/kg/min, and v_{max} of 17.3 km/h correspond to the results of previous research by Šentija et al. (1997), Chaouachi et al. (2009), and Sporiš et al. (2010).

Table 2 contains the basic descriptive parameters and parameters of statistical significance of the differences in the variables for the measurement of functional abilities of wing players, backcourt players and pivots in handball. The average values of RVO_{2max} for wing players (58.5±4.7 ml/kg/min), backcourt players (55.4±5.1 ml/kg/min) and pivots (53.1±5.2 ml/kg/min) are slightly higher than the values found in the research conducted by Šentija et al. (1997), Chaouachi et al. (2009), and Sporiš et al. (2010). The players that participated in this study were selected Croatian Division I Handball League players and members of the national team, who achieve top results in international competitions. Most variables for the measurement of functional abilities in the range between the minimum and maximum results include 4.5-5.0 standard deviations, suggesting an adequate dispersion of results. In the variable $RVO_{2max,}$the dispersion of results was slightly higher. The dispersion of results was lower for backcourt players and pivots, which is the consequence of the selection and specific requirements for each playing position.

Analysis of the differences invariables for the measurement of aerobic capacities between different playing positions

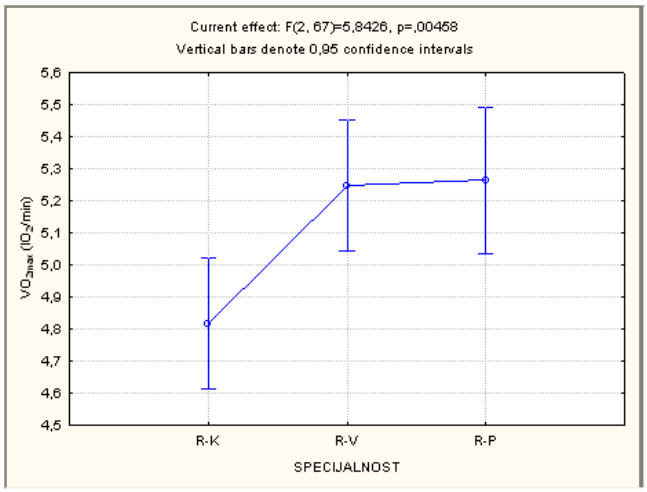

Figure 1 -Average absolute maximum oxygen uptake for wing players, backcourt players and pivots (VO_{2max};l/min)

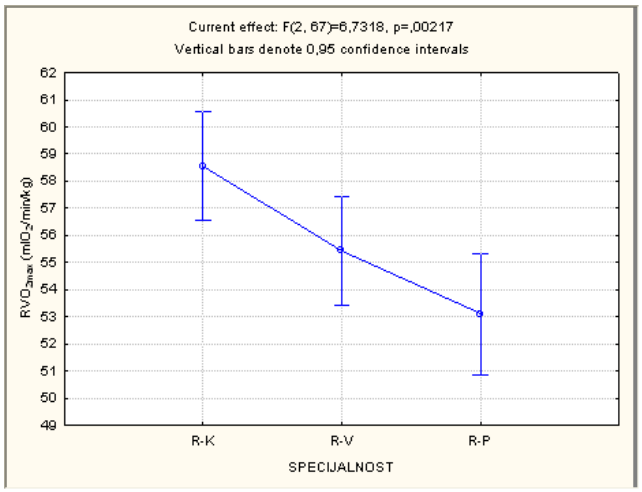

Figure2 - Average relative maximum oxygen uptake for wing players, backcourt players and pivots (RVO_{2max};l/min)

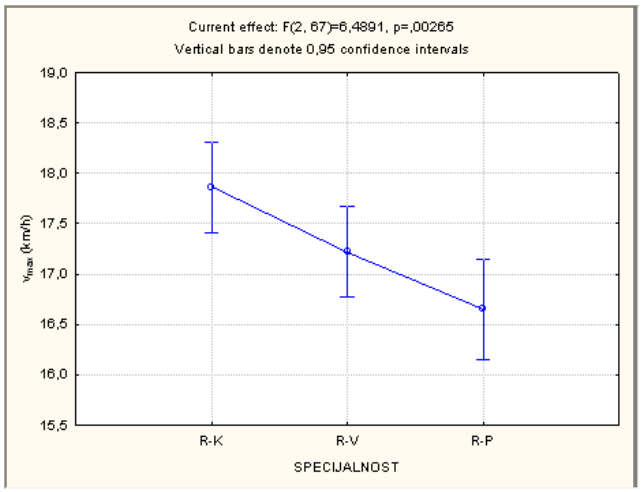

Figure 3 - Average maximum speed on the treadmill for wing players, backcourt players and pivots (V_{max}; km/h)

The analysis confirmed significant differences between variables for the measurement of anaerobic capacities of players at different playing positions. In the variable $VO_{2max,}$ scores for wing players were significantly lower than those of the backcourt players ($p<0.05$) and pivots ($p<0.05$) (table 2). The determined differences are the result of a positive correlation of the bodyweight and VO_{2max} ($p=0.00$, $r=0.61$), since significant differences in skeletal dimension and body weight factors were found between handball players at different playing positions (Milanović, 2011).

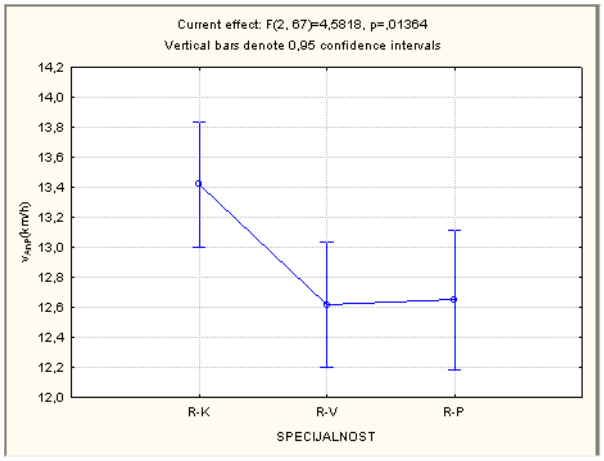

Figure 4 - Average speed at anaerobic threshold for wing players, backcourt players and pivots (V_{AnP};km/h)

In the variable $RVO_{2max,}$the scores of wing players, as compared to the scores of pivots, were significantly higher ($p<0.01$) (Table 2).This is due to the differences in specific requirements for different playing positions, since wing players cover longer distances (Michalsik, 2004) and spend a higher percentage of time performing maximum intensity activities (wing players 4%, backcourt players 3%, and pivots 2%, Šibila et al., 2004), which requires faster recovery in the varying conditions of the match. The statistical significance of the differences in the mentioned variables confirm the findings of studies by Šentija et al. (1997) and Sporiš et al. (2010), while the average values for each playing position are slightly higher than those found in previous studies (Šentija et al., 1997; Chaouachi et al., 2009; Sporiš et al., 2010). Other parameters for the measurement of anaerobic capacities showed that wing players had better scores than pivots in the variable v_{max}($p<0.01$), and better scores than backcourt players in the variable v_{AnP}($p<0.05$), which can be ascribed to the mentioned differences in the total distance covered during a match (Michalsik, 2004) and the differences in the percentage of time in which the maximum intensity activities are performed (Šibilaet al., 2004). Also, since the average duration of the offence play is 22-31 seconds and a total of 115-160 offence plays is executed during a match (Seco, 2008), there are many transition offence plays(counterattack, extended counterattack, quick centre) in which wing players play the key role.

The results of this study correspond to the results of the study conducted by Šentija et al. (1997) in terms of the obtained results and the significance of the differences in the variable v_{max}, while the study conducted by Sporiš et al. (2010) reports significantly higher scores for the backcourt players as compared to wing players and pivots.

The obtained results confirm the importance of an adequate level of aerobic capacity in handball since a handball match in volves a large number of short, high-intensity specific activities combined with the intervals of low-intensity play.

A high level of aerobic capacity enables faster recovery after short activities of high intensity (Reilly et al., 2003; Spencer et al., 2005), which suggests that anadequate level of aerobic capacity plays an important role in the success of a handball player.

Analysis of differences in variables for the measurement of anaerobic capacity of players atdifferent playing positions

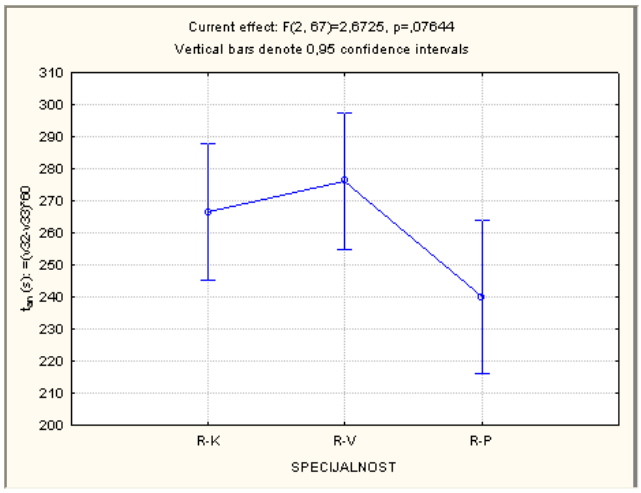

Figure 5 - Average time in the anaerobic zone for wing players, backcourt players and pivots (t_{an};s)

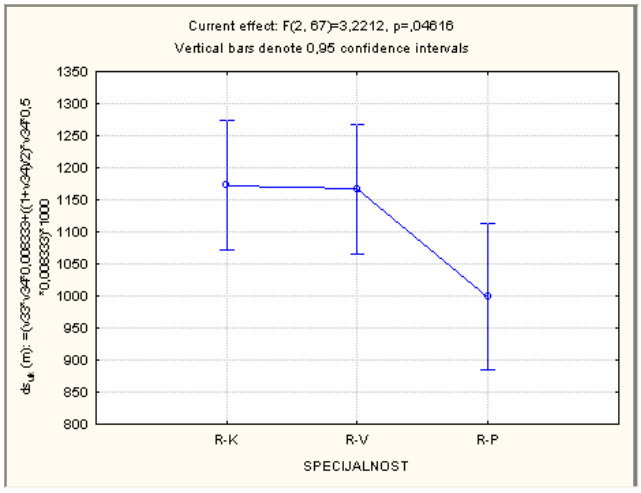

Figure 6 - Average distance covered in the anaerobic zone for wing players, backcourt players and pivots (ds_{uk};m)

In the variable "time in the anaerobic zone" (t_{an}) and the variable "distance covered in the anaerobic zone" (ds_{uk}), there were no statistically significant differences found between the anaerobic capacities of the players on different playing positions (Table 2). In the variable "time in the anaerobic zone" (t_{an}), the scores of the backcourt players were the highest (276 seconds), followed by those of wing players (266 seconds), and pivots (240 seconds).
In the variable "distance covered in the anaerobic zone" (ds_{uk}), wing players had the highest scores (1172 m), followed by backcourt players (1166 m), and pivots (998 m). Although there were no significant differences found between the scores of the players on different playing positions, differences were found in the scores of pivots as compared to wing players (p=0.07) and backcourt players (p=0.09).

In this test, the limiting factor was probably the calibration, which might have led to the absence of significant differences in the scores of the players on different playing positions. Also, the fact that running in a straight line was used in the test should be taken into account, since the differences in the anaerobic capacity would probably be higher if changes of direction were included in the test. Nevertheless, it can be concluded that, regardless of the playing position, anaerobic glycolytic capacity is an important requirement for all handball players who wish to be successful in training and competitions. Also, it must be taken into account that contemporary handball is focussed on accelerating the game, which is supported by the modifications of the rules. The fact that so many substitutions are allowed during the match reflects the idea that the players should play at a maximum intensity level. This is congruent with the studies conducted by Cardinale and Manzi (2008) and Loftin et al. (1996), indicating that the average HR during a handball game is 86% of HR_{max}, 78% of the time HR is above 80% of HR_{max}, and 36% of the time HR is between 90 and 100% of $HR_{max.}$ Also, the ratio between the high- and low-intensity activities in handball is between 1:3 and 1:5 (Šibila et al., 2004, according to Bon, 2001), which points to the relevance of well-developed anaerobic glycolytic capacity.

Conclusion

This study was conducted with the aim of analysing the differences in functional ability parameters of top handball players on different playing positions. The subject sample consisted of 70 handball players (25 wing players, 25 backcourt players, and 20 pivots) from the Croatian Division I Handball League. Statistically significant differences were found between handball players on different playing positions in parameters for the measurement of aerobic capabilities, while the analysis of the differences in anaerobic capacities showed no statistically significant differences. Significant differences in aerobic abilities could be explained by the morphologic differences of players on different playing positions (Milanović, 2011) and by different

tasks that the players on different playing positions have during the match (Michalsik, 2004, Šibila et al., 2004). The absence of statistically significant differences in the anaerobic parameters could be explained by the fact that the defined standards for anaerobic capacities do not take into account the playing positions in handball, in order to meet the training and competition requirements. This study provided useful information on the differences between handball players on different playing positions. The number of subjects was compatible with the purpose of the study and the defined hypotheses. However, a larger sample of subjects of different age groups and competition level groupsshould be considered in future studies so asto get a better idea of the differences between different groups of players.

Also, it would be important to further examine the playing positions in handball in more detail and to use specific tests for the measurement of motor and functional abilities with a view to getting a deeper insight into the specific requirements of each playing position in handball.

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RAZLIKE U AEROBNIM I ANAEROBNIM PARAMETRIMA IZMEĐU RUKOMETAŠA NA RAZLIČITIM IGRAČKIM POZICIJAMA

Sažetak

Cilj ovog istraživanja bio je usmjeren na analizu razlike u parametrima funkcionalnih sposobnosti vrhunskih rukometaša na različitim igračkim pozicijama. Uzorak se sastojao od 70 rukometaša (25 krilnih igrača, 25 igrača u polju i 20 pivotmena) iz I hrvatske lige. Pronađene su statistički značajne razlike između rukometaša na različitih igračkim pozicijama u parametrima za mjerenje aerobnih sposobnosti, dok analiza razlika u anaerobnim kapacitetima nije pokazala statistički značajne razlike. Značajne razlike u aerobnim sposobnostima mogu se objasniti morfološkim razlikama igrača na različitim pozicijama, kao i zbog sudjelovanja u različitim zadaćama igrača na različitim pozicijama tijekom utakmice. Vjerojatno bi bilo važno dodatno ispitati igračke pozicije u rukometu još detaljnije i koristiti posebne testove za mjerenje motorike i funkcionalnih sposobnosti u cilju dobivanja dubljeg uvid u specifičnim zahtjevima svakog igrača i njegove poziciju u rukometu.

***Ključne riječi**: rukomet, vrhunski igrači, funkcionalni testovi, pozicije u igri, razlike*

Received: October 11, 2015
Accepted: December 05, 2015
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