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ORIGINAL RESEARCH

Physiological profile of professional handball players regarding playing position

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Abstract

In the handball game players occupied specific position which requires unique physiological and physical attributes relating to technical and tactical requirements of each position in order to maximize sport performance on the court. The aim of this study was to quantify anthropometrical and physiological characteristics in elite Macedonian handball players and compare them regarding four different playing positions. In this study were included55handball players, different nationality, from RNM, participated in ergometry testing with Bruce protocol and body mass analysis with bioelectrical impedance analyzer, InBody 720. The players were divided in four groups according to playing position: wings (W), backs (B), pivots (P) and goalkeepers (G). Anthropometric parameters for all players were following: mean height was 186.3±7.1 cm, weight =85.37±13.7 kg, skeletal muscle mass (SMM) = 42.04 ± 6.2 kg; BMI = 24.54±2.8; BF%=13.4 ± 4.75 and WHR = 0.85± 0.06. Regarding the position, B/W/P/G for height were: 187.14 cm /180.0 cm/191.77 cm/186.8 cm; weight: 85.72 kg/72.67 kg/ 99.67 kg/85.33 kg; body fat percent: 12.26 %/11.92 %/16.3 %/14.7 %. The mean values for maximal oxygen consumption for B/W/P/G were 48.86/44.31/44.09/47.78 ml/kg/min. The BIA parameters of body composition in handball players regarding the playing position, showed statistically significant differences for all lean body mass parameters and obesity diagnose parameters, except for the body fat percent. According the cardio-physiological parameters derived from Bruce protocol handball players at different playing position had similar aerobic capacity.

Introduction

The standard handball game rules feature two teams with seven players on each side, in each team is allowed six outfielders (outcourt players) and one goalkeeper. The outcourt players are three backs, two fullbacks (left and right) and “center” backcourt player, two wings (left and right) and circle runner (pivot). The activity patterns of different playing positions are imposed by theirs specific on-court working roles. The physical demands in elite handball game influence the potential differences in physiological and anthropological characteristics of handball players regarding playing position (Michalsik, 2018).The knowledge of physiological profile of high level handball players provides substantial information for the assessment and evaluation of talents and optimization of training regimes for achieving the ultimate goals (Fieseler et al., 2017).

The goalkeeper is the player responsible to defend the goal from the deflect shots fired by the opposite team. The main role of the backcourt players is of defensive nature, blocking the opposition from shooting and scoring. The center back has position of playmaker, someone who participates directly in defensive and offensive actions. The chief role of the pivot position is to create openings for teammates or getting into good scoring position for themselves (The UK Rules, 2022). Accordingly the special playing position’s tasks, morphological, motoric and functional features are needed for handball players to be assigned for certain playing position. The anthropometric characteristics, especially height, weight and body mass components, are highly related to playing

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positions in male and female handball players (Michalsik et al., 2015; Karcheret al., 2014). Several investigations suggested that each specific position in handball requires unique physiological and physical attributes relating to technical and tactical requirements of each position in order to maximize sport performance on the court (Ghobadi et al., 2013; Haugen et al., 2016; Ruscello et al., 2021).

A sophisticated video analysis of the locomotion characteristics (intensity, distance, running) and major playing actions (shots, breakthroughs, fast breaks, errors and tackles) regarding the playing positions, showed that there was no significant difference in playing time in offensive actions between wing, pivots and backcourt players. Regarding the defensive actions during the entire match positional differences showed that backcourt players were more active than wing players. The wing players were involved in more intensive locomotive activities with less direct confrontation with opposite team players. Although the backcourt players have more number of shots per match, the scoring percent was better in pivots (Michalsik, 2018). The profiling of the handball players regarding the playing position, evaluation of body composition, cardiorespiratory capacity and physical characteristics, could be valuable tool for correct assigning to playing position and optimizing the strength and conditioning training regimes (Schwesig et al., 2017; Karcher & Buchheit, 2014).

The purpose of this study was twofold. The primary aim was to quantify anthropometrical and physiological characteristics in elite Macedonian handball players. The secondary aim was to compare the obtained anthropometric and cardio-physiological parameters between different playing positions.

Methods

A cross-sectional experimental design was conducted to analyze the body components and cardio-physiological parameters of professional handball players. Prior to participation, the experimental procedures were explained to all the participants, who gave their voluntary written informed consent.

Participants

The study sample was composed of 55 (fifty five) male handball players, members of First league in R.N. Macedonia. The average age of participants was 23.75 ±3.41 years, average height was 186.33±7.12 cm, average weight was 85.37 ±13.67 kg. The sample of players consisted of 22 back players (B), 13 wings (W), 11 pivots (P) and 9 goalkeepers (G).

Participants were tested during their routine medical examinations (check-ups) at the Laboratory for Sports Medicine at the Institute of Physiology, Faculty of Medicine in Skopje. All participants underwent ergometrical testing (Bruce protocol), bioelectrical impedance analysis of body mass composition and biochemical analysis (blood count). The ethical guidelines for human investigation are followed in accordance with Helsinki Declaration and the approval of Ethical committee is obtained.

Measures and Procedures

Anthropometric measures

Height was assessed to the nearest 0.001 m, using a stadiometer (Holtain Ltd., Crymych, UK). Body mass was measured to the nearest 0.1 kg, using an electronic scale (Seca Instruments Ltd., Hamburg, Germany).

Body composition analysis

Body composition was assessed with a segmental multifrequency bioimpedance analyzer (InBody 720, Biospace Co. Ltd., Seoul, South Korea). The following parameters were analysed: body mass (kg), height (cm),ideal weight (IW-kg) body mass index (BMI) (kg/m2), skeletal muscle mass (SMM - kg), body fat (BF - kg) and body fat percent (BF%), waist to hip ratio (WHR), intracellular and extracellular water (ICW, ECW) and basal metabolic rate (BMR).

Ergometrical testing

Cardiovascular functions capacity was tested with the Bruce protocol sub-maximal treadmill test in line with the ACSM guidelines. The duration of this ergometrical test is determined when the individual's submaximal heart rate was achieved. During the ergometric testing heart rates are registered at rest, before the test has started (HRRest), at the end of each minute during the first ten minutes of exercise duration and at the end of recovery phase, HRRec3. We analysed the following parameters: absolute values of maximal oxygen consumption (VO_2max –ml/kg/min), and heart rates at the rest before the beginning of the treadmill walking, heart rate at the end of recovery period, general endurance and speed endurance scores.

Statistical Analysis

Statistical analysis of the obtained results was made using the SPSS (v22.0; SPSS, Inc., Chicago, IL, USA).Standard descriptive statistics was used to determine mean and median values, standard deviation, and ± 95 confidence interval, minimum and maximum values were used for series with numerical attributes. Mean differences of selected anthropometric characteristics, body composition components, obesity diagnose parameters and cardio-physiological parameters between playing positions were tested using one-way univariate general linear model with a Tukey post hoc test. The significance level was set at $p < 0.05$. The differences between anthropometric parameters among players with different playing positions were determined by calculating a one-way Analysis of Variance (ANOVA). Partial comparisons between groups of respondents were made using the Bonferroni post-hoc test.

Results

Anthropometric characteristics and BIA body composition parameters of professional male handball players from elite Macedonian teams are presented in Table 1. For further data analysis players were divided into four groups according their playing position: backs (B), wings (W), pivots (P) and goalkeepers (G). Anthropometric characteristics and BIA body composition parameters for different playing positions are presented in Table 2.

The differences between anthropometric parameters among players with different playing positions are presented in Table 3. From the obtained values, it can be seen that between the four groups of respondents with different playing positions there are statistically significant differences in relation to the following anthropometric parameters: height, weight, ideal weight, SMM, BFM kg, BMI, ICW, ECW, BMR, obesity degree percent. Only regarding the BF %, no statistically significant differences were found between the groups of players with different playing positions (p=0.056).

Regarding the height, there is a statistically significant difference between the groups of respondents: backs and wings; wings and pivots. Wing players have a lower average height than pivots as well as backs.

Regarding the weight, there is a statistically significant difference between the groups of respondents: backs, wings and pivots, as well as between goalkeepers, wings and pivots. Wing players have a lower average weight than becks and pivots. Goalkeepers have a higher average weight than wing players and less than pivots.

Table 1
Descriptive statistics of BIA body composition parameters for whole sample (n=55).

		Height (cm)	Weight (kg)	Ideal weight (kg)	SMM (kg)	BFM (kg)	BMI (kg/m^2)	BF%	WHR	ICW (l)	ECW (l)	BMR (kcal)
Mean		186.33	85.37	84.62	42.04	11.78	24.54	13.39	0.85	33.91	20.04	1959.13
Median		186.33	85.37	84.62	42.04	11.78	24.54	13.39	0.85	33.91	20.04	1959.13
Std. Dev		7.12	13.67	11.22	6.22	5.64	2.84	4.75	0.06	4.58	2.75	218.18
Skewness		.222	.803	.757	.456	1.237	.578	.547	.941	.619	.622	.593
Kurtosis		-.180	1.139	.404	.233	1.611	-.119	.080	1.749	.259	-.204	.139
Minimum		171.50	56.30	64.00	28.90	3.20	19.30	4.60	.73	24.60	14.90	1517.00
Maximum		204.00	128.50	117.30	57.90	28.80	31.80	25.70	1.03	45.90	26.90	2524.00
Percentiles	25	181.00	76.80	77.30	37.80	7.50	22.40	9.60	0.81	30.50	18.00	1804.00
	50	186.00	83.20	82.60	41.30	11.40	24.20	13.40	0.83	33.20	19.80	1936.00
	75	190.50	93.10	90.80	45.10	13.80	26.30	15.80	0.88	36.10	21.60	2069.00

Table 2
Descriptive statistics of BIA body composition parameters for back players, wing players, pivots and goalkeepers.

	Height (cm)	Weight (kg)	Ideal weight (kg)	SMM (kg)	BFM (kg)	BMI (kg/m^2)	BF%	WHR	ICW (l)	ECW (l)	BMR (kcal)
Backs (n= 22)											
Mean	187.14	85.72	85.53	42.71	10.52	24.51	12.26	.84	34.63	20.49	1993.77
Median	187.00	85.15	84.65	42.10	10.85	24.25	12.90	.86	33.85	20.10	1958.00
Std. Dev	4.69	9.04	8.84	5.86	3.19	2.08	3.47	.04	3.90	2.27	181.79
Minimum	180.50	72.60	72.90	28.90	3.70	21.60	4.60	.73	30.00	17.50	1771.00
Maximum	196.50	107.0	107.0	57.20	16.60	29.40	18.60	.89	45.40	26.10	2487.00
Wings (n= 13)											
Mean	180.00	72.67	73.76	36.50	8.91	22.47	11.92	.82	29.52	17.37	1747.15
Median	180.00	71.40	74.50	36.30	7.50	22.00	10.30	.81	29.30	17.40	1737.00
Std. Dev	5.90	8.21	5.12	3.57	4.84	2.59	5.13	.045	2.75	1.36	127.09
Minimum	171.50	56.30	64.00	30.10	3.20	19.30	5.60	.76	24.60	14.90	1517.00
Maximum	192.50	90.30	82.60	43.50	23.20	29.80	25.70	.93	34.90	20.50	2003.00
Pivots (n= 11)											
Mean	191.77	99.67	96.10	47.69	16.74	27.06	16.30	.89	38.09	22.60	2160.82
Median	194.50	96.20	96.20	48.50	13.90	26.30	14.80	.87	38.80	23.00	2195.00
Kurtosis	-1.07	-.20	-.37	-.50	-.65	-.21	-.01	-.57	-.51	-1.15	-.69
Minimum	177.50	82.50	82.50	40.80	5.60	23.30	6.10	.77	32.80	19.20	1904.00
Maximum	204.00	128.5	117.3	57.90	28.80	31.80	23.20	1.03	45.90	26.90	2524.00
Goalkeepers (n=9)											
Mean	186.83	85.33	84.08	41.49	12.91	24.51	14.73	.85	33.37	19.64	1934.11
Median	187.00	83.20	82.70	40.10	13.20	24.20	15.80	.85	32.30	19.10	1887.00
Std. Dev	5.79	11.16	8.87	4.41	5.67	2.93	5.24	.05	3.38	2.21	165.08
Minimum	177.50	69.30	71.30	36.80	5.60	20.60	8.10	.78	29.80	16.80	1745.00
Maximum	195.50	101.0	101.0	50.40	23.70	28.90	24.00	.94	40.20	24.00	2267.00

There is a statistically significant difference at the 0.05 level ($p<0.05$) regarding the obesity parameter WHR. Wing players have lower average WHR values than pivots.

Multiple comparisons analysis showed that wings has significantly lower height than backs and pivots, while pivots had higher mean weight than wings, backs and goalkeepers. B and G do not differ in weight and height. Pivots had significantly higher muscular mass than wings. Pivots also had higher BMI than wings and backs, but similar to goalkeepers. The body fat percent (BF %) did not show statistically significant differences between any of the groups. The volume of total water (TW) including intracellular water (ICW) and extracellular water (ECW), are indicators of hydration status and soft lean mass. Both fluid compartments, ICW and ECW, were significantly higher in pivots (P) compared to W and G. These BIA variables were significantly lower in the lightest and leanest group, wings, (W) compared to B and P. Pivots had higher obesity degree than W and B, without significant difference with G.

Table 3
Comparative analysis of BIA body composition parameters in handball players regarding playing position (Mean ± SD).

Variables	(B) backs	(W) wings	(P) pivots	(G) goalkeepers	F	p
Height (cm)	187.14±4.69	180.00±5.9	191.77±8.51	186.83±5.79		
Weight (kg)	85.72±9.04	72.67±8.21	99.67±14.93	85.33±11.16	12.85	.000*
Ideal weight(kg)	85.53±8.84	73.76±5.12	96.10±10.1	84.08±8.87	13.45	.000*
SMM (kg)	42.71±5.86	36.50±3.57	47.69±5.46	41.49±4.41	9.75	.000*
BFM (Kg)	10.52± 3.19	8.91± 4.84	16.74± 7.36	12.91± 5.67	5.58	.002*
BMI(kg/m^2)	24.51± 2.08	22.47± 2.59	27.06± 2.66	24.51± 2.93	6.83	.001*
BF %	12.26±3.47	11.92± 5.13	16.30± 5.14	14.73± 5.24	2.68	.056
WHR	.84± 0.04	.82± 0.045	.89± 0.08	.85± 0.05	3.57	.020**
ICW (l)	34.63± 3.9	29.52± 2.75	38.09± 4.18	33.37±3.38	11.51	.000*
ECW(l)	20.49±2.27	17.37± 1.36	22.60± 2.62	19.64± 2.21	12.21	.000*
BMR (kcal)	1993.77±191.8	1747.15± 127.1	2160.82± 200.3	1934.11± 165.1	11.10	.000*
Obesity degree %	110.73± 9.41	101.31± 11.97	122.45± 12.32	111.11± 13.49	6.92	.001*

** Statistically significant differences between the groups at the 0.05 level after applying the Bonferroni post-hoc test.*
*** Statistically significant differences between the groups at the 0.01 level after applying the Bonferroni post-hoc test.*

Table 4
Comparison of cardio-physiological variables for handball players with different playing positions (Mean ± SD).

Variables	Back	Wing	Pivot	Goalkeeper	F	p
HRR (bp/m)	77.73 ± 15.02	88.31± 8.97	80.73 ± 11.5	78.44± 10.45	2.13	0.108
HRRec3 (bp/m)	113.91±11.0	118.29 ± 13.7	118.5 ± 3.11	114.6 ± 4.93	0.29	0.834
GE	4.73 ±0.46	4.54 ± 0.52	4.36 ± 0.51	4.67 ± 0.5	1.49	0.230
VO_2max (ml)	48.86 ±13.24	44.31 ± 3.73	44.09 ± 4.83	47.78 ± 4.82	1.05	0.380

HRR: Heart rate at rest; HRRec3: Heart rate at third minute of recovery period; GE: General endurance; VO_2max: Maximal oxygen consumption; bp/m: Beats per minute.

The differences in terms of the cardio-physiological variables obtained with Brus test protocol (HRR – heart rate at rest; HRRec3 – heart rate at recovery; GE – general endurance; VO_{2max} – maximal oxygen consumption) in players with different playing positions were determined by calculating a one-way Analysis of Variance (ANOVA). The pairwise comparisons between groups of respondents were made using the Bonferroni post-hoc test. From the reported values it can be seen that between the four groups of players there was no statistically significant difference for the mentioned variables.

The descriptive statistics for the maximal oxygen consumption is presented in table 5. The mean value of VO2 max for all participants was 46.55±9.16 ml/kg/min, and there was no statistically significant difference between players at specific playing position (p=0.23). Although backs showed the highest mean value (48.86 ±13.24 ml/min/kg) which was similar to goalkeepers (47.78 ± 4.82 ml/min/kg), they were not significantly better than wings (44.31 ± 3.73) and pivots (44.09 ± 4.83 ml/min/kg).

Table 5
Descriptive statistics for maximal oxygen consumption in handball players regarding playing position (ml/kg/min).

		Backs	Wings	Pivots	Goalkeepers	All Participants
n		22	13	11	9	55
Mean (ml/kg/min)		48.86	44.31	44.09	47.78	46.65
Median (ml/kg/min)		46.00	45.00	44.00	47.00	45.00
Std. Dev		13.24	3.73	4.83	4.82	9.16
Skewness		4.15	-1.45	.53	.31	5.15
Kurtosis		18.56	2.55	-.08	-1.13	33.50
Minimum		39.00	35.00	37.00	41.00	35.00
Maximum		53.00	49.00	53.00	55.00	55.00
Percentiles	25	44.00	44.00	40.00	44.00	44.00
	50	46.00	45.00	44.00	47.00	45.00
	75	49.25	47.00	46.00	52.50	49.00

Discussion

The results of our study confirm that handball players occupying different positions differ amongst themselves in terms of many anthropometric and physiological measurements. The pivots were the most robust, the height, the weight and all BIA lean mass variables and BIA obesity parameters were significantly higher than in other playing positions players. On the other side, wings were significantly lower, lighter and the most lean players, with the lowest obesity parameters between the four groups of players. The comparison between goalkeepers and becks showed similar height, weight, BMI, WHR, although the goalkeepers had insignificantly higher BF% than backs.

From these comparisons we can conclude that becks had highest soft lean mass and skeletal muscle mass. Wings were the leanest players, with lowest value of BIA obesity parameters. Body fat percent BF% was not significantly different in different playing position groups, so BF% does not show sensitivity to recognize the difference in body composition in this athletic population. Majority of our athletes had optimal body composition values as predicted for general healthy population, given the reference values from BIA result reports. So the nuances between these parameters in athlete's body composition are hard to recognize. The BIA sheet results offer information about ideal predicted weight, plus muscle and fat control, recommended changes for muscle and fat components which are needed to achieve ideal weight and body composition. If the real weight is equal to ideal, and the body composition is optimal, fat and muscle control are zero (0) kilogram, which means there is no need to change the body composition. In our respondents 86.4% of the becks had ideal body composition, 3 athletes (13.%) had need for fat control. In wings 38% (5 of 13) had ideal body composition, only one athlete had excess of fat mass, and 54% (7 of 13) had insufficient body mass, probably because they were very young, 18 years old. In pivots 45% (5 of 11) were heavier than there ideal weight, and in goalkeepers 3 out of 9 (33%) were overweight apropos the ideal weight.

The morphological differences between handball players regarding the playing position

The most prominent feature of handball play is its dynamic intermittent nature which imposes the specific metabolic demands on the players. They should be able to generate short, explosive and powerful movements (anaerobic energetic pathways) and fast recovering between the high intensity periods (aerobic energetic pathway) (Martinez-Rodriguez et al., 2020) The physiological and physical demands of the game in players require highly developed anthropometric and motoric qualities such as exquisite linear speed, agility, aerobic capacity, muscular strength and power of both, upper and lower limbs (Bilge, 2012). In general, empirical and scientific data showed that handball players are robust, huge athletes, with predominantly high body mass index due to the high muscular component (Muratović et al., 2014; Ruscelo et al., 2021). Numerous studies have indicated that certain physical characteristics are related to high level handball performance, especially higher fat free mass which is positively correlated with greater muscular power and strength (Cardinale et al., 2017; Ziv & Lidor, 2009). According to Moncef et al. (2012), backs and goalkeepers are heavier than wingers and forward center.

Elite handball players tended to be larger in stature, with higher, lean mass and larger hands dimensions (Fieseler et al., 2017). Investigations in world class beach handball players revealed following position-related differences: the back players (pivot/defenders) were taller and heavier and showed larger arm span than front players (wings/specialists) (Pueo et al., 2020). Sibila & Poris (2009) found that the wings differ the most from the other player groups in terms of their morphological body characteristics. Goalkeepers are relatively tall, with high values of body mass and the highest value of body fat component, whilst pivots had a higher quantity of muscle mass and robustness (Sibila & Pori, 2009). The average BMI of the handball players from Poland was 26.7, which is considered slightly above the norm and appears to be the result of higher fat free mass among the players (Lijewski et al., 2019)

Athletes typically possess a higher soft tissue mass and different fluid content than the general population (Di Credico et al., 202). Pivot players usually have the most athletic figure in terms of size and weight, while the backs are characterized by the android body type and low subcutaneous fat content, and a large mass of body cells. The wingers are usually slim, with low body fat percentage and significant extracellular mass (Lijewski et al., 2019). Regarding anthropometric characteristics, wings were players with lowest body height and weight, whereas pivots were heaviest players and players with highest body mass index (Krüger et al., 2014). Investigations in the Croatian and Serbian handball players noted that backcourt players and goalkeepers were superior in longitudinal and circumferential dimensions, while wings and pivots had lower longitudinal dimensions. Pivots showed higher body fat than players at other positions (Srhoj et al., 2006; Sporis et al., 2005).

Cardio-physiological differences between handball players regarding the playing position

It is well known that different handball playing positions require, and are based on, different players' morphological and physiological characteristics and therefore, it can be debated that physiological profiles in handball players are modulated by a playing position (Ruscello et al., 2021; Karcher & Buchheit, 2014; Michalsik et al., 2014; Pueo et al., 2020). Still there is lack of the research in the last decade which is focused on studying the aerobic capacity of the players at different playing position in handball. Although some studies have analyzed anthropometric and physiological characteristics of elite handball players, little information is available concerning the physical (e.g., strength, peak power sprint, and throwing performance) and physiological characteristics (e.g., aerobic capacity, anaerobic capacity, maximal oxygen consumption, spirometry) of contemporary professional handball players especially regarding the playing position. The differences in the results of published studies regarding the anthropometric, motoric and physiological features in handball players apropos different playing position could be due to different methodology of measurements and testing and different level of athletes (professional, elite, and sub-elite).

In our study the cardio-physiological parameters derived from Bruce ergometer protocol were insignificantly different in handball players at different playing position. The heart rate at standing position before the treadmill started was similar in all groups, and the mean values were near to the upper normal reference value for resting heart rate (around 80 bpm). The wing players showed insignificantly higher heart rate rest value (88.31±8.97). The heart rate at the recovery period, in the third minute after the ending of the test, was almost same in the backs and goalkeepers, as in wings and pivots. The level of decreasing of the heart rate during the recovery period showed capacity of the cardiovascular system for fast recovering. For period of two minutes heart rate decreased from submaximal values (170 bpm) to mean value around 115 bpm. Backs and goalkeepers had insignificantly higher maximal oxygen consumption than wings and pivots. Maximal oxygen consumption as variable is derived from exercise time or time needed for subject to achieve personal submaximal heart rate during ergo metrical testing. All handball players achieved 100%

or more than predicted value for VO_2max for healthy general population. The backs and goalkeepers showed insignificantly higher aerobic capacity compared to wings and pivots. General endurance is score calculated from duration of exercise time (Bruce test), and could be rated from 1 to 5. Consequently backs and goalkeepers got better general endurance score compared to wings and pivots, but without significant difference. All groups handball players had excellent general endurance score, above 4.5 score. Pivots had lowest mean values of 4.36 ±0.51 for general endurance.

Analysis of motion characteristics and metabolic demands regarding the different playing roles in 330 elite handball players which participated at German men's handball Bundesliga, showed that wings covered the longest distance (around 30% more) than other players (Bassek et al., 2023). Investigated the total sprint time and fatigue index among male handball players in different playing position Chittibabu (2014) concluded that lower total sprint time (32.75 sec) and fatigue index (7.60%) by repeated sprint ability is an important for wing players as they are the players who perform the most picks and require high levels of aerobic capacity to aid recovery after high-intensity bouts of activity. Wing players cover the largest distance during the match compared to pivots and backcourt players (Chittibabu, 2014). The general approach of sports scientists is that higher VO_2max may foster recovery and promote multi sprint performance (Hamilton et al., 1991) Spencer et al., 2005). In other investigation, Chittibabu (2013) compared aerobic and anaerobic capacity in handball players with different playing position and found that wing players showed greater aerobic capacity. The aerobic capacity was measured with Multi stage aerobic test (Chittibabu, 2013). Hermassi et al. (2019) measured aerobic capacity with Yo-Yo test and revealed differences in aerobic capacity in favor to wings regarding the pivots and backs.

There are a number of field-based fitness tests aiming to predict aerobic capacity with varying levels of accuracy (Mohoric et al., 2021). Analysis of positional differences for parameters of aerobic and anaerobic capacity (lactate concentration, heart rate, oxygen uptake, pulmonary ventilation etc.) among elite handball players showed that highest average values for oxygen consumption during different phases of shuttle run performance was found in pivots, lowest in the backs, but the differences were not statistically significant. The wings reached a significantly higher velocity than the pivots, but the parameters of cardiorespiratory function obtained by Cosmed K4 portable telemetry system were not in favor of the wings.

The anthropometric differences between playing positions may indicate the advantageous characteristics that the respective position demands, whereas the playing position differences in physical fitness characteristics may indicate training specificity issues that must be addressed cautiously (Hermassi et al., 2019). When compared force, power and velocity between first and second league players, and between backs, wings and pivots, the pivots were the strongest but the wings achieved the longest distance during Yo-Yo test, which qualified them as the players with the best aerobic capacity (Hermasii et al., 2019). Póvoas et al. (2014) analyzed physiological demands of elite handball players with special referents to playing position and according to their findings the backcourt players covered greater distance than wings and pivots. Backcourt players and pivots had higher mean and peak effective HR, and percentage of total time at intensities >80% maximal HR (HRmax) than wings (Póvoas et al., 2014). According to Ilic et al., competitive success in modern top-level handball might be more dependent on optimal tactical preparation than on the body composition and VO_2max of an individual athlete. Their findings showed that in young Serbian handball players, U20, average maximal oxygen consumption was low, and pivots had the highest VO_2max in absolute values and wings players in relative terms (Ilic et al., 2015). In the study of physiological profile of young handball players was found that backs and wings had a greater VO_2max than pivots and goalkeepers (Zapartidis et al., 2011).

The holistic approach to the individual and team performance determinants in handball players are based on the individual physical abilities: coordination, strength, aerobic and anaerobic endurance, constitution and disposition and nutrition. Team handball playing performance is based on the tactics, social factors and cognitive skills (Michalsik, 2018).The fitness profile is of great importance for the optimal training planning and health care of handball players, therefore it is important to measure and objectify their cardiorespiratory fitness. Wagner et al. (2016) reported that during a handball game, the athletes had oxygen consumption at range of 55-60 ml/kg/min. The maximal oxygen consumption estimated with outdoor testing (Yo-Yo test) in Romanian handball players was 49.32±2.32 ml/kg/min (Fenici et al., 2022). In similar research, in Tunisian handball players they found maximal heart rate between 161 and 199 bpm and maximal oxygen consumption between 43.6 and 58.3 ml/kg/min, during Yo-Yo test. Tunisian athletes showed low BF%, 11.22±4.63, and they found negative association between body fat mass and oxygen consumption (Moncef et al., 2012).

An analysis of the activity pattern of the players showed noticeable differences between individual playing positions. High-intensity locomotor activity was much greater in wingers than either backs or pivot players(Cardinale et al., 2017).The relative workload during the handball game is about 70–80% of the maximal oxygen uptake (VO_{2max}), and the total distance covered per full-time match (60 min) ranges between 3900 to 4700 m. The mean VO_{2max} in Danish elite handball players was 57.0 ±4.1 ml O_2/kg/min estimated with maximal ergometric testing. They did not find difference in maximal oxygen consumption in handball players regarding the playing position (Michalsik et al., 2015).Physical demands vary between different playing positions, with wing players performing faster breaks, and backcourt players and pivots experiencing more physical impacts with opponent players (Iannacconeet al., 2021).

Players of wings and backs positions had highest average HRs during the game, best times in 30-m sprint tests, best jumping performance, and best anaerobic endurance performance (Kruger et al., 2014). The research of physical abilities in huge group of elite handball players from several national teams showed that wings sprinted faster and jumped higher than pivots. Back players and wings showed better relative strength in squats than pivots, but pivots were stronger in bench press than wings (Haugen et al., 2016). In a similar study made by German researchers, wings and back positions had highest average heart rates during game and they showed the best anaerobic endurance parameters (Kruger et al., 2014).

From the previous literature it could be concluded that different playing positions in handball require special morphological and functional characteristics of the players. However, the observations of scientists are not completely identical, so that general conclusions can be drawn. The body structure, morphological and physiologic characteristics can influence sport performance, offensive and defensive actions, in a handball game. Coaches and other handball sport experts could use the knowledge of body composition features that are compatible with each specific playing position to design specific training and dietary programs depending on the playing position of each individual player.

Conclusions

The bioelectrical impedance body mass analysis shows significant difference for different playing position in handball. Obesity parameters were lowest in wings, while fat free mass parameters were higher in pivots. The standard obesity parameter, BF%, did not show significant difference between different playing positions. The maximal oxygen consumption was insignificantly different regarding playing position in handball.

Authors' Contribution

Study Design: JPG, VN; Data Collection: VR, MNB; Statistical Analysis: LjD, MNB; Manuscript Preparation: JPG, VR.

Ethical Approval

The study was approved by the Faculty of Medicine, in Skopje University of Ethical Committee for human research (2024/67) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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