

Body composition characteristics of handball players: systematic review

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Summary

Background: Handball play is complex and multifactorial, characterized by high-intensity explosive movements. Due to the high physical demands of handball, players require highly developed anthropometric and physical qualities. The evaluation of body composition (BC) is a key issue, especially the body content of fat and skeletal muscle.

Purpose: The aim of this systematic review is to determine the anthropometric and BC characteristics of handball players according to different characteristics such as age categories, playing position and gender.

Search strategy: The search for articles for this study was carried out in three different databases, PubMed, SPORTDiscus (EBSCO) and Web of Science.

Study selection: The inclusion criteria were; Studies recruiting male and female handball players at any age category and competitive level as participants, original investigations that present and compare anthropometric characteristics between handball players of different gender, competitive levels, playing positions, and/or age categories, and articles that present anthropometric characteristics as body weight, height, % fat mass, % muscle mass or % lean body mass, skinfolds and somatotype.

Results: 486 articles were identified after the searching process, 38 articles were selected and assessed for eligibility. This review presents the anthropometric characteristic of handball players, males and females of all ages. Height, body mass, BMI, fat mass, muscle mass, lean body mass and sum of skinfolds are presented and differentiate between gender, age and playing position.

Conclusions: This review provides a framework to help professionals effectively prepare players for the physiological demands of handball. Although the results are not very homogeneous, since elite athletes have better characteristics, the goal of every handball player would be to present similar results and by coaches evaluate players accordingly. But due to the limitations detected in the reviewed studies it is suggested that future research should adopt a longitudinal and multidimensional perspective.

Key words:

Body composition. Handball.
Anthropometry. DXA.
Bioimpedance.

Características de la composición corporal en jugadores de balonmano: revisión sistemática

Resumen

Antecedentes: El balonmano es un deporte complejo y multifactorial caracterizado por movimientos explosivos de alta intensidad. Debido a las altas exigencias físicas que se presentan, los jugadores requieren cualidades antropométricas y físicas específicas. Evaluar la composición corporal (CC) es esencial, principalmente el contenido de grasa y de masa muscular.

Objetivo: El objetivo de esta revisión sistemática es determinar las características antropométricas y CC de los jugadores de balonmano según edad, posición de juego y sexo.

Estrategia de búsqueda: La búsqueda se realizó en tres bases de datos diferentes: PubMed, SPORTDiscus (EBSCO) y Web of Science.

Selección de estudios: Los criterios de inclusión fueron; estudios que reclutan a jugadores y jugadoras de balonmano de cualquier categoría de edad y nivel competitivo, estudios que presentan y comparan características antropométricas entre jugadores de balonmano de diferentes géneros, niveles competitivos, posiciones de juego y/o categorías de edad, y artículos que presentan características antropométricas como el peso corporal, la altura, el porcentaje de masa grasa, el porcentaje de masa muscular, los pliegues cutáneos y el somatotipo.

Resultados: La búsqueda inicial fue de 488 artículos, tras la selección, eliminación de duplicados, y evaluación de los criterios de inclusión y exclusión, se evaluaron 38. Se presentan características antropométricas de los jugadores y jugadoras de balonmano de todas las edades; altura, masa corporal, IMC, masa grasa, masa muscular, masa corporal magra y suma de pliegues cutáneos según sexo, edad y posición de juego.

Conclusiones: La presente revisión proporciona un marco para ayudar a los profesionales a preparar de forma eficaz a sus jugadores. Aunque los resultados no son muy homogéneos, el objetivo de todo jugador de balonmano sería presentar resultados similares a los de élite. Debido a las limitaciones detectadas en los estudios revisados, se sugiere que las investigaciones futuras adopten una perspectiva longitudinal y multidimensional.

Palabras clave:

Composición corporal. Balonmano.
Antropometría. DEXA. Bioimpedancia.

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Introduction

Handball is an Olympic sports ball game that is characterized by a defensive action and a fast paced offensive action during the game with the aim of scoring goals¹. Handball made its Olympic debut at the XI Olympic games in Berlin, 1936, but this was a grass version with 11 players. The sport was then not included on the program, and it reappeared in its indoor version with seven players at the XX Olympic games in Munich, 1972². Nowadays all clubs and federations are listed by the International Handball Federation (IHF), which regulates the rules of handball at a competitive level, and periodically holds competitions and events.

In handball there are five well differentiated playing positions: 1) goalkeeper: in control of stopping the ball; he may not leave the six-meter area with the ball in his hand, but may touch it outside the area if it is passed by a teammate; 2) central: the axis of the team and the extension of the coach on the field; he is the one who commands in attack and defense, marks the plays, places the players and indicates where the static attacks should start from; 3) wing: are those who break the closed defenses from the goal area and assist, on most occasions, to the ends; 4) pivot: is responsible for getting into the defensive wall and open holes where possible, and 5) back: are those who begin the moves of static attack, moving the defense and throwing to goal, if there is space³.

To score goals, offensive players (6 players and a goalkeeper) try to establish an optimal position for the throwing player through fast moves over short distances by making powerful changes in direction (with and without the ball)⁴, individual action against defensive players and passing the ball using different offensive tactics.

Describing team handball play, especially to determine the factors influencing performance, is difficult because team handball play is complex and multifactorial, characterized by high-intensity explosive movements. Handball team must coordinate well their movements to run, jump, push, change direction and specific movements of team handball to pass, catch, throw, control and block. The intensities during play always change between standing and walking, jogging and running moderately, running and advancing fast, sideways and backwards^{5,6}, therefore a high specific level of endurance is important to maintain a high level of play throughout the game, in concrete two parts of 30 minutes each.

However, considering the intermittent nature of handball, it has been stated that performance is associated with the ability to produce high power in short time periods (anaerobic power) and the ability to recover between such high-intensity activities (aerobic power)⁶. For that, due to the high physical demands of handball, players require highly developed anthropometric and physical qualities (linear speed, change-of-direction speed, aerobic capacity, muscular strength and power) to succeed⁷.

The profiling of players can be a valuable tool when identifying talent, determining strengths and weaknesses, assigning playing positions, and optimizing the design of strength and conditioning training programs^{1,4,8}. Thus, the evaluation of body composition (BC) is a key issue in sports science as well as sports practice with special reference

to the body content of fat and skeletal muscle⁹. Previous research has indicated that certain physical characteristics are related to high level handball performance^{10,11}. A high body mass and stature is commonplace among players¹¹. Granados *et al.*¹² showed that the higher values of fat free mass resulted in a higher performance, especially because of the increase in the muscular power and strength. There are findings that also indicate relatively heterogeneous physical characteristics across all player positions in the team^{10,11}.

Examination anthropometric profiles could have great importance for optimal construction of training regimens to improve handball performance. Therefore, the collation of existing research to provide a clear understanding of the importance and development of physical qualities for handball players would be beneficial for research and practice. For this reason, the purpose of this review was to 1- present the anthropometric qualities of handball players by gender; and 2 - critically appraise the literature surrounding body composition using different methods, drawing information based on population characteristics (age, playing positions or performance level).

Methods

Search strategy

The present systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines¹³. Database searches were performed independently by three authors (AM, MM and MH). The reviewed articles were selected from an extensive search process including major computerized databases: PubMed (all database) SPORTDiscus (EBSCO) and Web of Science (all database), since their inception until now. Search strategy was developed to identify all relevant studies assessing the BC on handball athletes and it was: "handball" AND ("body composition" or "DXA" or "DEXA" or "Anthropometry" or "Impedance"). The review was registered in the prospective international register of systematic reviews; PROSPERO.

Inclusion and Exclusion Criteria

The inclusion criteria was according to the Population/Intervention/Comparison/Outcome(s) (PICO) criteria: a) Studies recruiting male and female handball players at any age category and competitive level as participants (population), b) original investigations that presents anthropometric characteristics between handball players of different gender, competitive levels, playing positions, and/or age categories (intervention), c) articles comparing anthropometric characteristics between handball players of different gender, competitive levels, playing positions, and/or age categories (comparison) and d) articles that present anthropometric characteristics as body weight, height, % fat mass, % muscle mass, skinfolds and somatotype (outcomes).

The exclusion criteria included: a) comments, opinions, and commentaries, interviews, letters to the editor, editorials, posters, conference abstracts, book chapters, and books; b) studies not present anthropometric characteristics of handball players of different gender, competitive levels, playing positions and/or age categories; c) studies which present players with diseases or injuries and d) lacking quanti-

tative information and details. Articles with these characteristics were not included in the review.

Data collection and analysis

A critical review of the papers was done to confirm the validity of the studies and to verify that they answered the research question, that design and sample were correct and if there were variables, or characteristics that could influence the interpretations and conclusions. The purpose was to collect the most relevant information from each included article. Three reviewers (AM, MM and MH) independently extracted data from included studies. The following variables were abstracted into a preformatted spreadsheet: authors, year of publication, characteristics of study participants (n, age, years, category), anthropometric variables (height, body mass, BMI, % fat mass, % lean body mass) and results.

Risk of bias across studies

To assess the methodological quality, the main tools were used according to the type of study¹⁴. Articles included in this review are cross-sectional studies, the scale used was ARHQ Methodology Checklist. Data extraction, quality assessment and risk of bias were performed independently and in duplicate by two investigators.

Results

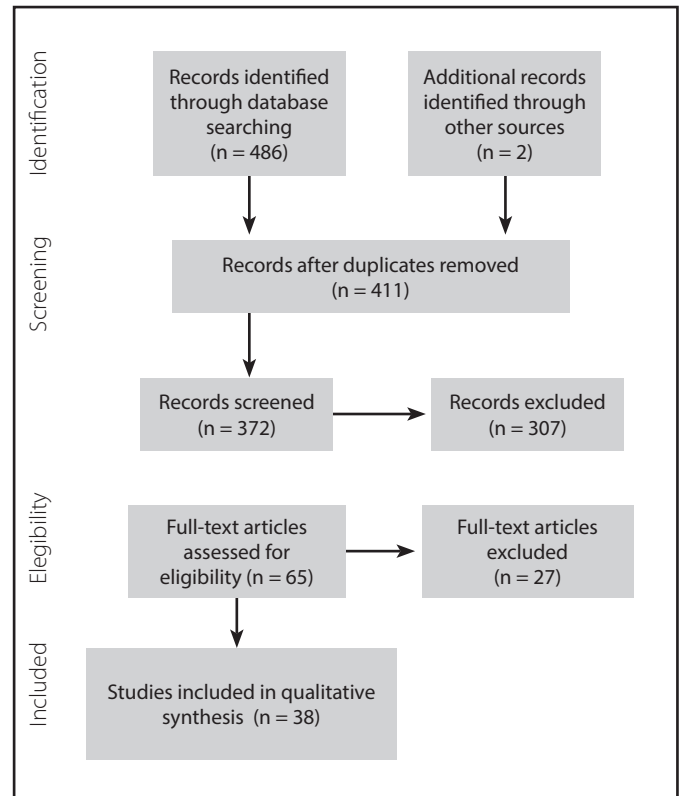
The search strategies yielded a preliminary pool of 486 possible papers. The full text of 65 articles were retrieved and assessed for eligibility according to the inclusion criteria. After a careful review of their full texts 27 articles were excluded and the remaining 38 articles were eligible for inclusion in the review (Figure 1). Particularly, 38 papers examined anthropometric profile of handball players according to their age categories^{12,16,17,23,26,28–30,40,42,51}, playing positions^{15,18,20–22,24,28,31,32,37,39,41,43–45,48}, gender^{15,38} or competitive levels^{12,23,47,49,51,25–27,30,34–36,46}. A number of the studies described the players body compartments using different formulas, however six studies used bioimpedance with TANITA^{37–42} and two used DXA^{50,51}. The results of Risk of bias have been showed at Figure 2.

Table 1 shows an overview of articles included in the qualitative synthesis, presents the sample size, nationality, playing position (if analyzed), category, genus of the sample, age, height (cm), weight (kg), BMI, sum of skin folds (mm) (if there has been measurement of skin folds that allow it), fat mass (%), muscle mass (%), bone mass (%) and free fat mass (kg) of male players who were measured BC with anthropometry. Table 2 presents the same data described above but for male players who were measured BC with anthropometry and DXA or bioimpedance or only with DXA or bioimpedance. Table 3 presents the same data as described above but for female players who were measured for BC by anthropometry. Table 4 presents the same data described above but of female players who were measured BC with anthropometry and DXA or bioimpedance or only with DXA or bioimpedance.

Nationality

Most of the studies performed on handball players were made in Spanish^{12,17,19,37,41,44,47,49}, in both females and males. In the case of

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) Flow diagram of the study selection process.



men, the second most repeated nationality among the studies is Serbian^{24,27,30,34,39,40} followed by Portuguese^{23,26,27}. Four of the studies were performed on players of different nationalities^{18,32,36,51}, but all of them Caucasian race. Only two studies did not specify the nationality of the players^{15,46}.

Elite team

Data on the anthropometric characteristics of elite handball players provides specific information that can help lead players to the most appropriate game⁴⁵. In addition, coaches and researchers may be able to use this data in the talent selection process. Analyzing the type of sample chosen by the different studies, a total of 32 of the studies present elite/professional players in their sample, namely 21 studies of male players and 11 of female players.

Body composition

The basic anthropometric variables analyzed in female players under 18 years of age present an average height (cm) of 167.53 ± 5.63, a weight (kg) of 60.56 ± 7.90 and a BMI of 21.58. For the general variables in female players over 18 years of age, they present an average height (cm) of 170.59 ± 6.33; weight (kg) of 66.89 ± 8.78 and BMI of 23.18. Female goalkeepers had an average height (cm) of 173.77 ± 5.06 and a weight of 71.06 ± 8.70 (kg). The wings show an average height (cm) of

Table 1. Body composition characteristics of handball male players measured with anthropometry.

Reference, Year	Mean (n)	Nationality	Position (n)	Category (n)	Gender	Age (years)	Height (cm)	Body mass (kg)	BMI (m ² /kg)	Sum. of Skinfold (mm)	Body fat (%)	Muscle mass (%)	Bone mass (%)	Lean Body Mass (Kg)	
Pires, 1986 ¹⁵	79		Goalkeeper Wings Back Pivot	National league	Male	17.97 ±0.92	181.58±7.68	75.48±7.4	22.89	-	9.892±2.33	-	-	-	
						17.8 ±1.15	178.26±4.75	69.94±8.12	22.01	-	8.97 ±2.31	-	-	-	
						17.73 ±1.05	181.32±6.21	76.01 ±10.91	23.12	-	9.03 ±2.27	-	-	-	
						17.8 ±1.05	175.56±4.78	66.56 ±9.28	21.60	-	9.28 ±3.46	-	-	-	
Jaric <i>et al.</i> , 2001 ¹⁶	18	Yugoslav		Yugoslav national team	Male	20.4±1.1	191.2 ± 6.3	87.7	23.99	-	11.1 ±2.6	52.1 ± 3.3	-	78.4 ± 7.4	
Ibnziaten <i>et al.</i> , 2002 ¹⁷	251	Spanish		Cordoba Handball Federation (CHF) /All- 251/ CHF- 10 YEARS /45/ CHF - 11 YEARS /47/ CHF -12 YEARS /51/ CHF - 13 YEARS /60/ CHF - 14 YEARS /48/	Male	12 ± 1.38	159.96 ±13.31	53.74 ±13.7	21.00	-	-	-	-	-	-
						10	143.8	40.27	19.47	-	16.19	42.23	19.33	-	
						11	151.3	45.96	20.08	-	15.32	43.21	19.26	-	
						12	158.32	53.43	21.32	-	14.93	45.11	18.9	-	
						13	167.94	59.77	21.19	-	14.35	46.23	19.06	-	
14	175.29	66.77	21.73	-	13.73	45.9	18.66	-							
Srhoj <i>et al.</i> , 2002 ¹⁸	49	European countries (Croatia, Bosnia and Herzegovina, Slovakia and Hungary)	All /49/ Goalkeeper /9/ Wings /19/ Back /37/ Pivot /9/	Senior	Male	24,49	190.79±6.59	91.29±7.57	25.08	71.92 ^a	-	-	-	-	-
							191.86	91.79	24.94	71.95 ^a	-	-	-	-	-
							187.02	85.12	24.34	68.35 ^a	-	-	-	-	-
							194.42	94.28	24.94	71.4 ^a	-	-	-	-	-
							183.85	92.58	27.39	81.58 ^a	-	-	-	-	-
Gorostiaga, <i>et al.</i> , 2005 ¹⁹	15	Spanish		Elite Amateur	Male Male	31 ± 3	188.7 ± 8	95.2 ± 13	26.94	-	13.8 ± 2	-	-	81.7 ± 9	
						22.2 ± 4	183.8 ± 7	82.4 ± 10	24.61	-	11.6 ± 3	-	-	72.4 ± 7	
Bezerra and Simão, 2006 ²⁰	63	South American	All /56/ All /7/ Goalkeepers /11/ Outside-left /9/ Outside-right /4/ Center /12/ Left Guard /6/ Right Guard /9/	Athletes of Amazon Club Selection of Amazon Cup	Male	24.52 ± 5.26	176.34±7.77	77.85 ±11	25.12	99.3 ± 40.2 ^b	23.1 ±10.6	-	-	-	59.04 ± 7
						22.1 ± 4.9	176.71±11.5	74.51 ±11.28	24.05	65.85±17.81 ^b	14.57 ±3.94	-	-	63.57±9.48	
						26 ± 6	175 ± 5.7	78.6 ± 22.3	25.67	118.2 ±39.3 ^b	28.1 ±10.7	-	-	55.5 ± 4.8	
						23 ± 3	175.1 ± 5.6	75 ± 6.9	24.46	81.6 ± 30 ^b	18.3 ± 7.4	-	-	60.9 ± 5.7	
						28 ± 8	174 ± 4.4	66.7 ± 3.2	22.03	64.3 ± 16.7 ^b	14.8 ± 4.5	-	-	56.7 ± 2.6	
24 ± 4	172.1 ± 8.9	77.7 ± 14.8	26.23	113.6 ±48.5 ^b	27 ± 14.8	-	-	55.3 ± 8.1							
22 ± 2	183.5 ± 8.2	86 ± 7.6	25.54	99.4 ± 36.5 ^b	22.7 ± 9.8	-	-	66.2 ± 7.8							
22 ± 5	181.4 ± 7.8	77.3 ± 6.6	23.49	84.7 ± 34.9 ^b	19.2 ± 9.2	-	-	62.2 ± 7.4							
Hasan <i>et al.</i> , 2007 ²¹	63	Asia	Goalkeeper /12/ Wing /18/ Back /15/ Center /18/		Male	25 ± 1.9	186.5±0.044	80.8 ± 7	23.23	33.9 ± 11.4 ^c	10.5 ± 3.3	49.8 ± 5.5	-	-	
						25 ± 0.8	184.2±0.055	81.6 ± 7.4	24.05	31.9 ± 5.4 ^c	10.4 ± 2.6	51.2 ± 6.2	-	-	
						24 ± 1.5	185.8±0.047	82.5 ± 5	23.90	34.2 ± 6.9 ^c	10.5 ± 1.7	52.2 ± 7.3	-	-	
						26 ± 1.9	183.7±0.024	84.7 ± 8.9	25.10	41.7 ± 11.5 ^c	10.8 ± 3.3	53.8 ± 7.7	-	-	
Vrbik <i>et al.</i> , 2011 ²²	37	Croatian	All /37/ Goalkeeper /5/ Wings attackers /9/ Back court players /17/ Pivot /6/	Elite and junior male Croatian national handball	Male	-	189.32 ±5.92	89.44 ± 10.32	24.9 ± 2.01	-	14.69 ± 4.48	-	-	-	
						-	191.7 ± 2.33	92.88 ± 11.36	25.24 ± 2.68	-	18.21 ± 4.11	-	-	-	
						-	181.84 ± 2.96	78.72 ± 5.05	23.82 ± 1.7	-	13.33 ± 3.69	-	-	-	
						-	192.14 ± 4.75	91.71 ± 8.52	24.81 ± 1.76	-	14.18 ± 3.49	-	-	-	
-	190.55 ± 5.2	96.21 ± 9.94	26.45 ± 1.96	-	15.27 ± 7.27	-	-	-							
Massuça and Fragoso, 2011 ²³	187	Portuguese		Top elite /24/ Moderate elite /53/ Sub-elite /31/ Moderate trained) /32/ Junior elite /47/	Male	26.38 ± 4.08	188.11 ± 5.36	86.88 ± 9.46	24.55	-	8.9 ± 3.65	-	-	88.23 ± 3.95	
						26.38 ± 4.9	182.2 ± 6.55	82.35 ± 11.22	24.1	-	12.43 ± 5.1	-	-	81.67 ± 6.99	
						23.81 ± 3.7	179.67 ± 6.5	79.37 ± 11.08	24.59	-	13.26 ± 5.67	-	-	79.46 ± 6.34	
						24.22 ± 5.11	178.47 ± 6.6	78.28 ± 15.52	24.58	-	15.03 ± 7.86	-	-	75.82 ± 10.3	
						18.13 ± 0.88	179.49 ± 16.5	80.53 ± 12.21	25.00	-	10.91 ± 5.61	-	-	83.44 ± 7.48	
Ilić <i>et al.</i> , 2011 ²⁴	32	Serbian	All /32/ Goalkeeper /4/ Wings /10/ Back /14/ Pivot /4/		Male	20.43 ± 1.16	190.7 ± 5.23	88.44 ± 8.98	24.33 ± 2.34	-	13.61 ± 5.86	50.44 ± 2.57	-	-	
						-	191.15 ± 2.71	92.05 ± 7.6	25.17 ± 1.66	-	17.81 ± 3.69	49.36 ± 2.84	-	-	
						-	187.08 ± 4.92	82.28 ± 8.1	23.53 ± 2.4	-	10.49 ± 3.07	51 ± 1.6	-	-	
						-	193.61 ± 4.38	89.83 ± 8.69	23.97 ± 2.16	-	12.35 ± 3.98	51.22 ± 1.64	-	-	
						-	189.08 ± 5.71	95.41 ± 5.8	26.74 ± 2.25	-	21.65 ± 9.72	47.38 ± 4.8	-	-	
Nikolaidis <i>et al.</i> , 2013 ²⁵	44	Greek		TEAM A (First of league - Greek championship) /14/ TEAM B (Second in the league) /17/ TEAM C (Eighth of the league) /13/	Male	24 ± 5.7	185.1 ± 6.5	87.6 ± 9	25.57 ± 2.4	-	16.6 ± 3.6	-	-	72.8 ± 5.3	
						27.2 ± 6.7	188.2 ± 6.1	87.5 ± 9.8	24.70 ± 2.4	-	17.8 ± 4	-	-	71.7 ± 6.2	
						25 ± 5.8	179 ± 4.7	81.8 ± 8.7	25.53 ± 2.7	-	18.6 ± 4	-	-	66.4 ± 5.5	
Muratovic <i>et al.</i> , 2014 ²⁶	15	Serbian		Handball premier league in Serbia	Male	23.13 ± 0.22	190.79 ± 6.59	91.29 ± 7.57	24.47 ± 0.65	-	12.41 ± 0.08	52.85 ± 0.8	15.29 ± 0.36	-	
Massuça <i>et al.</i> , 2014 ²⁷	167	Portuguese	All (167)	All (167) Top-Elite /41/ Non-Top-Elite /126/	Male	23.6 ± 5.3	-	-	-	-	-	-	-	-	
						26.2 ± 4.9	187.58 ± 5.62	87.51 ± 10.82	24.87	-	10.53 ± 5.46	46.66 ± 4.63	-	-	
						25.2 ± 4.8	180.53 ± 6.56	80.42 ± 12.39	24.68	-	13.33 ± 6.14	45.28 ± 5.65	-	-	

(continua)

Reference, Year	Mean (n)	Nationality	Position (n)	Category (n)	Gender	Age (years)	Height (cm)	Body mass (kg)	BMI (m ² /kg)	Sum. of Skinfold (mm)	Body fat (%)	Muscle mass (%)	Bone mass (%)	Lean Body Mass (Kg)	
Rousanoglou et al., 2014 ²⁸	60	Greek	All Elite Greek Junior National Teams /60/ All U 16 /20/ All U 18 /19/ All U 20 /21/ Goalkeeper /12/ Wings /13/ Back /15/ Center /10/ Pivot /10/	Elite Greek Junior National Teams U 16 U 18 U 20	Male	17.6±1.15	183.8±5.9	82.7±9	24.48	-	14.4±3	-	-	-	-
						15.9±0.4	182.4±6.6	78.2±8.2	23.50	-	14±2.4	-	-	-	
						17.4±0.5	184.1±5.8	84.2±9.9	24.84	-	14.6±3.3	-	-	-	
						19.3±0.6	184.7±5.2	85.5±7.7	25.06	-	14.5±3.2	-	-	-	
						-	184.5±4.9	84.1±9.3	24.71	-	15.3±3.1	-	-	-	
						-	178.9±6	76.6±7	23.93	-	13.2±2.3	-	-	-	
Moraes et al., 2014 ²⁹	44	South American		Child /21/ Youth /23/	Male	13.52±0.6	162.94±7.01	53.57±8.59	20.18	-	15.86±6.24	-	-	-	
						15.61±0.72	171.57±5.27	64.02±11.13	21.75	-	20.18±7.43	-	-	-	
Massuça and Fragoço 2015 ³⁰	212	Portuguese		All /212/ Top Elite /37/ Moderate Elite /54/ Sub Elite /35/ Moderate Trained /33/ Junior Elite /53/	Male	23.6±5.2	-	-	-	-	-	-	-	-	-
						25.9±4.7	187.24±5.25	86.59±10.52	24.70	-	10.53±5.46	51.54±3.68	-	74.67±9.65	
						26.4±4.9	182.16±6.5	82.61±11.27	24.90	-	12.61±5.26	50.33±2.95	-	67.5±11.43	
						24.3±4.2	179.87±6.25	79.14±10.71	24.46	-	13.02±5.51	50.3±4.1	-	63.04±9.34	
						24.2±5	178.56±6.52	78.18±15.28	24.52	-	14.85±7.81	48.31±4.94	-	59.66±14.8	
Barraza et al., 2015 ³¹	74	Chilean	Goalkeeper /9/ Wings /19/ Back /37/ Pivot /9/		Male	15±1	177.1±3.2	86.3±15.4	27.52	110.6±40.8 ^a	30.5±2.7	42.6±2.8	-	-	
						-	169.5±4.9	61.8±5.2	21.51	69±25.9 ^a	26.1±3.9	44.4±3.1	-	-	
						-	175.7±6.9	68.7±8	22.25	60.3±24.1 ^a	27.8±4.6	44±3.5	-	-	
						-	177.7±8.8	84.7±11.3	26.82	109.5±47.5 ^a	30.1±5.1	42.8±3.3	-	-	
Ramos-Sánchez F, 2016 ³²	19	1 Montenegro / 1 Serbian / 2 Slovenian / 15 Spanish	Goalkeepers Wings Extremes Pivots - Backs - Wings Central		Male	28.00±8.00	194.2	82.9	22.4	-	10.3	49.6	15.7	89.7	
						-	196.8	96.7	24.6	-	10.6	50.4	15.0	89.4	
						-	177.6	80.2	25.4	-	10.8	51.1	13.8	89.2	
						-	195.2	114.5	30.3	-	15.6	47.5	12.8	84.4	
Franz, J 2017 ³³	22	Brazilian			Male	14.91±1.15	175.22±10.32	68.38±10.36	22.34±2.58	-	17.66±4.95	-	-	-	
						-	-	-	-	-	-	-	-	-	
Masanovic, B 2018 ³⁴	15	Serbian		Junior premier league	Male	16.93±0.95	181.51±5.33	74.73±10.17	22.66±2.83	-	16.39±3.28	48.58±4.03	17.03±2.49	-	
Hermassi, S 2018 ³⁵	22	Tunisian		Junior: 14 - National /9 - international	Male	19.1±1.7	187±0.08	86.7±10.1	24.4 ±5.1	-	13.4±0.5	-	-	-	
Peña J, 2018 ³⁶	15	Different nationalities		First division profesional	Male	25.50±4.10	191.03±5.66	94.01±8.89	-	-	12.54±1.73	-	-	-	

BMI: Body Mass Index; ^a Sum of 6 skin folds (Triceps, Subscapular, Abdominal, Supraspinal, Front thigh and Medial Calf); ^b Sum of 7 skin folds (Triceps, Subscapular, Abdominal, Breastplate, Axillary medial, Thigh and Suprailiac); ^c Sum of 5 skin folds (Biceps, Triceps, Subscapular, Suprailiac and Anterior Thigh); ^d Sum of 8 skin folds (Triceps, Chest, Mid-Axillary, Subscapular, Suprailiac, Abdominal, Anterior thigh, and Calf).

Table 2. Body composition characteristics of handball male players measured with anthropometry and DXA or bioimpedance or only with DXA or bioimpedance.

Reference, Year	Mean (n)	Nationality	Position (n)	Category (n)	Gender	Age (years)	Height (cm)	Body mass (kg)	BMI (m ² /kg)	Sum. of Skinfold (mm)	Body fat (%)	Muscle mass (%)	Bone mass (%)	Lean Body Mass (Kg)
Ramos Campo et al., 2014 ²⁷	28	Spanish	All /8/ Goalkeeper/4/ Center/Wing /7/ Handed /12/ Pivot /5/	Handball Spanish professional national league (ASOBAL)	Male	28.4±0.9	191.6±1.4	97.1±2.3	26.45	-	-	-	-	-
						30.67±3.79	193±6.93	98.8±17.69	26.52	-	18.67±2.57	46.77	-	-
						26.57±2.64	187.57±4.5	87.84±5.6	24.97	-	13.24±3.69	49.79	-	-
						28±3.22	194.25±4.86	106.65±14.73	28.26	-	11.27±3.39	45.58	-	-
						28.25±6.4	191.42±7.51	95.18±8.57	25.98	-	12.93±7.45	61.44	-	-
Francesco Piscitelli, 2015 ³⁸	22	Italian			Male	21.2±4.3	179.4±6.7	80.0±11.8	25.0±3.1	-	16.4±4.7	-	-	-
Ilic et al., 2015 ³⁹	32	Serbian	All /32/ Goalkeeper /4/ Wings /10/ Back /14/ Pivot /4/	Serbian National U20	Male	20.43±1.16	190.7±5.23	88.44±8.98	24.33±2.34	-	13.61±5.86	50.44±2.57	16.74±0.99	-
						-	191.15±2.71	92.05±7.6	25.17±1.66	-	17.81±3.69	49.36±2.84	16.2±0.4	-
						-	187.08±4.92	82.28±8.1	23.53±2.4	-	10.49±3.07	51±1.6	17.27±0.89	-
						-	193.61±4.38	89.83±8.69	23.97±2.16	-	12.35±3.98	51.22±1.64	16.6±0.93	-
Jakovljevic, 2016 ⁴⁰	20	Serbian		Elite level	Male	23.7±3.72	189±4.15	91.6±8.14	25.7±2.31	64.82 ^a	10.7±3.76	-	-	-
						-	-	-	-	-	-	-	-	-
Sebastián Amat, 2017 ⁴¹	12 9 5	Spanish	Goalkeepers	Inferior categories	Male	11.5±1.5	160.35±7.42	53.25±8.04	20.7±2.81	-	12.36±6.52	-	44.03±6.05	-
						15±1.0	172.10±7.92	68.33±9.91	23.12±3.26	-	12.83±7.85	-	55.73±7.77	-
						18.5±1.5	183.40±4.03	88.94±9.32	26.58±2.3	-	16.66±4.71	-	70.18±4.88	-
Hoppe, 2017 ⁴²	10 11	Germany		Junior Adults	Male	18±1	184±0.3	81.8±6.3	24.00±1.3	-	10.8±1.7	-	72.8±4.1	-
						26±1	190±0.3	92.0±3.5	25.6±0.8	-	11.9±1.3	-	81±2.8	-

BMI: Body Mass Index; ^a Sum of 6 skin folds (Triceps, Subscapular, Abdominal, Supraspinal, Front thigh and Medial Calf); ^b Sum of 7 skin folds (Triceps, Subscapular, Abdominal, Breastplate, Axillary medial, Thigh and Suprailiac); ^c Sum of 5 skin folds (Biceps, Triceps, Subscapular, Suprailiac and Anterior Thigh); ^d Sum of 8 skin folds (Triceps, Chest, Mid-Axillary, Subscapular, Suprailiac, Abdominal, Anterior thigh, and Calf).

Table 4. Body composition characteristics of handball female players measured with anthropometry and DXA or bioimpedance or only with DXA or bioimpedance.

Reference, Year	Mean (n)	Nationality	Position (n)	Category (n)	Gender	Age (years)	Height (cm)	Body mass (kg)	BMI (m ² /kg)	Sum. of Skinfold (mm)	Body fat (%)	Muscle mass (%)	Bone mass (%)	Lean Body Mass (Kg)
Milanese et al, 2011 ⁵⁰	43	Italian	All Elite level /26/	Elite level	Female	26.4±5.77	169.2±6.04	67±7.91	23.4±5.33	112.9±26.06 ^d	23.3±5.33	-	-	47.98±4.66
			All sub-elite level /17/	Sub-elite level		17.3 ±2.25	166±5.1	64.4 ± 10.47	23.3±4.01	133.3±27.82 ^d	28.6±4.01	-	-	42.97±5.32
			Goalkeeper /7/			24±6.63	169,3±7.41	74.7±11.63	25.9±2.29	149±22.27 ^d	29.7±4.5	-	-	48.89±5.38
			Wings /18/			21.8±6.49	165,2±4.4	61 ± 6.6	22.3±2.16	113.5±27.56 ^d	24.4±5.03	-	-	43.25±4.72
			Back /14/			23.2±7.04	171±5.8	67.7±7.53	23.1±1.78	118.4±24.62 ^d	25.1±5.56	-	-	66.99±7.4
Pivot /4/		23.7±6.24	167±4.32	66.6±4.95	23.9±1.44	114.2±32.2 ^d	22.7±6.29	-	-	65.99±4.99				
Milanese et al, 2012 ⁵¹	43	Caucasian (37 Italian, 1 Ukrainian, 1 Slovenian, 1 Romanian, 1 Polish, 2 Argentine)		Italian national championships (PRE) /43/	Female	22.8±6.49	167.9±5.84	65.6±9.89	23.23±2.49	102.5±22.15 ^d	25.3±6.2	-	43.02±5.84	-
				Italian national championships (POST) /43/		22.8±6.49	167.9±5.84	65.2±9.58	23.00±2.32	105.4±26.01 ^d	24.9±5.59	-	43.13±5.7	-
				Elite level /26/		26.4±5.77	169.2±6.04	67±7.91	23.40±5.33	-	-	-	-	-
				Sub-elite level /17/		17.3±2.25	166±5.1	64.4±10.47	23.30±4.01	-	-	-	-	-
Piscitelli, 2015 ⁵⁸	24	Italian			Female	21.2±4.3	166.2±7.0	62.2±12.0	22.3±3.4	-	26.6±5.8	-	-	-

BMI: Body Mass Index; ^a Sum of 6 skin folds (Triceps, Subscapular, Abdominal, Supraspinal, Front thigh and Medial Calf); ^b Sum of 7 skin folds (Triceps, Subscapular, Abdominal, Breastplate, Axillary medial, Thigh and Suprailiac); ^c Sum of 5 skin folds (Biceps, Triceps, Subscapular, Suprailiac and Anterior Thigh); ^d Sum of 8 skin folds (Triceps, Chest, Mid-Axillary, Subscapular, Suprailiac, Abdominal, Anterior thigh, and Calf).

167.18 ± 4.87, and an average weight (kg) of 61.99±5.61. The back shows an average height (cm) of 174.97±5.943, and an average weight (kg) of 70.18 ± 7.30. The pivot players position show an average height (cm) of 171.39±5.92 and an average weight (kg) of 69.64± 6.89.

For men, if the sample is separated by age range, >18 years and <18 years, we observe that the mean of the anthropometric measurements are as follows: male players under 18 years of age present an average height (cm) of 175.04 ± 6.77, a weight (kg) of 69.29±9.69 and a BMI of 22.45. The goalkeepers present an average height (cm) of 179.34±5.44 and an average of 80.89 ± 11.40 weight (kg). The wings show an average height (cm) of 173.88 ± 4.83, and an average weight (kg) of 65.87± 6.66. The back shows an average height (cm) of 178.51±6.56 and an average weight (kg) of 72.36± 9.45. The pivot position players show an average height (cm) of 176.63±6.79 and an average weight (kg) of 75.63±10.29. For the general variables in male players over 18 years of age, they present an average height (cm) of 183.95± 6.38; weight (kg) of 84.24±10.07 and BMI of 24.83. Male goalkeepers have an average height (cm) of 187.330±4.345 and a weight of 88.60±13.675 (kg). The wings show an average height (cm) of 184.601±4.647, and an average weight (kg) of 81.795± 6.725. The back shows an average height (cm) of 190.489±4.498 and an average weight (kg) of 92.996±10.205. The pivots show an average height (cm) of 187.043±6.38 and an average weight (kg) of 91.869 ± 8.903.

Most of the studies in this review of handball players assessed BC with anthropometry and from these studies most used the anthropometric method of Jackson and Pollock^{52,53} to obtain the percentage of fat mass. As for female players over 18 years of age, to whom this formula was applied, the average results were height (cm) of 175.36±5.52; weight (kg) of 70.18±7.48 and fat percentage 19.51±3.87. Comparing the players if they are elite or not elite: as elite, the average height (cm) was 175.36±5.52, weight (kg) of 70.33±7.48 and fat percentage 19.49±3.87, and as non-elite players the average height (cm) was 175.40; the weight (kg) of 69.30 and the fat percentage 19.60%. As for male players over

18 years of age, to whom this formula was applied, the average results were height (cm) of 183.38±6.99; a weight (kg) of 84.09±11.03 and a fat percentage 14.28±5.40. In addition, thanks to the eight studies that could be grouped by this method, it was possible to differentiate between elite male players with an average height (cm) of 185.22±7.30; a weight (kg) of 85.89±10.53 and a fat percentage 13.18±4.65 and non-elite male players with an average height (cm) of 179.03±6.61; a weight (kg) of 78.83±12.17 and a percentage of 16.56±7.17.

Other studies, specifically three^{38,50,51} on female players and six³⁷⁻⁴² on male players, used the bioimpedance method to measure the BC of athletes. In the case of the female handball players the average height (cm) was 172.38±5.99; weight (kg) 69.69±9.67 and fat percentage 22.74±5.76. In the case of the male players the average height (cm) was 186.68±4.07; weight (kg) 89.93±7.89 and fat percentage 13.94±4.36.

Regarding the sum of skin folds, it was observed that most of the studies that calculated this parameter calculated the sum of 6 skin folds, (triceps, subscapular, supraspinal, abdominal, front thigh and medial calf). Specifically, the average sum of 6 skin folds in elite female players was 93.81±22.36 and non-elite 94.8±21.59. As for elite male players the average of this value was 68.37 and non-elite 87.35

Discussion

The aim of this review was to present the anthropometric qualities of handball players from different nationalities, drawing comparisons between age categories, and playing positions. Generally, the results show that in terms of BC, female handball players have a proportion of fat mass of around 20%, being somewhat lower in elite players. As for male players the proportion of fat mass is considerable, around 14%, being higher in non-elite players.

Evaluating and monitoring BC is a key issue in sports practice due to its link to performance and injury risk prevention⁹. In fact, body mass

can influence an athlete's speed, endurance, and power, whereas BC can affect an athlete's strength and agility²⁷. A greater muscle mass is often an advantageous characteristic in sports, as in team handball, where speed is so much of the essence.

In indoor team sports, the BC depend on the playing position and the sport discipline, being the BC results of the specific game actions of each playing position³⁷. It seems to be that specific BC and morphometric parameters could be considered as an important factor contributing to the athlete's respective performance in addition to the technique and sport experience⁴⁰. Morphological characteristics can influence the ability of players to respond better to the requirements of the certain position in the game.

Body composition in females

Women's handball is a sport that has experienced an accelerated development in the last decade, although it is true that studies of anthropometric characteristics are scarce. The correlation between some morphological characteristics of the body of handball players and their playing position is evident. This is attributed to the different technical and tactical tasks that players occupying different playing positions must execute.

As far as the playing position is concerned (considering 4 positions: back, wing, pivot and goalkeeper), the wings are the ones that show the most pronounced differences in the morphological parameters of the body, in comparison with other groups of players. They are significantly smaller and have significantly lower body mass⁴³⁻⁴⁵. The data observed in this review coincide with the above, the anthropometric values of the wings show the lowest weight and height compared to the other positions: height (cm) 167.180 and weight (kg) 61.98. This is due to the fact that the wings cover the largest field area and carry out most of the counterattacks, therefore they need lighter and faster bodies with the capacity for rapid changes of movement and agility⁴⁸.

Female back players are characterized by being tall, Bon *et al.*, 2015⁴⁵ value that has also been reflected in the analysis of this review, as they have the highest value of height 174.968 cm. Female goalkeepers are the heaviest of all players according to their position in the game. Due to the function of saving the goal, they have a more static role in the game, with fast and short acyclic activities⁴³. The data observed for the female goalkeepers in this review corroborate this, as they have the heaviest weight compared to the rest of the playing positions, 71.064 kg.

As for pivots, during an attack, they must catch the passes and are hindered by high defense players, therefore, high body height values can give them an advantage over defense players. The robustness of the body is also particularly important as they must carry out different actions in direct physical contact with the guards of the opposing team. However, looking at the results of this review, there is some controversy as the values do not stand out from any other position. The position specifications of the rear court players propose tall and strong players who must make different tactical and play assignments to the opponent's defense zones⁴³.

As for the changes that occur in BC throughout the season, Milanese, C⁵¹, showed that the anthropometry of handball players does not change significantly during the competitive season, except for some

redistribution of fat; however, BMC increases in the extremities and lean mass in the upper extremities after the season. These results are independent from the competitive level (elite/subelite) and playing position.

Comparing between the different competitive levels (elite; not elite), according to Milanese 2011⁵⁰, the results show that elite players have lower fat percentage, coinciding with what was observed in this review (Elite = 19.493%; No elite = 19.600%). In addition, it is also observed in relation to the sum of six folds of fat, elite players have lower values (93.81 mm) and non-elite players have higher values (94.8 mm). The current results suggest that the most experienced, powerful and aerobically conditioned players have an advantage in women's handball at the international level^{12,46,49}. Therefore a greater amount and intensity of training is needed to achieve a physical and corporal composition similar to that of the most successful teams.

Body composition in males

In general, the most successful teams are higher and have less body fat than the least successful (Hasan *et al.*, 2007). Gorostiaga *et al.*¹⁹ found that elite team-handball players were heavier and had a higher fat-free mass than the amateur team-handball players did and concluded that this seems to be advantageous in team handball. As regards the upper limb lengths (i.e., radiale-dactylion length), it seems that these measures are important for a better handball shot execution (the larger the radius of action the greater the power of the technical gesture) and for some defensive actions (e.g., blocking). Massaça and Fragoso, 2011²³ also concluded that the best athletes are taller, heavier, had higher fat-free mass, lower fat mass, higher socioeconomic status and higher weekly energy expenditure. Additionally, they have a higher value in arm span and muscle mass⁴⁹.

The differences are manifested considerably in the circular measures of the body volume and in dimensions of the skeleton. Back court players and goalkeepers are superior in the mentioned measures. With the findings of this review, wings and pivots have somewhat lower values of longitudinal dimensionality¹⁸ wings and pivots under 18, height 173.8 cm and 176.63 cm and wings and pivots over 18 height 184.6 and 187.04. Height of goalkeepers and backs are bigger in all cases. In addition, it would seem that, handball goalkeepers show an advanced age of maturity⁴¹.

However, there is a bit of controversy in some positions, as in another study⁵⁴, they determine that the goalkeepers, central and wing generally stand out for their high stature, with the central ones being more athletic (greater muscle mass) and the wing ones more corpulent, with a powerful shot. The back are fast, agile, lightweight players with great jumping capacity, so they often have less height, less weight and lower fat percentage. Pivots are robust players (higher weight, fat mass and volume) who function well in the body to body. These characteristics must be evaluated prior to the incorporation of the players to the team, since morphological optimization is fundamental to achieve the optimal development of the sports performance of each player⁵⁴.

Ramos-Sanchez F, 2016³² analyzed the first team of the Valladolid squad. According to their results, it seems that pivots are the heaviest players (with the highest percentage of fat mass); the wings, together with the pivots, the highest. No BMI differences were observed in the

groups. The greatest differences between the pivots and wings were established in body height, leg length, arm length, ankle breadth, body weight and calves circumference^{41,48}.

In terms of age, although comparison has been difficult, it appears that from 10 to 14 years, the percentage of fat mass decreases, and there is a change in the distribution of subcutaneous fat¹⁷. In addition, in line with the results of this review, it has been shown that height and body mass increase with age. It can be seen, there is a bit of controversy in determining, depending on the playing position, which are the tallest and heaviest. According to our results, the highest are the wings and pivots, while the heaviest are the goalkeepers and backs.

In terms of nationalities there are few studies that compare the same competitive level of teams from different countries, however Ilic, 2015³⁹, establishes comparison between some anthropometric results from nationalities such as Spanish, Serbian, English, kina, Japanese, Korean, Kuwait, Saudi Arabia, French, Italian, Croatian and Tunisian. According to this study, successful teams in the 1994 Asian games were higher and had less body fat than less successful teams. Compared with similar research, Serbian handball players had higher values of body height, body weight, and body fat than British, French, Asian, or Spanish division III handball players. The percentage of muscle mass was higher than that found in Saudi and Japanese handball athletes, but considerably lower than that found in Chinese, Korean, and Kuwaiti handball players. Despite the higher values of muscle mass, Kuwaiti players did not perform well during the Asian match period.

On the other hand Milanese, 2011⁵⁰ made the comparison in Italy between competitive levels (Elite vs. Sub-elite) as well as with players from other championships. The study suggested that players in Italian championships need a greater amount and intensity of training to achieve a physical and BC similar to those from the most successful national teams.

From all the studies analyzed, it can be deduced that the higher the quality level of the players, the greater their height and body mass and the lower their percentage of subcutaneous fat. Although it is true that there is a degree of heterogeneity in the results, both height and weight seem to increase with age. The higher players should be oriented to the positions of the players at the back. As for the pivots, coaches must consider, in addition to the height of the body, robustness. For goalkeepers, body height is very important; however, robustness criteria are also important. In the case of wings, body height is not a decisive factor and smaller players can also occupy this position, but a lower weight is favorable for this position.

Limitations

The main limitation of the present study was the variation in BC formulas used by several studies to measure one parameter, making it difficult to compare the findings of the collected studies. For instance, body fat percentage has been calculated using different formulas that cannot be used interchangeably, making a comparison impossible between the studies. However, a strength of this study was that it reviewed a large number of studies and parameters. Despite the variety of methods used, conclusions on the variation of the parameters by age, performance level, and position can be safely drawn when considering the within-study comparisons.

Future research

Future research is required to optimize talent identification and development programs. Future research should include intervention-based studies and quantify the training burden of athletes to understand the most appropriate strategies for improving physical qualities. In addition, studies should understand the relationship between physical qualities and match performance, while providing further consideration of the holistic development of the handball player, including technical ability, tactical knowledge, psychological characteristics, and the occurrence and reduction of injuries.

Conclusions

This review provides a framework to help professionals effectively prepare players for the physiological demands of handball. Since elite athletes have better characteristics, the goal of any handball player would be to present similar results. But due to the limitations detected in the studies reviewed it is suggested that future research should adopt a longitudinal and multidimensional perspective.

Conflict of interest

The authors do not declare a conflict of interest.

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