Anthropometric Profile, Vertical Jump, and Throwing Velocity in Elite Female Handball Players by Playing Positions

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Abstract

Vila, H, Manchado, C, Rodriguez, N, Abraldes, JA, Alcaraz, PE, and Ferragut, C. Anthropometric profile, vertical jump, and throwing velocity in elite female handball players by playing positions. *J Strength Cond Res* 26(8): 2146–2155, 2012—Women's handball is a sport, which has seen an accelerated development over the last decade. Although anthropometric and physical characteristics have been studied for male sports teams, in women's handball, studies are scarce. The aim of this study was twofold: first, to describe the anthropometric characteristics, throwing velocity, hand grip, and muscular power of the lower limbs in female handball players and second, to identify the possible differences in these parameters in terms of individual playing positions (center, back, wing, pivot, and goalkeeper). A total of 130 elite female Spanish handball players participated in the study (age 25.74 ± 4.84 years; playing experience 14.92 ± 4.88 years). Anthropometric assessment was performed for all the subjects following the International Society for the Advancement of Kinanthropometry protocols. Furthermore, all the subjects performed a vertical jump test (squat jump and countermovement jump). Hand grip and throwing velocity in several situations were also assessed. A 1-way analysis of variance and a Tukey post hoc test were used to study the differences among individual playing positions. Wings were less heavy, shorter, and showed a smaller arm span than did goalkeepers, backs and pivots ($p \leq 0.001$). Additionally, pivots were heavier than centers. Backs and pivots exhibited higher muscular mass than did wings. Total players' somatotype was mesomorphy endomorphy (3.89–4.28–2.29). Centers showed higher throwing velocity levels than did wings in 9-m throws from just behind the line, with a goalkeeper. Backs exhibited higher hand-grip values than did wings. Statistical differences have been established between wings and other specific playing positions, especially with pivot and backs. Coaches can use this information to select players for the different specific positions.

Key Words performance, somatotype, team sports, fitness assessment

Introduction

From the point of view of physical performance, handball is a complex, intermittent sport game, which requires maximum intensity efforts in a short period of time, where players jump, run, and throw the ball at a high velocity, followed by low intensity or rest moments (21). Several studies have reported that, in handball players, in addition to the technical skills and tactics, the anthropometric characteristics, and highs levels of force, power, and throwing velocity constitute the determining factors for the competitive success (14,15,20,43). It is deduced as a result of all these studies that the physical prevailing requirements of handball are the explosive force in the upper and lower limbs (player velocity and throwing velocity of the ball) and the maximal force and muscular power (required in contact moves against the opponents) (8,43).

It is well known that elite male handball players show the highest values of maximal force and muscular power than do nonactive male players and lower-level handball players (15,17), which is clearly an indication about the importance of these skills for success in handball. However, it is noticeable that when you divide the maximal force values between body mass or between fat-free mass (FFM), differences between elite male handball players and lower-level male handball players disappear (31). This aspect indicates to us the relevance of the muscular mass in male handball players.

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Table 1. Mean ± *SD* values corresponding to the anthropometric characteristics, body composition, and upper body length of female handball players according to their playing position.*

	Position	Center ($n = 16$)	Back ($n = 36$)	Wing ($n = 41$)	Pivot ($n = 18$)	Goalkeeper ($n = 19$)	Total ($n = 130$)
Anthropometric characteristics	Age (y)	27.94 ± 4.39	25.40 ± 4.61	24.85 ± 4.91	25.68 ± 4.05	26.47 ± 5.92	25.74 ± 4.84
	Years of practice	15.79 ± 5.15	15.18 ± 4.86	14.38 ± 4.80	14.44 ± 4.46	15.32 ± 5.57	14.92 ± 4.88
	Weight (kg)	65.65 ± 6.30†	71.13 ± 7.80‡	61.23 ± 4.29	74.65 ± 6.66‡	69.27 ± 7.66‡	67.55 ± 8.06
	Height (cm)	169.95 ± 5.37	174.19 ± 6.21‡	165.49 ± 4.83	176.19 ± 8.62‡	174.96 ± 6.30‡	171.31 ± 7.42
	Arm span (cm)	170.77 ± 6.55	176.05 ± 7.78‡	164.59 ± 7.03	175.83 ± 9.89‡	176.40 ± 7.60‡	171.57 ± 9.20
Body composition	BMI ($kg \cdot m^{-2}$)	22.71 ± 1.72	23.44 ± 2.32	22.35 ± 1.13	24.07 ± 1.71	22.60 ± 1.89	22.97 ± 1.86
	Σ4 Skinfolds	78.61 ± 25.23	75.15 ± 16.99	73.68 ± 14.50	81.54 ± 18.81	85.18 ± 22.57	77.56 ± 18.49
	Σ6 Skinfolds	91.13 ± 27.22	94.46 ± 23.29	90.14 ± 18.59	107.64 ± 25.29	101.69 ± 26.10	95.50 ± 23.49
	Muscular mass (kg)	25.19 ± 2.64	26.37 ± 2.52‡	23.29 ± 1.85	26.69 ± 2.46‡	24.71 ± 2.19	25.01 ± 2.60
Upper body length	Upper limb length	73.32 ± 3.60‡	75.45 ± 3.85‡	70.14 ± 2.55	75.28 ± 3.90‡	74.94 ± 3.38‡	73.35 ± 4.06
	Forearm length	23.97 ± 1.45	24.33 ± 1.75‡	22.87 ± 1.23	24.89 ± 1.32‡	24.71 ± 1.62‡	23.95 ± 1.66
	Hand length	18.54 ± 1.16	18.97 ± 1.24‡	17.78 ± 1.14	18.71 ± 1.53	18.89 ± 0.93‡	18.47 ± 1.29
	Hand width	19.46 ± 0.99	20.26 ± 1.56§	19.25 ± 1.55	19.96 ± 1.91	19.67 ± 1.57	19.70 ± 1.58

*BMI = body mass index.
†Significantly different from pivots ($p \leq 0.001$).
‡Significantly different from wings ($p \leq 0.001$).
§Significantly different from wings ($p \leq 0.05$).

Throwing velocity of the ball is an important skill in handball and a very important aspect for success (12,15,17,36,38). The velocity of a handball throw is not only dependent on the muscular strength but also on other aspects such as body segments coordination and technical skills (40). This velocity is an important aspect for success, because the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot.

In addition, the body composition of the athletes has attracted the interest of the scientific community, which is evidenced by the large number of articles that have been published describing the anthropometric profile of different sports (1,4,7,10,15,16,30,32). Research studies published since the 1928 Olympic Games have shown correlations between different sports and physical characteristics as another factor to consider in the success of a sport. It has been reported that in some sports, there is a clear physical prototype necessary to reach the highest levels of performance (10). It seems the body prototype proposed by researchers a decade ago is being substituted by another prototype based on specialization (32). These authors proposed that in sport, and also within the same sport, positions occupied in the playing field require unique physiological and physical attributes to get the highest performance. These issues are also important in handball because each specific position will require its own skills according to its task.

The truth is that there are few articles that evaluate together the physical condition, anthropometric profile, muscular power, and throwing velocity in handball players (5,7,12,15,16,29,36). This lack of research is even more important in elite women's handball because there are fewer studies that have been published (2,17,18,44), and furthermore, none of them have focused on studying the throwing velocity of the players. Coaches only have new information about male athletes and cannot use the information provided by the research because most of the studies pertain to men. It is necessary to study female handball players to check their own performance profile and provide new specific information to the coaches for improving their practices based on the literature. Coaches cannot use this information to design new training routines that lead them to higher performance levels.

Therefore, the aim of this study is twofold: first to describe the anthropometric profile, throwing velocity, maximal hand grip, and muscular power of the lower limbs in female handball players and secondly to identify the possible differences in these parameters in terms of individual playing positions.

Methods

Experimental Approach to the Problem

Body composition is a significant component of fitness for handball and can vary across positional groups (37). In addition, the throwing velocity of the ball is a major skill in handball and a very important aspect for success (12,15,17,36,38). Therefore, we assessed a total of 130 elite female handball players. The players were divided in the order of their specific playing position (centers, backs, wings, pivots, and goalkeepers). Our hypothesis is that there are specific anthropometric profiles and differences in terms of muscular power in female handball players by playing positions. The independent variable was the handball-specific playing position (centers, back, wings, pivots, and goalkeepers), and the dependent variables were the anthropometric profile, throwing velocity of the ball, and hand grip.

To describe the physique of the players, several anthropometric measures were taken: height, weight, 6 skinfolds (triceps, subscapular, abdominal, suprailiac, front thigh, and medial calf), 10 body girths (arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal, thigh, calf, and ankle), and 6 skeletal breadths (biacromial, biepicondylar-humerus, biepicondylar, biiliocristal, bitrochanteric, and bistyloid).

Ball throwing velocity was evaluated on an indoor handball court using 4 types of throws: penalty mark (7 m), throwing from 9 m just behind the line, with 3 step running (9 m), and with an upward jump. Ball speed for the throws was measured with a calibrated radar gun. Three trials were performed for each experimental situation, and the fastest throw for each type was used for analysis. In addition, maximal isometric hand-grip force was recorded using a handheld hand-grip dynamometer.

To assess lower body power, 2 kinds of maximal jumps on a Jump Mat were performed by handball players. The squat jump (SJ), starting with knees bent at 90° and without previous countermovement, and the countermovement jump (CMJ), starting from a standing position allowing for countermovement, with the intention of reaching knee bending angles of around 90° just before jump. The best jump in terms of flight time was analyzed.

Subjects

A total of 130 elite female handball players (25.74 ± 4.84 years) with a regular competitive background in handball (14.92 ± 4.88 years) participated in this study. All of them were playing in the top Spanish professional handball league. This league comprised female players who were part of the national Spanish teams participating at the juvenile, junior, and senior levels. During the year in which the study was carried out, this league was the number one in the European ranking. The sample was divided according to the specific playing positions of 16 centers, 36 backs, 41 wings, 18 pivots, and 19 goalkeepers. Physical characteristics of the players are shown in Table 1.

Procedures

The study was approved by the San Antonio Catholic University Committee for research involving human subjects. All the participants received verbal and written information about the study and gave an informed

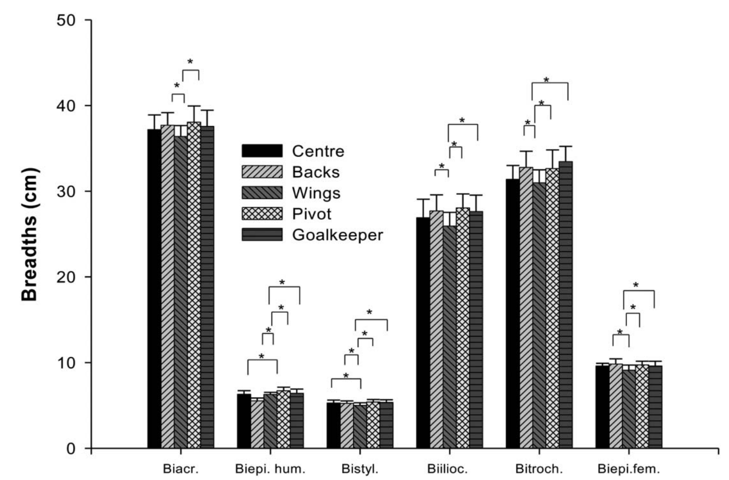

Figure 1. Bone breadth values. Significant differences among playing positions. *$p < 0.05$. Briacr. = biacromial breadth; Biepi. hum. = biepicondylar-humerus breadth; Bistyl. = bistyloid breadth; Biilioc. = biiliocristal breadth; Bitroch = bitrochanteric breadth; Biep. fem = biepicondylar breadth.

during the breakfast on the day when the measurements were made.

Anthropometric Evaluation

The International Society for the Advancement of Kinanthropometry (ISAK) protocol was used to determine the anthropometric profile of the handball players. The subjects were measured during one session and all of them postprandial state. Unilateral measurements were taken on the right side of the body. The participants wore light clothing and were barefoot.

The physical characteristics were measured in the following order: height, body mass, arm span, skinfolds, body girths, and skeletal breadths. The anthropometric program included about 30 measurements. Height and weight measurements were made on a set of scales (Seca, Barcelona, Spain) with an accuracy of 0.01 kg and 0.001 m, respectively. Six skinfolds (triceps, subscapular, abdominal, suprailiac, front thigh, and medial calf) were measured by a Holtain Skinfold Caliper with 10-g·mm^{-2} constant pressure. Ten limb and trunk girths (arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal, thigh, calf, and ankle) were measured using a Lufkin metal tape (Lufkin Executive Thinline, W606PM, USA) and 6 skeletal breadths (biacromial, biepicondylar-humerus, biepicondylar, biiliocristal, bitrochanteric, and bistyloid) were measured using an anthropometer (GPM, SiberHegner, Zurich, Switzerland) with an accuracy of 0.01 cm. Four lengths were measured using an anthropometer (GPM) with an accuracy of 0.01 cm in the upper limbs (upper limb length, forearm length, hand length, and hand width).

The anthropometric dimensions were measured twice (thrice for skinfolds) and obtained by one accredited level 2 and 3 accredited level 1 ISAK anthropometrists. The margin of error for the measurement was <2% for all skinfolds and <1% for all the bone breadths and body girths.

written consent before anthropometric and conditional assessment. This consent included the opportunity for the players to read the manuscript to be submitted for publication. Additional background information was provided by each player, including their date of birth, specific position, and the number of years of playing handball. The tests carried out on the first day were anthropometric, hand-grip, and vertical jump tests. On the second day, throwing velocity was tested. The participants performed the tests shortly before finishing the national league championship. All the subjects were well hydrated, and they were instructed to consume food and to drink as usual

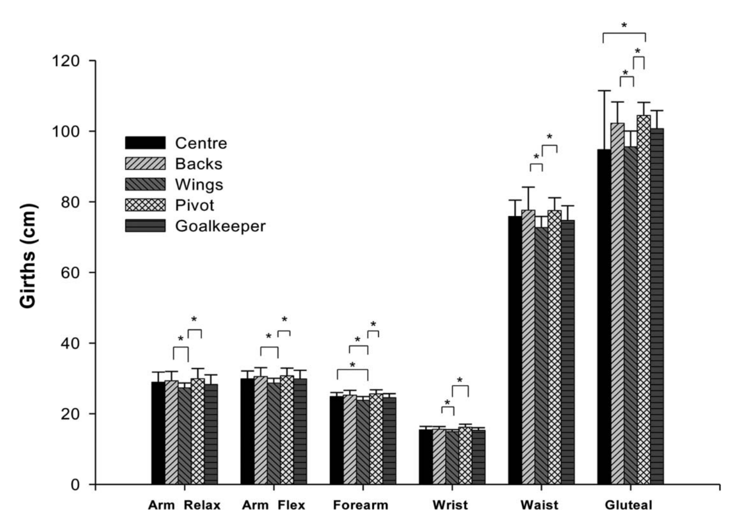

Figure 2. Upper body girth values. Significant differences among playing positions. *$p < 0.05$.

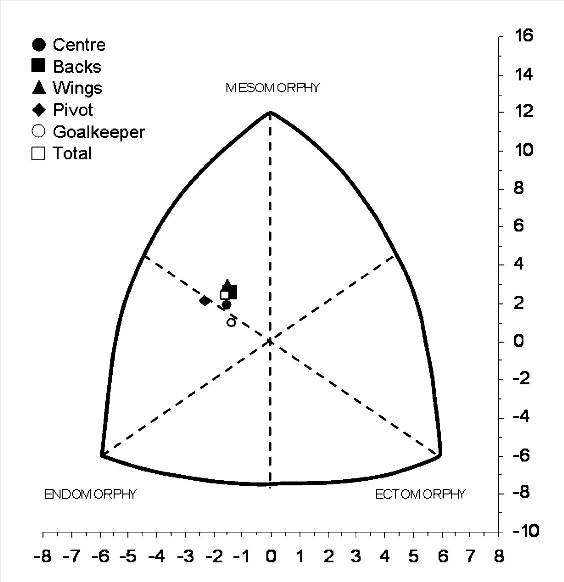

Figure 3. Representation of the somatotype in elite female Spanish handball players.

Several variables were found: (a) the body mass index (BMI) was calculated as weight (kilograms) divided by height (meters squared), (b) sum of 4 (triceps, subscapular, suprailiac, and abdominal) and 6 skinfolds (triceps, subscapular, supra-iliac, abdominal, front thigh, and medial calf), (c) FFM (kilograms) using the method described by Lee et al. (25), (d) selected anthropometric measures were used to determine somatotype following the methods described by Carter and Heath (6).

Throwing Velocity Test

Throwing velocity was assessed with a radar gun (StalkerPro Inc., Plano, TX, USA), with 100-Hz frequency of record and with $0.045\text{-m}\cdot\text{s}^{-1}$ sensitivity, placed behind the goal post and in a direction perpendicular to the player. This test has been shown to have a very good test-retest reliability intraclass correlation coefficient (ICC) of 0.96 and a coefficient of variation (CV) of 2.4% (9,29).

Before the throwing velocity assessment, the subjects performed a 15-minute warm-up focused on overhead throwing. After applying resin as desired, the subjects performed 2 different protocols of throw, one with a goalkeeper and one without. For both protocols, the subjects threw a standard handball as fast as possible toward a standard goal, using a single hand and their personal technique. The sequence of throwing was as follows: a throw from just behind the 7-m penalty mark, a throw from just behind the 9-m line, a 3-step running throw from the 9-m line, and a 3-step running throw from the 9-m line with a jump. Three throws of each type were performed, and the best trial was used for further analysis.

Only throws sent to the goal post were used for analysis. For motivational purposes, the players were immediately informed of their performance. A 3-minute rest elapsed between throws to avoid fatigue.

Maximal Isometric Hand Grip Force Test

Additionally, maximal isometric hand-grip force was recorded using a handheld hand-grip dynamometer (T.K.K. 5401, Tokyo, Japan), with a sensitivity of 10 N. This test gives an ICC of 0.954 and 0.912 for both left and right hands, respectively, and a CV of 4.9%. The study subjects were familiarized with the dynamometer with 3 repetitions to warm up. The players performed 2 repetitions at maximum intensity with the dominant hand. They did it at a standing position with the dynamometer set parallel to the body. In this position, the player was asked to exert maximal grip force without arm or wrist movement. The best trial was used for further analysis. For motivational purposes, the players were immediately informed of their performance. Three minutes of rest elapsed between trials to minimize the effects of fatigue.

Vertical Jump Test

Each subject performed 2 kinds of maximal jumps on a Jump Mat (Ergo Jump Bosco System®, Byomedics, SCP, Barcelona, Spain): the SJ, starting with knees bent at 90° and without previous countermovement, and the CMJ, starting from a standing position allowing for countermovement, with the intention of reaching knee bending angles of around 90° just before jump. In both jumps, the subjects kept their hands on their hips throughout the jumps, to avoid the possible contribution of the arms to the jump. The subjects completed 3 attempts of each type of jump, and the best one (in

TABLE 2. Mean ± *SD* values of hand-grip and vertical jump height of female handball players according to their play position.*

Position	*n*	Hand grip (N)	SJ (m)	CMJ (m)
Center	12	350.06 ± 36.36	0.452 ± 0.07	0.463 ± 0.07
Back	29	363.68 ± 53.02†	0.415 ± 0.09	0.418 ± 0.09
Wing	34	326.54 ± 44.49	0.454 ± 0.08	0.441 ± 0.10
Pivot	13	353.19 ± 59.49	0.394 ± 0.09	0.383 ± 0.09
Goalkeeper	16	350.84 ± 42.04	0.409 ± 0.09	0.414 ± 0.10
Total	104	346.72 ± 49.29	0.429 ± 0.09	0.426 ± 0.09

*SJ = squat jump; CMJ = countermovement jump.
†Significant different from wings ($p < 0.05$).

Table 3. Mean ± *SD* values corresponding to throwing velocity (meters per second) without the goalkeeper.

Position	*n*	7 m	9 m Just behind the line	9 m With 3-step running	9 m With an upward jump
Center	16	20.80 ± 1.42	21.11 ± 1.48	23.11 ± 1.10	22.47 ± 1.59
Back	36	20.93 ± 1.68	21.05 ± 1.57	22.96 ± 1.88	22.33 ± 1.59
Wing	41	20.30 ± 1.64	20.45 ± 1.55	22.10 ± 1.70	21.78 ± 1.42
Pivot	18	21.02 ± 1.84	20.78 ± 1.87	22.53 ± 1.77	22.00 ± 2.00
Goalkeeper	19	19.52 ± 0.93	20.23 ± 1.02	21.75 ± 1.68	20.79 ± 1.72
Total	130	20.58 ± 1.63	20.74 ± 1.55	22.52 ± 1.74	21.98 ± 1.62

terms of flight time) was used for the subsequent statistical analysis. For motivational purposes, the players were immediately informed of their performance. Between jumps, the subjects were allowed to recover for 3 minutes to avoid fatigue. Jump height was calculated using flight time. The CMJ showed an ICC of 0.94 and a CV of 3.6%, and the SJ showed an ICC of 0.93 and a CV of 4.2%.

Statistical Analyses

Standard statistical methods were used to calculate the mean and *SD*s. All data are expressed as mean ± *SD* (all data were checked for distribution normality and homogeneity with the Kolgomorov-Smirnov, Lilliefors, and Levene tests). A 1-way analysis of variance together with a Tukey honestly significant difference post hoc test was used to determine if significant differences existed among 5 playing positions (center, back, wing, pivot, and goalkeeper). The reliability of the throwing velocity, handgrip, and vertical jump tests was assessed using ICC. An ICC >0.90 is considered as high, 0.80–0.90 is moderate, and values <0.80 indicate that a field test is inadequate The CV of the field test was also calculated and was <5% for all the tests. The $p \le 0.05$ criterion was used for establishing statistical significance.

Results

Physical characteristics of the players are shown in Table 1. It can be assessed that wings are lighter, shorter, and have a smaller arm span, than do goalkeepers, backs, and pivots ($p \le 0.001$). Additionally, pivots are heavier than centers ($p < 0.001$). No significant differences among playing positions were found, neither in BMI nor in sum of 4 and 6 skinfolds (Table 1). Nevertheless, backs and pivots exhibit a higher muscular mass than wings do ($p \le 0.001$).

Significant differences were found ($p \le 0.001$) among wings and backs, pivots and goalkeepers, for upper limb lengths and forearm length. Goalkeepers and backs show a higher hand length than do wings ($p \le 0.001$). Backs show a greater hand width than wings do ($p \le 0.05$) (Table 1).In all breadths studied, wings show significant differences compared with backs and pivots ($p \le 0.05$). Wings exhibit significant differences ($p \le 0.05$) compared with goalkeepers in biepicondylar, biiliocristal, bitrochanteric, and bistyloid breadths. Wings show significant differences ($p \le 0.05$)

Table 4. Mean ± *SD* values corresponding to throwing velocity (meters per second) with the goalkeeper.

Position	*n*	7 m	9 m Just behind the line	9 m With 3-step running	9 m With an upward jump
Center	16	21.05 ± 1.90	21.73 ± 1.48*	23.35 ± 1.62	22.2 ± 1.27†
Back	36	20.48 ± 1.35	20.92 ± 1.73	22.17 ± 1.86	22.05 ± 1.76†
Wing	41	20.03 ± 1.42	20.22 ± 1.31	22.05 ± 1.43	21.49 ± 1.22†
Pivot	18	19.94 ± 1.87	20.62 ± 1.61	22.03 ± 1.63	22.29 ± 1.85†
Goalkeeper	19	19.40 ± 2.06	19.49 ± 0.98‡	20.69 ± 2.07‡	19.17 ± 1.52
Total	130	20.25 ± 1.59	20.64 ± 1.57	22.17 ± 1.72	21.72 ± 1.65

*Significantly different from wings ($p < 0.05$.
†Significantly different from goalkeepers ($p < 0.001$).
‡Significantly differences from centers ($p < 0.05$)

TABLE 5. Physical characteristics of female handball players in the literature.*

Studies	*n*	Position/level	Age (y)	Playing experience (y)	Height (cm)	Weight (kg)	BMI ($kg \cdot m^{-2}$)
Bayios et al. (2)	222	Greek league	21.5 ± 4.6	8.8 ± 4.2	165.9 ± 6.3	62.1 ± 9.1	23.6 ± 2.7
Filaire and Lac (11)	14	First-level French	24.1 ± 2.6		167.8 ± 5.3	61.0 ± 7.5	
Garcin et al. (13)	11	French	19.0 ± 0.8		168.4 ± 2.5	62.0 ± 5.2	
Granados et al. (17)	16	Elite	23.8 ± 4.0	12.7 ± 5.0	175.4 ± 8	69.8 ± 7	20.5 ± 5.0
Granados et al (17)	15	Amateur	21.4 ± 3.0	10.4 ± 3.0	165.8 ± 4	64.6 ± 5	23.3 ± 3.0
Hasan et al. (18)	11	Goalkeeper	23.0 ± 2.1		175.8 ± 0.01	68.3 ± 6.3	23.3 ± 2.8
Hasan et al. (18)	24	First line	22.0 ± 1.4		169.3 ± 0.02	62.2 ± 2.1	19.4 ± 2.4
Hasan et al. (18)	13	Centers	23.0 ± 4.0		171.8 ± 0.04	66.9 ± 4.5	20.6 ± 3.0
Hasan et al. (18)	12	Wings	21.0 ± 2.0		170.0 ± 0.08	63.5 ± 7.9	21.8 ± 2.9
Lian et al. (26)	52	Elite Norway	22.8 ± 4.3		169 ± 4.8	63.2 ± 5.1	
Manchado et al. (28)	16	Elite German	26.6 ± 3.8		176.0 ± 7.4	70.4 ± 6.8	
Ronglan et al. (34)	8	International Norway	23.1 ± 2.0		176.0 ± 0.05	71.2 ± 1.8	
Ronglan et al. (34)	7	National Norway	23.7 ± 2.1		179.0 ± 0.04	72.0 ± 6.3	
Present study	130	Elite	25.7 ± 4.8	14.9 ± 4.9	171.3 ± 7.42	67.5 ± 8.06	23.0 ± 1.9

*BMI = body mass index.

compared with centers in bistyloid breadth. In bitrochanteric breadth, statistical differences were found between centers and goalkeepers ($p \leq 0.05$) (Figure 1).

All girths analyzed show statistical differences ($p \leq 0.05$) between wings in contrast with backs and pivots. Likewise, centers show higher forearm girth than wings do ($p \leq 0.05$). In gluteal girth, statistical differences were found ($p \leq 0.05$) between pivots and centers (Figure 2).

The total somatotype of the players in the study was characterized as mesomorphy endomorphy (3.89–4.28–2.29) (Figure 3). No significant differences in the 3 somatotype components were found among the 5 groups. Mesomorphy is the main component for centers (3.83–4.01–2.30), backs (3.80–4.40–2.31), and wings (3.72–4.44–2.18). Endormorphy is the main component for pivots (4.46–4.37–2.12) and goalkeepers (4.02–3.85–2.67). Ectomorphy is the least important component for all the playing positions.

Hand-grip scores of the female handball players are shown in Table 2. Backs exhibit stronger hand-grip values than wings do ($p < 0.05$). No differences in hand-grip strength were found between other playing positions. Vertical jump scores (CMJ and SJ) of the female handball players are also shown in Table 2. There are no differences between playing positions in vertical jump height (SJ and CMJ).

Throwing velocity in the different situations is shown in Tables 3 and 4. When throwing without a goalkeeper, no differences in throwing velocity among playing positions were found, but statistical differences were observed when throwing with a goalkeeper. Centers show higher velocity values than do wings and goalkeeper when throwing from 9 m just behind the line throws with a goalkeeper ($p \leq 0.05$).

DISCUSSION

In handball, each playing position requires different skills that should be reflected in the player's body composition. The main goal of this study is to establish the anthropometric profile of elite female handball players by playing position and to notice that there are differences in anthropometric aspects by playing positions and no differences in force levels. This is a very important and novel issue because there are no studies on the differences in force levels and anthropometric profiles in elite female handball players; this article contains new information about female handball players by specific playing positions that could be extremely useful for coaches.

The mean height and weight of the players in this study (171.31 cm and 67.55 kg) listed in Table 5 are in line with recently published studies on handball (2,17,20,22,24,28,39,40). These studies reported a mean height and weight of about 169–175 cm and 66 kg, respectively, but are less than those reported by Hlatky and Holdhaus (19), which places these values at 174–176 cm for height and 70–72 kg for weight.

With regards to playing positions, the smaller and lighter players are wings, whereas greater values for height, weight, and arm span are shown by pivots, backs and goalkeepers. These results are not in line with those published by Hasan et al. (18), but they are in line with the physical demands of each position (37). It has to be noted that taller players are in the best position as wings and pivots on the playing field, because they have a better view of the playing field. Having a heavier weight can be an advantage for some players when fighting for the position in a one-on-one situation.

No differences were found in arm span among goalkeepers and the other specific positions, except for wings. This result was not expected because the goalkeeper seems to be a specific position, where arm span is essential for reaching the entire goal area.

With regard to fat mass and FFM values, we have to emphasize that BMI values for all the specific positions are lower than those reported for the principal Greek league's players (2) and young female Spanish players (17), but those values are higher than the ones exhibited by elite female Spanish handball players (17). This variation in the data confirms that BMI cannot be used to distinguish between fat mass and FFM. So, it is not a good adiposity index for athletes (27,33).

Wings exhibit lower FFM values than do pivots and backs. This is in agreement with specific position requests because wings rarely have contact with the defense, and furthermore, the movement agility and the ability to accelerate and decelerate quickly are fundamental in this specific position (28). A higher weight and muscular force can be an advantage when fighting for the spatial occupation at the 6 m line against the defenders. Therefore, a larger muscular mass can be considered an important characteristic for this specific playing position.

As for the variables that evaluate the length of the upper body limbs, specific positions of backs, pivots, and goalkeepers show similar values for all the lengths studied.

Nevertheless, there were differences among backs, pivots, and goalkeeper when compared with wings in all the lengths evaluated (except in the hand length and hand width for pivots) (Figure 1). Wings exhibited significant differences compared with centers in the upper body length. These results correlate with playing characteristics of the first line (centers and backs), where arm and hand lengths are important for achieving success in throwing skills (42). This longer upper body length allows pivots to receive control and power the ball among the defenders and in conflict situations. Higher upper body length allows goalkeepers to occupy a larger goal area. Wings show other needs in the game different from those of other specific positions. The length of upper body limbs does not seem to be so important because wings play close to the 6-m line, and they throw the ball near the goal (37). What is common among all specific positions is the hand width. It is a very useful characteristic that helps in the control and power of the ball, and it is considered, with hand length, to be an advantage in handball (36,42). This variable can be a useful criterion in the talent selection process in handball because it cannot be modified by training.

The breadths are similar to the girths. They confirm the differences among the specific positions of pivots and backs compared with wings.

The goalkeeper needs to have an athletic body shape, with an important factor being longitudinal characteristics. Therefore, biacromial, biiliocristal, and bitrochanteric breadths can contribute to the goalkeeper occupying a larger goal area (37). This is confirmed by the greater breadth values that the goalkeeper shows compared with those of wings and centers. It is notable that breadths are morphological parameters that are not modifiable by training and that can be related to strength levels (27). Therefore, this could be an interesting aspect in talent selection in handball (37,41).

Unlike lengths and breadths, girths are modifiable by training. Girth values confirm the difference among the specific positions of wings compared with those of backs and pivots.

We observed that pivots and wings had the most contact with the other team's defense, because their purpose on the playing field requires actions such as pushing, turning, and blocking. These actions need higher dynamic and static strength values (37). This is confirmed by the data obtained in this study and is supported by those published by Chaouachi et al. (7) and Srhoj et al. (37), who analyzed these variables in female Tunisian and Croatian handball players, respectively. However, these differ with those reported by Hasan et al. (18) in female Asiatic handball players. These differences could be because of ethnicity as Hasan's sample was composed of Asiatic players, whereas our sample mainly consisted of Caucasian players.

When we analyzed the somatotype of playing positions, we did not find any differences among specific positions, but we can say that centers and pivots show an endomorphy-mesomorphy somatotype, where mesomorphy and endomorphy are predominant. For backs and wings, the somatotype was mesomorphy endomorphy where the main component was mesomorphy. The principal component in all the specific playing positions was mesomorphy except for goalkeepers and pivots. This somatotype is in agreement with handball players' characteristics, where muscle mass is important. Ectomorphy showed the lowest values. These results concur with those of other articles published on male and female handball players (2,27).

Previously, one could expect that we would find significant differences among the specific playing positions in strength, jump, and throwing velocity; however, we only found significant differences in hand-grip strength between backs and wings.

The ability to grasp the ball is essential in handball, which is associated with the ability to grip it. A good grasp is related to the ball's velocity when throwing (42). Female handball players exhibit a mean hand-grip strength value of 347 N. By specific positions, backs are the players who show higher levels of hand grip, but these differences only have statistical significance between backs and wings. These results draw a parallel with those reported by Visnapuu and Jurimae (42). These authors concluded that height, weight, and BMI, as in hand skills, can influence hand-grip strength. Thus, backs are the players with a longer hand length and are those that achieve greater hand-grip strength values.

The CMJ scores of our players are higher than those previously reported (17,34). However, no significant differences were found in vertical jump, SJ, or CMJ among specific playing positions in our sample. We must take into account that vertical jump is related to higher power levels (3). So, we can conclude that our players exhibited similar values of lower body power without taking into consideration the specific playing position.

The throwing velocity in handball is important to achieve success in the sport because the faster the ball is thrown at the goal, the lesser the time the defenders and the goalkeeper have to save the shot. Other studies of elite female handball players show a mean throwing velocity of 17.1–22.2 $m \cdot s^{-1}$ (17,20,23,35,38,40,44). The velocities reached by our female handball players are in line with those of the aforementioned studies. If we compare 7-m velocities reported by Granados et al. (17), in female Spanish handball players, we notice that their players had a mean throwing velocity of 19.5 $m \cdot s^{-1}$. Our values are similar to throwing velocities with the goalkeeper (20.24 $m \cdot s^{-1}$) and without the goalkeeper (20.58 $m \cdot s^{-1}$). Nevertheless, the interpretation of these comparisons should be made with care because there are few studies published and the methodologies (radar gun, photogrammetry, electronic timing gates) and sample levels are also different.

No statistical differences in velocity were found based on the specific positions in any of the throwing types performed without a goalkeeper, but we found significant differences in velocity when throwing with a goalkeeper. Centers reached higher throwing velocities than wings did.

The truth is that, a priori, it could be expected that first-line players reached higher velocities than the other players (backs and centers) did, because it is a very common throw for this specific position. This is confirmed in our study, but only at 9 m with a 3-step run with a goalkeeper throw. We found statistical differences between centers and wings.

We conclude that wings exhibit important anthropometric differences when compared with the other specific playing positions in elite female Spanish handball players. In addition, mesomorphy is the principal component of the somatotype for all specific playing positions, except pivots and goalkeepers. It can be confirmed that muscle mass in female handball players carries a significant importance. In elite female Spanish handball players, there are no differences in the specific playing positions with regard to jump height, throwing velocity, and hand-grip strength.

Practical Applications

There are 4 important practical applications from this study: First, trainers should design routines that lead to improved muscle strength. The presence of higher muscle mass reflected in the mesomorphic component in female handball players constitutes a significant advantage to confront the intense body contact during a game. Second, because the positional demands of the game are different, explosive strength for jump and throw should be developed according to the individual playing positions and skill of the handball players, especially for back and wing players. Third, this study provides normative data and performance standards for elite female handball players competing in specific playing positions. Coaches can use this information to determine the type of anthropometric characteristics that are needed for specific positions. Finally, trainers should take into account some anthropometric characteristics during handball talent selection because they tend to be a requirement for future high-level performance. A database including such information from different teams and competitive levels would allow training professionals to compare their own data with those of other teams and better assess the effectiveness of their routines in improving the performance of their players.

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