

## Article

# Differences in the Anthropometric Measurements and Performance Tests of Qatari First Division Handball Players Depending on Position

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**Featured Application:** The aim of this study was to compare the anthropometric and physical characteristics of male team handball players and analyze the relationships between these parameters and playing positions. Because the test results reflect the unique qualities of individual handball playing positions, the results may be helpful for handball coaches and fitness trainers. In addition, they open the door to potential benefits in long-term athletic development as a route that might enhance conditioning routines and physical training programs in team handball players.

**Abstract:** This study sought to investigate the anthropometric traits and physical capabilities of team handball players, categorized based on their playing positions. A total of 50 male players (age:  $27.4 \pm 4.2$  years; body mass:  $92.8 \pm 14.2$  kg; height:  $1.87 \pm 0.08$  m; body mass index (BMI):  $26.3 \pm 3.3$  kg/m<sup>2</sup>) were categorized as Backs (12), Wings (14), Pivots (14), and Goalkeepers (10). The measurements included squat jumps (SJs), countermovement jumps (CMJs), sprint timings over 15 and 30 m, upper and lower limb muscle volume, change-of-direction T-Half test performance, and Yo-Yo intermittent recovery test performance. Depending on the position, the largest differences were detected for 30 m sprint ( $\eta_p^2 = 0.72$ ), 15 m sprint ( $\eta_p^2 = 0.71$ ), T-Half test ( $\eta_p^2 = 0.41$ ), half squat ( $\eta_p^2 = 0.35$ ), and bicipital skinfold of a throwing arm ( $\eta_p^2 = 0.34$ ). Bicipital skinfold showed the highest number (three) of relevant ( $r > 0.5$ ) relationships, especially in sprinting (sprint 15 m:  $r = 0.528$ ; sprint 30 m:  $r = 0.503$ ) and change-of-direction ability (T-Half test:  $r = 0.518$ ). Differences in physical performance and body type according to playing positions emphasize the value of goalkeeper-specific training and scouting for handball players, with a particular emphasis on both. This information might be helpful for optimizing position-specific training regimes.

**Keywords:** team sport; performance diagnostic; highly trained players; anthropometric

## 1. Introduction

Team handball is a physically challenging team sport that requires a variety of physical fitness qualities to achieve success on the court [1–3]. Team handball consists of repeated accelerations and decelerations, sprints, jumps, shots, rapid directional changes, and many tackles and screenings [2,4]. Team handball is a kind of sport that has many explosive movements; therefore, the emphasis is on the anaerobic capacity of the athletes. In addition, handball performance depends upon several individual skills and interactions between different teammates [3]. Although technical and tactical skills are the most important aspects, players' physical conditions must also be well-developed [5].

Recently, with the purpose of overcoming this inconvenience, different companies developed local positioning systems (LPSs) using ultra-wideband technology (UWB) [6] to track players and estimate the physical demands of handball [7]. Font et al. [8] found that handball players performed more than 1000 accelerations and decelerations during a handball game [8], and Luteberget et al. [9] found an average of  $3.9 \pm 1.5$  high-intensity events per minute (the sum of the accelerations, decelerations, and changes of direction greater than  $2.5 \text{ m}\cdot\text{s}^{-2}$ ). Font et al. [8] reported that wings, backs, and pivots performed a similar number of accelerations and decelerations. Furthermore, the number of high-intensity accelerations (HIAs) and high-intensity decelerations (HIDs) between different playing positions were different [8]. Wings ( $135 \pm 61$ ) performed slightly more HIAs than backs ( $128 \pm 55$ ) and pivots ( $112 \pm 34$ ); in contrast, backs ( $115 \pm 52$ ) performed a similar number of HIDs to wings ( $113 \pm 56$ ) and slightly more than pivots ( $100 \pm 29$ ).

Regarding contextual factors, some studies indicate differences in external load outcomes between the first and second half of the match; specifically, the time spent in high-intensity movements and in high-intensity running during matches decreases in the second half [7,8,10]. Moreover, the total distance covered in the first 10 min was slightly higher than the distance covered in the last 10 min of the game [11]. In addition, the initial values of player load/min declined throughout the halves [12]. When considering the available data, the technical activity profile is different between playing positions [7,8,10]. Wings perform moderately more fast breaks than backs; on the other hand, backs perform more throws than wings and pivots [1,7]. Moreover, backs perform more jumps, landings, stops, and COD [7]. Finally, pivots receive and give up more contact (tackles and screenings) [7].

Furthermore, some researchers indicate that there are no differences between top-ranked and lower-ranked teams [13–15] or between winners and losers [15] in the total distance covered and running pace during games. Multiple previous investigations of team handball athletes have indicated high levels of muscle force, power, and ball-throwing velocity, as well as tactics and technical skills, comprise the determining elements of performance [1,16–19]. Similarly, research on team handball players has highlighted notable variations in both the physical and anthropometric characteristics among different playing positions [3]. Athlete profiling serves as a valuable tool for identifying talent, determining playing positions, and optimizing the design of training programs [1,13,14,18]. Some might assume that professional team handball players who compete inside on a small court exhibit more uniformity in their playing positions than rivals who compete on wider fields, as is the case for soccer [1]. Nevertheless, according to several studies of handball professionals, there are noticeable disparities between playing positions in terms of the many physiological, physical, and anthropometric variables [13,15,18,20–22].

Physical and motor assessments, anthropometric measurements, and team handball performance have all been linked to successful match outcomes [1,13,18]. Some previous pieces of research have provided specific performance measures that might be the most pertinent [1,18,20]. For example, body composition could influence performance. Precisely, larger hand size or handgrip strength permits greater control of the ball, and a higher wingspan facilitates a greater occupation of space in offensive and defensive actions [1]. According to Granados et al. [23], a higher fat-free mass was associated with superior performance, particularly since it is associated with muscular power and strength. More-

over, recent studies noted the negative effect of high-percentage body fat on aerobic and anaerobic performance [24,25].

There are few pieces of research that consider physical condition, anthropometrics, and muscular power within a single study concerning team handball players [13,15,18,20–22]. This dearth of information is important to handball players and practitioners of different levels because knowledge of fitness profiles can be utilized for constructing specific training regimens to improve handball performance. At the same time, the individual physical demands that each player faces during a match should be considered within the process of training planning.

Therefore, the aim of this study was first to define the physical characteristics of male team handball players and then to interrogate the relationships between these parameters and playing positions. Our primary hypothesis was that these physical characteristics, performance values, muscle volumes, and ball-throwing kinetics would vary depending on position. The second hypothesis was that performance in the sprinting, jumping, throwing, and strength tests would be correlated with body fat and muscle volume.

## 2. Materials and Methods

### 2.1. Ethical Clearance

The investigation was conducted mid-preseason ahead of the competitive season. Ethical approval was granted by the Qatar University institutional review board (approval number: QU-IRB 1303-EA/20; renewed from 5 September 2023). The study complied with the Declaration of Helsinki. Participants gave informed written consent to participate after receiving both verbal and written explanations of the study. They retained the freedom to withdraw from the investigation at any point without repercussions.

### 2.2. Participants

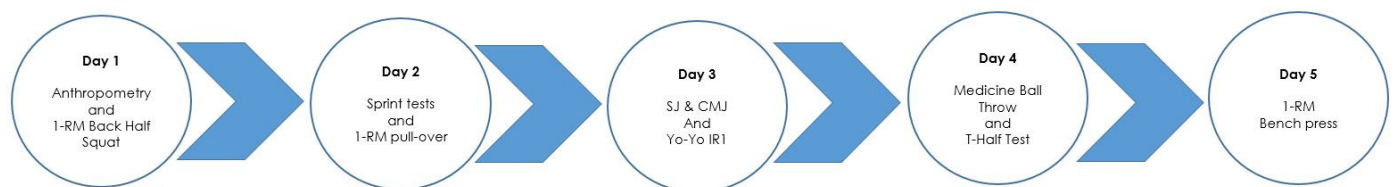
A questionnaire about participants' medical history, age, height, mass, training habits, injury history, handball experience, and level of competitive performance was completed ahead of the test battery. In total, 50 highly trained male handball players from the First National League, competing at the highest level in Qatar (age:  $27.4 \pm 4.2$  years; body mass:  $92.8 \pm 14.2$  kg; height:  $1.87 \pm 0.08$  m; BMI:  $26.3 \pm 3.3$  kg/m<sup>2</sup>), were included and tested. These participants were professional athletes representing four distinct clubs within the First National League, all of which had achieved national championship status in the preceding season. Additionally, participants' performance level was categorized in accordance with the criteria established by the Local National Handball Association as Top Elite (Professional Championship). Notably, 30% of the participants held the designation of national team players, having represented their club in prestigious tournaments, such as the IHF Men's Super-Globe, Asian Men's Handball Championship, and the World Cup, as well as various qualifying matches for the Handball Championship at both the Arabic and Asian levels. Furthermore, the remaining 70% of the participants were affiliated with clubs competing in the highest division of the Qatar handball league system.

Most of the players had been playing handball since they were 12–14 years old. Among them, the players were cadets and juniors (national team) and had  $8.7 \pm 4.9$  years of handball experience as senior players (minimum: 3 years). All participants in this study were judged to be in good health. The coaches or athletes themselves identified the player positions, categorizing them as Backs ( $n = 12$ ), Pivots ( $n = 14$ ), Wings ( $n = 14$ ), or Goalkeepers ( $n = 10$ ). Six players were left-handed. The common training plans for all clubs are based on the normal routine, consisting of six 90 min training sessions per week, plus a competitive game played at the weekend. Training sessions consisted mainly of technical–tactical skill development (60% of session time) and strength and conditioning routines (40% of session time).

### 2.3. Experimental Design

This cross-sectional study was conducted to identify variations in anthropometric and physical performance parameters among handball players in various field positions. Due to prior testing experience, the participants were familiar with the testing procedures. The tests were administered to players on the same team in the same order. The participants were instructed to keep their regular lifestyle and eating habits before and during the trial to minimize the impact of nuisance variables. The participants were requested to have their final (caffeine-free) meal at least three hours prior to testing. The subjects were instructed not to exercise the day before the test. Additionally, the participants consumed a minimum of 500 mL of water in the final hour before testing.

To reduce the impact of diurnal fluctuation, testing was conducted in an indoor handball hall between 18:00 and 20:00 following a competitive game. To avoid positive effects on muscle performance, the participants were instructed to abstain from drinking caffeinated drinks on the testing day. The determination of muscle volume and one repetition maximum (1-RM) of Back Half Squat occurred on day 1. On day 2, sprint tests and one repetition maximum (1-RM) of pull-over were completed. On day 3, the CMJ, SJ, and the Yo-Yo IR1 tests were completed. On the fourth day, the Medicine Ball Overhead Throw and change-of-direction ability (T-Half test) were assessed; finally, on the fifth day, one maximum repetition (1-RM) of Bench press was assessed (Figure 1).



**Figure 1.** Schedule of testing procedures and assessments.

### 2.4. Anthropometry

The anthropometric measurement methodology has been previously detailed and made available through gold open access publishing [14,26,27]. Briefly, the mass, stature, and BMI were assessed using conventional techniques. By using age-specific Durnin–Womersley equations and the four-site skinfold method with Harpenden calipers, %BF was calculated [14]. In addition, the previously described methods for estimating leg muscle volume, thigh muscle volume, cross-sectional area, maximal thigh section area, and upper limb muscle volume were used [26,27].

#### 2.4.1. Upper Limb Muscle Volume

The muscle volume of the upper limbs was estimated, as detailed previously, using the circumferences and skin-fold thicknesses measured at different levels of the arm and the forearm, the length of the upper limb, and the breadth of the humeral condyles [26,27]. Muscle volumes were estimated according to the following:

$$\text{Muscle volume} = \text{total limb volume} - (\text{fat volume} + \text{bone volume})$$

The total limb volume was estimated as the volume of a cylinder, based on its length (L), corresponding to the distance from the acromion to the minimum wrist circumference and the mean of five limb circumferences (axilla, maximum relaxed biceps, just proximal to the elbow, maximum over the relaxed forearm, and minimum above the styloid process) according to the formula

$$\text{Total limb volume} = (\sum C^2) \cdot L / 62.8$$

where  $\sum C^2$  is the sum of the squares of the five circumferences of the corresponding limb. Skin folds were assessed using a standard Harpenden caliper (Baty International, Burgess Hill, Sussex, UK). The fat volume was calculated as

$$(\sum C/5) \cdot (\sum S/2n)L$$

where  $\sum S$  is the sum of three skin folds for the upper limb (biceps, triceps, and mid-forearm), and “n” represents the number of skin folds measured on each limb.

Bone volume was calculated as

$$\pi \cdot (F \cdot D)^2 \cdot L$$

where D is the humeral intercondylar diameter, F is a geometric factor (0.21 for the upper limb), and L is the limb length, as measured above.

Standard equations were used to predict the percentage of body fat from the biceps, triceps, subscapular, and suprailiac skinfold readings [27]:

$$\% \text{ Body fat} = a \cdot \log(\sum 4 \text{ folds}) - b$$

where  $\sum S$  is the sum of the four skinfold readings (in mm), and a and b are constants dependent on sex and age.

#### 2.4.2. Leg Muscle Volume

Circumferences and skin-fold thickness at different levels of the thigh and the calf, the length of the leg, and the breadth of the knee condyles were measured to estimate the leg muscle volume.

$$\text{Muscle volume} = \text{total limb volume} - (\text{fat volume} + \text{bone volume})$$

The total limb volume was estimated as the volume of a cylinder, determined by the distance (L) from the trochanter major to the external malleolar of the ankle. The basal area of the cylinder was based on the mean area of five limb circumferences (C) (maximal thigh, mid-thigh, just below the patella, maximal calf, and just above the ankle).

$$\text{Total limb volume} = (\sum C^2) \cdot L/62.8$$

where  $\sum C^2$  is the sum of the squares of the five circumferences.

$$\text{Fat volume} = (\sum C/5) \cdot (\sum S/2n)L$$

where  $\sum S$  is the sum of four skinfolds (front-to-the mid-thigh, back of-to-the mid-thigh, back of calf and outside of calf), as determined by a Holtain skinfold caliper, and where n is the number of skinfolds measured.

$$\text{Bone volume} = \pi \cdot (F \cdot D)^2 \cdot L$$

where D is the femoral intercondylar diameter, and F is a geometrical factor (equal to 0.235 for the leg, implying that the bone radius is 23.5% of the femoral intercondylar diameter). The accuracy of this anthropometrical method was previously validated via a comparison using dual-energy X-ray absorptiometry ( $r = 0.94$ ;  $p < 0.01$ ) [26,27].

Mean cross-sectional area (CSA) of the thigh: The mean thigh CSA was calculated from the maximal and mid-thigh circumferences after the deduction of the appropriate skin-fold thicknesses:

$$\text{Circumference (C)} = 2\pi \cdot \text{Radius (R)}$$

$$R = C/2\pi$$

R is, thus, the radius of a transverse section of the muscular mid-thigh after deducting the thickness of the overlying skinfolds.

$$r = R - [(\text{mid-thigh anterior skin fold} + \text{mid-thigh posterior skin fold})/4]$$

## 2.5. Physical Performance

The methods are briefly explained to prevent replication because every physical performance has already been detailed and published through gold open access publication [4,14].

### 2.5.1. One Repetition Maximum Back Half Squat at 90 Degree Flexion

Prior to the main activity, the warm-up regimen entailed a set of five repetitions at loads ranging from 40% to 60% of the perceived maximum. Subjects firmly grasped the bar with both hands, positioning it on their shoulders. Subsequently, the knees were flexed to a 90-degree angle, and the subjects elevated themselves to an upright position with fully extended legs. For the assessment of the one repetition maximum (1-RM), the barbell was initially loaded with free weights equivalent to 90% of the pretest 1-RM. Two consecutive tests were administered, and upon successful completion of both repetitions, a 5 kg increment was added after a recovery interval of 3 min. This process continued until the participant accomplished two successful repetitions at their pretest 1-RM value, at which point, further loads of 1 kg were added after each recovery period [16]. If the second repetition could not be completed with the new load, the successfully lifted load was deemed the 1-RM. Typically, three to six lifts were required to ascertain the 1-RM [4].

### 2.5.2. Sprint Tests

Participants ran 40 m from a standing start [14]. The 15 m and 30 m timings were recorded using paired photocells (Racetime 2 SF, Microgate, Italy) that were located 1 m above the ground at the start and finish lines. Three trials were separated by 6–8 min of recovery, with the fastest times being used in the analyses.

### 2.5.3. One Repetition Maximum Pull-Over

Subjects were familiar with the required technique of the 1-RM<sub>PO</sub>, having used it in their weekly training sessions. The bar was positioned 0.2 m above the subjects' chests, supported by the bottom stops of the lifting cage. Successive eccentric-concentric contractions were performed from the starting position. For 1-RM<sub>PO</sub>, the warm-up for the definitive test comprised five repetitions at loads of 40–60% of the pre-test 1-RM<sub>PO</sub>. Thereafter, four to five separate attempts were performed until subjects were unable to extend their arms fully on two occasions. The load noted at the last successful extension was considered as the 1-RM<sub>PO</sub>. Two minutes of rest were allowed between trials [17].

### 2.5.4. Squat (SJ) and Counter Movement Jump (CMJ) Tests

CMJs and SJs were performed as previously described [28] using the Optojump photoelectronic system (Optojump Next, Microgate, Italy). Four trials interspersed by 30 s of rest were performed, and the best value (i.e., the largest jump height) was used for statistical analysis.

### 2.5.5. The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)

The Yo-Yo IR1 test was executed following the described protocol [29]. Participants performed 20 m shuttle runs at progressively increasing speeds until exhaustion, with 10 s of active recovery between runs. Trials were concluded for subjects who failed twice to reach the front line in time or expressed an inability to maintain the required speed [30].

### 2.5.6. Medicine Ball Overhead Throw

For the MBTs, a medicine ball weighing 3 kg and with a diameter of 21.5 cm was employed, completed as described previously [14].

### 2.5.7. Change of Direction Ability (T-Half Test)

Electronic timing sensors (photocells, Kit Racetime 2 SF, Microgate, Italy) were employed to record the T-Half tests, as previously described [31]. Participants performed two trials with a 3 min break between trials. The best trial was used for the statistical analyses [31].

### 2.5.8. One Maximum Repetition Bench Press

The bench press (1-RM<sub>BP</sub>) took place within a squatting apparatus, where the barbell was fixed at both ends, allowing only vertical movements due to linear bearings on two vertical bars. The participants were given four to five attempts with two-minute rest intervals until the athlete could no longer fully extend their arms. We considered the load lifted with the final valid extension as the value for 1-RM<sub>BP</sub>.

## 2.6. Statistical Analyses

For all variables, descriptive statistics, including means, standard deviations (SDs), and 95% confidence intervals (95% CIs) were provided. Normality testing using the Shapiro–Wilk test was conducted before data analysis. A two-factor univariate general linear model was used to examine the mean differences in the anthropometric and performance parameters among the playing positions (Pivots, Wings, Backs, and Goalkeepers, among others) [32]. The differences between the means (position effect) were deemed meaningful if  $p < 0.002$  and  $\eta_p^2 > 0.20$  [33]. Following a Bonferroni correction and considering the number of parameters/tests, we adjusted the  $\alpha$  error level ( $0.05/23 = 0.002$ ). Interpretation primarily relied on  $p$ -values, specifically for the dependent variable of playing position. This approach was adopted due to the limited number of instances (e.g., position-specific analysis) to avoid overestimating the mean differences.

To ascertain a power of 80% for the current study (to detect a mean difference of 2.90 cm in CMJ height), a power calculation was conducted using a two-sided  $t$ -test with an alpha level of 0.05, assuming a pooled standard deviation of 2.50 cm [34]. This calculation, performed prior to recruitment using nQuery Advisor 4.0 (Statistical Solutions, Saugus, MA, USA), yielded a required sample size of  $n = 6$  per group.

Pearson's product-moment correlations were employed to assess the relationships between the anthropometric parameters and performance parameters across various categories (e.g., sprinting, jumping, throwing, strength, and anthropometry). The interpretation of coefficients ( $r$ ) was as follows:  $<0.1$  = trivial;  $0.1$ – $0.3$  = small;  $0.3$ – $0.5$  = moderate;  $0.5$ – $0.7$  = large;  $0.7$ – $0.9$  = very large;  $0.9$ – $1.0$  = almost perfect [35]. Consequently,  $r^2 > 0.5$  (explained variance  $>25\%$ ) was considered meaningful and highlighted in bold. Given a sample size of  $n = 50$ , the critical value for the product–moment correlation, based on a two-sided  $t$ -test with  $\alpha = 5\%$ , was determined to be  $r = 0.273$  [36]. Statistical analyses were performed using SPSS version 28.0 for Windows (IBM, Armonk, NY, USA).

## 3. Results

### 3.1. Normal Distribution

A total of 13 variables (bicipital skinfold:  $p = 0.002$ ; tricipital skinfold:  $p < 0.001$ ; subscapular:  $p = 0.010$ ; cross sectional area:  $p < 0.001$ ; maximal thigh section area:  $p = 0.013$ ; sprint 15 m:  $p < 0.001$ ; sprint 30 m:  $p = 0.003$ ; CMJ:  $p = 0.006$ ; SJ:  $p = 0.014$ ; thigh muscle volume:  $p = 0.013$ ; upper limb muscle volume:  $p = 0.008$ ; Yo-Yo IR1:  $p = 0.001$ ; pull over:  $p = 0.042$ ) were not normally distributed.

### 3.2. Anthropometric Data

The Backs were slightly older than the Wings (30.8 ± 3.72 years vs. 26.9 ± 4.51 years) and taller than the Wings and Pivots (1.92 ± 0.08 m vs. 1.85 ± 0.08 m and 1.87 ± 0.06 m; Table 1).

**Table 1.** Demographic and anthropometric characteristics in relation to playing positions. CI = confidence interval. Relevant mean differences (dependent variable: positions) and maxima are marked in bold.

Playing Positions	Age [Years]	Playing Experience [Years]	Body Height [m]	Body Mass [kg]	BMI [kg/m <sup>2</sup> ]	Body Fat [%]
	Mean ± SD (95% CI)					
Pivots (n = 14)	26.2 ± 2.58 (24.1–28.3)	9.00 ± 7.21 (6.31–11.7)	1.87 ± 0.06 (1.83–1.91)	<b>98.9 ± 12.1</b> (91.8–106)	<b>28.2 ± 2.69</b> (26.6–29.8)	<b>21.6 ± 4.57</b> (19.4–23.7)
Wings (n = 14)	26.9 ± 4.41 (24.9–29.0)	7.93 ± 3.97 (5.24–10.6)	1.85 ± 0.08 (1.81–1.89)	83.5 ± 13.8 (76.4–90.6)	24.4 ± 2.23 (22.8–26.0)	17.4 ± 4.74 (15.2–19.5)
Backs (n = 12)	<b>30.8 ± 3.72</b> (28.5–33.0)	<b>9.92 ± 3.03</b> (7.01–12.8)	<b>1.92 ± 0.08</b> (1.88–1.96)	94.6 ± 10.9 (86.9–102)	25.8 ± 2.94 (24.0–27.5)	18.0 ± 2.81 (15.7–20.3)
Goalkeepers (GK; n = 10)	25.8 ± 4.64 (23.3–28.3)	8.00 ± 4.30 (4.82–11.2)	1.86 ± 0.08 (1.81–1.90)	94.9 ± 16.2 (86.4–103)	26.8 ± 4.29 (24.9–28.8)	20.3 ± 2.90 (17.8–22.8)
<i>p</i>	<b>0.012</b>	0.732	0.088	0.024	0.014	0.031
$\eta_p^2$	<b>0.21</b>	0.03	0.13	0.18	<b>0.20</b>	0.17
Partial effects ( <i>p</i> )	GK vs. Backs: 0.028 Pivots vs. Backs: 0.027	-	-	Pivots vs. Wings: 0.021	Pivots vs. Wings: 0.010	Pivots vs. Wings: 0.046

Age ( $\eta_p^2 = 0.21$ ) and BMI ( $\eta_p^2 = 0.20$ ) displayed relevant position effects. The effect was mainly determined by the difference between Pivots and Wings (age:  $p = 0.027$ , BMI:  $p = 0.010$ ; Table 1).

Regarding the anthropometric parameters in Table 2, we only found a relevant position effect for bicipital skinfold ( $\eta_p^2 = 0.34$ ) based on four partial position effects, especially for Goalkeepers and Pivots. On a descriptive level, Pivots showed the highest value in 75% (three out of four) of the parameters.

**Table 2.** Anthropometric variables in relation to playing positions. CI = confidence interval. Relevant mean differences (dependent variable: positions) and maxima are marked in bold.

Playing Positions	Bicipital Skinfold [mm]	Tricipital [mm]	Subscapular [mm]	Suprailiac [mm]
	Mean ± SD (95% CI)			
Pivots (n = 14)	9.00 ± 2.99 (7.48–10.5)	<b>13.4 ± 6.39</b> (10.6–16.3)	<b>17.9 ± 7.46</b> (14.5–21.3)	<b>21.4 ± 7.44</b> (18.1–24.8)
Wings (n = 14)	6.00 ± 3.14 (4.48–7.52)	10.1 ± 5.23 (7.23–12.9)	14.0 ± 8.01 (10.6–17.4)	14.1 ± 7.17 (10.8–17.5)
Backs (n = 12)	5.67 ± 2.96 (4.03–7.31)	9.67 ± 4.21 (6.60–12.7)	12.3 ± 3.14 (8.57–15.9)	16.7 ± 4.19 (13.0–20.3)
Goalkeepers (GK; n = 10)	<b>10.4 ± 1.71</b> (8.60–12.2)	12.5 ± 4.77 (9.14–15.9)	15.6 ± 4.43 (11.6–19.6)	15.2 ± 4.94 (11.2–19.2)
<i>p</i>	<b>&lt;0.001</b>	0.213	0.143	0.020
$\eta_p^2$	<b>0.34</b>	0.09	0.11	0.19
Partial effects ( <i>p</i> )	GK vs. Backs: 0.002 GK vs. Wings: 0.003 Pivots vs. Backs: 0.026 Pivots vs. Wings: 0.044	-	-	Pivots vs. Wings: 0.021



Regarding muscle volumes (Table 3), three relevant position effects were observed. The largest effect was calculated for thigh muscle volume ( $\eta_p^2 = 0.29$ ). Pivots were involved in three out of the four partial position effects. Except for upper limb muscle volume (Backs:  $3.86 \pm 0.94$  l) and maximal thigh section area (Wings:  $284 \pm 43.7$  cm<sup>2</sup>), Pivots exhibited the largest values.

**Table 3.** Muscle volumes in relation to playing positions. CI = confidence interval. Relevant mean differences (dependent variable: positions) and maxima are marked in bold.

Playing Positions	Leg Muscle Volume [L]	Thigh Muscle Volume [L]	Cross-Sectional Area [cm <sup>2</sup> ]	Maximal Thigh Section Area [cm <sup>2</sup> ]	Upper Limb Muscle Volume [L]
	Mean ± SD (95% CI)				
Pivots (n = 14)	<b>13.4 ± 2.04</b> (12.3–14.4)	<b>10.5 ± 1.31</b> (9.70–11.3)	<b>229 ± 20.5</b> (209–249)	277 ± 31.5 (259–295)	3.67 ± 0.31 (3.29–4.06)
Wings (n = 14)	12.1 ± 1.72 (11.1–13.2)	8.70 ± 1.61 (7.88–9.52)	214 ± 29.7 (195–234)	<b>284 ± 43.7</b> (265–302)	3.41 ± 0.97 (3.03–3.79)
Backs (n = 12)	11.9 ± 2.42 (10.8–13.0)	8.28 ± 2.06 (7.40–9.16)	180 ± 62.8 (158–201)	265 ± 36.3 (245–285)	<b>3.86 ± 0.94</b> (3.44–4.27)
Goalkeepers (GK; n = 10)	11.9 ± 1.03 (10.7–13.1)	9.98 ± 0.63 (9.01–11.0)	218 ± 8.85 (195–241)	239 ± 10.1 (217–261)	3.19 ± 0.07 (2.74–3.64)
<i>p</i>	0.169	<b>&lt;0.001</b>	<b>0.010</b>	<b>0.016</b>	0.141
$\eta_p^2$	0.10	<b>0.29</b>	<b>0.22</b>	<b>0.20</b>	0.11
Partial effects ( <i>p</i> )	-	Pivots vs. Backs: 0.003 Pivots vs. Wings: 0.017	Pivots vs. Backs: 0.007	GK vs. Wings: 0.016	-

### 3.3. Physical Performance Data

Concerning sprinting and jumping performance (Table 4), apart from CMJs (Pivots:  $44.4 \pm 2.21$  cm), Wings were the players with the highest performance level in three parameters (15 m and 30 m sprint and SJ). For the sprinting parameters, we detected a large position effect for all parameters (15 m sprint:  $\eta_p^2 = 0.71$ ; 30 m sprint:  $\eta_p^2 = 0.72$ ). The differences were mainly induced due to the lower performance of goalkeepers. Goalkeepers were involved in 70% (7 out of 10) of the partial position effects.

**Table 4.** Sprinting and jumping performance depending on playing positions. CI = confidence interval. Relevant mean differences (dependent variable: positions) and performance maxima are marked in bold.

Playing Positions	15 m Sprint [s]	30 m Sprint [s]	CMJ [cm]	SJ [cm]
	Mean ± SD (95% CI)			
Pivots (n = 14)	2.54 ± 0.21 (2.47–2.61)	4.39 ± 0.26 (4.29–4.50)	<b>44.4 ± 2.21</b> (43.0–45.7)	40.3 ± 4.71 (38.4–42.1)
Wings (n = 14)	<b>2.39 ± 0.09</b> (2.31–2.46)	<b>4.11 ± 0.19</b> (4.00–4.22)	43.8 ± 3.21 (42.4–45.2)	<b>42.2 ± 3.38</b> (40.3–44.0)
Backs (n = 12)	2.39 ± 0.10 (2.31–2.47)	4.22 ± 0.19 (4.10–4.33)	42.7 ± 3.06 (41.2–44.2)	39.9 ± 2.77 (37.9–41.9)
Goalkeepers (GK; n = 10)	2.93 ± 0.07 (2.84–3.02)	4.97 ± 0.13 (4.84–5.10)	41.7 ± 0.77 (40.1–43.3)	37.9 ± 1.32 (35.7–40.1)
<i>p</i>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	0.075	0.035
$\eta_p^2$	<b>0.71</b>	<b>0.72</b>	0.14	0.17
partial effects ( <i>p</i> )	GK vs. Wings: <0.001 GK vs. Backs: <0.001 GK vs. Pivots: <0.001 Pivots vs. Backs: 0.049 Pivots vs. Wings: 0.030	GK vs. Wings: <0.001 GK vs. Backs: <0.001 GK vs. Pivots: <0.001 Pivots vs. Wings: 0.003	-	GK vs. Wings: 0.024

Regarding endurance and throwing performance, for all parameters/tests, the relevant position effects were calculated (Table 5). The position effects differed from  $\eta_p^2 = 0.23$  (medicine ball throw) to  $\eta_p^2 = 0.41$  (T-Half test) and were also generated by the markedly lower performance of goalkeepers.

**Table 5.** Agility, endurance and throwing performance depending on playing positions. CI = confidence interval. Relevant mean differences (dependent variable: positions) and performance maxima are marked in bold.

Playing Positions	T-Half Test [s]	Yo-Yo IR 1 Test [m]	Medicine Ball Throw (3 kg) [m]
	Mean ± SD (95% CI)		
Pivots (n = 14)	5.97 ± 0.40 (5.78–6.17)	1391 ± 288 (1250–1533)	<b>11.6 ± 1.09</b> (11.1–12.2)
Wings (n = 14)	5.80 ± 0.36 (5.61–6.00)	<b>1591 ± 282</b> (1449–1732)	10.2 ± 1.22 (9.62–10.8)
Backs (n = 12)	<b>5.62 ± 0.32</b> (5.41–5.83)	1533 ± 294 (1381–1686)	10.8 ± 0.80 (10.2–11.5)
Goalkeepers (GK; n = 10)	6.45 ± 0.35 (6.22–6.68)	1104 ± 117 (937–1271)	11.2 ± 1.03 (10.5–11.9)
<i>p</i>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.007</b>
$\eta_p^2$	<b>0.41</b>	<b>0.33</b>	<b>0.23</b>
Partial effects ( <i>p</i> )	GK vs. Wings: <0.001 GK vs. Backs: <0.001 GK vs. Pivots: 0.016	GK vs. Wings: <0.001 GK vs. Backs: 0.002	Pivots vs. Wings: 0.005

When compared with sprinting performance, smaller position-specific differences were calculated for strength performance (Table 6). The partial eta squared ( $\eta_p^2$ ) ranged from 0.05 (bench press) to 0.35 (half squat). Whereas Wings were the strongest players in these tests, Goalkeepers consistently showed the lowest strength performance (Table 6).

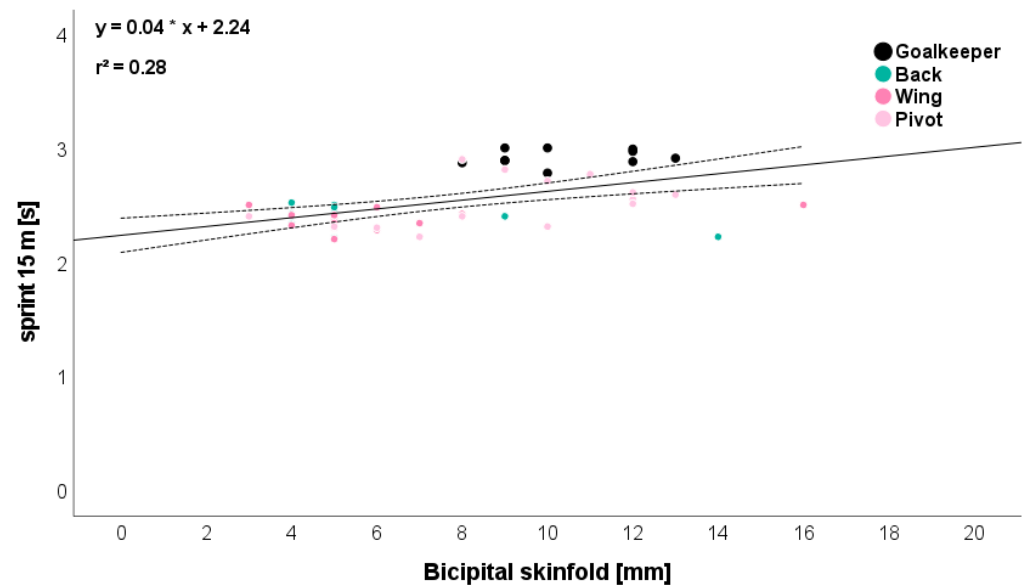
**Table 6.** One-repetition maximum performances depending on playing positions and normalized by body mass. CI = confidence interval. Relevant mean differences (dependent variable: positions) and performance maxima are marked in bold.

Playing Positions	One-Repetition Maximum (1-RM) Test		
	Bench Press [kg/kg]	Pull Over [kg/kg]	Half Squat [kg/kg]
Mean ± SD (95% CI)			
Pivots (n = 14)	1.27 ± 0.25 (1.13–1.40)	0.53 ± 0.13 (0.48–0.59)	2.34 ± 0.53 (2.12–2.56)
Wings (n = 14)	<b>1.35 ± 0.26</b> (1.22–1.48)	<b>0.55 ± 0.10</b> (0.50–0.61)	<b>2.69 ± 0.41</b> (2.47–2.91)
Backs (n = 12)	1.29 ± 0.22 (1.15–1.44)	0.52 ± 0.09 (0.46–0.58)	2.28 ± 0.29 (2.05–2.52)
Goalkeepers (GK; n = 10)	1.19 ± 0.26 (1.03–1.35)	0.48 ± 0.08 (0.42–0.55)	1.87 ± 0.32 (1.61–2.13)
<i>p</i>	0.467	0.439	<b>&lt;0.001</b>
$\eta_p^2$	0.05	0.06	<b>0.35</b>
Partial effects ( <i>p</i> )	-	-	GK vs. Wings: <0.001 GK vs. Pivots: 0.046

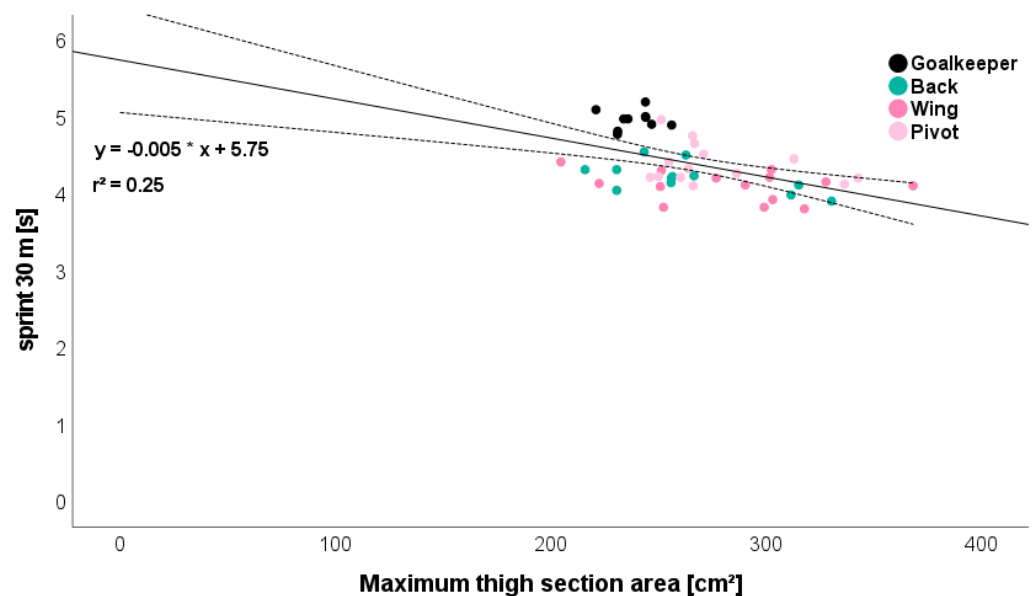
### 3.4. Relationships between Parameters

The following relevant ( $r > 0.5$ ) correlations between different categories and dimensions were observed:

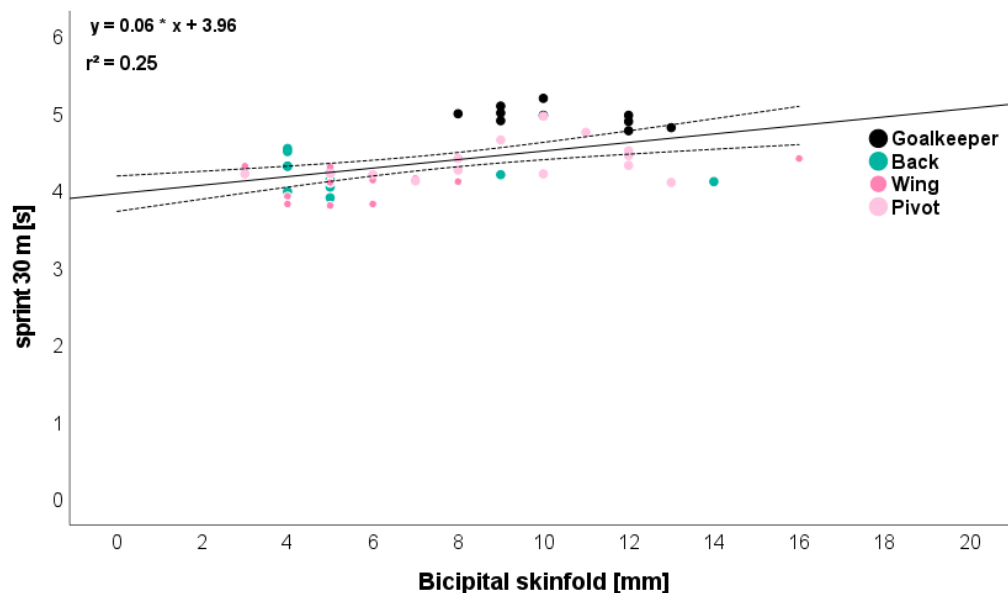
- Bicipital skinfold vs. 15 m sprint:  $r = 0.528$  (Figure 2);
- Bicipital skinfold vs. T-Half test:  $r = 0.518$ ;
- Maximal thigh section area vs. 30 m sprint:  $r = -0.504$  (Figure 3);
- Bicipital skinfold vs. 30 m sprint:  $r = 0.503$  (Figure 4).



**Figure 2.** Relationship between bicipital skinfold and 15 m sprint, depending on playing positions. Please note that one dot can represent several subjects.



**Figure 3.** Relationship between maximal thigh section area and 30 m sprint, depending on playing positions. Please note that one dot can represent several subjects.



**Figure 4.** Relationship between bicipital skinfold and 30 m sprint, depending on playing positions. Please note that one dot can represent several subjects.

#### 4. Discussion

The primary aim of this study was to discern differences in the physical attributes, anthropometric factors, and performance of team handball players based on their playing positions. The results indicate significant variations among professional team handball players in Qatar concerning anthropometric features (e.g., muscle volume in the upper and lower limbs) and physical characteristics, including muscle strength, power, and short sprint ability.

##### 4.1. Anthropometric Data

It is widely reported that anthropometry is an important variable for optimal performance in team handball. Moreover, anthropometry is known to differ between levels of play [37]. Although certain characteristics, such as total body mass, may be beneficial in some playing positions in handball, it may only be advantageous in one position. Wings displayed the lowest body mass and Pivots were the players with the largest amount of body fat. The largest differences were observed for body fat, whereas the muscle volume parameters did not show any relevant differences between the different positions of the players. In comparison, Haugen et al. [3] reported that Norwegian Wings were 6–9 cm shorter and had a body mass that was 10–20 kg less than the other handball positions, and Pivots showed the highest BMI values of all the outfield positions.

Hermassi et al. [4] indicated that the pivots in an entire sample of professional male handball players between the ages of 20 and 21 had the longest backs and had the best levels of body mass and body percentage fat. Past studies [15,16,20,38,39] provide information on the age (23.1–31.3 years), height (1.82–1.91 m), and weight (82.2–95.6 kg) of elite male European handball players. The average anthropometric characteristics reported in these articles matched those found in the current investigation, in addition to those found in first and second German league teams by Krüger et al. [2]. The anthropometric data from the present investigation revealed that muscle volume was not different between different positions. This finding contradicts previous work [4], where it was observed that wings had less muscle volume than backs. The leg muscle volume discovered in the current study was comparable to that of male team handball players reported by Hermassi et al. [40] but smaller than that of elite handball players [41]. Furthermore, the overall muscle volume of the legs surpassed the previously estimated values for both young adult males [27] and soccer players [42]. Various factors, such as physical performance

level, body composition, diet, and hormonal influences, contribute to the differences in leg muscle volume observed among handball groups [4]. When analyzing the somatic structure of Greek handball players from teams that differed in their handball rank in the Greek league, Nikolaidis et al. [43] showed comparable results. Greek handball players, though, performed a little worse than the participants in the present study. According to the findings of other authors [40,44] the level of body fat percentage observed in the present study was also the lowest among the top athletes.

#### 4.2. Physical Performance Data

The size of the lower limbs and the body's center of mass have a significant impact on jumping performance. According to various publications, athletes who have longer lower limbs perform better in vertical jumps in this situation [40,45]. Jumping is a crucial facet of team handball players' activity, and in this study, we observed that CMJs and the T-Half test exhibited the largest performance differences between players. However, Wings showed the highest jumping performance level. Backs were the players with the greatest change-of-direction ability and speed independent of playing level. The only performance that displayed marginal differences in all categories based on player position was for CMJs.

Success in handball competitions depends on having well-developed muscular strength because team handball is characterized by muscular explosive motions carried out at high velocities [4,18]. Higher maximum strength levels clearly benefit maintaining muscle contractions during the full game.  $1\text{-RM}_{\text{PO}}$  exhibited the largest performance difference between players. In addition, the highest number of top values (four out of six) was observed for Backs. A recent study [4] reported that the difference between performance levels was greater in the upper limb than in the lower limb.

Several studies [7,8,11,46] indicate that the time handball players spent walking or standing was still more than 50% of the total playing time. In contrast, they spent less than 10% of the total playing time running at high intensity or sprinting. Although these high-intensity actions (running or sprinting) represent a small percentage of the total, they are crucial for game outcomes (e.g., sprinting to win a ball and sprinting during counterattacks) [1,7]. Wings need to be particularly quick because they participate more frequently in fast breaks and counterattacks than other positions during games. Only the 15 m sprint data exhibited a noteworthy difference between players, which supports a previous investigation [4] that observed superior sprint performance (15 m and 30 m) in the wings of first-league players compared to the wings of second-league players. In the present study, Wings were the fastest players, and then Pivots. According to Haugen et al. [3] and Krüger et al. [2], players in the wing and back positions in the German first division were faster than players in the pivot and goalkeeper positions. Moreover, among the playing positions, wings covered greater distances at high-intensity running and sprinting than backs and pivots [7,8,11,46]. These results could be related to their increased participation in the counter-attack phase [7,10].

Handball incorporates exercises that call for strong anaerobic and aerobic capabilities, just as other team sports. In our study, between the positions, endurance performance differences were small [3]. The covered distance measured by the Yo-Yo IR 1 test ranged from  $1533 \pm 294$  m (Backs) to  $1391 \pm 288$  m (Pivots). An average difference of only 142 m was observed across all positions (Wings:  $1591 \pm 282$  m vs. Backs:  $1533 \pm 291$  m). Hermassi et al. [4] indicated the distance covered during Yo-Yo IR1 showed an intergroup difference between elite first and second-league German handball players assigned to different playing positions.

The ability to perform intermittent high-intensity exercise and recover quickly from these high-intensity bouts should be considered when choosing team handball players because match analyses have revealed that handball match play frequently involves these high-intensity activities [20,38]. Given this situation, and in agreement with our findings, Krüger et al. [2] noted that because wings and backs engage in more repetitive sprint actions than pivots and goalkeepers during a game, endurance capacity appears to be more

important to them [47]. In contrast, Hermassi et al. [4] reported that aerobic capacity (e.g., Yo-Yo IR1) was the only test that exhibited a between-level difference ( $\eta_p^2 = 0.348$ ) among the backs and wings of second-league players and the backs and wings of first-league players. Recent time motion analysis showed that the back and wing positions frequently engage in high-intensity sprint activities during a game, which call for strong anaerobic capacity and heightened resistance to fatigue [48]. In fact, we discovered that during the endurance test, the Backs and Wings ran at the highest top speeds [4].

In terms of competition level, a recent systematic review [7] showed that elite handball players cover an average of  $3664.4 \pm 1121.6$  m during a match, except for in a study by Belka et al. [49], where a higher distance was covered for all positions. These results may indicate a larger use of rotations and, thus, less playing time in national team players because this type of competition has a high density of games in a relatively short period of time [11].

Finally, concerning playing positions, wings and backs covered a moderately greater distance than pivots, regardless of the technology used to measure it [7]. Finally, running pace presents small differences between playing positions. For example, Font et al. [8] and Belka et al. [49] observed greater running speed for wings ( $64.5 \pm 10.4$  m·min<sup>-1</sup> and  $115 \pm 6.2$  m·min<sup>-1</sup>, respectively) and backs ( $61.9 \pm 8.7$  m·min<sup>-1</sup> and  $119 \pm 6.1$  m·min<sup>-1</sup>, respectively) when compared to pivots ( $56.5 \pm 6.6$  m·min<sup>-1</sup> and  $106 \pm 8.1$  m·min<sup>-1</sup>, respectively). Conversely, Manchado et al. [46] reported higher running speeds for center backs ( $98.3 \pm 36.1$  m·min<sup>-1</sup>) and pivots ( $91.2 \pm 42.7$  m·min<sup>-1</sup>) when compared to backs ( $88.7 \pm 32.8$  m·min<sup>-1</sup>) and wings ( $85.1 \pm 32.9$  m·min<sup>-1</sup>).

#### 4.3. Relationships between the Parameters of Different Dimensions

Our observed correlations demonstrate that short sprints and agility are sensitive to associations with anthropometric parameters in team handball players. The results of our study indicated that thigh muscle area was correlated to performance in short sprint distances performance, and the bicipital skinfold is closely associated with short sprint and agility performances. The most pertinent of our findings is that a handball player must do a variety of physical tasks and skills, such as acceleration, jumping, sprinting, agility, and direction change [1,2].

It has been reported that all sports performance parameters can be modified by the athlete's anthropometric characteristics and body composition [50]. The fat percentage can influence sprint time and body power [51]. A link between muscle mass and agility has been shown in several studies [48] in team sports such as handball, futsal, hockey, and volleyball [52–54]. However, there are few pieces of research concerning the anthropometrics of team handball players in relation to their competitive performance [4,14,18]. Castillo et al. [51] concluded that there was a relationship between bicep brachii skinfold and T-Half test agility performance in female futsal players. The results obtained in this study in terms of bicep skinfold and agility were similar to the studies on athletes in sports with the same characteristics [51].

Numerous pieces of research have examined the connection between lower-limb muscularity and sprint performance [55–57]. It has been reported that maximal thigh section area muscles are advantageous for achieving higher performance in 30 m sprint performance in team handball players [16], as well as sprinting ability in soccer players [58], middle-distance runners [55], long-distance runners [59] and 100 m sprint performance [60]. However, in team sports in general, the capacity to accelerate over a short distance is essential. Handball players must repeatedly perform short explosive actions and efforts, such as sprints (e.g., 15–30 m), with frequent direction changes followed by maximal intensity movements [1,58].

The ability of the lower limb muscles to generate force has been linked to short-distance sprint running performance in several studies [56,57]. However, Chelly et al. [58] found a positive correlation between short acceleration and thigh cross-sectional area, as well as muscle volume. It makes sense that a player with more muscle would be able to accelerate

and move more quickly [57,60,61]. Although starting velocity and recovered sprint ability give a coach valuable information, routine testing is not feasible. It is crucial to identify laboratory and field experiments that have a strong correlation with these measures.

#### Limitations

The main limitation of this study is the lack of generalizability. As this study was conducted in only one nation, specific sociocultural, geographical, and/or genotypic characteristics may be present, which we were unable to examine. This may explain some of the variance between our findings and those conducted in other nations or continents. Secondly, without more resources, it was impossible to compare competition levels, which may have provided some additional insights into these data. Thirdly, the 5-day testing duration could suggest the prior testing day may influence the subsequent testing days. Furthermore, tests were conducted after a competitive match, so fatigue may have impacted the results. Finally, even though the focus of our study was on the connection between anthropometric factors and performance, future studies should take neuromuscular markers into consideration when considering the predictors of team handball-related performance in young athletes.

#### 5. Conclusions

This study offers details on the anthropometric traits and physical abilities of team handball players who were categorized by playing position. Our results highlight the relationship between playing position, physical characteristics, physiological characteristics, and anthropometric variables in team handball. Wing players outperformed the players of all other positions in terms of relative strength, vertical leap height, and sprinting velocity because they are lighter. In this work, goalkeepers performed less well than other positions in the throwing, sprinting, and leaping categories, highlighting the difficulty of developing a reliable performance and diagnostic program.

In addition, bicipital skinfold and the section area of thigh muscles are associated with short sprint distance performance, and this result may be useful for coaching staff to evaluate players' anthropometric characteristics and decide what might be modified to enhance team handball performance. Additionally, the study provides data that can be compared in upcoming team handball-related body composition and performance studies.

Handball coaches should create position-specific training concepts because it is obvious that different playing positions have different performance capacities. In addition, handball scientists who want to create a physical program aimed at increasing the muscle volume in their athletes' lower limbs will find this material valuable. At the highest level of handball competition, this information is also helpful in the talent selection process. Further high-quality research is required due to a variety of concerns, including the considerable statistically significant heterogeneity among the existing studies and the evidence of publication bias.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

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