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Sport Specific Skills Differentiates Performance Levels Better Than Anthropometric or Physiological Factors in Beach Handball

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Keywords: Sand sports; elite athlete; sport skills;

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Abstract

Beach handball is characterized by high and low-intensity efforts on an unstable surface. Players are expected to display high levels of physical performance on sand, though there is no data concerning success in elite players. **Purpose:** This study aimed to address anthropometric, fitness, and sport specific skills components in beach handball, by comparing elite national team beach handball players (world champions) to sub-elite players (playing at a regular club). **Method:** A total of 91 senior players (more than 21 years-old) of both genders (19 world champions) were assessed for: anthropometry, 5 meters acceleration, 15 meters sprint, handgrip strength, horizontal jump and 3 specific sport-specific skills (ball velocities in standing, inflight and spin throwing) at a beach court. Anthropometric, physiological and sport-specific skill tests variables were analyzed as a multiple dependent variable using a multivariate analysis of variance (MANOVA) with sex and level (elite vs sub-elite) as the fixed factors. SPSS (25.0) was used, significance was assumed at $p<0.05$. **Results:** The results highlighted that for male and female athletes, horizontal jump, 6-m standing, spin and inflight throwing discriminated between elite and sub-elite groups ($p<0.001$). **Conclusion:** The study suggests that the factors which differentiate between elite and sub-elite performers in beach handball are horizontal jump and technical ability via the performance of specific throwing skills, rather than anthropometric or any other physical variables, irrespective of sex. These findings highlight some of the relevant physical capacities and skills that need to be developed over the years of preparation of top-level beach handball players.

Keywords: Sand sports; elite athlete; sport skills;

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1. Introduction

Beach handball is a recently-created sport, characterized by high-intensity displacements and actions, interspersed with lower intensity efforts. It involves specific actions, as jumps, passes, throws and blocks, with the added difficulty of executing these skills on an unstable surface (sand) (Pueo, Jimenez-Olmedo, Penichet-Tomas, Ortega Becerra, & Espina Agullo, 2017).

Though derived from indoor handball (Achenbach et al., 2018), beach handball has become a popular discipline, and included in the Youth Olympic Games. Its specific rules are designed to maintain high intensities throughout the game, substitutions are made continuously, and several players must have universal characteristics for the game, as they do not have a specific position. Successful performance therefore relies on the ability to perform multiple bouts of high intensity exercise whilst, at the same time, executing skilled movements. Therefore, beach handball players are expected to display high levels of physical performance in different tests, especially when completed on sand (Binnie, Peeling, Pinnington, Landers, & Dawson, 2013).

Although there is evidence on the role of genetic factors and training process in determining elite athlete´s success, and distinguishing them from less well-performing athletes (Tucker & Collins, 2012), there is no data concerning success in elite beach handball players. Gorostiaga et al. (2005) reported that when comparing court handball athletes with different training backgrounds, elite players have been getting taller and heavier over the last two decades. Wagner et al. (26) stated that one of the most reliable variables to differentiate between performance levels in court handball players is throwing performance. Studies also revealed that male and female handball players differ in anthropometric characteristics and performance in maximal aerobic power, throwing, jump and sprint tests (Gorostiaga et al., 2005; Granados, Izquierdo, Ibañez, Bonnabau, & Gorostiaga, 2007; Moss, McWhannell, Michalsik, & Twist, 2015; Wagner, Fuchs, Fusco, et al., 2018). While the aforementioned studies have examined different combinations of anthropometric and physical fitness parameters, to date, very few studies explored beach handball and its athletes' performance, looking at specific beach handball technical skills, especially in world champions.

Understanding which of these variables are determinant in elite performers, when comparing to non-elite ones, can then be used to tailor training, talent identification and long-term athlete development planning for beach handball (as in other sports (Kelly & Williams, 2020)). Given the nature of beach handball, which requires execution of specific technical skills, such as throwing and catching whilst at the same time physically working at high intensities on the sand, it is important to understand if physical or technical aspects may be more or less influential in determining success in beach handball. Due to the different demands of playing the sport on the beach, compared to court handball, particularly the transition from a solid to semi solid playing surface, it is important for coaches to understand how anthropometric, fitness and specific skills differentiate skilled and less skilled performers in the specific sand environment. Although there have been studies of this type for different court and field sports (Bottoni, Gianfelici, Tamburri, & Faina, 2011; Verburgh, Scherder, van Lange, & Oosterlaan, 2016; Woods, Raynor, Bruce, McDonald, & Robertson, 2016), including court handball (Lidor et al., 2005; Mohamed et al., 2009; Wagner, Fuchs, & von Duvillard, 2018), at present, beach handball is a relatively new sport and there is a lack of information related to elite´s determinants for success. Thus, this study aimed to address anthropometric, physical, and sport specific skills components in beach handball, by comparing elite national team beach handball players (world champions) to sub-elite players (playing at a regular club). We hypothesize that elite athletes better performed in all physical and specific skills tests, when comparing to non-elite athletes, and that those variables are determinant in differentiating elite and non-elite athletes.

2. Methods

2.1 Experimental Approach to the Problem

This cross-sectional study aimed to describe physical and technical parameters of sand sports players (male and female) of 91 senior players (more than 21 years-old; 19 world champions). This study was conducted during the pre-game warm-ups, in the 13rd Taça KIKA Beach Handball Tournament, held in João Pessoa/Brazil, in January/2019, during 5 days.

Tests were conducted at the beach court from 08:00 a.m. to 10:00 a.m. and from 16:00 p.m. to 18:00 p.m., according to games schedule, in a way that each player could be assessed before his/her first game to ensure fatigue from games did not influence values obtained during the subsequent physical fitness and skills-based testing. The sand was uniformized with a squeegee before each trial, in order to minimize possible sand depth differences and standardize

the procedures among athletes.

The players were previously familiarized with the protocols and performed the respective tests in the following order: 1) handgrip strength on dominant and non-dominant hand; 2) acceleration/speed; 3) horizontal jump; 4) specific throwing velocities. Trained assessors, under the supervision of the senior researchers, conducted the tests while providing verbal encouragement to the players, especially in the all-out sprints.

Information about environmental conditions were registered during the 4-day tournament, according to the Weather Forecasting and Climate Studies Center, from the Brazilian Government. Temperature ranged between 27.8 and 30.4 ºC, the air humidity between 64 and 69% and the wind velocity between 2.57 and 3.08 m/s.

2.2 Participants

A total of 91 players (55 male) participated in the study. The participants were beach handball athletes for at least 10 years, and were involved in specific beach handball training at least three times per week (on average 90 minutes per session), and 1-2 physical/strength session(s) per week involving plyometrics, injury prevention and power training. From the 91 senior players, 19 (12 female) were considered elite (world champions).

The Helsinki Declarations' ethical aspects were followed (2), and the evaluation methods and procedures were approved by an local Ethics Board. All the players were informed of the experimental risks and signed an informed consent document prior to the investigation.

2.3 Anthropometric variables

The anthropometric variables of height (m) and body mass (kg) were measured in each participant. Height was measured using a stadiometer (Holtain, Ltd., Pembrokeshire, UK), and body mass was measured with a bioimpedance scale (InBody 570, Biospace Co. Ltd, Seul, Korea). Body mass index (BMI) was calculated from body mass and body height (kg/m^2).

2.4 Physical variables

Different physical tests were used to assess players´ performance, and a high reliability between measures has been previously reported (Lemos et al., 2020).

Acceleration – 5-m and Sprint – 15-m

Participants ran two, 15-m sprints on sand, separated by 5 minutes of rest. The starting

position was standardized, with the lead-off foot behind the starting line, which was placed 1-m behind the first-time gate. Photocell gates were placed at the start, and at 5 and 15-m and used to time the sprint performance. Participants attempted to run the 15-m as fast as possible. The best time from the 2 attempts was recorded (0–5 m: acceleration; 0–15 m: sprint). Sprint times were measured using photocells (Speed Test 6.0 standard, Cefise, São Paulo, Brazil).

Horizontal Jump

From a parallel standing position and with arms hanging loose to the side, participants were instructed to jump as far as possible in horizontal direction and to land on both feet, with 1-min interval between three trials. Participants undertook three trials with the best score being used for subsequent analysis. The distance (cm) in centimeters, measured from the starting line to the point where the most proximal heel landed on the floor was assessed. Evidence of acceptable reliability and validity of the test in athletes has been shown (Krishnan, Sharma, Bhatt, Dixit, & Pradeep, 2017).

Handgrip Strength

Upper body strength was measured using a handgrip dynamometer (TKK 5101 Grip D; Takei, Tokyo Japan) as it is reliable as a measure of musculoskeletal fitness of the upper extremities in athletes (Trosclair et al., 2011). The participant squeezed gradually and continuously for at least two seconds, performing the test with both the dominant and non-dominant hand, with the elbow in full extension. The test was performed three times for each hand, with 1-min interval between trials. The maximum score for each hand was recorded in kilograms force (kgf). The highest value registered per side was retained for analyses.

Sport specific skills

Sport specific motor skills were assessed using 6-m, spin and inflight overarm throwing tests. The players were instructed to throw a standard beach handball size (male: 450 g; 58 cm circumference; female: 350 g; 56 cm circumference) at maximal velocity on the upper half of the goal (over 1-m of the ground), 6-m distance of the goal, using the dominant hand. Three different specific overarm throws (6-m, spin and inflight) were performed three times per throwing type, with an interval of 1-min between consecutive trials. Firstly, athletes performed the 6-m throwing test, a standing throw equivalent to the 7-m throw in court handball. Following these athletes performed the spin throw, a jumping throw with a 360º body rotation,

and the inflight throw, in which the athletes must grasp the ball in the air and throw it before touching their feet on the sand. These last two techniques are commonly used in beach handball, once its high technical standard will be awarded with 2 points in the game.

When the speed of throws using the same technique differed more than 20%, a fourth trial was performed, and the maximal throwing speed registered was kept for analysis (after eliminating the most discrepant value). The speed of each throwing was measured using a radar device (Stalker Sport; Applied Concepts, Inc., Plano, TX, USA). The radar unit was placed in ~2-m behind the goal and with a height ~1,5-m from the ground.

2.5 Statistical procedures

Descriptive procedures were performed for all variables and values are reported as mean and standard deviation (SD). The distribution of each variable was examined using the Shapiro-Wilk normality test. All sport-specific skill tests, anthropometric and physiological variables were analyzed as a multiple dependent variable using a multivariate analysis of variance (MANOVA) with sex and level (elite vs sub-elite) as the fixed factors. SPSS Software – version 25.0 (Macintosh) was used, and significance was assumed at $P<0.05$.

3. Results

Table 1 shows descriptive characteristics of the elite and sub-elite athletes by sex.

Table 1. The mean (±SD) differences of all sport-specific skill tests, anthropometric and physiological variables between Elite and Sub-elite.

	Male Mean (SD)		Female Mean (SD)	
	Elite (7)	Sub-elite (48)	Elite (12)	Sub-elite (24)
Age	26.5 (6.3)	20.9 (3.2)	28.0 (5.5)	21.8 (3.8)
Height (m)	1.8 (.1)	1.8 (.1)	1.7 (.0)	1.7 (.0)
Body mass (kg)	83.8 (13.4)	77.6 (12.6)	66.4 (6.9)	64.0 (8.5)
% Body fat	13.1 (4.0)	14.8 (5.3)	26.8 (5.1)	24.4 (7.7)
Fat free mass (kg)	41.7 (6.9)	37.4 (5.6)	26.8 (3.3)	26.7 (3.4)
5 meters (sec)	1.0 (.0)	1.1 (.1)	1.1 (.1)	1.1 (.1)
15 meters (sec)	2.5 (.0)	2.6 (.1)	2.8 (.1)	2.8 (.1)
Horizontal jump (cm)	247.7 (16.4)	218.0 (22.8)	193.8 (17.8)	174.3 (24.2)
Standing throw (km/h)	88.3 (6.7)	77.2 (5.7)	68.5 (6.6)	62.6 (7.0)
Spin throw (km/h)	85.7 (5.7)	75.6 (14.5)	65.3 (5.6)	56.0 (9.6)
Inflight throw (km/h)	85.3 (6.4)	74.7 (6.8)	64.1 (6.5)	57.7 (7.3)
Handgrip dominant (kgf)	62.3 (8.7)	56.8 (11.4)	41.6 (5.7)	36.7 (4.6)

Handgrip non-dominant (kgf)	57.8 (9.4)	51.6 (10.2)	38.9 (7.2)	33.6 (3.9)

The multivariate analysis, adjusted for age as a covariate, highlighted that 4 performance variables discriminated between elite and sub-elite athletes (Table 2).

Table 2. The mean (±SE) differences adjusted for age of all sport-specific skill tests, anthropometric and physiological between groups

Variables	Male Mean (SE)		Female Mean (SE)			
	Elite	Sub-Elite	Elite	Sub-Elite	η^{p2} sex	η^{p2} level
Height (m)	1.8 (.03)	1.8 (.02)	1.7 (.03)	1.7 (.02)	.424*	.020
Body mass (kg)	82.0 (4.91)	78.5 (2.29)	63.9 (4.52)	64.5 (3.50)	.260*	.025
% Body fat	12.6 (2.43)	15.1 (1.13)	26.1 (2.23)	24.5 (1.73)	.433*	.000
Fat free mass (kg)	40.9 (2.33)	37.8 (1.09)	25.7 (2.14)	26.9 (1.66)	.514	.031
5 meters (sec)	1.0 (.04)	1.1 (.02)	1.1 (.03)	1.1 (.03)	.221*	.016
15 meters (sec)	2.5 (.07)	2.6 (.03)	2.8 (.06)	2.8 (.05)	.439*	.058
Horizontal jump (cm)	247.7 (8.92)	219.2 (4.17)	190.6 (8.20)	174.9 (6.36)	.527*	.228*
Standing throw (km/h)	88.4 (2.65)	77.1 (1.24)	68.6 (2.44)	62.5 (1.89)	.597*	.275*
Spin throw (km/h)	85.4 (3.26)	75.7 (1.52)	64.8 (3.00)	56.1 (2.32)	.287*	.122*
Inflight throw (km/h)	85.2 (2.79)	74.7 (1.30)	63.9 (2.57)	57.8 (1.99)	.608*	.249*
Handgrip dominant (Kgf)	61.3 (4.27)	57.3 (1.99)	40.2 (3.92)	37.0 (3.04)	.449*	.047
Handgrip non-dominant (kgf)	56.2 (3.71)	52.5 (1.73)	36.6 (3.41)	34.0 (2.64)	.461*	.072

* Indicates significant differences, apart from age ($P<0.001$)
There was no significant sex*level interaction

The MANOVA revealed a significant difference due to playing level and sex ($P<0.001$), but no significant level-by-sex interaction.

4. Discussion

This study examined the importance anthropometric, fitness, and sport specific skills components in beach handball in distinguishing between world beach handball players to sub-elite players, and is unique in examining beach handball top athletes, what extends scientific understanding of the topic and adds important and useful information for coaches in preparing athletes and tailoring training programs for this sport. The results of the current study suggest that the factors which differentiate between elite and sub-elite performers in beach handball are technical ability via the performance of sport specific skills rather than anthropometric or physiological variables, irrespective of sex.

Although beach handball is a Youth Olympic sport, as no prior studies have presented data relating to performance in the sport, it is difficult to compare the results of the current study to prior work. In court handball, explosive force in the upper and lower limbs (throwing velocity of the ball and player velocity) are essential for athletes' success (Chelly, Hermassi, & Shephard, 2010). Strength and/or power of the upper and lower body limbs are needed to subsequently result in efficiency during the transfer of momentum through the pelvis and trunk to the throwing arm (Wagner, Buchecker, von Duvillard, & Muller, 2010). So, both strength and power (Chelly et al., 2010; Granados et al., 2007; Marques, van den Tilaar, Vescovi, & Gonzalez-Badillo, 2007) and technique (van den Tillaar & Ettema, 2007; Wagner, Pfusterschmied, Von Duvillard, & Muller, 2012) are positively related to throwing velocity. The unadjusted (Table 1) or age adjusted (Table 2) results of the current study would broadly align with this assertion.

The differences in physiological and mechanical aspects between beach and court handball are substantial. The specific characteristics of games in beach handball and the environment in which it is performed produce quite a very specific set of movement requirements for optimal performance compared to court handball, including the specific throwing techniques required for successful participation. Prior studies focusing on court handball showed that though throwing released speed of the ball is an important skill and a very important aspect for success (Gorostiaga et al., 2005; Granados et al., 2007; Manchado, Tortosa-Martinez, Vila, Ferragut, & Platen, 2013; van den Tillaar, 2004). This throwing velocity is not only dependent on muscular strength, but also on aspects such as body segment coordination and technical skills (Van Muijen, Joris, Kemper, & Van Ingen Schenau, 1991). In the current study, athletes performed the 3 specific throws aiming a determined target. Indeed, when court handball athletes perform a throw emphasizing accuracy, ball speed is approximately 85% of the maximal ball speed. This may indicate that experienced athletes are trained to throw accurately at high ball release speed (van den Tillaar & Ettema, 2003), which aligns with the results from the present study.

Players are required to execute throws that demand high velocity to beat the goalkeeper (Gorostiaga et al., 2005; I Zapartidis et al., 2009). Unlike court handball, in beach handball, the spin and the inflight throws are worth two points, and are widely used during matches. These two specific beach handball throws require greater body control and coordination, which are developed over the years of practice. In our sample of beach handball players, both elite and sub-elite players were able to throw accurately, but with different ball release speeds, a factor that may increase with skill level (García, Sabido, Barbado, & Moreno, 2013; Wagner,

Pfusterschmied, Klous, von Duvillard, & Muller, 2012). So, in our sample, throwing performance may be more strongly related to an optimal throwing technique, instead of to trunk and throwing arm power alone (Wagner, Fuchs, & von Duvillard, 2018). Moreover, specific aspects of the beach handball environment, such as wind speed and direction, and the instable surface, hinder execution of skilled performance and demand a greater movement pattern that should be developed along the years of practice. Such demands may result in an emphasis on technical skills over physiological or anthropometric factors for success (Vila, Zapardiel, & Ferragut, 2020).

The results of the present study also highlighted horizontal jump as an essential factor that differentiated between elite and sub-elite performers in both sexes. It is important to mention that horizontal jump performance is negatively correlated with sand-based acceleration and sprint times ($r = -0.369$ and -0.411, $p < 0.05$) and can predispose players to perform better in high-intensity match actions (Lemos et al., 2020). The elite athletes´ better performance is unsurprising (Moss et al., 2015), given the importance of jumping in different specific sport´s techniques, such as throwing and specially blocking. Given that beach handball is played in sand surface, lower limbs power allows players to perform jumps that require a great horizontal component to block the opponent´s shot. It is also important to note that as aerial goals are worth two points, it demands athletes do be able to produce high muscle power in the lower limbs. In fact, horizontal jump distance presented a correlation of 0.357 with spin throw speed in beach handball players (Lemos et al., 2020).

In our study, no anthropometric variables differentiate performance between elite and sub-elite player's performance. Differences in anthropometric characteristics between player´s performance are widely available for male team handball players (Gorostiaga et al., 2005; Mohamed et al., 2009; Zapartidis, Vareltzis, Gouvali, & Kororos, 2009). These findings are likely a result of overall greater body mass of elite players, alongside higher musculature to withstand court handball´s characteristic body contact and game-specific actions. Conversely, in beach handball matches there are less body contacts (hits and pushes) compared to court handball, potentially resulting in a lesser demand on anthropometric attributes for success in beach handball. Moreover, although age is different between groups, the relationship between age and all the dependent variables was explored, both in elite and sub-elite groups, and age was not a significant covariate with any of the dependent variables. Nonetheless, future studies involving larger number of participants are necessary to explore possible relationships between age/training experience and performance variables in beach handball players.

The specific physiological and mechanical components required in beach sports, including beach handball are substantially different from those needed when playing on a stable surface. Moreover, the characteristics of the environment during beach handball (wind, temperature) and its rules, including specific throwing techniques, create quite a very specific set of movement requirements for optimal performance. Indeed, in training context, procedures are based on general knowledge, or on the subjective opinion of ‘‘expert’’ selection coaches, although scientific data (i.e. objective measures of technical, tactical, and physical characteristics) can be used to complement coaches’ opinion of an individual player’s abilities. In beach handball, few scientific data are available. Thus, the current results may support coaches, by redirecting their priorities in daily training planning. Moreover, the results of the current study are unique given the elite sample in the present study comprised the top elite beach handball world champions, that have been dominating the world ranking for at least ten years. As such, the current study adds important insight and key steps for coaches and athletes and may support future beach handball studies and practice.

5. Conclusion

This study shows that anthropometric and physical performance in strength-power-speed tests (with exception of horizontal jump distance) do not discriminate between elite and sub-elite beach handball players, but that technical performance in sport specific throwing skills are the differentiating factor between elite and sub-elite performers. This information is key to support coaches and physical coaches on training preparation, and on achieving athlete’s best performance.

What does this article add?

There are no scientific studies showing the most effective training strategies to lead players to achieve the elite level in beach handball. This study shows that specific anthropometric and physical performance in strength-power-speed tests (with exception of horizontal jump distance) do not discriminate between elite and sub-elite players but that technical performance in sport specific throwing skills are the differentiating factor between elite and sub-elite performers. It is evident that these anthropometric and physiological characteristics need to be considered while detecting and developing talent in this sport. However, preparing players to achieve the elite level necessarily implies developing specific

body control and coordination to perform the highly-skilled attacking throwing actions by improving both strength-power but especially the technical aspects of the throws.

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