Title Page

Conditional analysis of elite beach handball according to specific playing position through assessment with GPS

Authors

Juan Carlos Zapardiel[1*] PhD; Iván Asín-Izquierdo[1*] MSc

**These authors contributed equally to this work*

Affiliations

1. Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, University of Alcalá, Madrid, Spain

Address for reprint requests / corresponding author:

Asín-Izquierdo, Iván

Department of Biomedical Sciences. Faculty of Medicine and Health Sciences.

University of Alcalá, Madrid, Spain

Campus Científico-Tecnológico: Crta. de Madrid-Barcelona, Km. 33,600. Alcalá de Henares, 28871, Madrid, SPAIN

E-mail address: ivanasizq@gmail.com Telephone number: + 34 627526847

Running heading: Conditional analysis of beach handball according to specific playing position

Abstract

Beach handball needs to continue to develop. For this reason, observational studies that analyze competitive demands are necessary. Therefore, our objective in this work was to carry out performance assessment of the beach handball players regarding specific playing positions during competition, without modifying the specific structure of the game. The study included 57 elite beach handball players. The results showed that significant differences were found in most of the variables studied when the specific playing positions were compared. Our work has led us to conclude that the assessment of the conditional demands of beach handball players in competition must be done considering the specific playing positions.

Key words

Sand, high competition, playing position, performance, beach handball, match.

Introduction

Beach handball is a relatively new sport that has achieved great growth and development in a few years. The sport was created on the Island of Ponza (Italy) in 1992 (Pehrer, & Werkmeister, 2006) and in just twenty-six years it is already played on five continents, and constantly expanding. A special scoring system in which spectacular goals, penalties and goalkeeper's goals are awarded with two points, a playing field with rectangular areas, very ample substitution areas and the tiebreaker set system, the shoot-out, make it a very attractive sport to the spectator (Zapardiel, 2015).

This is a very demanding sport from a physical point of view mainly due to the rules of the game and the game surface. This surface has to be made up of fine sand and must have a depth of 40 cm (International Handball Federation, 2014). Each team is composed of four players performing different functions both in the offensive and defensive game phase. In the offensive phase, the participants are the specialist player (goalkeeper who leaves his goal), the wings and the pivot. During the game, the wing can be replaced after the offensive phase or he can position to defend (fixed wing). In turn, in the defensive phase, teams are usually made up of other players different from the ones taking part in the offensive phase because the regulations not only allow an unlimited number of substitutions but also facilitate them making the substitution area bigger. In this case, the defensive game is organised with the goalkeeper, the defense centre, the defense right and the defense left.

Although beach handball is a little-studied sports specialty, the number of investigations has recently increased in different fields (Bago, 2016; Bebetsos, 2012; Cruić, Vuleta, Bazzeo, & Ohnjec, 2011; Lara, 2011; Morillo-Baro, 2016; Morillo-Baro, 2009; Morillo-Baro, & Hernández-Mendo, 2015; Morillo-Baro, Reigal, & Hernández-Mendo, 2015; Pehrer, & Werkmeister, 2006; Pueo, Jiménez-Olmedo, Penichet-Tomas, Ortega, & Espina, 2017; Zapardiel, 2015; Zapardiel, Asín-Izquierdo, Moya, Lebrero, García, & Lozano, 2017;

Zapardiel, Lara, & Rodríguez, 2013). However, none of the investigations mentioned above has had as main objective the conditional analysis of beach handball according to specific positions, although there are big conditional differences depending on the post. San Pedro (2008) made a performance assessment of the specialist player in beach handball but not of the rest of specific positions.

The observation of the general conditional demands of beach handball has established important requirements with a series of actions of constant high intensity (Pehrer and Werkmeister, 2006). This series of actions, 6-7 s at high speed, has short recoveries, and almost never homogeneous (Morillo-Baro, 2009), and they keep repeating during both 10-minute halves of the match (International Handball Federation, 2014). Effort intensity during competition ranges from vigorous to very vigorous during 70% of the playing time, taking the heart rate as reference, which shows records that range between 80% and 83% of the maximum heart rate when the ball is in play (Lara, 2011). In another study, where tests carried out on beach sand with elite beach handball players (adapted Course-Navette and maximum speed during 15 m), average values of blood lactate of 13.44 mmol/l were observed and anaerobic glucolysis was determined as the main way of energy production in this sport (Bago, & Sáez, 2013).

Regarding game time, time-motion in beach handball players during competition has been studied with GPS technology. An average active time during a 10-minute set resulted in 8.8 minutes and 9.3 minutes for male and female, respectively (Pueo et al., 2017). Other examples of the time-motion measurement from a conditional assessment are beach tennis (Pérez, Prau, & Santos, 2013), beach football (Castellano, & Casamichana, 2010) or handball (Michalsik, & Aagaard, 2015; Wagner, Finkenzeller, Würth, & Duvillard, 2014).

Likewise, the distance covered by team sport players during competition has been studied, this being one of the external load variables most used with GPS technology. Pueo et al. (2017)

determined that the distance travelled by high performance beach handball players during 10 minutes was 617 m for male and 559 m for female (Pueo et al., 2017). This distance has also been measured in handball (Michalsik, & Aagaard, 2015; Póvoas, Seabra, Ascensão, Magalhães, Soares, & Rebelo, 2012; Wagner, Finkenzeller, Würth, & Duvillard, 2014).

Another aspect measured in beach handball is the distance travelled in speed sections. Pueo et al. (2017) observed that most of the distance covered in this sport oscillates between 0.5 y 13 km/h. In the case of beach football, almost half of the movement is done at speeds that ranging between 0.1 and 0.4 km/h, and the rest of the movements between 0.4 and 13 km/h (Castellano, & Casamichana, 2010). In the same line of observational study of the conditional demands of beach handball, accelerations and decelerations (Pueo et al., 2017) as well as heart rate (Bago, & Sáez, 2013; Lara, 2011; Pueo et al., 2017) have been measured. On the contrary, no beach handball research assessing the physical condition in a global way has been found. However, it has been found in other sports; in these cases, variables that relate load and time, a method to quantify training load such as the training impulse (TRIMPs), a method to quantify the training load in relation to heart rate and time with load intensity, or total player load have been used.

In all the studies related to conditional aspects of beach handball previously commented (Lara, 2011; Bago, & Saez, 2013; Pueo et al., 2017), beach soccer (Castellano, & Casamichana, 2010) and in many others regarding handball (Corvino, Tessitore, Minganti, & Sibila, 2014; Corvino, Vuleta, & Šibila, 2016; Dello-Iacono, Ardig, Meckel, & Padulo, 2016; Manchado, Tortosa-Martínez, Vila, Ferragut, & Platen, 2013; Porostiaga, Pranados, Ibáñez, González-Badillo, & Izquierdo, 2006; Póvoas, at al., 2012), all players are assessed as a single group and not according to specific playing positions. In some cases, the game structure of the sport was modified in order to carry out the assessment (Pueo et al., 2017). Therefore, if our aim is to make an objective observation of the demands of the beach handball player, it must be done regarding specific playing positions and not modifying the structure of the game. Hence, our objective in this study is to carry out a conditional assessment of the beach handball player according to specific playing positions during competition using GPS technology and without modifying the structure of the game.

Materials and method

Sample

Twenty five male (mean age: 25.3 ± 4.8 yrs; body weight: 86.9 ± 9.5 kg; body height: 187.5 ± 7.4 cm) and thirty two female (mean age: 25.3 ± 4.8 yrs; body weight: 60.7 ± 3.8 kg; body height: 168 ± 3.8 cm) elite beach handball players were recruited for this study. All the players were observed during the pre-competition meetings prior to 2017 European Championship. They were also informed about the research protocol and they gave their written informed consent. The Ethics Committee at the University of Alcalá gave institutional approval to this study in accordance with the spirit of the Declaration of Helsinki.

Table 1. Distribution of sample by sex, height, weight and age (±SD)

Material

To collect data, three receivers GPS (Global Positioning System) & GNSS (Global Navigation Satellite System) OptimEye S5 Catapult Sport, 10Hz GPS, and inertial system were used: 3D Accelerometer 100Hz, 3D Pyroscope 100Hz, 3D magnetometer 10Hz. An automatically synchronized Polar system to monitor physiological data of heart rate was used. This tool is validated by research in a multitude of scientific studies (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014; Luteberget, Holme, & Spencer, 2018; Nicolella, Torres-Ronda, Saylor, & Schelling, 2018).

Record sheets were used both for collecting individual data of players in each match and for registering situational variables, as the result and playing times. All registers were collected by just one researcher with over 25 years’ experience in beach handball. In addition, all matches were recorded with a SONY HDR-CX240 video camera to perform a subsequent review of the recorded data.

Study variables

The variables used to assess the internal and external load at mechanical, neuromuscular, cardiorespiratory and metabolic levels were (Edwards, 1993):

- *Activity time*: time in which the player exceeds the speed of 1 km/ h.
- *Total distance travelled:* metres travelled by a player.
- *Velocity and velocity bands:* player speed and time spent in each band previously assigned. Band 1: 1-5.9 km/h; band 2: 6-8.9 km/h; band 3: 9-11.9 km/h; band 4: 12-14.9 km/h; band 5: more than 15 km/h.
- *N accelerations and decelerations:* number of accelerations and decelerations measures by GPS.
- IMA ACCEL and IMA DECEL (>2.5 m/s): number of accelerations and decelerations higher than 2.5 m/s measured by accelerometer.
- *Total jump*: number of jumps made at any height measured by GPS.
- IMA Jump (>0.4 m): number of jumps higher than 40 centimeters measured by accelerometer.
- *Beats per minute*
- *TRIMPs*: assessment of workload intensity based on the relationship heart rate-activity time.
- Total Player Load (PL): assessment of load intensity through mathematical formula based on the data obtained by the accelerometer in all planes (Boyd, Ball, & Aughey, 2011).
- *PL 1DUp%*: percentage of accelerations in the coronal plane over the total player load.
- *PL 1DFwd%*: percentage of accelerations in the sagittal plane over the total player load.
- *PL 1DSide%:* percentage of accelerations in the transverse plane over the total player load.

Protocol

Firstly, the technical staff of the selections was contacted to explain the research project and to request the pertinent permission. Subsequently, the informed consent was sent to the players to be signed.

Before the data collection, the players performed the relevant warm-up to play a beach handball match. During the warm-up, the players to whom the device was going to be placed were agreed with the selectors. They must be players who did not change their playing position during the 10 minutes of the measurement.

Five minutes before each game the chosen players were placed the heart rate bar, the vest and the device. After this and once the initial and individual situational data of the players were obtained, the exact time of start of the matches was noted. All variations in the scoreboard were recorded by time segments of two minutes. All games were recorded to certify the data collected. After finishing each game, the devices were removed. The matches were analysed separately.

Data were transferred every day to the Open Field tool of Catapult Sport for analysis.

Statistical analysis

Statistical analysis was carried out using SPSS software (version 22). A descriptive analysis of the variables studied was carried out, using the Kolgomorov-Smirnov test to check normality. Subsequently, the inferential analysis was carried out. The variables that followed normality and that showed significance in the Levene test were studied with the Welch test; those that did not show significance were studied with the ANOVA test. The variables that did not follow normality were studied with the Kruskal-Wallis test. The Tukey test was used for the post hoc tests of ANOVA; the test of Pames-Howell was used for the post hoc of Welch test; and the Mann-Whitney U-test was used for the post hoc of Kruskal-Wallis test. A two-way ANOVA (factor sex and position) was performed to compare differences in position between male and female players and their interaction between these factors.

Results

The effects of sex and position on all variables are shown in Table 2. Significant position and interaction effects in distance, number accelerations, number decelerations, number of jumps, IMA jumps and total player load were found. The differences of these variables regarding the position can be attributed to the interaction of sexes.

Table 2. Effects of sex and position on all variables

Table 3 shows the activity time according to the specific playing position during a 10-minute set (match set). In the general analysis regarding specific positions of women, statistically significant differences were found ($p <.001$). In the detailed analysis, significant differences were found between the fixed wing and the wing ($p <.001$), the defender ($p = .004$) and the pivot ($p = .001$). In the general analysis between the specific positions of men, statistically significant differences were found ($p = .001$). In the detailed analysis, statistically significant differences were found between the pivot and the specialist ($p = .028$), the wing ($p = .013$), and the fixed wing ($p = .005$), and between the fixed wing with the defender ($p = .003$).

On the other hand, in table 3, the distance travelled it is also showed according to the specific playing position during a 10-minute set. In the general analysis between the specific positions of women, statistically significant differences were found ($p = .002$). In the detailed analysis, statistically significant differences were found between the fixed wing and wing ($p = .001$) and the defender ($p = .001$). No significant differences were found between the specialist nor with the wing ($p = .414$) nor with the pivot ($p = .368$), nor with the defender with the pivot ($p = .788$). In the general analysis between the specific positions of men, statistically significant differences were found ($p = .000$). In the detailed analysis, statistically significant differences were found between the wing and the fixed wing ($p = .016$) and with the specialist ($p = .010$), between the defender and the fixed wing ($p = .004$) and the pivot ($p = .010$). No significant differences were found between the pivot and the wing ($p = .114$).

Finally, in table 3, the distance travelled it is showed in each previously assigned speed section. This has been compared by specific positions. In the general analysis of women, statistically significant differences were observed in all the speed sections, except for the speed section greater than 15 km / h (p <.01). In the detailed analysis, significant differences occur between the fixed wing and the rest of the specific posts (p <.01). In the general analysis of men, statistically significant differences were observed in the speed section between 1 and 6 km / h (p <.05). In the detailed analysis, significant differences can be seen between the specialist, the wing and the fixed wing (p <.01).

In the general analysis of the maximum speed of women, statistically significant differences were observed (p = .003). In the detailed analysis, significant differences were found between the wing and the specialist (p = .009) and the fixed wing (p = .007). In the general analysis of the maximum speed of men, statistically significant differences were observed (p <.001). In the detailed analysis, there are differences between the specialist and the wing (p = .014) and the pivot (p <.001); between the wing and the fixed wing (p = .003); and between the fixed wing and the pivot (p = .003).

Table 3. Activity time (±SD), distance travelled (±SD), distance covered in speed sections and maximum speed (± SD) in a 10-minute set regarding specific position

Table 4 shows the total number of accelerations and decelerations performed in a 10- minute set depending on the specific position and measurements with GPS system and IMA system (inertial system).

The general analysis of GPS measurements of women showed statistically significant differences (p <.001) in accelerations and decelerations. In the detailed analysis of the number of accelerations, there were differences between the fixed wing and the specialist (p <.001), the wing (p <.001), the defender (p = .026) and the pivot (p = .018). In the detailed analysis of the number of decelerations, the differences existed between the fixed wing and the specialist (p <.001), the wing (p = .001), the defender (p = .001) and the pivot (p <.005). In men, the general analysis showed statistically significant differences (p <.001) in the three variables. In the detailed analysis of the number of accelerations, the differences existed between the specialist and the wing (p = .008) and the pivot (p = .006); and between the fixed wing and the wing (p = .002), the pivot (p = .002) and the defender (p = .033). In the decelerations, the differences existed between the specialist and the fixed wing (p = .004), the defender (p = .022) and the pivot (p = .002); and between the fixed wing and the wing (p = .001), the defender (p = .003) and the pivot (p <.001). In the jumps, differences were only found between the fixed wing and the pivot (p = .001).

In the analysis with IMA, women did not show statistically significant differences in any of the variables. In men, the general analysis showed significant differences in the decelerations (p = .022), in the accelerations to the left (p = .008) and to the right (p = .009), and in the jumps (p =. 001). In the detailed analysis of the decelerations, significant differences were found between the fixed wing and the specialist (p = .032) and the wing (p = .035); however, in the accelerations to the right and left, differences were only found between the specialist and the pivot (p = .001). In the jumps, the significant differences existed between the fixed wing and the specialist (p = .007), the wing (p = .009), and the pivot (p = .025).

Table 4. Total number of accelerations, decelerations and jumps (± SD) depending on the specific position measured by GPS and IMA

Regarding internal load variables, Table 5 shows heart rate data depending on the specific playing position. In the general analysis between the specific positions of women, statistically significant differences were found in the minimum pulsations (p = .000), in the maximum (p = .016) and in the average (p = .004). In the detailed analysis of the minimum heart rate, statistically significant differences were found between the specialist and the fixed wing (p <.001), the defender (p = .012), and the pivot (p <.001); between the wing and the fixed wing (p <.001) and the pivot (p = .017), and between the fixed wing and the defender (p = .005). In the detailed analysis of the average heart rate, statistically significant differences were only found between the wing and the fixed wing (p = .009). In the detailed analysis of the average heart maximum, differences were only found between the fixed wing (p = .005) and the specialist, and the wing (p = .007).

In the general analysis by heart rate zones (> 80%) of women according to the specific positions, significant differences were only found in the 80-90% area, observing significant differences between the fixed wing and the specialist (p <.001), the wing (p <.001), the defender (p <.001) and the pivot (p = .002).

In the general analysis between the specific positions of men, only statistically significant differences were found in the minimum pulsations (p = .014). Neither in the maximum pulsations (p = .091) nor in the mean of the pulsations (p = .092) were significant differences found. In the detailed analysis of the minimum pulsations, only statistically significant differences were found for the wing with the fixed wing (p = .015) and with the pivot (p = .023).

In the general analysis by heart rate zones according to the specific positions of men, no significant differences were found.

Table 5. Beats per minute (±SD) according to gender based on specific position

Finally, to assess the competitive load in beach handball, Table 6 shows the TRIMPs and the different data of Player Load in a 10-minute set depending on the specific position. In women, in the general analysis, significant differences were found in all the variables except in the Player Load 1DSide%. In the detailed analysis of the TRIMPs we found significant differences of the fixed wing with the specialist (p = .006) and with the wing (p = .020). In the detailed analysis of the Total Player Load we found significant differences of the fixed wing with the rest of the specific posts (p <.001). In the detailed analysis of the Player Load 1DUp% we only found significant differences between the wing and the pivot (p = .001). On the other hand, in a detailed analysis of the Player Load 1DFwd% we found significant differences between the pivot and the wing (p = .002) and with the defender (p = .035).

In men, in the general analysis, significant differences were found in the Total Player Load (p <.001), in the Player Load 1DUp% (p <.001), in the Player Load 1DFwd% (p = .001) and in the Player Load 1DSide% (p <.001). In the detailed analysis of Total Player Load we found significant differences between the specialist with the wing (p <.001), with the defender (p = .001) and with the pivot (p <.001); and between the fixed wing with the wing (p <.001), with the defender (p = .001) and with the pivot (p <.001). In the detailed analysis of Player Load 1DUp% we found significant differences between wing and the rest of the specific positions (p <.001). In the detailed analysis of the Player Load 1DFwd%, we found differences between the pivot and the wing (p = .024) and the fixed wing (p =.026). Finally, in the detailed analysis of the Player Load 1DSide% we found significant differences of the specialist with the wing (p <.001) and with the pivot (p = .002); and of the wing with the fixed wing (p = .008), with the defender (p = .020) and with the pivot (p = .001).

Table 6. TRIMPs y Player Load (±SD) por sexo en función del puesto específico

Discussion

During the short history of beach handball, only research articles related to conditional demands have been published, taking as a reference the means of the whole group. In no case have the specific playing positions been taken into account. Our contribution to scientific knowledge has been the conditional assessment of elite beach handball players according to specific positions. With this article, we provide a series of data that should be the reference of the study of the physical condition in the beach handball player. In most of the variables studied there have been significant differences in both men and women. Therefore, the physical condition of the beach handball player should be programmed in the most individualized way possible.

Currently, there is only one study that has assessed the conditional demands of beach handball players with the GPS system (Pueo et al., 2017). In this article, the means of all the specific positions were taken as a reference and although it will be the reference article of this discussion, we will do it by comparing the means that we also found in our study.

Beach handball is a very particular sport in relation to activity time due to the continuous substitutions of players that occur during a match. Pueo et al. (2017) found activity times of 8.8 minutes in men and of 9.3 in women in a ten-minute set. A great difference can be observed with the data from our study where the highest average activity time was found in men with 6.1 minutes. The player who enjoys more activity time during a beach handball match is the one who is not substituted, the fixed wing; in our study this player showed an activity time of 7.7 minutes, far from the average observed in the study by Pueo et al. (2017). The reason for this difference is determined by the fact that players were not substituted during the match in Pueo et al (2017). In other sports, we can observe the difference in this variable depending on the play structure. In handball, the average active time in a 10-minute set is 8.9 minutes for men and 8.4 for women (Michalsik, & Aagaard, 2015). In beach tennis, the average real playing time over a 10-minute period is 2.1 minutes (Pérez, Prau, & Santos, 2013). What is really remarkable about our study is that there are significant differences between several of the specific playing positions; this has never been studied in beach handball before. In this sense, we believe that if we want to make an objective assessment in this sport, valuations must always be made regarding specific positions.

The distance travelled by team players during competition is one of the most widely used external load variables with GPS technology. The sources consulted make a description of the distances travelled and compare them with different sports, with sports played on different court surfaces, with different assessment criteria and with assessment criteria that do not fit into the game structure of the sport. Our proposal aimed at strictly respecting the game structure of beach handball and, hence, the simple comparison of distances would not provide meaningful data to the scientific field. Therefore, we carried out the comparison based on the activity time. Under this premise, we can conclude that the studies by Pueo et al. (2017), Michalsik and Aagaard (2015) and ours are very similar regarding the distance traveled by men in 1 minute of activity time, 70, 73 and 73 $m \cdot min^{-1}$ respectively. In our study, women made 78 $m \cdot min^{-1}$, 79 in Michalsik and Aagaard (2015) and 60 in Pueo et al. (2017). It should be noted that in the study by Michalsik and Aagaard (2015) the valued sport is handball that is practiced on a hard surface. On the same surface, beach soccer increases the distance travelled in 1 minute of activity time, 97.7 $m \cdot min^{-1}$ (Castellano, & Casamichana, 2010). The explanation for this difference can be found in the dynamics of the beach soccer game in which long movement patterns without a ball are made in a larger field.

Another valued aspect in beach handball is the distance travelled in speed sections. Pueo et al. (2017) observed that both men and women spent most of their active playing time between walking and jogging. The same situation occurs in our study. Men are 56.8% of active time at speeds between 1 and 6 km / h, and women 62.8% of active time. In beach soccer, there is the highest activity time between these speeds, 70.1% in Castellano and Casamichana (2010), and 85.8% in Scarfone, Antonio, Carlo, Laura and Antonio (2015). Both in Pueo et al. (2017) and in our study, beach handball players (men and women) are approximately 30% of the activity time running. In beach soccer this time is reduced to 22% in Castellano and Casamichana (2010) and 11.8% in Scarfone et al. (2015). In our study, men are running fast about 3% of their activity time, as in Pueo et al. (2017), Castellano and Casamichana (2010) and Scarfone et al. (2015). In the case of women, 2% both in Pueo et al. (2017) and in our study. As mentioned in previous paragraphs, what is really remarkable is that in our study there are significant differences between several of the specific playing positions. In both men and women, the fixed wing is the player who is at speeds between 6 and 12 km/h most of the activity time. This data is something that must be taken into account for individualized physical preparation. In our study, the maximum speed was reached by the fixed wings in both men and women. The wings were the ones with the lowest maximum speed, finding significant differences with the fixed wings and the specialists. Women reached a maximum speed of 6.0 m/s and men of 7.1 m/s, a higher speed than the data collected by Castellano and Casamichana (2010) in beach soccer players, 6.0 m/s.

The intensity of an activity can also be measured through the number of accelerations that occur in this activity. In order to be able to compare with other sports that do not have the same temporal structure as beach handball, we will adjust the number of accelerations to those produced in one minute. Pueo et al. (2017) found that in a beach handball match there was an average of 2.6 acc/min in men and 2.2 acc/min in women. In our study we found 18.4 acc/min in men and 16.0 acc/min in women. When the accelerations were carried out above 2 m / s2, the study by Pueo et al. (2017) showed 0.05 acc / min in women and 0.1 acc / min in men. In our study, we found a higher number of accelerations, 0.24 acc / min in women and 0.44 acc / min in men. The coincidence between both studies is found when we observe that in the two studies accelerations above 2 m / s2 are twice as high in men as in women. In the study by Pueo et al. (2017) the substitutions of players that are made in a beach handball match are not made; for this reason, the observed differences can be justified since in the substitutions of players there are accelerations and decelerations. We have not found any study of sports accelerations that use the beach sand playing surface. In handball, Barbero, Pranda-Vera, Calleja-González and Del Coso (2014) found 5.4 acc / min in men. In this study, the specific playing positions were compared. In this sense, Barbero et al. (2014) did not find significant differences in relation to the accelerations of the athletes. In our study of beach handball, we did find significant differences between the different positions. This is justified by the different playing structures of both sports.

Regarding the maximum heart rate, the results are lower than other studies of beach handball (Pueo et al., 2017; Lara, 2011), as in other sports such as beach soccer where higher maximum heart rate figures are found (Castellano, & Casamichana, 2010; Scarfone, et al., 2015). This could be due to the fact that in our study the players made the frequent breaks that occur in the official beach handball matches, something that differs from the rest of the studies because either it was not considered in the studies of beach handball or the structure of game is different in other sports. However, the average heart rate data are higher, although very similar to those provided by other scientific studies in competition (Castellano, & Casamichana, 2010, Scarfone, et al., 2015). Regarding the activity time in sections of heart rate percentage, we obtained very similar times to those obtained in handball by Pueo et al. (2017), both in the 80-90% zone, and in the zone >90%); and inverse to those obtained in beach soccer (Castellano, & Casamichana, 2010) with a large percentage of time in zone >90%.

The continuous substitutions taking place in official beach handball matches give the assessments made using GPS devices very special features. In spite of this, in the data collection of this study we wanted to reflect all the substitutions that occurred during an official match. Our decision was made based on reflecting everything that takes place in this type of matches as accurately as possible. To provide a more complete assessment of the internal load that occurs in a beach handball match, the variables TRIMPs and Player Load were also collected and analyzed.

In most of the variables studied in our work, significant differences were found between the different specific positions of beach handball, so we believe that it is necessary to make this type of assessment following this line, if we want it to be objective. It has already been done in other sports (Barbero et al., 2014; Dellal, Wong, Moalla, & Chamari, 2010; Di Salvo, Baron, Tschan, Montero, Bachl, & Pigozzi, 2007; Miñano, 2015; Zubillaga, Porospe, Hernandez, & Blanco, 2009) and the significance is marked by the structure of the sport and the type of variable studied.

Conclusions

Given the quality of the sample, we can ensure that the data obtained correctly represent the conditional information and competition profile of professional beach handball players. There are significant differences in the conditional data of competition in beach handball players according to sex; in addition, significant differences can be observed depending on the playing position, both in men and women. Given the novelty of this research study, new studies of a similar profile are necessary to determine the conditional structure and physiological response of the beach handball player in competition, giving solidity to the data provided in this scientific study.

Practical applications

This study has shown differences in the conditional assessment of the specific positions of elite beach handball players. This makes us understand that not all beach handball players have the same conditional needs to compete. Therefore, the conditional training of elite beach handball players should be focused on the development of physical abilities individually. This could lead to better performance of the athlete's energy system.

Lines for investigation

After observing the results obtained in this research project and verifying that scarce research of this type can be found in beach handball, it would be interesting to carry out more research in this aspect with the objective of establishing a foundation and being able to confirm a conditional profile of the professional beach handball player.

From that point, it will be interesting to assess the variation of the athlete’s results in terms of different contextual and situational elements, such as model of game, rival, competition, result, etc. also being able to observe the data at different moments of the competition, as well as to determine all this in the different levels of performance of the beach handball player.

Acknowledgments

The authors have no acknowledgments to declare.

Declaration of interest statement

The authors declare that they have no conflicts of interest.

References

Bago, P. (2016). *Efectos del entrenamiento pliométrico en arena seca sobre las variables determinantes del rendimiento en jugadores de balonmano playa.* (Doctoral Thesis). Universidad Pablo Olavide, Sevilla, Andalucía.

Bago, P., & Sáez, S. (2013). Effects of a multistage shuttle run 15 meters test on heart rate, lactate and rating of perceived exertion in beach handball players. *XVIII Annual Congress of the European College of Sport Science*, Barcelona, España.

Barbero, J.C., Pranda-Vera, J., Calleja-González, J., & Del Coso, J. (2014). Physical and physiological demands of elite team handball players. *International Journal of Performance Analysis in Sport*, *14*(13), 921–933.

Bebetsos, P. (2012). *Beach handball from A to Z*. Basel: International Handball Federation.

Boyd, L. J., Ball, K., & Aughey, R. J. (2011). The reliability of MinimaxX accelerometers for measuring physical activity in Australian football. *International Journal of Sports Physiology and Performance, 6*(3), 311-321.

Castellano, J., & Casamichana, D., (2010). Heart rate and motion analysis by GPS in beach soccer. *Journal of Sports Science and Medicine, 9*(1), 98–103.

Corvino, M., Tessitore, A., Minganti, C. and Sibila, M. (2014). Effect of court dimensions on players' external and internal load during small-sided handball games. *Journal of Sports Science and Medicine, 13*(2), 297–303.

Corvino, M., Vuleta, D., & Šibila, M., (2016). Analysis of Load and Players Effort in 4vs4 Small-Sided Handball Pames in Relation To Court Dimensions. *Kineziologija, 48*(2), 26–27.

Cruić, I., Vuleta, D., Bazzeo, M., & Ohnjec, K. (2011). Situational efficiency of teams in female part of tournament in the world beach handball championship in Cadiz. *Proceedings 6th International Scientific Conference on Kinesiology*, Opatija, Croatia, pp. 524–528.

Dellal, A., Wong, D., Moalla, W., & Chamari, K. (2010). Physical and technical activity of soccer players in the French First League - with special reference to their playing position. *International Sportmed Journal, 11*(2), 278-290.

Dello-Iacono, A., Ardig, L.P., Meckel, Y., & Padulo, J. (2016). Effect of Small-Sided Pames and Repeated Shuffle Sprint Training on Physical Performance in Elite Handball Players. *Journal of Strength and Conditioning Research, 30*(3), 830–840.

Di Salvo, V., Baron, R., Tschan, H., Montero, F. J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine, 28*(3), 222-227.

Edwards, S. (1993). *The heart rate monitor book*. New York: Polar CIC Inc.

International Handball Federation. (2014). *Rules of the game*. IHF: Basilea. Retrieved from www.ihf.com

Johnston, R.J., Watsford, M.L., Kelly, S.J., Pine, M.J., & Spurrs, R.W. (2014). Validity and interunit reliability of 10 Hz and 15 Hz GPS units for assessing athlete movement demands. *J Strength Cond Res, 28*(6):1649-55.

Lara, D. (2011). La respuesta cardiaca durante la competición de balonmano playa femenino. *Apunts Medicina De L'Esport, 46*(171), 131-136.

Luteberget, L.S., Holme, B.R., & Spencer, M. (2018). Reliability of Wearable Inertial Measurement Units to Measure Physical Activity in Team Handball. *Int J Sports Physiol Perform, 13*(4):467-473.

Manchado, C., Tortosa-martínez, J., Vila, H., Ferragut, C., & Platen, P. (2013). Performance Factors in Women's Team Handball. *Journal of Strength and Conditioning Research, 27*(6), 1708– 1719.

Michalsik, L. B., & Aagaard, P. (2015). Physical demands in elite team handball: comparisons between male and female players. *The Journal of Sports Medicine and Physical Fitness, 55*(9), 878–891.

Miñano, F.J. (2015). *Análisis de la actividad física competitiva en jugadores de fútbol de un equipo de excelencia*. (Doctoral Thesis). Universidad Politécnica de Madrid, Madrid, España.

Morillo-Baro, J. P., & Hernández-Mendo, A. (2015). Análisis de la calidad del dato de un instrumento para la observación del ataque en balonmano playa. *Revista Iberoamericana de Psicología del Ejercicio y el Deporte, 10*(1), 15-22.

Morillo-Baro, J.P. (2009). *Balonmano Playa*. Sevilla: Wanceulen.

Morillo-Baro, J.P. (2016). *Análisis observacional del ataque posicional en balonmano playa y perfil psicosocial del jugador*. (Doctoral Thesis). Universidad de Málaga, Málaga, Andalucía.

Morillo-Baro, J.P., Reigal, R.E., & Hernández-Mendo, A. (2015). Análisis del ataque posicional de balonmano playa masculino y femenino mediante coordenadas polares. *Revista Internacional de Ciencias del Deporte, 11*(41), 226-224.

Nicolella, D.P., Torres-Ronda, L., Saylor, K.J., & Schelling, X. (2018). Validity and reliability of an accelerometer-based player tracking device. *PLoS One, 13*(2), e0191823.

Pehrer, A., & Werkmeister, N. (2006). *Beach-Handball. Der Neue Sommersport*. Pöppingen: PA.

Pérez, J.A., Prau, D., & Santos, D. (2013). Performance analysis through the use of temporal activity patterns of elite players in beach tennis. *Journal of Human Sport and Exercise*, *8*(3), S694-S701.

Porostiaga, S.M., Pranados, C., Ibáñez, J., González-Badillo, J.J., & Izquierdo, M. (2006). Effects of an entire season on physical fitness changes in elite male handball players. *Medicine and Science in Sports and Exercise*, *38*(2), 357–366.

Póvoas, S.C.A., Seabra, A.F.T., Ascensão, A.M.R., Magalhães, J., Soares, J.M.C., & Rebelo, A.N.C. (2012). Physical and physiological demands of elite team handball. *Journal of Strength and Conditioning Research*, *26*(12), 3366–3376.

Pueo, B., Jimenez-Olmedo, J.M., Penichet-Tomas, A., Ortega, M., & Espina, J.J. (2017). Analysis of time-motion and heart rate in elite male and female beach handball. *Journal of Sports Science and Medicine*, *16*(4), 450–458.

San Pedro, J. M. (2008). Estudio monográfico del segundo portero de ataque en campeonato del mundo de balonmano playa Cádiz 2008. *Revista digital efdeportes, 13(126).*

Scarfone, R., Antonio, T., Carlo, M., Laura, C., & Antonio, A. (2015). Match analysis heart-rate and CMJ of beach soccer players during amateur competition. *International Journal of Performance Analysis in Sport*, *15*(1), 241–253.

Wagner, H., Finkenzeller, T., Würth, S., & Von Duvillard, S.P. (2014). Individual and team performance in team-handball: A review. *Journal of Sports Science and Medicine, 13*(4), 808–816.

Zapardiel, J.C. (2015). *Valoración isocinética de los músculos rotadores del complejo articular del hombro en jugadores de balonmano playa.* (Doctoral Thesis). Alcalá de Henares, Madrid, España.

Zapardiel, J.C., Asín-Izquierdo, I., Moya, I., Lebrero, C., Parcía, D., & Lozano, D. (2017). Assessment of the satisfaction degree of beach handball practice in students of sports sciences. *EHF Scientific Conference*, Vienna, Austria.

Zapardiel, J.C., Lara, D., & Rodríguez, M. L. (2013). Beach handball to improve jumping power. *EHF Scientific Conference*, Vienna, Austria.

Zubillaga, A., Porospe, P., Hernandez, A., & Blanco, A. (2009). *Comparative analysis of the high-intensity activity of soccer players in top level competition*. London: Routledge.

Table 1. Distribution of sample by sex, height, weight and age (±SD)

	Height (cm)	Weight (kg)	Age (years)
Female (n=32)	168.00 (3.86)	60.78 (3.87)	25,38 (4.82)
Male (n=25)	187.52 (7.48)	86.96 (9.53)	25.40 (3.26)

Table 2. Effects of sex and position on all variables

	Sex		Position		Interaction	
	F	**p**	**F**	**p**	**F**	**p**
Activity Time	14.2	.001	13.0	.000	3.8	.110
Distance	11.8	.001	19.8	.000	9.8	.000
N Accelerations	6.5	.014	14.1	.000	4.5	.003
N Decelerations	5.6	.022	14.1	.000	5.0	.002
IMA ACCEL(>2.5m/s)	2.0	.161	2.3	.072	.3	.828
IMA DECEL(>2.5m/s)	5.2	.026	4.9	.002	1.4	.219
N Jumps	20.5	.000	.8	.513	3.8	.009
IMA Jumps (>0.4m)	22.9	.000	10.9	.000	8.3	.000
Average Beats Per Minute	1.3	.256	5.1	.002	2.0	.107
TRIMPs	2.5	.115	9.1	.000	1.5	.202
Total Player Load	4.0	.045	27.9	.000	6.6	.000

N. accelerations: number of accelerations measured by PPS, N. decelerations: number of decelerations measured by PPS, IMA ACCEL(>2.5m/s): number of accelerations > 2.5 m/s measured by IMA, IMA DECEL(>2.5m/s): number of decelerations > 2.5 m/s measured by IMA, N Jumps: number of jumps measured by PPS, IMA Jumps (>0.4m): number of jumps >0.4m measured by IMA, TRIMPs: assessment of workload intensity based on the relationship heart rate-activity time, Total Player Load: assessment of load intensity through mathematical formula based on the data obtained by the accelerometer in all planes

Table 3. Activity time (±SD), distance travelled (±SD), distance covered in speed sections and maximum speed (± SD) in a 10-minute set regarding specific position

	SP	S (n=8)	W (n=6)	FW (n=7)	P (n=4)	D (n=7)	$\overline{X}$(n=32)
F	AT (min)	5.3 (2,1)	2.9 (1.1)	7.7 (1.3)	3.0 (1.7)	4.2 (1.0)	4.8 (2.3)
	Distance (m)	317.8(100.3)	292.7 (29.2)	630.1 (66.8)	286.7 (7.1)	282.1 (102.7)	369.7 (158.4)
	Distance (m) 1-6 km/h	168.8 (55.5)	139.0 (59.7)	370.0 (23.5)	256.7 (9.3)	177.5 (71.2)	220.1 (99.8)
	Distance (m) 6-9 km/h	67.4 (25.6)	62.9 (16.4)	136.4 (34.1)	14.6 (17.2)	56.3 (21.9)	72.6 (44.4)
	Distance (m) 9-12 km/h	31.1 (17.3)	23.9 (4.9)	71.0 (39.0)	1.8 (3.6)	17.0 (9.9)	31.7 (30.1)
	Distance (m) 12-15 km/h	13.1 (11.5)	23.5 (16.3)	13.2 (10.4)	.0 (.0)	1.0 (1.5)	10.8 (12.8)
	Distance (m) +15 km/h	1.6 (1.7)	2.3 (2.5)	1.6 (2.6)	.0 (.0)	1.3 (1.5)	1.2 (1.9)
	Maximum speed (m/s)	5.7 (1.0)	3.9 (0.5)	6.6 (1.0)	4.6 (0.1)	4.6 (1.0)	5.1 (0.1)
	SP	**S (n=6)**	**W (n=4)**	**FW (n=5)**	**P (n=4)**	**D (n=6)**	**$\overline{X}$ (n=25)**
M	AT (min)	6.7 (0.4)	7.1 (1.8)	7.6 (0.9)	4.3 (0.4)	4.8 (0.4)	6.1 (1.5)
	Distance (m)	607.6(103.2)	310.8 (19.5)	597.3 (86.3)	284.1 (6.7)	354.8 (25.5)	445.6 (156.3)
	Distance (m) 1-6 km/h	412.6 (121.9)	141.7 (67.8)	354.1 (85.9)	256.3 (30.1)	237.7 (65.5)	290.6 (122.2)
	Distance (m) 6-9 km/h	88.7 (59.2)	49.2 (±9.9)	104.0 (50.8)	16.4 (19.7)	58.0 (40.6)	66.5 (49.6)
	Distance (m) 9-12 km/h	55.8 (54.0)	21.4 (8.1)	74.0 (43.9)	4.9 (9.8)	58.0 (40.6)	38.0 (40.6)
	Distance (m) 12-15 km/h	9.0 (12.6)	15.0 (14.0)	21.2 (13.1)	1.5 (2.7)	.0 (.0)	9.1 (12.3)
	Distance (m) +15 km/h	.0 (.0)	2.3 (2.6)	2.5 (5.1)	.0 (.0)	.0 (.0)	.8 (2.5)
	Maximum speed (m/s)	6.5 (0.3)	3.6 (0,7)	7.1 (0.6)	4.7 (0.2)	5.7 (0.7)	5.7 (1.2)

F: female, M: male, PP: playing position, AT: activity time, S: specialist, W: wing, FW: fixed wing, P: pivot, D: defender, $\overline{X}$: sample average

Table 4. Total number of accelerations, decelerations and jumps (±SD) depending on the specific position measured by GPS and IMA

	PP	S (n=8)	W (n=6)	FW (n=7)	P (n=4)	D (n=7)	$\overline{X}$ (n=32)
F	N Accelerations	151.6 (41.8)	146.0 (67.9)	233.1 (20.7)	144.0 (23.5)	160.7 (41.4)	169.4 (52.5)
	N Decelerations	132.0 (38.5)	128.0 (57.3)	230.4 (21.6)	133.7 (14.4)	137.7 (46.4)	154.2 (55.3)
	IMA ACCEL(>2.5m/s)	2.1 (2.7)	3.5 (2.5)	3.1 (4.9)	3.2 (1.5)	.7 (1.2)	2.4 (2.9)
	IMA DECEL(>2.5m/s)	1.2 (1.5)	2.6 (1.8)	2.8 (2.8)	2.7 (1.8)	2.1 (2.1)	2.2 (2.0)
	IMA COD L (>2.5m/s)	1.8 (2.1)	2.6 (1.8)	4.4 (5.7)	2.5 (1.2)	2.2 (2.6)	2.7 (3.2)
	IMA COD R (>2.5m/s)	1.7 (1.9)	2.6 (1.8)	5.1 (5.1)	3.5 (.9)	2.2 (3.3)	3.0 (3.2)
	N Jumps	1.3 (1.7)	3.6 (2.9)	3.1 (3.2)	3.5 (.5)	1.8 (2.3)	2.5 (2.4)
	IMA Jumps (>0.4m)	.0 (.0)	.0 (.0)	.4 (.7)	1.0 (.0)	.2 (.7)	.2 (.5)
	PP	**S (n=6)**	**W (n=4)**	**FW (n=5)**	**P (n=4)**	**D (n=6)**	**$\overline{X}$ (n=25)**
M	N Accelerations	235.5 (41.1)	146.0 (71.5)	254.0 (12.9)	144.0 (32.5)	184.6 (15.8)	198.0 (55.3)
	N Decelerations	223.8 (44.4)	132.5 (60.0)	244.4 (21.1)	126.0 (18.4)	157.1 (12.6)	181.6 (57.4)
	IMA ACCEL(>2.5m/s)	5.1 (2.4)	3.7 (2.0)	5.2 (2.5)	3.7 (1.1)	3.8 (1.7)	4.4 (2.0)
	IMA DECEL(>2.5m/s)	2.0 (1.0)	2.5 (1.7)	11.2 (4.2)	2.7 (0.5)	3.6 (2.3)	4.4 (4.1)
	IMA COD L (>2.5m/s)	6.6 (2.1)	2.2 (2.0)	6.6 (3.7)	2.2 (.5)	4.1 (1.4)	4.6 (2.8)
	IMA COD R (>2.5m/s)	6.1 (1.1)	2.5 (1.7)	6.6 (2.6)	3.7 (.9)	5.0 (0.8)	5.0 (2.0)
	N Jumps	7.1 (2.2)	3.2 (3.2)	7.0 (.7)	3.7 (.5)	6.3 (1.9)	5.7 (2.4)
	IMA Jumps (>0.4m)	.3 (.5)	.0 (.0)	4.0 (1.2)	1.0 (.0)	2.1 (2.3)	1.5 (1.8)

PP: playing position, F: female, M: male, S: specialist, W: wing, FW: fixed wing, P: pivot, D: defender, $\overline{X}$: sample average, N. accelerations: number of accelerations measured by PPS, N. decelerations: number of decelerations measured by PPS, IMA ACCEL(>2.5m/s): number of accelerations > 2.5 m/s measured by IMA, IMA DECEL(>2.5m/s): number of decelerations > 2.5 m/s measured by IMA, IMA COD L (>2.5m/s): number of accelerations to the left >2.5 m/s measured by IMA, IMA COD R (>2.5m/s): number of accelerations to the right >2.5 m/s measured by IMA, N Jumps: number of jumps measured by PPS, IMA Jumps (>0.4m): number of jumps >0.4m measured by IMA

Table 5. Beats per minute (±SD) according to gender based on specific position

	PP	S (n=8)	W (n=6)	FW (n=7)	P (n=4)	D (n=7)	$\overline{X}$ (n=32)
F	Minimum (bpm)	96.3 (9.4)	108.7 (15.1)	147.4 (14.7)	137.5 (6.4)	120.2 (16.1)	120.2 (22.9)
	Maximun (bpm)	164.1(15.2)	147.8 (17.2)	174.9 (7.6)	160.1 (10.8)	168.8 (15.1)	163.9 (15.5)
	Average (bpm)	134.3 (14.5)	133.1 (18.7)	163.6 (10.9)	151.3 (12.7)	144.1 (17.4)	144.7 (18.1)
	80-90% (min)	1.7 (1.2)	2.1 (2.0)	7.4 (1.8)	3.2 (0.3)	3.2 (1.5)	3.6 (2.6)
	>90% (min)	.26 (.31)	.01 (.03)	.62 (.81)	.02 (.05)	.74 (.10)	.37 (.66)
	PP	**S (n=6)**	**W (n=4)**	**FW (n=5)**	**P (n=4)**	**D (n=6)**	**$\overline{X}$ (n=25)**
M	Minimum (bpm)	129.4 (11.8)	114.3 (5.1)	137.1 (11.3)	136.9 (5.7)	125.9 (10.2)	128.9 (11.7)
	Maximun (bpm)	169.1 (7.3)	154.3 (10.1)	171.8 (11.3)	160.3 (1.5)	162.9 (12.7)	164.4 (10.8)
	Average (bpm)	153.6 (10.4)	139.2 (9.3)	155.4 (10.9)	151.1 (5.5)	146.8 (7.9)	149.6 (9.9)
	80-90% (min)	4.8 (2.5)	2.2 (2.4)	5.5 (3.8)	3.1 (0.9)	2.1 (2.0)	3.6 (2.7)
	>90% (min)	.14 (.22)	.15 (.31)	.12 (.17)	.00 (.00)	.10 (.26)	.11 (.21)

PP: playing position, F: female, M: male, S: specialist, W: wing, FW: fixed wing, P: pivot, D: defender: $\overline{X}$: sample, average, BPM: beats per minute

Table 6. TRIMPs y Player Load (±SD) por sexo en función del puesto específico

	PP	**S (n=8)**	**W (n=6)**	**FW (n=7)**	**P (n=4)**	**D (n=7)**	**$\overline{X}$ (n=32)**
F	TRIMPs	23.5 (8.0)	18.8 (10.1)	38.7 (4.6)	33.8 (2.1)	28.9 (9.7)	28.4 (10.2)
	Total PL	36.3 (10.3)	33.6 (6.4)	71.6 (10.9)	30.5 (3.3)	40.7 (15.3)	43.8 (18.2)
	PL 1DUp%	41.2 (3.2)	38.9 (.4)	42.9 (3.3)	43.3 (.9)	38.6 (2.0)	40.8 (3.0)
	PL 1DFwd%	27.5 (2.2)	28.0 (.5)	27.0 (2.5)	25.5 (.5)	29.7 (2.8)	27.7 (2.3)
	PL 1DSide%	31.1 (1.8)	32.7 (.6)	30.0 (1.2)	31.1 (.3)	31.5 (2.2)	31.2 (1.7)
	PP	**S (n=6)**	**W (n=4)**	**FW (n=5)**	**P (n=4)**	**D (n=6)**	**$\overline{X}$ (n=25)**
M	TRIMPs	36.2 (6.3)	18.9 (11.8)	38.6 (9.6)	34.0 (2.2)	33.0 (4.9)	32.8 (9.4)
	Total PL	66.0 (13.0)	32.3 (6.6)	67.2 (6.1)	30.3 (1.9)	43.5 (6.2)	49.7 (17.5)
	PL 1DUp%	44.1 (1.0)	38.7 (.8)	42.9 (1.0)	43.3 (.4)	43.0 (.7)	42.6 (1.9)
	PL 1DFwd%	27.3 (1.7)	27.9 (.7)	27.9 (1.0)	25.5 (.5)	26.8 (1.9)	27.1 (1.5)
	PL 1DSide%	28.5 (.7)	33.1 (.3)	29.1 (1.2)	30.9 (.1)	30.1 (1.4)	30.1 (1.8)

PP: playing position, F: female, M: male, S: specialist, W: wing, FW: fixed wing, P: pivot, D: defender, $\overline{X}$: sample, average, TRIMPs: assessment of workload intensity based on the relationship heart rate-activity time, Total PL: assessment of load intensity through mathematical formula based on the data obtained by the accelerometer in all planes, PL 1DUp%: percentage of accelerations in the coronal plane over the total player load, PL 1DFwd%: percentage of accelerations in the sagittal plane over the total player load, PL 1DSide%: percentage of accelerations in the transverse plane over the total player load.