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Comparison of internal and external load metrics between won and lost game segments in elite beach handball

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ABSTRACT
Purpose. The extraordinary evolution of beach handball requires the relationship between the specific internal and external load in this sport to be determined in order to continue its development. For this reason, the objective of this study was to compare won and lost game segments in beach handball matches to determine if there is a relationship between winning and losing a set and the external and internal loads experienced by an elite beach handball player.
Methods. The data of 57 elite beach handball players were collected over ten matches, which were divided into time segments of 2 minutes each, making a total of 100 game segments. Data were collected using GPS and GNSS technology.
Results. The results showed significant differences in the variables distance per minute (*d* = large in male and medium in female), velocity band 2 distance (*d* = very large in male and large in female) and band 3 distance (*d* = very large in male and medium in female), accelerations (number) (*d* = large in male and medium in female), player load per minute (*d* = medium in male and in female), velocity work/rest ratio (*d* = very large in male and in female) and total jumps (number) (*d* = medium in male and large in female).
Conclusions. We conclude that the external and internal load variables that determine winning or losing a game segment in elite beach handball are distance per minute, velocity bands 2 (6–8.9 km/h) and 3 (9–11.9 km/h) distance, accelerations (number), player load per minute, velocity work/rest ratio and total jumps (number), both in the male and female categories. The highest values of these variables are observed in the won segments, except for the number of jumps in women.
Key words: situational effects, match intensity, performance, GPS, sand

Introduction

Beach handball is a young sport – it is about to turn 30 years old – but it is fully integrated into all international sports organisations. It is practiced on all continents and its easiness to play has made it one of the most practiced beach sports in the world. The International Handball Federation, the continental handball federations and the International Olympic Committee organise the different continental and world handball championships for both clubs and national teams [1]. The coaches and physical trainers of these clubs and national teams therefore need information for the correct development of the specific motor skills and the conditional capacities of beach handball.

Research studies on the effectiveness of motor skills specific to beach handball in international championships show substantial equality among most teams [2–4] and it is plausible that the specific internal and external loads placed on the participants during beach

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handball in one way or another determine the differences between elite teams. In a beach soccer investigation [5], an analysis of goals scored and their relationship with the physiology of the game showed that the goals scored were mainly associated with the interaction of physical and psychological factors. In this sense, investigations studying the specific internal and external loads and the limiting factors of these loads in beach handball have been carried out in recent years.

The external and internal loads of elite beach handball players have been analysed using GPS technology [6–12] and the physiological response was measured by recording the heart rate (HR) [6, 8, 9, 13–16]. Also, maximum VO_2 has been studied [17], as well as muscle damage markers such as creatine kinase (CK) and lactate dehydrogenase (LDH) [14,18] and the effects of training and changes by age categories in the physical fitness profile, condition and capabilities such as movement speed or strength [19, 20] in high-level beach handball players.

To the best of our knowledge, one aspect that has not yet been analysed is whether the specific external and internal loads of beach handball and their limiting factors can influence the performance of players. As mentioned above, the "winning" and "losing" teams of matches have been compared based on the effectiveness of specific motor skills. Saavedra et al. [2] compared the statistics of international beach handball matches between winning and losing teams in order to try to explain the performance of elite beach handball players. The findings showed that there exists great equality between all teams and that what differentiated the winning teams from the losing teams was the team's overall rating and total points, two aspects that in principle do not have an exclusive relationship with motor skills specific to beach handball. In a study following the same line of research by Dol et al. [3], among the results obtained, significant differences were found between winners and losers in the number of shots, goalkeeper saves and blocks, but the losing teams were those with the highest percentage of saves and of blocks compared to the winning teams while, in theory, the winning teams should be those with the highest percentages in these skills. In contrast, the number of throws was higher in the winning teams. An analysis of the goalkeepers in team sports should complete the general analysis of team behaviour [21]. This last ability could be more related to the conditional capacities, and also with the strategy or collective tactics of these teams [12].

In football, the performance related to the external and internal load was evaluated based on the result and performance levels. Buchheit et al. [22] examined teams' performance in the periods before and after a goal by comparing the total distance covered by the team in one minute. The performance of the race during the 5 minutes before a goal was slightly higher than the performance for the rest of the match. Lago et al. [23] compared the distances covered in different speed bands of the lost, won, and tied game segment. Teams performed less high-intensity activity when winning than when losing, but covered more distance by walking and jogging when winning. For every minute won, the distance travelled at maximum or sub-maximum intensities decreased by one metre compared to each minute lost. For every minute won, the distance covered in walking and jogging increased by two metres compared to every minute lost. In an investigation aimed at identifying the tactical and performance variables that could differentiate the winning and losing teams in the 2018 World Cup [24], the time of action in high-intensity situations was chosen among the study variables. The winning teams, among other variables, were those performing the largest number of high-intensity actions.

Rampinini et al. [25] studied how the distances covered in each velocity band and the running intensity varied according to the competitive level of the opponent teams.

Other research [26, 27] also studied the relationships of the conditional capabilities with performance levels. In this case, the accelerations and maximum running speed of elite soccer players were analysed. In all the studies reviewed for this research, in which the relationship between performance levels and conditional capacities was analysed [25–27], it was observed that the highest conditional capacities coincided with the highest performance levels.

In rugby, Black and Gabbett [28] analysed the pace of play strategies of winning and losing teams. To do this, they divided and compared the matches using quartiles, assessing the total distance travelled, including periods of low and high speed, and repeated episodes of high-intensity effort. The results showed a different pacing strategy between winning teams and losing teams.

In conclusion, based on the beach handball research published so far, substantial equality between the elite beach handball teams has been observed. Studies of this sport have focused on the analysis of the effectiveness of specific motor skills and have not determined the key performance factors. In other sports, whether the external and internal loads are decisive in the performance of the competition has been investigated. In most of these studies, the data collection system utilised GPS technology. For these reasons, the objective of this study is to compare the sets won with the sets lost in elite beach handball matches to learn if there are determinant performance factors among the external and internal loads that can be collected with GPS (Global Positioning System) and GNSS (Global Navigation Satellite System).

Material and methods

Participants

Twenty-five male (mean age: 25.38 ± 4.82 yrs; body weight: 86.96 ± 9.53 kg; body height: 187.52 ± 7.48 cm) and thirty two female (mean age: 25.38 ± 4.82 yrs; body weight: 60.78 ± 3.87 kg; body height: 168.00 ± 3.86 cm) elite beach handball players were recruited for this study. The participants train 5 days per week and play a weekly competition match. During the winter season, they practice the handball modality and, during summer, they practice beach handball. All the players in this study train with their respective beach handball clubs during the summer and attend training camps with the national team during different periods of approximately 7 days. All the players were observed during ten pre-competition matches prior to the European Championship. The data records were taken with temperatures ranging 14–25°C and humidity ranging 19–49%.

Measures

To collect data, three GPS (Global Positioning System) and GNSS (Global Navigation Satellite System) OptimEye S5 10Hz GPS receivers and an inertial system with a 100 Hz 3D Accelerometer, 100 Hz 3D Gyroscope and 10 Hz 3D magnetometer were used (Catapult OptimEye S5, Catapult Innovations, Melbourne, Australia). An automatically synchronised T31c Polar system (coded transmitter) (Polar T31c, Polar Electro, Kempele, Finlandia) was used to monitor HR physiological data. This tool is validated by research in a multitude of scientific studies [29–31].

Record sheets were used both for collecting the individual data of the players in each match and for registering situational variables, such 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 loads were:

– Distance/minute: metres travelled per minute.

– HR: the speed, in beats per minute, at which the heart beats. In this study, the minimum, maximum and average heart rates were collected.

– Maximum heart rate (HR_{max}): the maximum heart rate value that each player reached during the measurements.

– Time spent in different HR zones: activity time in certain heart rate intervals. In this study, the time period between 80 and 90% of the HR_{max} and the time period above 90% of the HR_{max} were collected. The thresholds were selected in order to analyse high intensity. Effort intensity during competition ranges from vigorous to very vigorous during 70% of the playing time, taking the HR as reference, which shows records that range between 80% and 83% of the HR_{max} when the ball is in play [15]. Therefore, reporting the time spent at > 80% HR_{max} is relevant.

– HR exertion: the product of the time spent in consecutive HR bands times a weighting factor, where time in higher HR bands is more heavily weighted. This data were provided by the Catapult software.

– Velocity and velocity bands: player speed and time spent in each previously assigned band. 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 [8].

– High metabolic power efforts: number of efforts made with high intensity metabolic power (> 20 $W \cdot kg^{-1}$) [32].

– Peak meta power: the highest instantaneous energy expenditure within a specified band.

– *N* accelerations and decelerations: number of accelerations and decelerations measured by GPS.

– TRIMP: training impulse. Assessment of workload intensity based on the heart rate-activity time relationship [33].

– Player load: assessment of load intensity through a mathematical formula based on the data obtained by the accelerometer in all planes [34].

– Velocity work/rest ratio: time working divided by time resting, where work and rest are defined by the velocity thresholds defined in the software.

– Total jumps: number of jumps made at any height measured by GPS.

Procedures

First, the technical staff of the selections were contacted to explain the research project and to request the pertinent permissions. 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. The goalkeeper was not assessed in this study, while the other players were assessed. It was agreed with the national coaches that the players chosen for the study could not change roles or be substituted during the whole game [8, 35].

Five minutes before each set, the chosen players were given the HR monitor, the vest and the device. After this and once the initial and individual situational data of the players were obtained, the exact starting time of the matches was noted. All variations in the scoreboard were recorded in time segments of two minutes. All games were recorded to certify the data collected. After each game finished, the devices were removed. The matches were analysed separately. The analyses were performed throughout the 10-minute sets, excluding the recovery time between both sets. Four 10-minute sets were played each day with 5-minute breaks between sets.

The data were transferred daily to the OpenField tool by catapult sports for analysis.

The games were divided into time segments of two minutes each, and all variations in the scoreboard were recorded for each segment. To analyse the positive and negative game segments, each of the recorded 2-minute segments were separated and named. Each 2-minute game segment ending with a positive score of four points or more was called a winning game segment. Each 2-minute game segment ending with a negative score of four points or more was called a losing game segment. Segments with scores of 3 points or fewer were eliminated. In this way, 271 2-minute game segments were obtained for the final analysis: 125 for the men (37 positive and 88 negative) and 146 for the women (62 positive and 84 negative).

The beach handball matches analysed were played on silica sand courts, double washed, with a grain of 0.5 mm diameter and with a depth ranging from 0.4 to 0.5 m.

Statistical analysis

Statistical analysis was carried out using the SPSS software (version 22). A descriptive analysis of the variables studied was performed. The Kolmogorov-Smirnov test was used to check for normality. Subsequently, the inferential analysis was carried out.

To compare the load and won-lost game segments, the variables that followed normality were studied with the *t*-test, while the variables that did not follow normality were studied with the Mann-Whitney *U* test. To calculate the magnitude of differences, Cohen's *d* (*d*) was used. Cohen's *d* was interpreted as: very small (0–0.01), small (0.02–0.2), medium (0.3–0.5), large (0.6–0.8), very large (0.9–1.2) and huge (> 1.2) [36].

To compare the load and won-lost game segments and their interaction with the gender factor, a generalised linear model test was performed. To calculate the magnitude of differences for the generalised linear model test, omega squared (ω^2) was used. Omega squared was interpreted such that < 0.06 was low, 0.06–0.15 was moderate and > 0.15 was large [37, 38].

Statistical significance was established as $p < 0.05$.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the University of Alcalá Ethics Committee (approval No.: CEI/HU/2019/08).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Table 1 shows the comparison between the won and negative game segments of the study variables, and the interaction of this comparison between men and women. The effect size was found in order to compare the positive and negative game segments of the men and women that showed significance, as shown in Table 1 (*d*). In the same way, in the interaction by gender, the result of omega partial squared (ω_p^2) is shown for the variables that showed significance.

Figure 1 shows the variables in which there were statistically significant differences in both men and women: distance per minute (*d* = large in male and medium in female), velocity band 2 total distance (*d* =

Table 1. Results of the inferential analysis of won and lost game segment of men and women, and their interaction based on gender

Variables	2MGS	Male			Female			Interaction	
		Mean ± *SD*	*p*	*d*	Mean ± *SD*	*p*	*d*	*p*	ω_p^2
Distance/minute (m)	Won Lost	52.96 ± 20.90 41.04 ± 17.96	0.00*	0.60^{b}	44.11 ± 20.31 37.74 ± 19.00	0.03*	0.32^{μ}	0.29	–
Minimum heart rate (beats/min)	Won Lost	123.27 ± 20.82 131.27 ± 18.81	0.03*	0.30^{μ}	121.65 ± 31.91 123.50 ± 31.33	0.28	–	0.36	–
Maximum heart rate (beats/min)	Won Lost	161.57 ± 13.64 165.59 ± 13.39	0.13	$0.25^{\&}$	167.11 ± 17.57 168.10 ± 18.46	0.62	–	0.47	–
Mean heart rate (beats/min)	Won Lost	147.53 ± 13.54 150.60 ± 14.10	0.26	–	147.40 ± 22.39 149.38 ± 18.08	0.56	–	0.81	–
Heart rate exertion	Won Lost	231.74 ± 49.97 219.45 ± 47.40	0.19	–	210.66 ± 52.49 217.85 ± 45.49	0.17	–	0.13	–
Time HR 80–90% HR_{max} (min)	Won Lost	0.69 ± 0.80 0.75 ± 0.81	0.96	–	0.78 ± 0.74 0.79 ± 0.74	0.92	–	0.78	–
Time HR more 90% HR_{max} (min)	Won Lost	0.03 ± 0.11 0.02 ± 0.07	0.57	–	0.10 ± 0.26 0.07 ± 0.20	0.81	–	0.58	–
Velocity band 1 (1–5.9 km/h) distance (m)	Won Lost	59.45 ± 24.12 57.57 ± 29.54	0.56	–	50.63 ± 23.87 46.48 ± 24.67	0.30	–	0.72	–
Velocity band 2 (6–8.9 km/h) distance (m)	Won Lost	21.41 ± 14.52 9.91 ± 10.96	0.00*	0.89^{b}	20.35 ± 11.57 12.66 ± 12.20	0.00*	0.60^{b}	0.23	–
Velocity band 3 (9–11.9 km/h) distance (m)	Won Lost	13.40 ± 11.64 5.19 ± 7.74	0.00*	$0.93^{\$}$	8.22 ± 7.33 6.04 ± 8.38	0.00*	$0.25^{\&}$	0.01*	$0.04^{\#}$
Velocity band 4 (12–14.9 km/h) distance (m)	Won Lost	3.13 ± 5.24 1.30 ± 2.87	0.02*	0.38^{μ}	3.63 ± 7.51 1.47 ± 3.05	0.16	–	0.78	–
Velocity band 5 (< 15 km/h) distance (m)	Won Lost	0.25 ± 1.07 0.15 ± 1.10	0.81	–	0.47 ± 1.30 0.12 ± 0.79	0.01*	0.33^{μ}	0.37	–
Maximum velocity (km/h)	Won Lost	11.97 ± 2.64 11.35 ± 3.78	0.29	–	12.05 ± 2.86 10.44 ± 3.47	0.00*	0.47^{μ}	0.24	–
High metabolic power efforts (W/kg^2)	Won Lost	1.51 ± 1.39 1.34 ± 1.49	0.33	–	1.37 ± 1.32 1.15 ± 1.53	0.08*	$0.15^{\&}$	0.88	–
Peak meta power (W/kg^2)	Won Lost	34.69 ± 12.02 33.18 ± 15.62	0.59	–	32.71 ± 9.70 29.85 ± 14.01	0.14	–	0.67	–
Number of accelerations (m/s^2)	Won Lost	46.92 ± 10.00 36.53 ± 14.73	0.00*	0.73^{b}	39.24 ± 13.06 33.73 ± 14.18	0.01*	0.39^{μ}	0.16	–
Number of decelerations (m/s^2)	Won Lost	41.03 ± 14.19 34.36 ± 13.36	0.01*	0.49^{μ}	34.10 ± 13.58 32.79 ± 12.75	0.55	–	0.12	–
TRIMP	Won Lost	6.94 ± 1.99 6.41 ± 2.31	0.45	$0.23^{\&}$	5.89 ± 2.40 6.23 ± 2.31	0.35	–	0.15	–
Total player load	Won Lost	12.02 ± 4.27 9.09 ± 4.30	0.00*	0.64^{b}	10.61 ± 4.63 8.69 ± 4.60	0.24	–	0.40	–
Player load/minute	Won Lost	5.08 ± 1.89 4.14 ± 1.91	0.01*	0.45^{μ}	5.07 ± 2.28 4.07 ± 2.11	0.00*	0.48^{μ}	0.90	–
Velocity work/rest ratio	Won Lost	0.88 ± 0.61 0.55 ± 0.44	0.00*	0.55^{μ}	0.91 ± 0.78 0.53 ± 0.52	0.00*	0.64^{b}	0.69	–
Total jumps number	Won Lost	1.38 ± 1.01 1.06 ± 1.13	0.04*	0.31^{μ}	0.23 ± 0.46 0.81 ± 1.04	0.00*	0.57^{μ}	0.00*	$0.02^{\#}$

HR – heart rate, HR_{max} – maximum heart rate, 2MGS – 2-minute game segment, TRIMP – training impulse,
$^{\&}$ small, $^{\mu}$ medium, ^{b} large, $^{\$}$ very large, $^{\#}$ low; * significant differences

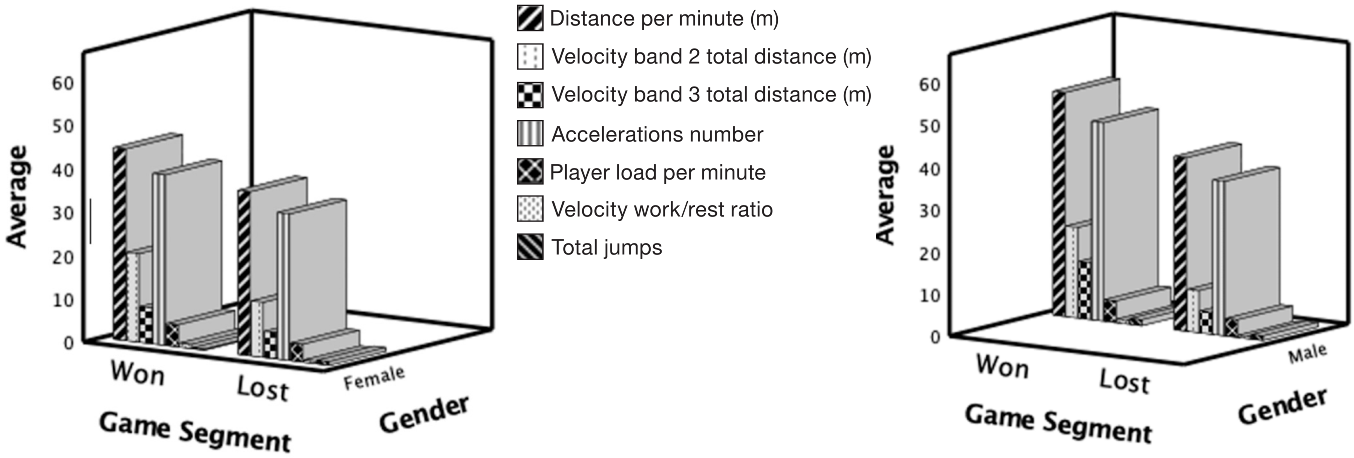

Figure 1. Variables that showed significant differences in both men and women

large in male and female), velocity band 3 total distance (*d* = very large in male and large in female), number of accelerations (*d* = large in male and medium in female), player load per minute (*d* = medium in male and female), velocity work/rest ratio (*d* = medium in male and large in female) and total jumps (*d* = medium in male and female).

Discussion

This study investigated the differences between won and lost game segments in elite beach handball matches to learn whether or not there are performance determinants between the external and internal loads. The distance per minute, the distance travelled between 6 and 12 km/h, the number of accelerations, the player load per minute, the velocity work/rest ratio and the total jumps are the variables showing significant differences in both men and women. In all the mentioned variables, the winning game segments obtained better results than the losing game segments, except for the jumps in women, who performed fewer jumps in the losing game segments than in the winning game segments. This suggests that the high capacities of movement, acceleration, and speed and intensity of beach handball players could be decisive in performance during the competition of this sport modality.

To the best of our knowledge, no beach handball articles comparing conditional aspects aimed at elucidating what could determine winning or losing a game of this sport modality have been published. For this reason, the present findings will be discussed in relation to research from other team sports (e.g., football and rugby) that assessed this aspect.

In the distance per minute variable of this research, men performed 12 metres more on average in the winning game segments than in the losing game segments. For their part, women performed 6 more metres per minute in the winning game segments. In both cases, significant differences were found. These results do not agree with the results found in soccer [23] where the difference in the distances covered between the winning and losing game segments were minimal. In the study analysed in soccer, for every minute won, the distance covered at maximum intensity decreased by 0.95 metres compared to each minute lost. At submaximal intensity, for every minute won, the distance travelled decreased by 1.1 metres compared to every minute lost. These differences could be explained by the different surfaces on which beach handball and soccer are practiced, and because they have very different game structures. However, in soccer with a modified game structure (5-a-side small-sided games), which is more similar to that of beach handball (fewer players and with a numerical imbalance), significant differences were found in the distance covered [39]. In this case, the distance travelled was lower when winning in superiority conditions, but higher when winning in inferior conditions.

In this study, six out of the seven variables regarding HR did not undergo significant variation based on the winning and losing game segments in men or women. Along the same lines, in an investigation with soccer players, HR was not influenced by the status of the match scoreboard [39]. The exception to our research was the variable of minimum HR, but only in men, in which significant differences were observed. In this variable, lower average beats were obtained for the players who won the game segments. Therefore, in elite beach handball, aerobic capacity development training should be one of the goals for coaches.

One of the variables that showed significant differences in both men and women was the distance travelled by players in sections differentiated by travel speeds. Specifically, the differences were found between 6 and 12 km/h. Between 6 and 9 km/h, the distance travelled by players doubles for both men and women in the winning game segments, and between 9 and 12 km/h, the distance travelled by men in the winning game segment triples. In previous beach handball studies, the longest distances covered in a match were between 4 and 13 km/h in both men and women [8,9]. Therefore, the ability to cover longer distances at these speeds could be a performance factor in beach handball. Unlike beach handball, soccer teams that are tied or losing travel more distance at medium and high intensities than teams that are winning, reaching a 50% decrease in the distance travelled. This is because the teams that are winning the game try to carry out a strategy to keep possession of the ball and, to do this, they reduce the pace of the game [23]. In beach handball, this type of strategy cannot be carried out since the team would be in passive play and would be sanctioned by the referees. Also, in soccer, a trend was found in the winning teams of the 2018 World Cup. These teams used a counter-attacking strategy at a high pace of play, covering greater distances at speeds above 25 km/h [24].

The maximum travel speeds that can be reached in elite beach handball matches range between 17 and 20.5 km/h in men's matches and between 14 and 18.5 km/h in women's matches [6, 8]. The maximum travel speed recorded in the matches in our study was approximately 12 km/h in both men and women, and significant differences were shown only in the case of women. Even so, we could not determine that the maximum speed is an indicator of beach handball performance since the speeds collected in our study are well below the maximum speeds that can be reached in matches at this level.

The total player load variable showed significant intensity differences only in men when the winning and losing game segments were compared; but when the player load per minute was compared, significant differences were found in both sexes. Due to the continuous substitutions in a beach handball match, the player load per minute may be a better indicator of the intensity measurement in this sport, compared to the total player load. Studies of intermittent intensity sports such as netball determined that measuring intensity with the total player load can be problematic, since it only reveals the average physical effort of the game, which can be considered a misguided measure of the intensity of the game, particularly in sports that are very intermittent in nature [40].

No articles studying the variables velocity work/rest ratio, accelerations, and number of jumps in relation to the winning and losing game segments were found. In this study, these three variables showed differences in both men and women. 25% more accelerations per minute were performed in winning game segments. In a beach handball sample of the same level, the accelerations did not show differences between the first and second sets [9], which indicates that the accelerations might not be affected by the accumulated fatigue during a beach handball match. Therefore, the differences could be determined because the players who won the game segments were more able to accelerate or because the team with winning game segments generated more tactical actions requiring accelerations. The velocity work/rest ratio is related to work and rest time, and we believe it is a variable that should be studied much more in beach handball due to the constant substitutions of players of this sport modality. These results may provide relevant information for the design of training tasks in accordance with the rhythm of the game in competition. In the number of jumps, the differences did not show the same relationship in the groups of men and women. In men, more jumps were carried out in the winning game segments; in women, it was the opposite case, more jumps were carried out in the losing game segments. This contradiction and the low number of jumps collected per game segment led us to continue studying this variable. In the winning game segments in female games, it is possible that the importance of the attack was mainly based on stand and penetration shots (not registered as jumps) of the specialist player and this, in the end, may lead to better results, as opposed to in male beach handball. Some studies corroborate the greater role of the specialist player in women's offensive game compared with men's [41–43].

Conclusions

Coaches and trainers must know the external and internal loads most important to sports performance in beach handball and, with this, design and evaluate training sessions and competitions for elite beach handball teams. The best sports performance in elite beach handball seems to be determined by accumulating distance covered in the ranges of 6–12 km/h in men and 6–9 km/h in women, and higher values of velocity. The distance per minute and the player load per minute are better performance indicators than the same total variables when game segments are studied. Both in the previously indicated variables and in the number of accelerations and velocity work/rest ratio, higher values are observed in the game segments won in comparison to the game segments lost. The results of the game segments and their relationship with the jumps are different for men and women. Men follow the general trend: a greater number of jumps is observed in the winning segments. However, for women, the number of jumps is lower in the game segments won, possibly due to differences between the sexes in the actions that determine performance in competition.

Research limitations

It should be considered that the data collected come from friendly beach handball matches and that, to our knowledge, this is the first study to be carried out on the performance of game segments in this sport. The same analysis should be performed in official competition matches to reinforce the results and conclusions of this study. In addition, the analysis considered the score but not the outcome of the actions and the position of the players was not specifically considered.

Practical applications

A high aerobic-anaerobic endurance capacity should be considered a prerequisite for success in beach handball. For this reason, we suggest that coaches develop training programs aimed at increasing endurance. Also, we suggest working during workouts at travel speeds between 9 and 12 km/h in men's workouts and between 6 and 9 km/h in women's workouts. Training to improve acceleration must be included among their objectives. To assess training intensity, we recommend using the distance per minute and player load per minute variables.

Future work

To reinforce the results and conclusions of this research, this same analysis should be performed in official competition matches. Along the same lines, the relationship between game segment and conditional capacities could be studied, including aspects of collective tactics. In order to determine the variables that best identify the intensity at which beach handball is practiced, the relationships between the variables player load and total distance could be studied, taking into account the real activity time in very short partials. The relationships between game segment performance and jumps should continue to be studied to attempt to justify the differences between men and women. In this sense, one possible study hypothesis is that the differences are marked by the offensive game strategies of the teams. A final line of research could be the study of the variable velocity/rest ratio, since it is related to work and rest time, and beach handball, due to the substitutions system, has very peculiar relationships between work and recovery.

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Disclosure statement

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Conflict of interest

The authors state no conflict of interest.

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