Apunts Sports Medicine 59 (2024) 100460

Contents lists available at ScienceDirect

Apunts Sports Medicine

journal homepage: www.apunts/org

Original Article

Analysis of the physical fitness and determinants of performance of beach handball athletes

Francine De Oliveira[a,e], Victor Gonçalves Corrêa Neto[b,c], Gilson Ramos de Oliveira Filho[d,e], Marcel Lima Lessa de Souza[e,1], Jaime Souza Torres[e,h], Wellington Esteves[h], Rudney Uezu[h], Igor Ramathur Telles de Jesus[g], Estêvão Rios Monteiro[a,e,f,g,*]

[a] Escola de Educação Física e Desportos, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil
[b] School of Health Sciences, Gama e Souza University Center, Rio de Janeiro, RJ,Brazil
[c] Physical Education Graduate School, Estácio de Sá University (UNESA), Rio de Janeiro, RJ, Brazil
[d] Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil
[e] Undergraduate Program in Physical Education, Centro Universitário Augusto Motta (UNISUAM), Rio de Janeiro, RJ, Brazil
[f] Undergraduate Program in Physical Education, IBMR University Center, Rio de Janeiro, RJ, Brazil
[g] Postgraduate Program in Rehabilitation Sciences, Centro Universitário Augusto Motta (UNISUAM), Rio de Janeiro, RJ, Brazil
[h] Board of Directors of the Brazilian Beach Handball Federation, Brazil

ARTICLE INFO

Article History:
Received 5 June 2024
Accepted 14 August 2024
Available online xxx

Keywords:
Beach handball
Performance
Elite athletes
Sports

ABSTRACT

Introduction: Beach handball, an emerging team sport derived from indoor handball, is characterized by high-intensity efforts. This study aimed to analyze the physical fitness profiles of elite beach handball players of both sexes and identify the characteristics that determine anaerobic power performance among these athletes.

Material and methods: A cross-sectional study was conducted with 25 elite beach handball players. Anaerobic power, sprint performance, and change-of-direction ability were assessed.

Results: There were no significant differences between men and women in anaerobic power and change-of-direction ability. Men showed better performance in the 15-meter sprint test (p = 004). A moderately strong positive correlation was found between anaerobic power and age. BMI did not significantly correlate with power performance.

Conclusions: Age is an important determinant of anaerobic power, whereas body mass index does not play a significant role, especially among males.

Introduction

Beach handball is a rapidly growing team sport derived from indoor handball, known for its high-intensity efforts,[1] and these intrinsic characteristics have been corroborated using global positioning system analyses.[2] Scientific research on this topic is also gradually arising, especially regarding sports performance. Previously, Lemos et al.[3] compared sport-specific performance, fitness, and anthropometric measurements between elite and sub-elite players of both sexes. The results suggests that power performance, expressed by the horizontal jump, and technical ability during throwing are the variables that differentiate between categories irrespective of sex. Also, aspects regarding nutrition and performance of these athletes have been investigated.[4,5] Sex differences in sports performance are a vastly discussed topic among scientific literature. However, scientific evidence concerning this sample can still be considered scarce.

Considering the profile of this sport, the adequate jumping, sprinting, and change-of-direction ability are considered of utmost importance,[6] as well as anaerobic capacity. Previously, Ortega-Becerra et al.[7] aimed to determine if different physical capabilities had any relationship with throwing velocity of handball players of distinct ages, an important marker of specific performance. According to the results, throwing velocity is associated with lower-limb strength, upper-limb, jumping and sprint capacities, which highlights the importance of these activities, even though there are considerable differences between handball and beach handball. In this scenario, Mancha-Triguero et al.[8] conducted a comparative analysis between indoor handball and beach handball and observed that the indoor activity imposed greater physical demands. The authors equipped

* Corresponding author at: Postgraduate Program in Rehabilitation Sciences − Centro Universitário Augusto Motta (UNISUAM), Rua Dona Isabel 94, Bonsucesso, Rio de Janeiro, RJ, Brazil.
E-mail address: profestevaomonteiro@gmail.com (E.R. Monteiro).
[1] 0000-0001-9687-7463

https://doi.org/10.1016/j.apunsm.2024.100460

players in both modalities with heart rate monitors to assess internal load and used and inertial device (Wimu®) to evaluate movement and physical activity which was further analyzed through the SPro® software. However, it is worth mentioning that both samples were composed of U-16 athletes, limiting the extrapolation of their results. Also, the analysis of the determinants of performance in a variety of sports and occupational scenarios has been playing and important role in scientific literature.

Considering the demand on knowledge concerning beach handball, the purpose of this study was to analyze the physical fitness profile of a sample composed of elite beach handball players of both sexes. In addition, the authors aimed to observe which characteristics would determine anaerobic power performance among these elite athletes. We hypothesize that age and anthropometric measurements will significantly correlate with physical performance in these athletes.

Material and methods

Ethical considerations

The procedures of the present study were carried out in accordance with Resolution No 466/12 of the Brazilian National Health Council. The study was submitted and approved by the Augusto Motta University Centre ethics committee [6.827.696] and were conducted in accordance with the Declaration of Helsinki.

Design

This was a cross-sectional study in which the sample was selected by convenience. Participants were elite beach handball players (male n = 11; female n = 14) and were assessed at the final list of those selected to compete in the 2023 IHF Beach Handball Global Tour. Descriptive statistics are displayed on Table 1. Age, body mass index (BMI), and 15-meter sprint in the male group, as well as age, 15-meter sprint, and relative maximum power in the female group are expressed as median and interquartile range since they had their normality rejected, other variables should be read as mean and standard deviation (Table 1).The participants were evaluated at the same time of the day, aiming to avoid the influence of the circadian rhythm. Each participant was instructed to wear comfortable clothing for testing procedures and received an authorization from their medical department to participate in the present investigation.

Participants

Participants were instructed to avoid any vigorous exercise and caffeine or alcohol ingestion 12 h prior testing and, were familiarized with testing procedures. Inclusion criteria consisted of a) being selected to compete in 2023 IHF Beach Handball Global Tour; b) being over 18 years old; c) being free from any musculoskeletal injury at the time of evaluation. Exclusion criteria consisted of a) athletes who werent given permission of their medical department to participate in this investigation; (b) any kind of musculoskeletal injury that led to training absence for eight days or more in the six months prior to testing; (c) individuals who had ingested caffeine or alcohol during the last 12 h prior testing. All participants were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in this study. Testing were all conducted on sand due to the sport's specificity.

Table 1
Comparisons pf the descriptive statistics for each group.

	Male	Female	p-value
Age (years)	26.00 (24.00–34.00)	22.00 (18.75–34.75)	.323
Body Mass (kg)	89.67 ± 13.15	67.57 ± 7.59	.001
Height (cm)	172.81 ± 57.39	173.49 ± 7.38	.937
Body Mass Index (kg/m^2)	23.91 (22.98–25.46)	22.13 (20.14–23.80)	.014
Change of Direction (seconds)	5.43 ± 0.46	5.52 ± 0.47	.635
15-meter Sprint* (seconds)	2.37 (2.20–2.40)	2.57 (2.51–2.74)	.004
MARP (watts/kg)	21.80 (16.19–24.58)	20.16 (18.82–26.43)	.956
MIRP (watts/kg)	13.33 ± 4.11	10.73 ± 2.84	.075
ARP (watts/kg)	16.98 ± 4.09	15.23 ± 3.77	.281

* Significant difference between groups; MARP = Maximum Relative Power; MIRP = Minimum Relative Power; ARP = Average Relative Power.

Procedures

Initially, anthropometric measurements and information regarding the subject's playing position were collected. Height was measured to the nearest 0.1 cm and body mass to the nearest 0.1 kg. Descriptive statistics are displayed on Table 1. Participants performed a standard warm-up with a 10-minute duration in which they performed low-intensity jogging during the first 5 min. Ballistic movements to the lower limbs were added during the last 5 min. Following warm-up, the Running-Based Anaerobic Sprint Test (RAST), 15-meter sprint test, and the change-of-direction test were conducted, always in this order, with a 10-minute passive interval between tests.

Running-Based Anaerobic Sprint Test (RAST): Before conducting the assessments, the total body mass of the participants, including the attire worn during the tests, was measured using a bioimpedance scale (OMRON® HBF-514, Brazil). The RAST Test involved completing six maximal 35-meter sprints, with a 10-second passive recovery period in between.[9] The timing was recorded for each sprint (Iphone 14 Pro Máx®, USA). Four evaluators simultaneously carried out the evaluation, two of them at each end, one of them being responsable to record the time of the sprint and the other one responsable for the recovery period (stopwatch). The test started after the command "*Ready? Go!*", with the timer being immediately started after the beggining of the sprint. Absolute power (Pabs) for each sprint was calculated by considering the individual's time (t), distance (D), and body mass (MC): (Pabs (W) = (MCxD^2) / t^3) .[10] Variables such as maximum relative power, minimum relative power, and average relative power were determined by the ratio between their absolute values and the individual's body mass.[11]

15-meter sprint: Maximal acceleration was assessed through the 15-meter linear sprint test. Participants were instructed to star 0.5 m behind the mark in an athletic position and sprint all the way till the finish line as fast as possible.[12] Two attempts were allowed, with the best execution time being recorded, and a 3-minute rest interval between attempts. Performance was recorded in seconds and hundredths of a second (two decimal places). A manual stopwatch was used. Two evaluators simultaneously carried out the evaluation, one of them responsible for the stopwatch at the finish line and another evaluator at the starting point giving the initial command. The test started after the command "*Ready? Go!*", with the timer being immediately started after the beggining of the sprint.

Change of Direction (Square Test): A four-meter square was marked on the floor with cones place in each of the four cones. The athletes started from a standing position, with one foot slightly advanced immediately behind the starting line. Upon the evaluator's signal, they should move towards the next cone diagonally. Next, they run towards the cone to their left and then move to the diagonal cone (crossing the square diagonally). Finally, they run towards the last cone, which corresponds to the starting point[13] (Fig. 1).

The athlete must touch each of the cones that mark the path with one of their hands. The stopwatch should be started by the evaluator as soon as the evaluated person took their first step, touching the

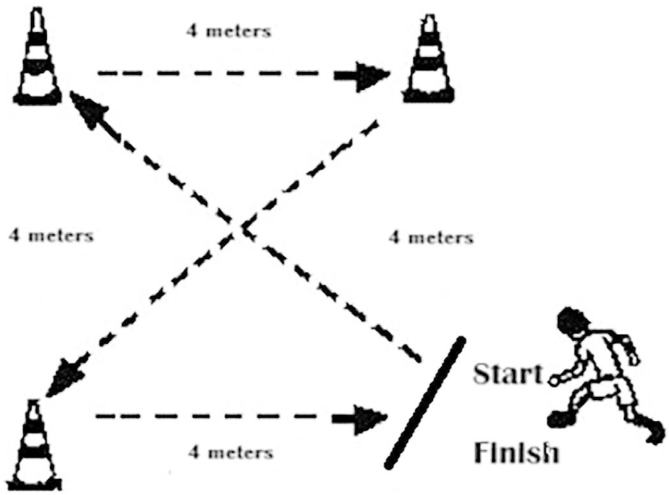

Fig. 1. Schematic of the change of direction (Square Test).

inside of the square. Two attempts were allowed, with the best execution time being recorded, and a 3-minute rest interval between attempts. Performance was recorded in seconds and hundredths of a second (two decimal places). A manual stopwatch was used. Two evaluators simultaneously carried out the evaluation, one of them responsible for the stopwatch at the end of the test and another evaluator at the starting point giving the initial command. Evaluators were placed side by side. The test started after the command "Ready? Go!", with the timer being immediately started after the beggining of the sprint.

Statistical analysis

The Shapiro-Wilk test was performed to test the normality of data distributions followed by skewness and kurtosis analyses, along with graphical inspection of histograms and QQ-plots.[14] The variables age, BMI, and 15-meter sprint in the male group, as well as age, 15-meter sprint, and relative maximum power in the female group, had their normality rejected. For the analyses involving these variables, non-parametric statistics were used for inferences, and the median and interquartile range were used to describe measures of central tendency and dispersion, respectively. Meanwhile, for inferential tests involving only normally distributed variables, parametric analysis was applied, using the mean and standard deviation as measures of central tendency and dispersion, respectively.

To compare the differences between measurements in the male and female groups, the independent samples T-test was conducted when the variable displayed a normal distribution in both groups. When the normality of the variable was rejected in one of the groups, the Mann-Whitney test was conducted. Regarding correlations, the Pearson product-moment correlation coefficient was applied to variables with a normal distribution, while the Spearman correlation coefficient was used for correlations involving any variable that deviated from the normal distribution. The strength of correlations was classified according to Chan's (2003b)[15] proposal with <0.3 being poor, 0.3−0.5 being considered fair, 0.6−0.8 moderately strong, and at least 0.8 being considered a strong correlation. The coefficient of determination was calculated whenever the correlation was significant. Data were entered into IBM SPSS Statistics 20 software for analysis and the level of significance was set at 5 % ($p \leq 0.05$).

Results

The male group showed significantly higher body mass and BMI compared to females. Men also performed better in the 15-meter sprint (p=.004). There were no significant differences in anaerobic power and change-of-direction ability between sexes. Age showed a moderately strong positive correlation with anaerobic power in both sexes, while BMI did not significantly correlate with power performance (Table 2). The female group showed a significant and negative correlation between 15-meter sprint and power (p<.05) (Table 2). Age showed a moderately strong correlation with maximum and average power, while fairly correlate with minimum power (p<.05).

Discussion

The purpose of this study was to investigate the physical fitness of a sample composed of beach handball players. Also, the determinants

Table 2
Correlations between age, BMI, 15-meters sprint performance, change-of-direction ability, and anaerobic power performance.

	Male athletes			Female athletes		
	MARP	MIRP	ARP	MARP	MIRP	ARP
BMI						
R	−0.109	−0.227	−0.145	−0.415	−0.299	−0.411
Classification	poor	poor	poor	fair	poor	fair
p − value	.375	.251	.335	.070	.149	.078
R^2	–	–	–	–	–	–
Age						
R	0.572	0.746	0.609	0.550	0.453	0.512
Classification	mod.strong	mod.strong	mod.strong	mod.strong	fair	mod.strong
p − value	.033	.004	.023	.021	.052	.031
R^2	0.327	0.556	0.370	0.302	–	0.262
COD						
R	−0.667	−0.797	−0.754	−0.248	−0.365	−0.207
Classification	mod.strong	mod.strong	mod.strong	poor	fair	poor
p − value	.012	.002	.004	.392	.099	.239
R^2	0.444	0.635	0.568	–	–	–
Sprint						
R	−0.138	−0.143	−0.290	−0.577	−0.630	−0.681
Classification	poor	poor	poor	mod.strong	mod.strong	mod.strong
p − value	.343	.338	.194	.015	.008	.004
R^2	–	–	–	0.332	0.396	0.463

BMI = body mass index; MARP = maximum relative power; MIRP = minimum relative power; ARP = average relative power; COD = change of direction; mod.strong = moderately strong.

of anaerobic power performance were investigated. The demanding characteristics of a beach handball match highlights the need of adequate anaerobic power performance since there's a strong explosive component exemplified by the need of high-intensity intermittent sprints.[16] In this scenario, the adequate ability to endure this type of physical activity can be determined by distinct factors. A considerable amount of research highlights the relationship between distinct anthropometric measurements and performance in different sports.[17,18] However, in the present investigation, BMI did not display a significant correlation with anaerobic power performance in both sexes, nevertheless, age seemed to play an important role in this matter.

Aging has a considerable impact on an individual's decline in anaerobic capacity. In the present sample it was possible to observe a positive moderately strong correlation between power performance and age, considering most of the presented variables, and especially among males. Gent and Norton[19] presented a cross-sectional study measuring the relative change in the three energy systems across a 30-year age range. The results displayed that both anaerobic energy systems declined significantly with no change in aerobic capacity. On the other hand, Bagley et al.[20] observed a similar decline in both aerobic and anaerobic power with aging in a sample composed of endurance and power masters' athletes. It's worth mentioning that the expected decline in performance across the age spam may be a consequence not only of this natural process, but the reduction in levels of physical activity, a bias that should be considered in cross-sectional and longitudinal studies, however, this rationale may not apply to athletes. Still, in the present sample this positive correlation may reflect training adaptation, since this sample is composed of young individuals who are <30 years old and may not be suffering any deleterious effect of age on performance yet.

Change-of-direction (COD) ability has been associated with power capacity in a variety of studies composed of distinct athletic samples.[21,22] In the present study, COD was associated with lower limb power only among male athletes. Interestingly, Hornikova and Zemkova[23] observed in their review that usually COD ability is associated with explosive strength, however, none of the studies investigated used square test as testing tool. Different testing procedures may lead to distinct strategies while performing the activity. The adequate ability to coordinate movements and react to different cues, like the positioned cones, also influences adequate performance.[24]

It is well established that COD and agility can be determined by a wide set of distinct features like power, strength, muscle activation, and cognitive skills.[25,26] Also, differences between genders regarding kinematics during cutting maneuvers may help explain the results of the present study.[27] The authors of the present investigation also hypothesize that differences between genders in this sample may be explained by discrepancies in strength production capacity. It's worth highlighting that aside from the typical analysis of jumping performance and force production of knee flexors and extensors, it seems that hip and trunk muscles also play a relevant role in COD activities,[28] and this was not evaluated. In this study, a statistically significant difference between sexes regarding 15-meter sprint capacity was also observed, with male athletes displaying better performance. Nevertheless, sprint performance among males was not correlated to power which reinforces the perception that determinants of performance differ between sexes in a sample composed of elite handball athletes, and that adequate performance is a complex endeavor.

This study confirms that age is a significant determinant of anaerobic power in elite beach handball players, while BMI appears less relevant. These findings does not align with previous research showing age-related declines in anaerobic capacity. Interestingly, change-of-direction ability correlated with power only among male athletes, possibly due to differences in strength and kinematics between sexes. Future research should include body composition analysis and explore other factors influencing performance.

Conclusion

Age seems to be an important determinant of anaerobic power in a sample composed of elite beach handball players. On the other hand, BMI doesn't seem to play a relevant role on anaerobic power performance especially among males. The results also suggest that, aside from power, other factors may have greater influence on COD and sprint performance. These findings can help coaches tailor training programs aiming to enhance athletic performance focusing on power development. Future research should focus on body composition, playing position and other performance determinants.

Conflicts of interest

The authors declare that they have no competing interest.

Confidentiality of data

The authors declare that they have followed the protocols of their work center on the publication of patient data.

References

1. Pueo B, Jimenez-Olmedo JM, Penichet-Tomas A, Ortega Becerra M, Espina Agullo JJ. Analysis of time-motion and heart rate in elite male and female beach handball. *J Sports Sci Med*. 2017;16:450–458.
2. Sánchez-Sáez JA, Sánchez-Sánchez J, Martínez-Rodríguez A, Felipe JL, García-Unanue J, Lara-Cobos D. Global positioning system analysis of physical demands in elite women's beach handball players in an official Spanish championship. *Sensors*. 2021;21:850.
3. Lemos L, Nevill A, Duncan MJ, et al. Sport-specific skills differentiate performance levels better than anthropometric or physiological factors in beach handball. *Res Q Exerc Sport*. 2022;93:682–687.
4. Martínez-Rodríguez A, Sánchez-Sánchez J, Martínez-Olcina M, Vicente-Martínez M, Miralles-Amorós L, Sánchez-Sáez JA. Study of physical fitness, bone quality, and mediterranean diet adherence in professional female beach handball players: cross-sectional study. *Nutrients*. 2021;13:1911.
5. Martínez-Rodríguez A, Sánchez-Sánchez J, Martínez-Olcina M, et al. Professional male beach handball players performance profile. *Nutrients*. 2022;14:4839.
6. Sánchez-Malia L, Rodiles-Guerrero F, Pareja-Blanco M, Ortega-Becerra. Determinant factors for specific throwing and physical performance in beach handball. *Sci Sports*. 2022;37:141.
7. Ortega-Becerra M, Pareja-Blanco F, Jiménez-Reyes P, Cuadrado-Peñafiel V, González-Badillo JJ. Determinant factors of physical performance and specific throwing in handball players of different ages. *J Strength Cond Res*. 2018;32:1778–1786.
8. Mancha-Triguero D, González-Espinosa S, Córdoba LG, García-Rubio J, Feu S. Differences in the physical demands between handball and beach handball players. *Revista Brasileira de Cineantropometria e Desempenho Humano*. 2020;22:72114.
9. Gabrys T, Stanula A, Gupta S, et al. A comparative study on the performance profile of under-17 and under-19 handball players trained in the sports school system. *Int J Environ Res Public Health*. 2020;17:7979.
10. Citherlet T, Crettaz Von Roten F, Kayser B, Guex K. Acute effects of the wim hof breathing method on repeated sprint ability: a pilot study. *Front Sports Active Living*. 2021;3: 700757.
11. Andrade VL, Zagatto AM, Kalva-Filho CA, et al. Running-based anaerobic sprint test as a procedure to evaluate anaerobic power. *Int J Sports Med*. 2015;36:1156–1162.
12. Gonzalo-Skok O, Tous-Fajardo J, Suarez-Arrones L, Arjol-Serrano JL, Casajús JA, Mendez-Villanueva A. Single-leg power output and between-limbs imbalances in team-sport players: unilateral versus bilateral combined resistance training. *Int J Sports Physiol Perform*. 2017;12:106–114.
13. Mello JB, Pedretti A, Bergmann GG, Gaya AR, Ubago-Guisado E, Gaya ACA. Sprint and upper limbs power field tests for the screening of low bone mineral density in children. *Front Physiol*. 2022;13: 1066462.
14. Chan YH. Biostatistics 101: data presentation. *Singapore Med J*. 2003;44:280–285. a.
15. Chan YH. Biostatistics 104: correlational analysis. *Singapore Med J*. 2003;44:614–619. b.
16. Ingebrigtsen J, Jeffreys I, Rodahl S. Physical characteristics and abilities of junior elite male and female handball players. *J Strength Condition Res*. 2013;27:302–309.
17. Ziv G, Lidor R. Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. *Sports Med*. 2009;39:547–568.
18. Menargues-Ramírez R, Sospedra I, Holway F, Hurtado-Sánchez JA, Martínez-Sanz JM. Evaluation of body composition in CrossFit® athletes and the relation with their results in official training. *Int J Environ Res Public Health*. 2022;19(17):11003.
19. Gent DN, Norton K. Aging has greater impact on anaerobic versus aerobic power in trained masters athletes. *J Sports Sci*. 2013;31:97–103.

20. Bagley L, McPhee JS, Ganse B, et al. Similar relative decline in aerobic and anaerobic power with age in endurance and power master athletes of both sexes. *Scand J Med Sci Sports*. 2019;29:791–799.
21. McFarland IT, Dawes JJ, Elder CL, Lockie RG. Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. *Sports*. 2016;4:11.
22. Scanlan AT, Wen N, Pyne DB, et al. Power-related determinants of modified agility t-test performance in male adolescent basketball players. *J Strength Condition Res*. 2021;35:2248–2254.
23. Horníková H, Zemková E. The importance of core strength for change of direction speed. *Front Physiol*. 2024;15: 1376422.
24. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. *J Sports Sci*. 2006;24:919–932.
25. Spiteri T, Cochrane JL, Hart NH, Haff GG. Nimphius S. Effect of strength on plant foot kinetics and kinematics during a change of direction task. *Eur J Sport Sci*. 2013;13:646–652.
26. Spiteri T, Newton RU, Binetti M, Hart NH, Sheppard JM, Nimphius S. Mechanical determinants of faster change of direction and agility performance in female basketball athletes. *J Strength Cond Res*. 2015;29(8):2205–2214.
27. McLean SG, Lipfert SW, Van Den Bogert AJ. Effect of gender and defensive opponent on the biomechanics of sidestep cutting. *Med Sci Sports Exerc*. 2004;36(6):1008–1016.
28. Kozinc Ž, Smajla D, Šarabon N. The relationship between lower limb maximal and explosive strength and change of direction ability: comparison of basketball and tennis players, and long-distance runners. *PLoS ONE*. 2021;16(8): e0256347.