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**Original Article**

# Reliability of a linear sprint test on sand in elite female beach handball players

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**Abstract**:
Beach Handball (BH) is a new sport that emerged from handball in the 90s, its popularity has been increasing in recent decades to the point that it is postulated as an Olympic sport. This study examines the test-retest reliability of a sprint test executed on sand surface in elite beach handball players of the Spanish national team. Thirteen female players participate in this study (age: 24.6±4.3 years; height: 169.5±4.9 cm; body mass: 62.7±5.22 kg; body mass index (BMI): 21.8±1.38 kg/cm$^2$). Following a standardized warm-up protocol, the players make three consecutive attempts on the same day with three minute of recovery time between trials, race times were taken at 5 m and 10 m. The testing protocol consisted of a 10 m linear sprint, with timing gates placed at the start, 5 m and 10 m using Photocells. The test-retest consistency of the three attempts was studied through intraclass correlation coefficient (ICC), resulting in $ICC_{5m}$=0.8 (good); $ICC_{10m}$=0.88 (good), Pearson correlation (*r*), $r_{5m}$=0.81 (high); $r_{10m}$=0.91 (high), typical raw error ($TE_R$), $TE_{R5m}$=0.05 s; $TE_{R10m}$= 0.06 s, and typical standardized error (TEs), $TE_{S5m}$=0.47; $TE_{S10m}$= 0.38, change in mean (0.04 s to 0.06 s), coefficient of variation $CV_{5m}$=7.99%; $CV_{10m}$=6.58%.In addition, Bland-Altman graphs were made for a better analysis of the data showing high level of agreement in both distances. In conclusion, the use of photocells to measure the linear sprint time in elite beach handball players of the Spanish national team has proven to be a consistent method when test-retest reliability is studied in the distances of five and ten meters on sand surfaces.
**Key Words***:* **consistency, photocells, test-retest, evaluation, velocity.**

## Introduction

Beach Handball (BH) is a new sport that emerged from handball in the 90s (Sena et al., 2012). Its popularity has been increasing in recent decades to the point that it is postulated as an Olympic sport, as evidenced by the celebration of the 2018 Youth Olympic Games tournament in Argentina. Despite being a young sport, it has been included within the structure of the international handball federation, allowing BH to grow quickly and consolidate as a mediatic sport. Numerous competitions at international level have been celebrated, such as the world championships that began to be held in 2004 and continue until today, since the next championship will be held in 2022 in Greece (Pueo et al., 2020). Therefore, BH has become an elite sport in which the minimum differences are crucial and needs a training plan that allows optimizing the results to the maximum, controlling the different key factors as accurately as possible to win (Larsen et al., 2021).

Beach Handball, like many team sports such as football, field hockey, rugby, and handball, is characterized by numerous sprints executed at different intensities, fast changes of direction, jumps, physical confrontations, throws, blocks, and other specific movements. Many of these actions are derived from the handball technique (Pueo et al., 2017; Wagner et al., 2019). Despite this, several differences between the two sports make their physical demands different, such as the field, BH is played on a smaller court (27 x 12 m), or timing, two 10-min periods, and tiebreaker set if necessary. In addition, the number of field players is smaller, with only three players compared to five in indoor handball. This implies that the number of contacts is lower and could mean that each player performs more explosive actions (Lemos et al., 2020). But the main difference will be found in the nature of the BH field itself, the ground is formed of sand, which will condition the displacements (Gaudino et al., 2013; Silva et al., 2015), since it is an irregular surface that deforms when the player's foot confronts it (Penichet-Tomás et al., 2019), modifying the footprint. The internal load carried out will be greater when is compared to hard surfaces as a consequence of the above modifications performed by the athlete when running on sand surfaces (Pereira et al., 2022; Teixeira et al., 2021). Thus, the characteristics of the sprint that are going to be carried out in BH will be special and consequently need a specific analysis, which is adapted to the peculiarities of the sand (Larsen et al., 2021).

Sprint tests are common for athletes of many disciplines (Link et al., 2019; Macadam et al., 2019). Sprinting speed can be considered as a key factor in elite BH (Sánchez-Malia et al., 2022). Therefore, the outcomes from a sprint test can be used to individualize the exercise, adjusting the training loads for each position player, and helping to identify strengths and weaknesses in BH (Haff & Triplett, 2016). For this


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purpose, the data obtained from each athlete must be known accurately. viz., the test must be valid and reliable. Therefore, if the sprint tests are not consistent, errors can be reached that will result in the non-achievement of the desired objectives. Consequently, it is advisable to determine the reliability as part of its validity, understanding reliability as the consistency, or repeatability, of a measure (Thomas et al., 2015).

Altmannid et al. (2019) found that for more than 40 studies reviewed on a linear sprint in soccer players, intraclass correlations (ICC) of >0.75 with coefficient of variation (CV) < 3% for both intraday and interday reliability, obtaining the best result by using radars or photocells, and finding better result in longer distances. Global positioning systems (GPS), and accelerometers show less reliable results than photocells or time motion capture, but both are portable and easy to use tools, and its use is increasing (Macadam et al., 2019). In a study with young rugby players, it was found CV of 1.0% to 1.54% for photocells, 4.69% to 5.16% for GPS, and 5.43% to 14.12% for accelerometers (Waldron et al., 2011). On the other hand, there are no studies where reliability tests are carried out on sand. Hammami et al. (2022) determined the ICC of 5 and 10 m for handball players after seven weeks of sand training based, obtaining values of ICC of 0.914 and 0.907 for 5 m and 10 m respectively. However, despite the fact that the training routines were executed in the sand, the speed tests were carried out on a hard surface. Similarly, Larsen et al. (2021) found that ICC in test-retest for 5 m and 15 m using photocells, were 0.74 and 0.90 respectively (CV 1.30% and 0.83%), but these data are on a firm surface. Although the tests were also performed on sand, ICC was not determined, but both surfaces were compared, resulting in no correlation between surfaces for the time values of 5 m, and positive association in 15 m. This difference seems to indicate that the first strides in the sand, where the acceleration occurs, will differ significantly from those made on firm ground. These kinds of accelerations are common in BH and confirm the need to carry out the tests in the most realistic conditions possible to reach more valuable conclusions.

Therefore, the use of photocells to determine the time in sprints in beach handball players seems to yield acceptable reliability values on a hard surface. However, no studies were found where the tests were carried out on a sand, which is the surface on which the competition will take place. Consequently, obtaining data on the test-retest reliability of the sprint for elite female BH players is necessary to increase the knowledge of the validity of the sprint test on sand surfaces, and the velocities and tests can be accepted as valid for speed measurements in BH players. Despite the growing interest in BH, to the knowledge of the authors, no studies were found in which sprint test reliability measurements were made in BH players in sand surface. Therefore, the aim of this study was to determine the consistency, expressed as reliability in the test-retest of the linear sprint in the distances of five and ten meters on sand surface in elite BH players.

## Material & methods

*Participants*

The study sample was composed of 13 elite female BH players (age: 24.6±4.3 years; height: 169.5±4.9 cm; body mass 62.7±5.22 kg; Body mass index (BMI): 21.8±1.38 kg/cm$^2$) participating in the Annual Spanish Beach Handball Cup. They all were professional players belonging to the National Beach Handball Team of the Royal Spanish Handball Federation which ranked first in the World Championships held in Hungary, 2016. This sample represented the population of Spanish female international elite players. Subjects were instructed to conduct normal dietary habits and report to the measurement in a fully hydrated state. All participants were previously informed about the aims of the study, the experimental protocol, and the procedures of the study and voluntarily gave written informed consent to participate in the study, the Ethics Committee at the University of Alicante approved this study (IRB No. UA-2019-01-19) in accordance with the Declaration of Helsinki.

*Experimental design*

In this study, sprint test performance was carried out on a sand surface, with the purpose of determining the reliability of the test-retests on female BH players during the first call with the national team to prepare for the Beach Handball World Championship. Data were collected at beginning of June, during the third day of the stage after 12 h of rest since the last conditioning activity. Subjects were distributed in an aleatory way in groups of four people, the order in which tests were carried out both intragroup and between groups was established, and it was maintained until the end of the study.

*Test protocol*

A warm-up protocol was designed, which included five minutes of soft running, followed by dynamic mobility exercises and a second and specific part in which several 10 m sprints were carried out increasing the intensity of these progressively until they arrived near the maximum velocity at the end of the warm-up. After the warm-up, subjects made two 10-m sprints to familiarize the experimental protocol. Next subjects started with the first attempt of three, the starting position was standardized placing the distal phalanx of the foot behind the starting line without touching it, starting line was placed 1m behind the first time gate, photocells were located at 0, 5 and 10 m, the subjects began to run when they heard an acoustic signal and they were instructed to that run as fast as they could. Data were collected automatically from 0-5 m and 0-10 m gaps. After 5 minutes, subjects began the second attempt (Retest1) following the protocol identically to the first attempt and a third attempt was made 5 minutes after finished the second (Retest2). All procedures were performed on sand surfaces of the facilities set up for the practice of BH.

*Instruments*

Sprint times were measured using photocells (Polifemo Radio Light, Microgate, Bolzano, Italy) with a resolution of 0.125s (Trajkovi et al., 2020), transmitting information automatically through radio signals each time an infrared beam is cut.

*Statistical analysis*

Descriptive data are reported as mean and standard deviation (mean ± SD). The Shapiro–Wilk normality test was used, which resulted in a normal distribution. The reliability as the consistency of repeated measurements of 5 m and 10 m tests was evaluated using the intraclass correlation coefficient (ICC) for consecutive pairwise analysis of trials (Will G. Hopkins, 2015). It was also determined CV (%), typical observed and standardized errors (TE), changes in mean, and Pearson correlation. In all statistical tests, the confidence interval was set at 95%. In addition, Bland-Altman graphs were made for a better analysis of the data. To interpret the results, the following criteria were applied for changes in mean and Typical error: negligible (< 0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2), very large (2-4), and extremely large (>4) (Will G. Hopkins, 2015). ICC values were interpreted as poor (< 0.5), moderate (0.5-0.75), good (0.75-0.9) and excellent (> 0.9) reliability (Koo & Li, 2016). The guideline proposed by Cohen (1998) is followed to interpret the practical relevance of a Pearson correlation coefficient: 0.10, 0.30, and 0.50 can be interpreted as low, medium, and high, respectively. The analysis of the data obtained was performed using the statistical program SPSS 26.0 (IBM Statistics, Illinois, USA).

**Results**

Table 1 shows mean and standard deviation of the values of time obtained for the linear sprint tests in the two distances five a ten meter and each of the three trials.

Table 1. Linear sprint test times at 5 m and 10 m (mean ± SD)

| | Test (s) | Retest 1 (s) | Retest 2 (s) | Mean of tests (s) |
|---|---|---|---|---|
| 5 m | 1.22 ± 0.09 | 1.23 ± 0.1 | 1.21 ± 0.08 | 1.22 ± 0.09 |
| 10 m | 2.15± 0.13 | 2.12 ± 0.16 | 2.11±0.13 | 2.13 ± 0.01 |

Table 2 depicts the variables related to the consistency of the tests for the two distances. The standardized change in mean shows negligible or small values in all measures, whereas TE were small in all situations, and ICC values were interpreted as good for all tests.

Table 2. Reliability measures for linear sprint tests at 5 m and 10 m

| | 5 m | | | 10 m | | |
|---|---|---|---|---|---|---|
| | 2-1 | 3-2 | Mean of tests | 2-1 | 3-2 | Mean of tests |
| Change in mean (s) | 0.0 ± 0.04 | -0.01± 0.04 | | -0.03 ± 0.03 | -0.01 ± 0.06 | |
| $TE_R$ (s) | 0.05 (0.03-0.08) | 0.04 (0.03-0.04) | 0.05 (0.03-0.07 | 0.04 (0.03-0.07) | 0.07 (0.05-0.11) | 0.06 (0.04-0.08) |
| SE (observed SD, s) | 0.02 (0.01-0.03) | 0.02 (0.01-0.03) | 0.02 (0.01-0.03) | 0.03 (0.02-0.05) | 0.03 (0.02-0.05) | 0.03 (0.02-0.05) |
| Change in mean (stand.) | 0.01 ± 0.43 | -0.10 ± 0.45 | | -0.21± 0.24 | -0.10 ± 0.49 | |
| $TE_S$ | 0.51 (0.36-0.86) | 0.53 (0.38-0.87) | 0.47 (0.36-0.71) | 0.28 (0.20-0.46) | 0.49 (0.35-0.82) | 0.38 (0.29-0.57) |
| Pearson correlation | 0.81 (0.52-0.94) | 0.82 (0.48-0.94) | 0.81 | 0.95 (0.84-0.99) | 0.83 (0.52-0.95) | 0.91 |
| ICC | 0.83 (0.52-0.94) | 0.81 (0.50-0.94) | 0.81 (0.57-0.93) | 0.94 (0.82-0.98) | 0.83 (0.54-0.95) | 0.88 (0.70-0.96) |
| CV (%) | 7.56 | 7.56 | 7.99 | 6.73 | 6.85 | 6.58 |

s= seconds; SE= smallest effect; $TE_R$= Typical error (raw data); $TE_R$= Typical error (standardized data); SD = standard deviation; Stand. = standardized data; ICC= intraclass correlation; CV= Coefficient of variation

Figure 1 represents a Bland-Altman plot in which the consecutive attempts made for both sprint distances are compared.

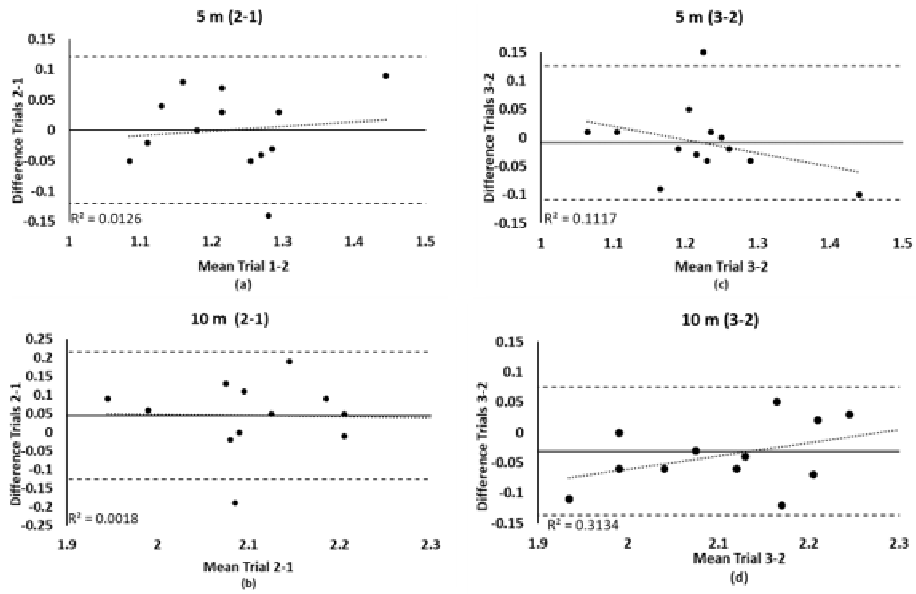


Figure 1. The solid line shows the mean between trials (systematic bias); upper and lower dashed lines show a mean ± 1.96*SD (random error). The scattered line shows regression (proportional bias).

**Discussion**

The aim of this study was to check if a linear sprint test for beach handball female players on a sand surface over the distance of 5 m and 10 m is reliable, and therefore it could be used in the future for the evaluation and control of speed test in sand surfaces, by using photocells. The main findings in the presented study are that ICC in a test-retest intraday determination, shows values that can be interpreted as good, high Pearson correlation coefficients and CV ranging from 6.58% to 7.99%, In addition, the values obtained for the changes in the standardized mean are interpreted as low or negligible, which suggests that the learning between repetitions is negligible. These results are in concordance with other studies that evaluate the reliability of the linear sprint (Altmannid et al., 2019), but broadly, the values obtained in this study are lower in terms of reliability. Bland- Altman plots showed high level of agreement since most of the points are within the upper and lower limits of agreement set at 95% (0.96*SD ± Mean).

When comparing the reliability of both distances, it can be seen that in general terms the distance of 5 m test yields values that indicate lower reliability than 10 m, despite the fact that the values of change in the mean are smaller (0.01 to -0.1 for 5 m and -0.21 to -0.1 for 10 m). $TE_S$ is bigger for 5 m sprint than 10 m (0.47 vs 0.38) which is symptomatic of the existence of a greater error in the 5 m tests, implying that reliability increases with distance. Values of $TE_R$ ranged from 0.05 to 0.06 s, therefore, it seems that the error is consistent over these distances. Also, the CV (absolute reliability) decreases as distance increases. These observations agree with the results obtained by Larsen et al. (2021) who detected a similar trend over distances of 5 m and 15 m, in a sample of beach soccer players. Nevertheless, the tests that these authors conducted for reliability were carried out on a firm surface and obtained lower CV values (1.30%) for 5 m test. Their results for ICC were smaller in 5 m (0.74) and similar for 15 m. In addition, they found significant differences between the results obtained on sand and those obtained on firm surface, highlighting the need to develop sand tests specific to each sport.

Photocells, despite being automated, are not exempt from error. The measurement will depend on the height of the time gate, its precision, and which part of the body: arm, chest, leg, or head cuts the light beam, (Bond et al., 2017; Condello et al., 2020; Cronin & Templeton, 2008; T. A. Haugen et al., 2012; T. Haugen & Buchheit, 2016). Furthermore, the 5 m sprint is included in the initial start, which could cause an increase in the error due to the variability of these mentioned factors and may affect the reliability. On the other hand, in the first meters of the sprint the acceleration occurs in a more accentuated way than in the following meters, where the maximum speed is reached and the movement stabilizes. In such phase, together with the start, the forces exerted against the ground will be greater. In an unstable surface as sand, this process will cause greater deformations and generate bigger instabilities, making each stride different in each attempt (Silva et al., 2015), the sum of these processes can add more variance to the test. Therefore, although the trends are comparable to other studies (Altmannid et al., 2019; Darrall-Jones et al., 2016; Link et al., 2019) the reliability values are slightly worse, especially for the 5 m test.

In addition, the values obtained are equivalent to or even better than those obtained by the sprint tests using inertial sensors, which are increasingly used, and most of them are validated for linear sprint tests (Macadam et al., 2019).

Although the small sample size is due to limited access to elite BH players, the obtained results indicate that the consistency of the sprint tests using photocells is acceptable. But more investigation with larger samples, possibly male, with sprints with longer distances and changes of direction, is needed to examine the reliability of sprints on sand surfaces for BH players or other related sports.

**Conclusions**

In conclusion, the use of photocells to measure the sprint time in elite beach handball players of the Spanish national team has proven to be a consistent and reliable method in the distances of five and ten meters on sand surfaces obtaining better results as the distance increases. Therefore, it can be considered as an ecological option for coaches and physical trainers to obtain accurate field data that allows to carry out an evaluation and control of the progress of top-level beach handball players in a more realistic way.

**Conflicts of interest**

All authors declare that they have no conflicts of interest.

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**References:**

Altmannid, S., Ringhof, S., Neumann, R., Woll, A., & Rumpf, M. C. (2019). *Validity and reliability of speed tests used in soccer: A systematic review*. https://doi.org/10.1371/journal.pone.0220982

Bond, C. W., WIllaert, E. M., & Noonan, B. C. (2017). Comparison of three timing systems: reliability and best practice recommendations in timing short-duration sprints. *Journal of Strength and Conditioning Research*, *31*(4), 1062–1071.

Cohen, J. (1998). Statistical power Analysis for the Behavioral sciences. In *Journal of the American Statistical Association* (Vol. 84).

Condello, G., Khemtong, C., Lee, Y. H., Chen, C. H., Mandorino, M., Santoro, E., Liu, C., & Tessitore, A. (2020). Validity and reliability of a photoelectric cells system for the evaluation of change of direction and lateral jumping abilities in collegiate basketball athletes. *Journal of Functional Morphology and Kinesiology*, *5*(3). https://doi.org/10.3390/JFMK5030055

Cronin, J. B., & Templeton, R. (2008). Timing Light Height Afects Sprint Times. *Journal of Strength and Conditioning Research*, *22*(1), 318–320. https://doi.org/https://doi.org/10.1519/jsc.0b013e31815fa3d3

Darrall-Jones, J. D., Jones, B., Roe, G., & Till, K. (2016). Reliability and usefulness of linear sprint testing in adolescent rugby union and league players. *Journal of Strength and Conditioning Research*, *30*(5), 1359–1364. www.nsca.com

Gaudino, P., Gaudino, C., Alberti, G., & Minetti, A. E. (2013). Biomechanics and predicted energetics of sprinting on sand: Hints for soccer training. *Journal of Science and Medicine in Sport*, *16*, 271–275. https://doi.org/10.1016/j.jsams.2012.07.003

Haff, G. G., & Triplett, N. (2016). *Essentials of Strength Training and Conditioning*. Human Kinetics Publishers Inc. https://doi.org/10.1016/s0031-9406(05)66120-2

Hammami, M., Gaamouri, N., Ramirez-Campillo, R., Aloui, G., Shephard, R. J., Hill, L., & Chelly, M. S. (2022). Effects of supplemental jump and sprint exercise training on sand on athletic performance of male U17 handball players. *International Journal Of Sports Science and Coaching*, *17*(2), 376–384. https://doi.org/10.1177/17479541211025731

Haugen, T. A., TØnnessen, E., & Seiler, S. K. (2012). The difference is in the start: impact of timing and start procedure on sprint running performance. *Journal of Strength and Conditioning Research*, *26*(2), 473–479.

Haugen, T., & Buchheit, M. (2016). Sprint Running Performance Monitoring: Methodological and Practical Considerations. *Sports Medicine*, *46*(5), 641–656. https://doi.org/10.1007/s40279-015-0446-0

Koo, T. K., & Li, M. Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/J.JCM.2016.02.012

Larsen, M. N., Ermidis, G., Brito, J., Ørner, C., Martins, C., Filipe Lemos, L., Krustrup, P., & Rago, V. (2021). Fitness and Performance Testing of Male and Female Beach Soccer Players-A Preliminary Investigation. *Frontiers in Sports and Active Living | Www.Frontiersin.Org*, *3*, 636308. https://doi.org/10.3389/fspor.2021.636308

Lemos, L., Oliviera, V., Duncan, M., Ortega, J., Martins, C., Campillo, R., Sanchez, J., Nevill, A., & Nakamura, F. (2020). *Physical fitness profile in elite beach handball players of different age categories*.

Link, D., Weber, M., Linke, D., & Lames, M. (2019). Can positioning systems replace timing gates for measuring sprint time in Ice Hockey? *Frontiers in Physiology*, *10*(JAN), 1882. https://doi.org/10.3389/FPHYS.2018.01882/BIBTEX

Macadam, P., Cronin, J., Neville, J., & Diewald, S. (2019). Quantification of the validity and reliability of sprint performance metrics computed using inertial sensors: A systematic review. *Gait and Posture*, *73*(July), 26–38. https://doi.org/10.1016/j.gaitpost.2019.07.123

Penichet-Tomás, A., Ortega Becerra, M., Jiménez-Olmedo, J. M., Pueo, B., & Espina Agulló, J. J. (2019). Incidencia lesiva en jugadores españoles de élite de balonmano playa (Incidence of injury in elite Spanish beach handball players). *Retos*, *36*, 83–86. https://doi.org/10.47197/retos.v36i36.66726

Pereira, L. A., Boullosa, D., Moura, T. B. M. A., Mercer, V. P., Fernandes, V., Bishop, C., & Loturco, I. (2022). Post-Activation Performance Enhancement in Sprinters: Effects of Hard Versus Sand Surfaces. *Journal of Human Kinetics*, *82*(1), 173–180. https://doi.org/10.2478/HUKIN-2022-0062

Pueo, B., Espina-Agullo, J. J., Selles-Perez, S., & Penichet-Tomas, A. (2020). Optimal body composition and anthropometric profile of world-class beach handball players by playing positions. *Sustainability (Switzerland)*, *12*(17). https://doi.org/10.3390/SU12176789

Pueo, B., Jimenez-Olmedo, J. M., Penichet-Tomas, A., Ortega Becerra, M., & Espina Agullo, J. J. (2017). Analysis of Time-Motion and Heart Rate in Elite Male and Female Beach Handball. In *©Journal of Sports Science and Medicine* (Vol. 16). http://www.jssm.org

Sánchez-Malia, J. M., Rodiles-Guerrero, L., Pareja-Blanco, F., & Ortega-Becerra, M. (2022). Determinant factors for specific throwing and physical performance in beach handball. *Science & Sports*, *37*(2), 141.e1-141.e6. https://doi.org/10.1016/J.SCISPO.2021.02.008

Sena, J. E. A., Gomes, A. L. J., Mimbacas, A., & Ferreira U.M.G. (2012). Dermatoglyph, somatotype and body composition in beach handball: comparative study among different level of sportive qualification/Dermatoglifia, somatotipo e composicao corporal no beach handball: estudo comparativo entre diferentes niveis de qualificacao esportiva. *Motricidade*, *8*(s2). https://go.gale.com/ps/i.do?id=GALE%7CA337071082&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=1646107X&p=AONE&sw=w&userGroupName=anon%7E32171b88

Silva, A. S., Coeli Seabra Marques, R., de Azevedo Lago, S., Guedes Santos, D. A., Lacerda, L. M., Silva, D. C., & Soares, Y. O. M. (2015). Physiological and nutritional profile of elite female beach handball players from Brazil. *The Journal of Sports Medicine and Physical Fitness*, *56*(5), 503–509. https://europepmc.org/article/med/25665744

Teixeira, A. S., Silva, J. F., Haupenthal, A., Nakamura, F. Y., Castagna, C., & Guglielmo, L. (2021). High-Intensity Intermittent Exercise Performed on the Sand Induces Higher Internal Load Demands in Soccer Players. *Front. Psychol*, *12*, 713106. https://doi.org/10.3389/fpsyg.2021.713106

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2015). Research Methods in Physical Activity. In *BMC Public Health* (seventh, Vol. 5, Issue 1). Human Kinetics. https://ejournal.poltektegal.ac.id/index.php/siklus/article/view/298%0Ahttp://repositorio.unan.edu.ni/2986/1/5624.pdf%0Ahttp://dx.doi.org/10.1016/j.jana.2015.10.005%0Ahttp://www.biomedcentral.com/1471-2458/12/58%0Ahttp://ovidsp.ovid.com/ovidweb.cgi?T=JS&P

Trajkovi, N., Sporiš, G., Krističevi, T., Madi, D. M., & Bogataj, Š. (2020). The Importance of Reactive Agility Tests in Differentiating Adolescent Soccer Players. *International Journal OfEnvironmental Researchand Public Health*. https://doi.org/10.3390/ijerph17113839

Wagner, H., Sperl, B., Bell, J. W., & von Duvillard, S. P. (2019). Testingspecific physical performance in male team handball playersand the relationship to general tests in team sports. *Journal of Strength and Conditioning Research*, *33*(4), 1056–1064. www.nsca.com

Waldron, M., Worsfold, P., Twist, C., & Lamb, K. (2011). Concurrent validity and test–retest reliability of a global positioning system (GPS) and timing gates to assess sprint performance variables. *Https://Doi.Org/10.1080/02640414.2011.608703*, *29*(15), 1613–1619. https://doi.org/10.1080/02640414.2011.608703

Will G. Hopkins. (2015). A spreadsheet to compare means of two groups. *Sportscience 19*, 36–44. https://sportsci.org/2015/ValidRely.htm