©Journal of Sports Science and Medicine (2010) **9,** 98-103
http://www.jssm.org

Research article

Heart rate and motion analysis by GPS in beach soccer

Julen Castellano [1]✉and David Casamichana [2]
[1] University of the Basque Country, [2] University of Malaga, Spain

Abstract
Although beach soccer has become increasingly popular in recent years very little scientific research has been conducted into the sport. A pilot study was carried out with the aim of examining the physiological (heart rate) and physical (motion analysis) responses of beach soccer players during competitive matches. Ten players (age 25.5 ±0.5 years; height 1.80 ± 0.08 m; weight 78.2 ±5.6 kg.) were studied over five beach soccer matches. The physiological demands were analysed by measuring heart rate (HR) using telemetric devices, while the physical profile was evaluated by recording motion and speed by means of GPS devices. During competitive matches, players obtained a HR_{mean} of 165.2 bpm (86.5% HR_{max}), with 59.3% of the time participating (TP) corresponding to values above 90% of the HR_{max}. The distance covered per minute of participation was 97.7 m, with 9.5% of this distance corresponding to high-intensity running and 2.5% to sprint; the work:rest ratio was 1.4:1 and the maximum speed 21.7 km·h^{-1}. These results showed that beach soccer is an intermittent physical activity of greater intensity than other team games. It requires a major contribution from the anaerobic system as emphasis is placed on players making quick bursts of high-intensity activity separated by brief rest periods.

Key words: Match, beach soccer, performance, motion analysis, heart rate.

Introduction

Beach soccer is one of the world's fasting growing sports, particularly since FIFA began to promote and organise it through competitive matches, courses and other initiatives (http://www.fifa.com/aboutfifa/developing/beachsoccer/).

The sport involves teams of five (four outfield players and a goalkeeper) with an unlimited number of substitutions, thus enabling play to be maintained at a high pace. Although the sport has been played in various recreational formats for several years now, it was not until 1992 that the rules of the game were established and a pilot tournament held in Los Angeles. The first professional beach soccer matches were played the following year in Miami Beach, and in 1995 the first World Beach Soccer Championship was organised, with Brazil the winners. This was followed by the first Pro Beach Soccer Tour in 1996 and the setting up of the Beach Soccer Euroleague in 1998.

Due to its rapid growth and appeal the sport was incorporated into the FIFA structure in 2004 and the first Beach Soccer World Cup was held on Copacabana beach Brazil in 2005, with France beating Portugal in the final. Despite this growth in its popularity, lack scientific research has been conducted into the sport and there are many aspects worthy of investigation (Scarfone et al., 2009).

In terms of the physical profile, and despite the fact that studies have been carried out with in different forms and levels of eleven-a-side soccer (Castagna et al., 2003; Di Salvo et al., 2007; Stroyer et al., 2004; Tessitore et al., 2005), soccer sevens (Capranica et al., 2001) and indoor soccer (Barbero et al., 2008) we have found no such research with respect to beach soccer. As regards the sport's physiological profile there is only one study (Scarfone et al., 2009), although as it focused on a friendly match without substitutions we believe that the physiological profile under match conditions may differ from that reported by these authors, due mainly to the fact that unlimited substitutions are permitted in competitive matches.

Recent technological developments (Carling et al., 2008) permits highly detailed analysis of factors relating the physical match performance. The incorporation of GPS technology into sport has enabled the physical profile to be investigated in many sporting disciplines as it allows players to be monitored at the same time and improves the effectiveness of the analysis period (Aughey and Fallon, 2010). Several studies have evaluated these devices on team sport activities and have achieved acceptable levels of accuracy and reliability (MacLeod et al., 2009) for most of the relevant measures in team sports that involve short demands and non-linear intermittent sprints. However, according to Coutts and Duffield (2010), they may offer poor reliability for high-intensity activities. This limitation may be of less relevance in the context of beach soccer as players can not run as high-intensities as in other forms of soccer, because a playing surface that does not enable such rapid movements as those attainable on other surfaces.

We believe that improving performance in a given sport requires specific training and that this is more effective when the demands of the sport are known (Pereira et al., 2007). In this regard both physical and physiological analysis provide highly useful information to both the scientific and applied community (Drust et al., 2007). Knowing the distance covered or the range of speeds attained in doing so can help in planning training sessions and developing suitable training programmes to improve the specific physical condition of participants. In addition, this information can also be used to evaluate players' performance (Barros et al., 2007).

The present pilot study aimed, in the context of Spanish official amateur beach soccer matches, to examine two aspects: the physiological response through the telemetric recording of heart rate (HR) and the physical

Received: 30 October 2009 / Accepted: 31 December 2009 / Published (online): 01 March 2010

Table 1. Beach soccer matches, periods, players, records and their duration.

No. of matches	No. of periods	No. of players	N. of records	Duration of each period	Total duration of match	TP
2	2	5	20	10 min	20 min	10.17 ± 1.38
2	2	5	20	12 min	24 min	12.27 ± 3.15
1	3	5	15	12 min	36 min	15.37 ± 3.47

Note: TP refers to the *time participating* of each player in minutes (min) and seconds ±standard deviation of each match.

response by means of GPS technology.

Methods

Participants

The study was conducted during the annual Spanish beach soccer championship held in July 2009. Although ten players took part in the matches studied only five of them (age 25.5 ± 0.5 years; height 1.80 ± 0.08 m; weight 78.2 ± 5.6 kg) were recorded (one out-and-out defender, two defenders who also went forward and two strikers who also dropped back). All the players were semi-professionals who competed in beach soccer tournaments at the end of their normal soccer season; they had an average of ten years experience in the official eleven-a-side game, as well as experience in beach soccer. Each player was informed about the research design and the requirements, benefits and risks of the study, and they all gave their informed consent prior to the start. In addition, the Ethics Committee at the University of the Basque Country gave institutional approval to this study, conforming to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

The games studied consisted of two matches of two 10-min periods, two matches of two 12-min periods and one match of three 12-min periods, thus giving a total of 55 records. Each player's contribution was considered in terms of the *time participating* (TP), defined as the time during which each participant was involved in play, i.e. any rest periods or time spent on the bench were excluded. The data were expressed in relative terms according to the number of minutes during which the participants were involved in play, thus enabling comparisons to be made both within and between matches. The TP values for each type of match are shown in Table 1.

Physiological variables: heart rate

The parameter used to evaluate the physiological component was HR, which was recorded at 5 s intervals during each match using telemetric devices (Polar Team Sport System, Polar Electro Oy, Finland). The HR of the five participants was continuously recorded during all the matches. The HR monitors were also worn during the YYIRT1 (Bangsbo et al., 2008) in order to determine the maximum heart rate (HR_{max}) of each player (Krustrup et al., 2003). This value was then used as a standard against which to define four intensity zones: *<75%, 76–84%, 85–89%* and *>90%*HR_{max}. We quantified the percentage of time spent within each intensity zone during the competitive matches, as well as the mean heart rate (HR_{mean}) and the HR_{max} reached in each match, expressed in both absolute values (beats per min: bpm) and relative values (percentage of maximum heart rate [*%*HR_{max}] and mean heart rate [*%*HR_{mean}]).

Physical variables: speed and distance covered

The players' movement during five competitive matches was measured using a portable GPS device (MinimaxX, Team Sports 2.0, Catapult Innovations). A continuous recording was made using these GPS devices at a sampling frequency of 5 Hz for the same five players during all the matches. For the data analysis five speed zones were established: *stationary–walking* (0–3.9 km·h^{-1}), *jogging* (4.0–6.9 km·h^{-1}), *quick running* (7.0–12.9 km·h^{-1}), *high-intensity running* (13.0–17.9 km·h^{-1}) and *sprint* (>18 km·h^{-1}). The speed zones and movement categories chosen are similar to those used in other studies conducted in different sports (Barros et al., 2007; Di Salvo et al., 2007; Rampinini et al., 2007). However, given that the present study involves a playing surface that does not enable such rapid movements as those attainable on other surfaces (the maximum speed achieved by players did not exceed 21.7 km·h^{-1}) the speed categories were adapted accordingly. The physical variables studied were: total distance covered in the TP (when the player is on the pitch), the maximum speed, the percentage of distance covered in each one of the speed categories, the *work:rest* ratio (estimated using the distance covered at a speed of 0–3.9 km·h^{-1}

Table 2. Absolute and relative values of heart rate for all the players (5) and matches (11 measurements for each participant): mean, standard deviation (±SD) and confidence interval (CI–95%) with respect to the *time of participation* (TP), as well as the temporal distribution in the different intensity zones.

	Mean (±SD)	CI–95%	%TP
HR_{mean} (bouts·min^{-1})	165 ± 20	155–175	
%HR_{mean}	86.5 ± 9.6	81.7–91.3	
HR_{max} (bouts·min^{-1})	188 ± 6	185–191	
%HR_{max}	98.5 ± 2.2	97.4–99.6	
HR_{min} (bouts·min^{-1})	121 ± 5	109–134	
%HR_{min}	63.5 ± 2.3	57.3–69.6	
<75% HR_{max} (min:sec)	02:43 ± 04:40	00:24–05:02	18.8 %
76–84% HR_{max} (min:sec)	01:02 ± 00:43	00:40–01:23	8.8 %
85–89% HR_{max} (min:sec)	01:38 ± 01:07	01:05–02:12	12.1 %
>90% HR_{max} (min:sec)	07:45 ± 04:34	05:28–10:01	59.3 %

Note. HR_{max} is the maximum heart rate, HR_{mean} is the mean heart rate and HR_{min} is the minimum heart rate. The relative values refer to the% of the $HR_{max.}$

Table 3. Time participating and distribution of time according to running intensity: mean, standar deviation (± SD) and confidence interval (CI-95%). Percentage of distance covered in each speed category for all the players considering only their time participating (TP) (n = 55 measurements).

	Mean (±SD)	CI–95%	%TP
Time participating (min:sec)	11:48 ± 3:05	10:28–13:09	
Maximum speed (km·h^{-1})	21.67 ± 4.5	19.7–23.6	
Stationary-walking (min:sec)	5:17 ± 2:23	4:17–06:18	43.67 %
jogging (min:sec)	3:04 ± 0:43	2:46–03:23	26.50 %
Quick running (min:sec)	2:25 ± 0:49	2:14–02:56	22.79 %
High-intensity running (min:sec)	0:26 ± 0:11	0:21–00:31	3.79 %
Sprint (min:sec)	0:05 ± 0:05	0:03–00:07	0.87 %
Work:rest ratio	1.4 ± 0.6	1.1–1.6	

as a 'rest' period, while all the categories with speeds above 4 km·h^{-1} were considered as 'work' or 'activity'), and the effort rate at different intensities; the latter was expressed in absolute terms (TP), indicating the mean number of efforts made per match, and in relative terms as each *minute of participation* (MP). The typical error expressed as a coefficient of variation (CV) (Hopkins, 2000) was 4.6% for total distance, 7.6% for *stationary–walking* (0–3.9 km·h^{-1}), 4.6% for *jogging* (4.0–6.9 km·h^{-1}), 6.5% for *quick running* (7.0–12.9 km·h^{-1}), 8.9% for *high-intensity running* (13.0–17.9 km·h^{-1}) and 18.9% for *sprint* (>18 km·h^{-1}). The CV for peak speeds was 4.4%.

Statistical analysis

Due to the nature of the study and the small sample the data are mainly presented in descriptive terms, using means, standard deviations (±SD) and the 95% confidence interval (CI-95%). All the statistical analyses were performed using *SPSS 16.0 for Windows* (SPSS Inc, Chicago, USA).

Results

Physiological response

Table 2 shows the physiological characteristics associated with the mean values obtained in the competitive beach soccer matches, the mean heart rate corresponding to 86.5% of the HR_{max}; the maximum values obtained during the matches reached 98.5% of the HR_{max}. With regard to the percentage of time corresponding to each intensity zone, it can be seen that the category *>90% HR_{max}* accounts for the largest time percentage, while the least amount of time corresponded to 75–84% of the HR_{max}.

Physical response

During the mean time of 11.48 min played by each player in each match (TP) the distribution of running speeds is as shown in Table 3. The maximum speeds attained were less than 22 km·h^{-1}. For almost half the time (43.7%) players were stationary or walking, while around a quarter of the time (26.5%) they were engaged in *jogging*. Around 30 s were spent on high-intensity running or sprints.

As regards their movement, players covered a total distance of 1135 ± 26.8 m during their TP, with a relative distance of 97.7 ± 15.1 m per min (m·min^{-1}) in the MP. The distribution of distances covered at different intensities is shown in Table 4. As can be seen the categories *quick running* (7.0–12.9 km·h^{-1}) and *jogging* (4.0–6.9 km·h^{-1}) are those in which players cover the most distance.

The number of efforts corresponding to each player also follows a particular distribution. Table 5 presents these values in the TP (absolute) and MP (relative or per min) for the matches analysed.

Table 6 presents the effort rate according to the speed categories and the distances covered, showing that the latter differs as a function of the former. It can be seen that efforts in which a player covers more than 5 m are the most common in the categories of highest intensity.

Figure 1 shows the mean distance and duration of efforts during the competitive matches for each speed category, showing that the longest mean distance and the longest mean duration were both achieved in the quick running category (7.0–12.9 km·h^{-1}).

Discussion

This study aimed to examine the physical and physiological response of players during several matches of an amateur beach soccer tournament.

To the best of our knowledge only one study (Scarfone et al., 2009) has recorded the physiological profile of beach soccer players, although this was during a friendly in which all the players played three periods of a full twelve minutes. This differs from competitive matches in which unlimited substitutions are allowed, a ruling that the teams usually take advantage of in order to get the

Table 4. Absolute and relative distances covered and distances in relation to the running intensity: mean, standard deviation (±SD) and confidence interval (CI-95%). Percentage of distance covered in each speed category for all the players considering only their time participating (TP) (n = 55 measurements).

	Mean (±SD)	CI–95%	%TP
Distance TP (m)	1135 ±26.8	1020.9–249.9	
Distance MP (m)	97.7 ±15.1	91.2–104.2	
Stationary-walking (m·min^{-1})	21.4 ±3.9	19.7–23.0	22.92 %
jogging (m·min^{-1})	25.6 ±4.9	23.5–27.7	26.08 %
Quick running (m·min^{-1})	36.3 ±11.4	31.5–41.3	36.21 %
High-intensity running (m·min^{-1})	9.5 ±3.3	8.1–10.9	9.46 %
Sprint (m·min^{-1})	2.6 ±2.4	1.6–3.6	2.54 %

Table 5. Frequency of effort according to each movement category, expressed in absolute terms (TP) and relative terms (per min, MP); mean, standard deviation (±SD) and confidence interval (CI-95%) (n = 55 measurements).

	Absolute (TP)		Relative (MP)	
Speed zones	Mean (±SD)	CI–95%	Mean (±SD)	CI–95%
4–6.9 km·h^{-1}	60 ± 17.0	52.8–67.2	5.1 ± .7	4.8–5.4
7.0–12.9 km·h^{-1}	37.6 ± 10.4	33.2–42.0	3.2 ± .6	2.9–3.5
13.0–17.9 km·h^{-1}	11.7 ± 4.6	9.7–13.6	1.0 ± .3	0.9–1.1
>18 km·h^{-1}	2.6 ± 2.1	1.7–3.5	.2 ± .2	0.1–0.3

most out of players at each point. For this reason the present results will be compared with those obtained in studies of other forms of soccer (such as five-a-side) or other team sports (basketball or handball), which have similar characteristics in terms of dimensions, number of players involved and a rule allowing unlimited substitutions.

As regards physiological intensity a high percentage of time corresponded to high-intensity zones (59.3% of time in the category *>90% HR_{max}*), this being consistent with the findings of Scarfone et al. (2009). Both the HR_{mean} and the percentages of time spent in each intensity zone show similar (although slightly lower) values to those obtained in studies of indoor soccer (Barbero et al., 2008; Castagna et al., 2009) and basketball (Matthew and Delextrat, 2009), where substitutions are also unlimited. Whereas in the case of indoor soccer and basketball the HR_{mean} was 90% and 92.5% of the HR_{max}, respectively, with 83.2% and 93.1% of time participating corresponding to values above 85% of the HR_{max}, the present study obtained a HR_{mean} of 86.5% of the HR_{max}, with 71.4% of time participating being above 85% of the HR_{max}. In situations in small-sided soccer games the HR_{mean} ranges between 83% and 90% of the HR_{max} in terms of different structural variables of training such as the number of players participating in the task, the dimensions of space and the encouragement of coach (Hill-Haas et al., 2009; Katis and Kellis, 2009; Rampinini et al., 2007). However, it should be remembered that this comparison involves different modalities played by players of a different level on playing surfaces that are not always similar. This point needs to be underlined since for the same speed the energy expended when running or walking on sand is greater (Pinnington and Dawson, 2001; Zamparo et al., 1992). Caution should therefore be exercised when interpreting the physiological and physical profile for activities played on this kind of surface.

With respect to the physical analysis it is worth noting that the mean distance covered per match in the TP was 1135 m. However, this distance is influenced by the length of time each player is on the pitch. Therefore, it cannot be used as an indicator of the players' particular physical performance, as would be the case in standard soccer or rugby where the number of substitutions is limited. As pointed out by Barbero et al. (2008), in sports that allow unlimited substitutions the distance covered per minute (MP) is more representative of the general intensity of the activity performed and can be used as a global index of the match's intensity. In our case this took a value of 97.7 m·min^{-1}. This distance in MP is less than that reported by studies of indoor soccer players: 117.3 m·min^{-1} (Barbero et al., 2008) and 121 m·min^{-1} (Castagna et al., 2009), recorded using two-dimensional photogrammetry, and 118 m·min^{-1} (Barbero & Castagna, 2007), recorded using similar GPS technology to that employed in the present study. The distance recorded in the present study is also less than that obtained in young Brazilian soccer players, who covered 118, 105 and 109 m·min^{-1} at the under-15, under-17 and under-19 levels, respectively (Pereira et al., 2007) and that reported for small-sided soccer games with different formats, with distances close to 107 m·min^{-1}(Hill-Haas et al., 2009). In addition, it is less than the 100 m·min^{-1} reported for Spanish pre-adolescents (Barbero et al., 2007). Finally, it should be noted that the values obtained here are higher than those reported using GPS technology (83.7 m·min^{-1}) with rugby players (Cunniffe et al., 2009).

As regards the maximum speed reached at specific points in the matches (21.7 km·h^{-1}) it is important to mention the handicap imposed by the playing surface in beach soccer. Sand reduces the maximum force and the maximum applied power, increasing the time of impact and impulse (Barrett et al., 1997; Giatsis et al., 2004). This type of surface absorbs part of the applied energy, reducing the reaction force (Bishop, 2003), and this can lead to a lower maximum speed of movement due to the sand's instability (Giatsis et al., 2004).

The *work:rest* ratio is a fairly general measure that provides information about the nature of the activity. In the present study its value of 1.4:1 (for every minute of '*rest*' there are 1.4 minutes of '*work*') reflects the intermittent nature of a very high-intensity sport. This figure is close to that obtained in indoor soccer (1:1), but differs considerably from the values reported for sports that do not allow unlimited substitutions: 1:5.7 in rugby (Cunniffe et al., 2009) or 1:3.5 in young soccer players (Barbero et al., 2007).

With regard to the mean distances and durations of the different movement categories, the mean distance

Table 6. Frequencies according to distance covered and speed of the recorded efforts, the values showing the mean, standard deviation (±SD) and the confidence interval (CI-95%) (n = 55 measurements).

	Distances for each effort					
	0–5 m		5–10 m		10–40 m	
Speed zones	Mean (±SD)	CI–95%	Mean (±SD)	CI–95%	Mean (±SD)	CI–95%
4–6.9 km·h^{-1}	44.5 ± 15.4	37.8–51.2	12.7 ± 4.0	11.03–14.45	3.3 ± 1.8	2.6–4.1
7.0–12.9 km·h^{-1}	10.9 ± 4.3	9.0–12.7	12.6 ± 5.2	10.4–14.9	14.0 ± 5.3	11.7–16.3
13.0–17.9 km·h^{-1}	2.3 ± 1.0	1.8–2.7	6.1 ± 2.9	4.8–7.4	3.4 ± 1.9	2.6–4.2
>18 km·h^{-1}	–	-	1.7 ± 1.5	1.1–2.4	1.0 ± 1.5	0.4–1.6

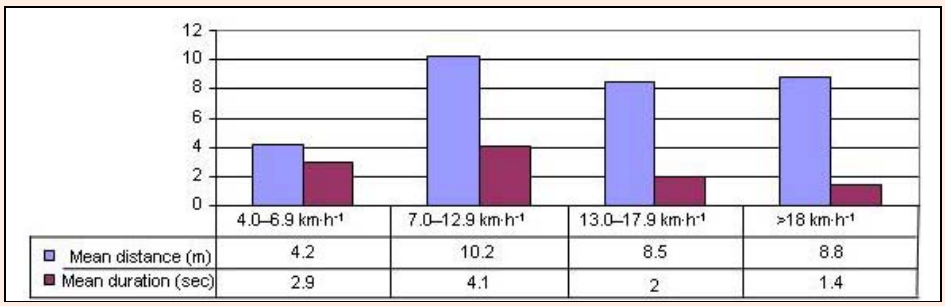

Figure 1. Mean distance and duration of efforts according to the speed categories.

covered during the highest intensity efforts was 8-10 m, while their duration was less than 2 s. This illustrates the importance in beach soccer of players being able to make quick bursts of acceleration, which is more relevant than the maximum speed reached since efforts are short in both duration and distance covered. As a result, players do not reach the maximum speed they would attain on other surfaces.

This study is the first to describe the time–motion characteristics in beach soccer. However, one limitation of the present study concerns the interpretation of the time-motion results, because the GPS units have been shown reliability at high-intensity running being relatively poor (Petersen et al., 2009).

Conclusion

It can be concluded that beach soccer is an intermittent sport of very high intensity whose physiological profile shows that more than half the time is spent at intensities above 90% of the HR_{max}, thus requiring large amounts of energy via the anaerobic system (Scarfone et al., 2009). The distance covered per minute of play is around 100 m with a *work:rest* ratio of 1.4:1. The durations and distances covered at high intensity are short but repeated, thus underlining the importance of players' ability to make continuous bursts of acceleration. These data should be taken into account when proposing training protocols in this mode, prioritizing actions intermittent high intensity and short duration with breaks lasting less working time.

As this study is descriptive in nature and only includes a small number of subjects and matches it does not address certain important aspects such as variations produced by fatigue over successive matches or the level of individual players. Furthermore, given the small sample size it did not seem appropriate to focus on the specific playing positions. However, we believe that this should be done in future research as studies of other sports have shown how the physical demands of each position vary (Di Salvo et al., 2007; 2009). This more specific focus would increase our knowledge of beach soccer and help to improve training programmes by developing their degree of specificity. Only thus will it be possible to apply knowledge of the sport's physical and physiological demands in a more detailed way.

Acknowledgments

This study is part of the project entitled *Avances tecnológicos y metodológicos en la automatización de estudios observacionales en deporte*, funded by Spain's Dirección General de Investigación, Ministerio de Ciencia e Innovación (PSI2008-01179) over the period 2008-2011. The authors would also like to thank the University of the Basque Country and sports material company RANKING S. L. for providing the *GPS MinimaxX* devices used in carrying out the study.

References

Aughey, R. and Fallon, C. (2010) Real-time versus post-game GPS data in team sports. *Journal of Science and Medicine in Sport*, in press.

Bangsbo, J., Iaia, M., and Krustrup, P. (2008) The yo-yo intermittent recovery test. A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine* **38**, 37-51

Barbero, J. C., Soto, V. M., Barbero, V. and Granda, J. (2008) Match analysis and heart rate of futsal players during competition. *Journal of Sports Sciences* **26**, 63-73.

Barbero, J. C., Barbero, V. and Granda, J. (2007) Perfil de actividad durante el juego en futbolistas infantiles. *Apunts. Educación Física y Deportes* **4**, 33-41.

Barbero, J. C. and Castagna, C. (2007) Activity patterns in professional futsal players using global position tracking system. *Journal of Sports Science and Medicine* **6**, 208-209.

Barrett, R., Neal, R. and Roberts, L. (1997) The dynamic loading response of surfaces encountered in beach running. *Journal of Science and Medicine in Sport* **1**, 1-11.

Barros, R.M.L., Misuta, M.S., Menezes, R.P., Figueroa, P.J., Moura, F.A., Cunha, S.A., Anido R. and Leite, N.J. (2007) Analysis of the distance covered by the first division Brazilian soccer players obtained with an automatic tracking method. *Journal of Sports Science and Medicine* **6**, 233-242.

Bishop, D. (2003) A comparison between land and sand-based tests for beach volleyball assessment. *Journal of Sports Medicine and Physical Fitness* **43**, 418-423.

Capranica, L., Tessitore, A., Guidetti, L. and Figura, F. (2001) Heart rate and match analysis in pre-pubescent soccer players. *Journal of Sports Sciences* **19**, 379- 384.

Carling, C., Bloomfield, J., Nelsen, L. and Reilly, T. (2008) The role of motion analysis in elite soccer: contemporary performance measurement techniques and work rate data. *Sport Medicine* **38**, 839-862.

Castagna, C., D'Ottavio, S. and Abt, G. (2003) Activity profile of young soccer players during actual match play. *Journal of Strength and Conditioning Research* **17**, 775-780.

Castagna, C., D'Ottavio, S., Granda, J. and Barbero, J. C. (2009) Match demands of professional Futsal: a case study. *Journal of Science and Medicine in Sport* **12**, 490-494.

Coutts, A. and Duffield, R. (2010) Validity and reliability of GPS devices for measuring movement demands of team sports. *Journal of Science and Medicine in Sport* **13,** 133-135.

Cunniffe, B., Proctor, W., Baker, J. and Davies, B. (2009) An evaluation of the physiological demands of elite rugby union using global positioning system tracking software. *Journal of Strength and Conditioning Research* **23**, 1195-1203.

Di Salvo, W., Baron, R., Tschan, H., Calferon, F. J., Bachi, N. and Pigozzi, F. (2007) Performance characteristics according to playing position in elite soccer. *International Journal of SportsMedicine* **28**, 222-227.

Di Salvo, W., Gregson, W., Atkinson, G., Tordoff, P. and Drust, B.

(2009) Analysis of high intensity activity in premier league soccer. *International Journal of Sports Medicine* **30**, 205-212.
Drust, B., Atkinson, G. and Reilly, T. (2007) Future perspectives in the evaluation of the physiological demands of soccer. *Sports Medicine* **37**, 783-805.
Giatsis, G., Kollias, I., Panoutsakopoulos, V. and Papaiakovou, G. (2004) Biomechanical differences in elite beach-volleyball players in vertical squat jump on rigid and sand surface. *Sports Biomechanics* **3**, 145-158.
Hill–Haas, S., Dawson, B., Coutts, A. and Rowsell, G. (2009) Physiological responses and time–motion characteristics of various small–sided soccer games in youth players. *Journal of Sports Sciences* **27**, 1–8.
Hopkins, W. G. (2000) Measures of reliability in sports medicine and science. *Sports Medicine* **30**, 1–15.
Katis, A. and Kellis, E. (2009) Effects of small-sided games on physical conditioning and performance in young soccer players. *Journal of Sports Science and Medicine* **8**, 374-380.
Krustrup, P., et al. (2003). The Yo–Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity. *Medicine and Science in Sports and Exercise* **35**, 697-705.
MacLeod, H., Morris, J., Nevill, A. and Sunderland, C. (2009) The validity of a non- differential global positioning system for assessing player movement patterns in field hockey. *Journal of Sports Sciences* **27**, 121-128.
Matthew, D. and Delextrat, A. (2009) Heart rate, blood lactate concentration, and time-motion analysis of female basketball players during competition. *Journal of Sports Sciences* **27**, 813-821.
Pereira, N., Kirkendall, D. T. and Barros, T. L. (2007) Movement patterns in elite Brazilian youth soccer. *Journal of Sports Medicine and Physical Fitness* **47**, 270-275.
Petersen, C., Pyne, D., Portus, M. and Dawson, B. (2009) Validity and Reliability of GPS Units to Monitor Cricket-Specific Movement Patterns. *International Journal of Sports Physiology and Performance* **4**, 381-393.
Pinnington, H. C. and Dawson, B. (2001) Running economy of elite surf iron men and male runners, on soft dry beach sand and grass. *European Journal of Applied Physiology* **86**, 62-70.
Rampinini, E., Coutts, A., Castagna, C., Sassi, R. and Impellizzeri, F.M. (2007) Variation in top level soccer match performance. *International Journal of Sports Medicine* **28**, 1018-1024.
Rampinini, E., Impellizzeri, F.M., Castagna, C., Abt, G., Chamari, K., Sassi, A. and Marcora, S.M. (2007) Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences* **25**, 659-666.
Scarfone, R., Tessitore, A., Minganti, C., Ferrragina, A., Capranica, L. and Ammendolia, A. (2009) Match demands of beach soccer: a case study. In: *Book of abstracts of 14th Annual Congress of the European College of Sport Science*. July 24-29, Oslo-Norway. 54.
Stroyer, J., Hansen, L. and Klausen, K. (2004) Physiological Profile and Activity Pattern of Young Soccer Players during Match Play. *Medicine and Science in Sports and Exercise* **36**, 168-174.
Tesittore, A., Meeusen, R., Tiberi, M., Cortis, C., Pagano, R. and Capranica, L. (2005) Aerobic and anaerobic profiles, heart rate and match analysis in older soccer players. *Ergonomics* **48**, 1365-1377.
Zamparo, P., Perini, R., Orizio, C., Sacher, M. and Ferretti, G. (1992) The energy cost of walking or running on sand. *European Journal of Applied Physiology* **65**, 183-187.

Key points

- The distance covered per minute of play is around 100 m.
- Beach soccer is an intermittent sport with a *work:rest* ratio of 1.4:1.
- The playing surface in beach soccer is an important handicap to obtain maximum speeds.
- Beach soccer has a high physiological intensity, with more than half of the game is spent at intensities above 90 % of the HRmax.

AUTHORS BIOGRAPHY

Julen CASTELLANO
Employment
Professor at Basque Country University (UPV-EHU), Spain
Degree
PhD
Research interests
Performance analysis in team sports; Methodology in Behavioural Sciences.
E-mail: julen.castellano@ehu.es

David CASAMICHANA
Employment
PhD Student, Málaga University (Spain)
Degree
MSc
Research interests
Physiological development in soccer athletes.
E-mail: davidcasamichana@gmail.com

✉ **Julen Castellano**
University of the Basque Country, Faculty of Physical Activity and Sport Sciences, C/ Lasarte 71, 01007 Vitoria, Álava, Basque Country, Spain