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MATCH ANALYSIS AND HEART RATE OF BEACH SOCCER PLAYERS DURING AMATEUR COMPETITION

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ABSTRACT

The aim of this study was to examine the physiological responses and activity patterns of a friendly beach soccer match involving varsity players. Ten male players (age 23.6 ± 4.4 yrs; body mass 71.8 ± 3.8 kg; height 1.77 ± 0.05 m) of a university beach soccer varsity team were recruited. A friendly match was arranged to evaluate heart rates, blood lactate, power performance of the lower limbs, match activities (time motion analysis (TMA) considering: standing, walking, low-intensity running, medium-intensity running, high-intensity running and sprinting), and match technical and tactical aspects (passes in the action, player involved in an action, shots, goals, and the origin and types of shot). The match imposed a mean heart rate (HR) of 166 beats·min^{-1} (*SD* = 16), corresponding to an overall mean of 85.3% (*SD* = 8) of the theoretical (220-age) HR_{max}. The mean value of blood lactate was 6.20 mmol·l^{-1}. The results of TMA showed that for approximately 51% of the match, the players performed very low-intensity activities and only 3% at maximum intensity. Finally, the notational analysis (NA) showed that during 60.8% of the offensive actions only 2 players were involved and 54.1% of the offensive actions were performed by one pass. These results indicate that beach soccer is an intermittent sport of high intensity with a significant involvement of anaerobic metabolism. The results of TMA and NA clearly underscore that sand does not favour the movements of players and, in particular, high-intensity running. Furthermore, the organization of teamwork is difficult to implement, because irregular rebounds often prevent precise passes among the players.

Keywords: Blood lactate, Fitness, Football, Performance analysis, Team sport

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INTRODUCTION

Beach soccer started in Brazil in the 1930s (Coelho, 2002). Originally, it was conceived as a different form of soccer played on a sand surface, with the main purpose of maintaining the trained players’ technical skills during the summer break. Over the years this game increased its popularity worldwide, played in different formats (Costa, 2006). Thus, in 1993, the USA hosted the first professional international competition in Miami (Florida, USA). Thereafter, beach soccer has become a truly global sport, as evidenced by the participation of teams, coming from

16 countries of the world, in the 2009 FIFA Beach Soccer World Cup (Dubay, United Arab Emirates). Whilst the last few years have seen beach soccer players coming mainly from soccer and futsal, at present they are more and more specialized in this sport. However, despite its growing popularity, which enables it to be played both at amateur and professional level, there is still a paucity of studies regarding the different aspects of beach soccer (Scarfone et al., 2009). Indeed, to the best of our knowledge only two AA (Castellano & Casamichana, 2010) have investigated beach soccer, studying HR and motion analysis by GPS, while there are a lot of studies investigating futsal, reporting data about cardiovascular changes, HR and match analysis (Castagna et al., 2007; Barbero-Alvarez et al., 2008; Tessitore et al., 2008; Barbero-Alvarez, 2010) and plenty on soccer that have studied the physiological aspects and match analysis (Mohr et al., 2003; Stolen et al., 2005; Drust et al., 2007). A beach soccer match is played on a sand surface pitch (35/37 x 26/28 m) and consists of three 12-minute periods, with 5 players per team on the field (one of whom is the goalkeeper) and an unlimited number of substitutions (FIFA, 2008). It can be classed as an invasion game (Hughes & Bartlett, 2002), characterized by intermittent physical activity (Castellano & Casamichana, 2010), in which the periods vary in intensity and duration and are alternated by recovery pauses. Thus, the patterns of movement defy precise modelling and the discrete events do not occur in a predictable sequence (Drust et al., 2007). However, the game profile of beach soccer is affected by the specific sand surface of the pitch, which does not enable the players to cover the same short distances with the speeds achievable in futsal and soccer (Castellano & Casamichana, 2010). In fact, the dynamic loading response on sand differs from those obtained on the different pitch surfaces used in other team sports (i.e., soil, natural and artificial grass, hard wood), because the sand surface determines differences in running technique and the rate extent of musculoskeletal loading (Barrett et al., 2008). In addition, it has been shown that running on sand surfaces is affected by the density and distribution of the sand (i.e. deep or easy moving sand), and determines a higher work load due to the increased work done by the lower extremity (Lejeunne et al.,1998; Giatsis et al., 2004). Furthermore, another activity affected by the sand pitch surface is jumping, a study on volleyball players performing 4 different vertical jumps demonstrated different jump height values significantly lower on sand than on land (Bishop, 2003). Considering the aforementioned aspects determined by the pitch surface, in order to analyse the TMA of beach soccer players, the speed zones of the different movement categories have to be modified as suggested by Castellano & Casamichana (2010) compared with those utilized for soccer and futsal (Bangsbo et al., 1991; Barbero et al., 2008). For instance, Castellano & Casamichana (2010) observed a limit of 21.7 $km \cdot h^{-1}$ for the maximum speed achieved by the players during competitive matches, whilst in elite soccer this velocity can be classed as high-intensity running (HIR) activity (Di Salvo et al., 2009). Considering that knowledge of the metabolic load experienced during competition is required to plan specific training programmes (Coutts et al., 2003), understanding the determinants of performance at different competitive levels could help this process (Reilly et al., 2009). In Italy beach soccer is very popular and most people are amateurs with previous soccer experience, they play matches without substitution, especially at the seaside. Therefore, the aim of this study was to investigate the physiological demands and movement patterns during a beach soccer match played by amateurs.

METHOD

Participants

Ten male university students were recruited to participate in this study (age 23.6 ± 4.4 yrs; height: 1.77 ± 0.05 m and body mass: 71.8 ± 3.8 kg). All of them were soccer players with regular training, had competed at soccer amateur championships and had beach soccer experience of at least three years as amateurs. All subjects were healthy, did not have any recent injury and had a physical examination and were cleared of any medical disorders that might limit their participation. Each player was informed about the research design and the experimental procedures (HR monitor, blood lactate test, vertical jump test), and they all gave their informed consent prior to the start. In addition, the Ethics Committee at the Magna Græcia University, Catanzaro, Italy, gave institutional approval to this study, conforming to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Experimental Design

The HR responses and kinematic parameters of each individual were simultaneously recorded during a friendly beach soccer match, consisting of three 12-min periods with 3 min breaks in between. The players' turnover (substitutions) was not applied in order to reproduce the typical amateur condition. Despite it being friendly, the match was refereed by an expert referee belonging to the local committee (Catanzaro, Italy) of the Italian Referees Association (Aia). The game profile of each player was obtained using synchronized footage and HR from an overhead view of the sand court. Furthermore, the participants were assessed on the same day with measurements of blood lactate and power performance of the lower limbs, using a counter movement jump (CMJ). All subjects were well instructed to approach the test from a standing position and squatted until their fingertips touched the ground and then immediately jumped for maximal height.

Procedures

Match Analysis

Video footage of the match was collected using 5 Hi8 Pro cameras (SONY, Japan) in order to record the match and individual movements of all players. Three stationary cameras were positioned at a height of 3 m on the grandstand, 1 at the halfway line and 2 in the 2 penalty areas. Furthermore, to record sideward movements 2 cameras were positioned at a distance of 3 m behind the two baselines (Figure 1). All the cameras were managed by experienced video operators. Successively, the video recordings were stored, synchronized and replayed on the hard disc of a computer in order to provide material for the analysis of an individual player's manual work rate. The pitch was divided into 4 areas (defensive, pre-defensive, pre-offensive and offensive) using the grid system proposed by Grehaigne et al. (2001). Then, the video recordings were analysed frame by frame with an accuracy of 0.04 s and the movement pattern analysis was performed manually, using the formula s/t*3.6 to calculate the speed action. The movement patterns were classed into the following categories as per Castagna et al. (2009): 1) *standing* (S, 0−0.4 $km \cdot h^{-1}$); 2) *walking* (W, 0.5−6.0 $km \cdot h^{-1}$); 3) *low-intensity running* (LIR, 6.1−12.0 $km \cdot h^{-1}$); 4) *medium-intensity running* (MIR, 12.1−15.4 $km \cdot h^{-1}$); 5) *high-intensity running* (HIR, >15.5 $km \cdot h^{-1}$) and 6) *sprinting* (SP, >18.3 $km \cdot h^{-1}$). The frequency and duration of each activity were also analysed in relation to the 3 match periods. To carry out the NA, the following parameters were chosen: 1) number of players involved in the action; 2) number of passes (NP); 3) number of shots and shot position (NS); 4) number of crosses (NC); 5) number of corners (NCR) and 6) number of passes from the goalkeeper (NGP). To eliminate any inter-observer variation in the measurements, the same experienced observer scored the footage of all players; he previously showed the following test-retest 95% limits of agreement for each variable: running –0.64 to 0.48 s; walking –0.76 to 0.53 s; standing –0.15 to 0.09 s. No difference was reported for the match analysis of the competition. These random errors in observations were deemed satisfactory.

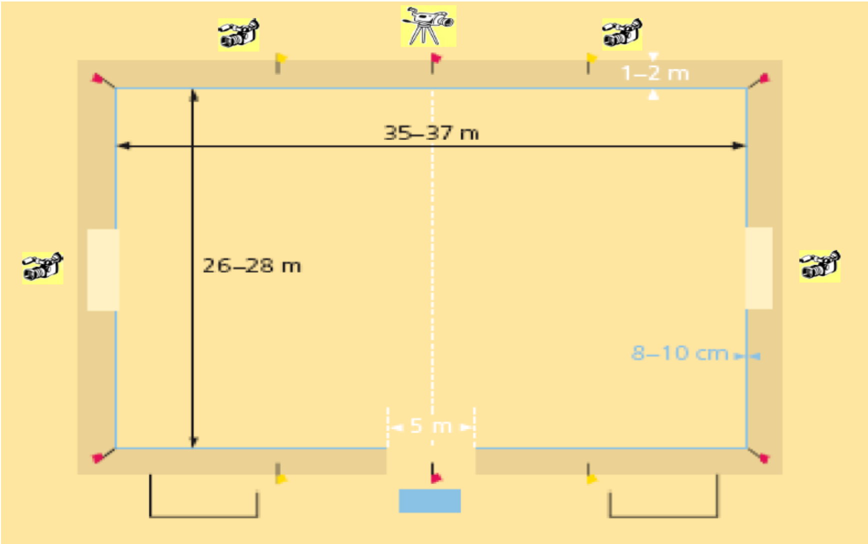

Figure 1: The play court and positioning of the video cameras

Heart Rate

Heart rate during the game was recorded at 5 s intervals using Polar Team System (Polar Electro Oy, Kempele, Finland) HR monitors placed around the chest of the players. At the end of the match the data were downloaded to a computer and processed using the Polar Precision 3.0 software (Polar, Kempele, Finland). The effort intensities were expressed in relation to the theoretical individual HR_{max} calculated with the formula 220–age (Karvonen & Vuorimaa, 1988), and classed into the following categories: <65% HR_{max}; 66−75% HR_{max}; 76−85% HR_{max}; 86−95% HR_{max} and >95% HR_{max} (Bangsbo, Norregaard & Thorso, 1991; Helsen & Bultynck, 2004; Tessitore et al., 2005).

Blood Lactate Concentration

The individual blood lactate (La) determination was carried out by means of the collection of an untreated capillary from a fingertip, using 5 Accusport Lactate Analyzers (Roche, Basel, Switzerland). The measurements for all participants were performed after the warm-up, at the 3rd and 6th minute at the end of the first and second periods, and at the 3rd, 6th and 9th minute at the end of the match.

Field Test

A CMJ was assessed by means of an optical acquisition system (Optojump, Microgate, Udine, Italy) to measure flying and ground contact times. Then, calculations of the height of the jumps for each individual trial were made. Prior to testing, the players underwent a 15 min standardized warm-up period, then the CMJ were performed following the procedures described by Komi & Bosco (1978), requiring the subjects to descend from a standing position and perform an immediate jump for maximum height, maintaining the hands on their hips throughout the movement. The height of a jump was estimated using an Optojump system (Microgate, Bolzano, Italy). In order to correctly perform the tests, from the standing position the players were required to bend their knees to a freely chosen angle, which was followed by a maximal vertical thrust. The effect of the arm swings was minimized by requesting the subjects to keep their hands on their hips. Any jump that was perceived to deviate from the required instructions was repeated. To evaluate the power of the lower limbs, all players performed the CMJ test 4 times (after the warm up, at the end of the 1st and 2nd periods and the match, respectively), each time 2 trials were allowed with a 3 min recovery period between trials to avoid fatigue effects. Moreover, players received encouragement to perform their best and the peak values were used for statistical analysis. The collected data could be used to improve the training programme of the beach soccer players.

Statistical Analysis

The statistical analyses of TMA, NA, HR, blood lactate and CMJ were conducted using SPSS 17.0 for Windows (SPSS, Inc., Chicago, IL). Variables were presented as mean values and standard deviations; statistical significance was set at an alpha level of $p = 0.05$. The Kolmogorov test was applied to test the normal distribution of the variables. Analysis of variance with repeated measurements was used to test for differences between categories of variables in the 3 match periods. Post hoc assessment of significant F ratios was undertaken by means of a Bonferroni multiple comparison test, also for the non-parametric data.

RESULTS

Match Analysis

The percentage of total time spent in each of the 6 movement categories are summarized in Table 1. The analysis between periods showed a significant effect for standing activity ($p = 0.028$), with post hoc analysis confirming a difference between the 1st and 3rd periods ($p = 0.005$). The analysis of time spent by the field players for the different movement categories shows walking was the highest activity. In particular, data shows that half of the game time (50.8%) was spent at very low intensity (walking and low-intensity running), a consistent time standing (35%), a short time at medium intensity (11.8%) and only a very short time at high and maximal intensity (<3%) (Table 1). This unbalanced profile toward low intensity was particularly marked when analysing the profiles of the goalkeepers, who spent 84.8% of the time standing, while no data were collected for low-intensity and high-intensity running classes. During the match a total of 208 ± 30 and 112 ± 26 changes of activity were performed by field players (n = 8) and goalkeepers (n = 2), respectively.

The mean duration of individual actions in seconds (sec) is shown in Table 2.

Table 1: Match activities, speed categories, percentage of time during the match, mean ± SD

Categories	Speed	(%)
Standing	0−0.4 km·h^{-1}	35.0 ± 6.4%
Walking	0.5−6.0 km·h^{-1}	45.5 ± 5.3%
Low-intensity running	6.1−12.0 km·h^{-1}	5.3 ± 1.2%
Medium-intensity running	12.1−15.4 km·h^{-1}	11.8 ± 4.3%
High-intensity running	>15.5 km·h^{-1}	<1 ± 0.1%
Sprinting	>18.3 km·h^{-1}	2.2 ± 1.0%

Table 2: Match activities, mean time duration in seconds (sec) and standard deviations (SD)

Categories	Time duration (sec) mean ± SD
Standing	7.2 ± 0.6
Walking	9.9 ± 0.8
Low-intensity running	5.5 ± 0.6
Medium-intensity running	5.5 ± 0.4
High-intensity running	2.3 ± 0.2
Sprinting	2.5 ± 0.1

The analysis of technical-tactical aspects showed that 60.8 ± 0.4% and 26.5 ± 5.8% of actions were performed involving 2 and 3 players, respectively (Figure 2). As it relates to the analysis of passes, data showed that 54.1 ± 0.2%; 25.1 ± 5.7% and 20.8 ± 6.2% of actions were performed with 1, 2 and >3 passes, respectively (Figure 3). Furthermore, a total number of 92 shots were performed, of which 52 were on target with 14 goals scored and 40 off target. Excluding the 4 corners for each team, none of the teams performed cross actions. Furthermore, the performance of goalkeepers showed 70 returns, 55 of which were served to teammates, while 15 were captured from the opponents.

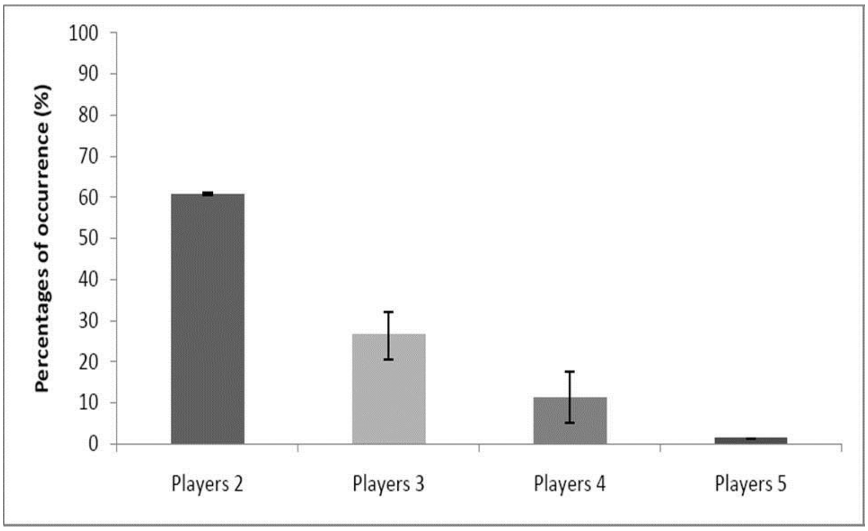

Figure 2: Percentages of players involved in the action of the match (mean ± SD)

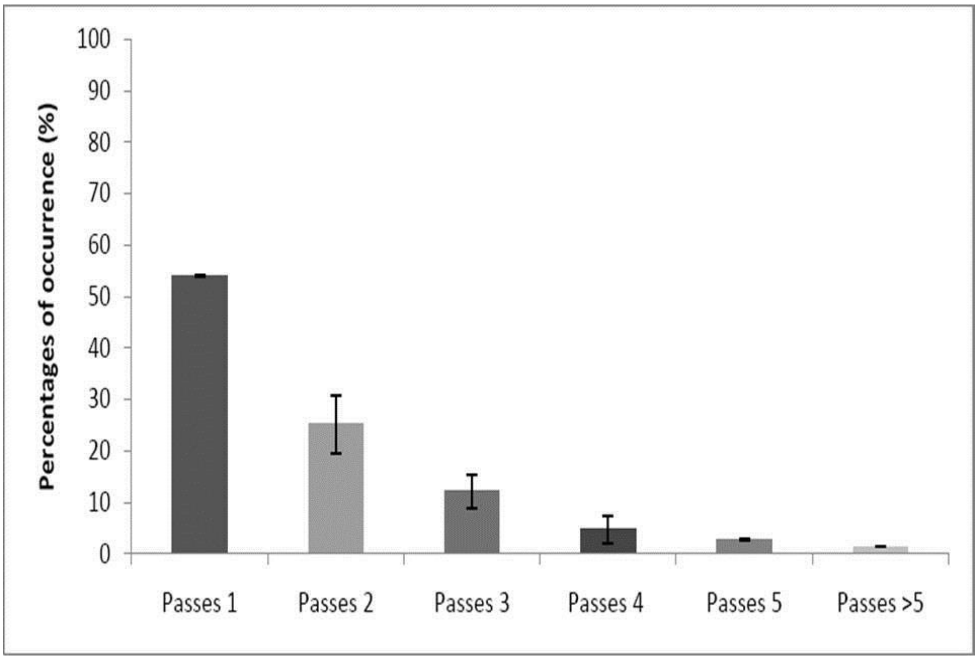

Figure 3: Percentages of passes in the action of the match (mean ± SD)

Heart Rate

The overall mean of HR beats during the match was 166 beats·min^{-1} (*SD* = 16). The mean HR values corresponded to an overall mean of 85.3% (*SD* = 8) of the theoretical (220-age) HR_{max} (Table 3).

Table 3: Absolute and relative values of heart rate for all the players (8): mean (±SD)

	HR (beats·min^{-1}) Mean (±SD)	**%HRmax (220-age) Mean (±SD)**
HR_{mean}	166 ± 16	85.3 ± 8.0
HR_{max}	188 ± 11	96 ± 5.9
HR_{min}	117 ± 17	60 ± 14.5

Note: HR_{mean} = mean heart rate; HR_{max} = maximum heart rate; HR_{min} = minimum heart rate. The relative values refer to the % of the HR_{max}

The analysis of the intensity of effort imposed on field players showed mean values of 8.1 ± 7.6; 11.3 ± 6.5; 26.6 ± 4.0; 35.0 ± 11.6 and 19.0 ± 6.8% of playing time spent at exercise intensities corresponding to <65%, 65−75%, 76−85%, 86−95%, >95% of their theoretical HR_{max}, respectively. Furthermore, the analysis between periods (Figure 4) showed a significant (P = 0.008) decrease of occurrence toward the end of the match for the class 65−75% of HR_{max} (periods: first = 4.8%, second = 11.4% and third = 17.8%) and the class 86−95% of HR_{max} (periods: first = 46.4%, second = 35.3% and third = 23.2%). Post hoc analysis showed differences between the 1st and 3rd periods of $p < 0.05$ and $p = 0.035$, respectively.

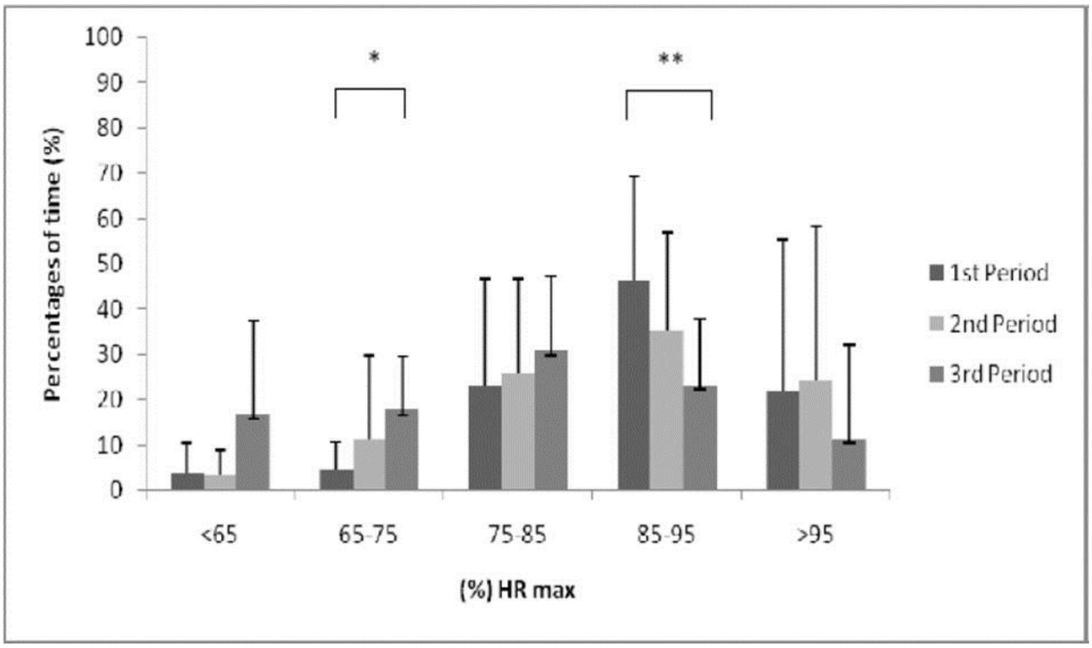

Figure 4: Percentages of time spent in different categories of effort during the first, second and third period (mean + SD). *Significant difference (P<0.05) between the 1st and 3rd period. **Significant difference (P=0.035) between the 1st and 3rd period

Blood Lactate Concentration

At the end of the warm up, blood La values ranged from 1.5−3.0 mmol·l^{-1}. Peak mean La values were always registered at the end of each period, with similar values after the 1st and 2nd ones (6.7 ± 1.0 and 6.7 ± 3.8 mmol·l^{-1}, respectively), and a lower value after the 3rd period (Table 4).

Field Test

For the jump tests (CMJ), the most suitable for beach soccer, with respect to pre-match condition (36.6 ± 5.3 cm), significantly higher performances ($p < 0.004$) were found at the end of the match periods (first = 39.5 ± 6.5 cm; second = 40.9 ± 6.4 cm and third = 39.2 ± 6.0 cm) (Table 4).

Table 4: Physiological measurements during the match (mean ± SD)

	Blood Lactate (mmol·l^{-1})	**CMJ (cm)**
After warm up	1.5−3.0	36.6±5.3*
First period	6.7±1.0	39.5±6.5
Second period	6.7±3.8	40.9±6.4
Third period	5.3±2.7	39.2±6.0

* Significant difference (P < 0.004) between warm-up and the match periods

DISCUSSION

Beach soccer enjoys worldwide popularity and a number of elite and amateur players take part in official and friendly matches. Although there are more and more practitioners there is still a lack of scientific knowledge about players' performance. The only study of Castellano & Casamichana (2010) showed that at an elite level, beach soccer is characterized by an intermittent activity of greater intensity than other team sports. In spite of the observation of a single friendly match has to be considered a limit of the present study, although the main purpose was to investigate the game profile of a beach soccer match played by non-professional players, that in Italy people often play without substitutions. Thus, instead of the time participating, considered as the time during which each player is directly involved in play, in our study, data have been collected through the continuous participation in all match periods. As a consequence of this condition (no turnover) a first relevant question is when did fatigue occur during participation and what was the cause? Compared with the only study investigating the physiological profile of beach soccer players, and based on individuals' time participating (Castellano & Casamichana 2010), our subjects showed higher values spent in standing and walking activities, lower values in low-, medium- and high-intensity running, while surprisingly a similar value accounted for sprinting. Conversely, comparing our subjects with futsal players (Barbero et al., 2008) it is interesting to note the relevant difference of time spent standing and walking (35% and 45% for beach soccer players; 0% and 9% for futsal players, respectively), while the time spent sprinting by our sample accounted for 6-fold less than that spent by futsal players (2.2% vs 13.7%, respectively). The explanation of these huge differences between our subjects and those of the mentioned study can be attributed to three aspects: 1) the constraints induced by the different field surface (sand vs wood, for beach soccer and futsal, respectively); 2) the different level of competition (non-professional vs professional) and 3) the different setting of playing time participation (continuous vs turnover). The constraints induced by the sand surface of the pitch can also explain the different duration of sprint action (93% of which lasted < 3 seconds) compared with standing and walking actions (55% and 72%, which ranged 6−20 seconds, respectively).

The fact that compared with other team sports sprinting on the sand requires high energetic expenditure, could also explain our data regarding a longer time elapsing between sprints to recover (156.3 ± 51.1 sec) and the appreciably lower number of change of activities counted during the match (208 ± 11) when compared with futsal players (468 ± 77, Dogramaci et al., 2011), despite our subjects playing all 36 minutes of the match. In consideration of the NA it is interesting to note that in the present study most of the actions of the match were performed involving only 2 players, while a lower number involved more than 3 players. This is related to the ability of the players, who were non-professional soccer players and playing beach soccer they found it more difficult to pass the ball. In fact, a sand surface of the court makes it very difficult to control the ball, as it rolls on an irregular surface and changes direction in an unpredictable way. This aspect requires a high skill level to perform high collective play and influences the efficacy of the shots performed far from the goal line. For this reason, the best tactical solution is probably playing the ball in the air, but this technique needs high skill levels. In order to determine the players' internal workload, the individual HR were registered during the 3 periods, while the effort intensities were expressed in relation to the individual percentage of

HR_{max} calculated by means of the formula 220-age (Karvonen & Vuorimaa, 1988). The results of this study show that during the friendly beach soccer match the amateur players had an HR overall mean of 166 ± 16 beats·min^{-1}, corresponding to a mean of 85.3% ± 8 of their theoretical HR_{max}. Besides, more than half the playing time is spent at an intensity superior to 85% of the HR_{max}. A recent study on beach soccer reported similar HR mean values of 165 ± 20 beats·min^{-1} (range 121−188 beats·min^{-1}), corresponding to 86.5 ± 9.6% of HR_{max} (Castellano & Casamichana 2010). These data show that despite our subjects having spent a lower time at medium- and high-intensity running activities and a higher time standing and walking, the internal load was the same. However, compared with futsal players these values were lower than those reported in the literature for elite players (174 ± 7 beats·min^{-1} and 90% HR_{max}, respectively; Barbero et al., 2008). Analysing the effort intensity in relation to the match periods, a marked decrease for values > 85% of HR_{max} was observed during the third period (14 and 49% less compared with the 1st and 2nd ones, respectively). This decrease could be related to the physiological demands and be associated with the reduction of the intensity of the activities registered during the third period. Even though indirectly, to assess the rule of glycolytic metabolism as energy utilized during the match, the lactate values were collected (Bishop, 2001). This study shows the average and range values: 6.2 ± 0.8 and from 3.3 to 13.2 mmol·l^{-1} respectively, that were slightly higher than those reported for futsal players: 5.3 mmol·l^{-1} (Barbero-Alvarez et al., 2008), despite our players participating in the entire match (36 minutes). Therefore, it is clearly evident that our data are comparable with other team sports, where the players' turnover were applied, and is due to the intermittent activity that in amateur beach soccer is characterized by longer and more frequent recovery phases alternate with very short high-intensity ones.

Furthermore, we evaluated the lower limb power of the amateur beach soccer players using the CMJ test, understanding how much the sand surface influences jumping ability. The results showed a significant difference ($P < 0.004$) among different periods, with lower mean values measured before the match with respect to the end of the play periods. It can be speculated that the increase in jump ability was correlated to greater neuromuscular activation (Impellizzeri et al., 2008). In fact the sand, having absorbent qualities, probably induces neuromuscular adaptations leading to improvement in performances requiring the stretch-shortening cycle, such as jumping and sprinting (Impellizzeri et al., 2008). For this reason, to improve the performance of beach soccer players it's necessary to plan a specific training programme on a sand surface to increase strength levels of the lower limbs.

CONCLUSIONS

This study is the first to describe the physical performance and game-specific skills of amateur players in a beach soccer match. Despite the quite significant limitations of the study such as the small sample size, low technical level and turnover absence, it is nonetheless possible to draw useful information from it. Beach soccer is an intermittent sport where high- and low-intensity actions alternate. Technical analysis showed that during the match most of the offensive actions involved 2 players with 1 pass. For half the duration of the match, the HR was superior to 85% of the HR_{max}, so beach soccer requires large amounts of energy via the anaerobic system. The blood lactate data demonstrated the fatigue of the players, which reduced the play intensity in the third period probably from lack of specific training on a sand surface. Specific training, such as high-intensity intermittent training with short breaks, is useful to increase the beach soccer players' performance.

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