*Acta Kinesiologica 19 (2025) Issue.1*
DOI. 10.51371/issn.1840-2976.2025.19.1.3


**Original Investigation**

# Performance Profile of Young Beach Soccer Player: External and Internal Load in Under 15 Beach Soccer Players

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***Purpose:*** Beach soccer represents a new sports training offering for young practitioners. This study aims to investigate (a) the internal (IL) and external load (EL) parameters recorded during an official match in Under-15 (U15) soccer players; (b) whether the beach soccer match load differs from11-a-side soccer.
***Methods:*** 38 young soccer players (age: 14.42 ± 0.63 years, body mass: 48.54 ± 9.27 kg; stature: 161.54 ± 8.79 cm, training background: 6.42 ± 2.51 years) participated to the study. Performance was carried out on a sand field with beach soccer ball, for 3×12min each. During the match and at the end of the match IL and EL were collected.
***Results:*** The IL values obtained show that the beach soccer match imposes high cardio-vascular intensity: young soccer players spent most of the distance covered (74%) in the High Intensity Heart Rate ranges of 80-90% and 90-100% of HRmax and average HR of about 95% of HRmax. The Borg Scale value was 8.77 ± 0.26 a.u.. Each young player participated in the match for 25.06 ± 1.33 min. The total distance covered was 2185.66 ± 264.22 m, while the distance covered per minute of play showed a value of 74.15 ± 7.19 m. A peak speed of 18.63 ± 1.87 km/h was recorded. The average recorded speed value was 4.39 ± 0.43 km/h. The distance measured in moderate-and high-intensity running was significantly lower than the value of low-intensity running ($P$= .0002).
***Conclusions:*** Beach soccer seems to be a complementary and integrative activity for the training of the U15 soccer player. Sand training can be considered a valuable complementary means for the physical efficiency of the U15 soccer player. The external and internal load of beach soccer provides a valid alternative to traditional surface training.

***Keywords:*** beach soccer, young soccer player, external load, internal load, sand surface.

## Introduction

The focus of the research is on understanding the performance demands of youth soccer and all disciplines that derive from the 11-a-side soccer[1-4]. Beach soccer is a variation of traditional soccer played on a beach or sand. It's a fast-paced and physically demanding sport, with a few key differences from standard soccer[5].
The Fédération Internationale de Football Association (FIFA) welcomed beach soccer in 2004 and since 2009 has been organizing the FIFA Beach Soccer World Cup, which is open to national teams. This introduction has allowed beach soccer to spread rapidly and count many practitioners.
Beach soccer, as well as other sports derived from soccer (e.g., Futsal) allows for a broadening of sports opportunities in the youth and absolute levels.
The countries that now recognize the sport are more than 200 in the world: the number of international competitions has also definitely increased in both men's and women's areas, reaching more than 30 international events each year.
In Italy, too, the number of practitioners has significantly increased and the Youth and School Sector of the Italian Football Federation (YSS-FIGC) organizes new and relevant national and regional competitions allowing Under 15 and Under 17 practitioners to increase opportunities for competitive sports practice. The official competition involves a field between 35×26m and 37×28m in size; the five barefoot players (1 goalkeeper and 4 movement players) must score targets by kicking inside 2 goals (5.5×2.2m); 15 players can take part in the competition and the number of possible substitutions is unlimited[5]. This opportunity is dictated by the need to provide an adequate recovery period due to high energy expenditure imposed by the match.
The competition, held on a sand surface, is conducted in halves of 12 minutes for each one (three periods) alternated with 3-minute of recovery in-between. The playing time is effective: in fact, the referee stops the stopwatch due to a foul play, a corner, the ball going out of the field, if there is a free kick or a penalty).
The specific characteristics of sand allow performance in a highly variable environment that requires the soccer player to adapt all soccer-specific movements according to the uneven surface: among the movements most affected by sand are certainly ball control and shooting technique[5].
The sand characteristics have prompted research attention[6-8]: although sand has been considered an interesting medium for the development of motor skills for many years, only a few years ago has it been investigated as to its effects on athletic performance[9-11]. In soccer, it has been observed that the use of sand can expand training possibilities[9]. And the use of sand has also been proposed as an alternative to or in combination with conventional surfaces[9,12].
So far in soccer, it has been observed that through sand, training

sessions can be organized to increase the intensity of drills, lactate production, to act on body composition or to structure effective return-to-train/return-to-play pathways or to reduce the overuse injury risk[13].
The rationale used in the proposition of sand as a training surface is based on knowledge derived from comparisons with what occurs on natural and artificial grass: the sandy surface allows for high values of internal load and low values of external load[11].
The muscular activation and energy cost of locomotion on sand are very high because the surface results in greater dissipation of elastic energy: this characteristic makes it possible to have a suitable training alternative[6].
Some particular characteristics, such as lower musculo-tendon efficiency[15] or increased hip and knee flexion[15,16] probably as a result of reduced impact on sand lead to a complexity of movements in sand.
In particular, foot placing on sand may not ensure the correct relationship with the surface and promote pronation with a consequent alteration of the athlete's stance and balance[15,16].
This complexity in managing the movements and stability of the soccer player's body is even more evident during the acceleration phase or in short sprints because of longer contact times[12].
Although scientific knowledge makes it possible to identify many areas of application of sand for increasing athletic performance, there are some aspects in the literature that require more analysis: the functional demands resulting from an official sand soccer match in young soccer players are unknown.
The only study in the literature was conducted with young Under-17 soccer players and with a training background of about 10 years[5].
Another study conducted on adult soccer players with reference to internal and external load analysis is available in the literature: however, the observed matches had heterogeneous durations ranging from 20 to 36 minutes[17]. In this regard, it is useful to mention that the regulation of the duration of the official competition has fixed that the competitive event for all categories is 3 halves of 12 minutes each: this innovation requires to study again the beach soccer performance profile.
Further analysis is needed because sand compared to conventional surfaces requires a higher energy expenditure, evidenced by lactate accumulation that can be 2 to 3 times higher, at the same speed.[15,18] Furthermore, it remains to be known what functional demands are put on the athlete running on sand at speeds above 11 km/h and what happens when these runs last longer than 10 minutes[15].
All this knowledge can be achieved through available and wearable technologies that allow monitoring throughout the duration of an official match.
In this regard, today through global positioning systems (GPS) and heart rate monitors it is possible to record key external and internal load parameters during official matches, without constraining performance.
The physiological responses (e.g., heart rate) that can be detected and the main external load parameters that identify performance (e.g., number of sprints, distance in meters covered in sprints, high-speed running, total distance, number of decelerations, etc.) can be recorded in relation to the wearable device[19].
As a result, training sessions can be scheduled with the highest accuracy[20].
Therefore, this study aims to investigate (a) the internal and external load parameters recorded during an official match in Under-15 soccer players; (b) whether, and to what extent, the beach soccer match load differs from11-a-side soccer.

## Materials and Methods

***Participants***

38 young soccer players (all movement players) participated to the study (age: 14.42 ± 0.63 years, body mass: 48.54 ± 9.27 kg; stature: 161.54 ± 8.79 cm, training background: 6.42 ± 2.51 years). Inclusion criteria were: 90% compliance in the last 4 weeks of training with the team, no injuries in the 4 weeks prior to the study, being available for competition without limitation.
Heart rate monitors and Global Position System (GPS) are tools frequently used by young soccer players in both training and competition. Players who participated in the match for at least 5 minutes without incurring an injury[21] were included in the data analysis.

***Experimental design***

To monitor internal load parameters, the Ratings of Perceived Exertion (RPE) scale version CR-10[23] was adopted; the RPE scale was collected at the end of the match. GPS at 18.8 Hz (GPEXE® SYSTEM, EXELIO SRL, Udine, Italy) was used to monitor external load parameters[24].
The following variables were measured: the number of accelerations (> 2 m/s) and decelerations (< -2 m/s), the equivalent distance (m), the total distance run (m), peak velocity (km/h), distance run per minute (m), average metabolic power (W/kg), average metabolic power (W/kg) expressed during active phases (MPE avg power) and during recovery phases (MPE rec avg power), equivalent distance (m).
Using the running ranges established in the literature[24,25], the distances covered by walking (< 7.30 km/h), running at low intensity (7.30-14.50 km/h), running at moderate intensity (14.50 - 19.90 km/h), running at high intensity (19.90-25.20 km/h) and covered in sprinting (> 25.2 km/h)[25,26] were recorded; in addition, the distance run at low power (< 20.00 W/kg), high power (>20.00 W/kg) and high speed (>25.20 km/h) was recorded[24,25].
The official beach soccer match was monitored on a regulation sand surface (35×28 m), using a beach soccer ball and organized according to the rules duration (3×12min, rest 3min). The matches were monitored in outdoors at a temperature of 24 °C with a humidity of 62%. The RPE value was at the end of the exercise bout[27].

***Statistical Analysis***

All results are expressed as mean±(SD). Shapiro-Wilk test was used to verify the assumption of normality of the distributions for each raw data. *t*-test was used to assess differences at the five speeds HR range and run intensities. For the differences between the averages that were significant, Cohen's *d* was used to check the effect size index. As for the effect size index (Effect Size), after calculating the δ index it is possible to convert it into Effect Size: ≤ .20 small; .50 average; ≥ .80 large[28]. The significance level was fixed $P \leq .05$ using Statistical Package for Social Science software (Version 28.0, IBM SPSS Statistics, Chicago, IL, USA).

## Results

Mean HR recorded during the matches was 175.77 ± 14.26 beats per minute (bpm), which corresponded to 95.75 ± 7.76% of HRmax being 205 bpm. No statistically significant differences in average HR were observed in the three match periods. (Figure1).
The HR range in which players spent most of the running distance (45%) was >90% of HRmax; in addition, young soccer players spent most of the distance covered (74%) in the HIHR

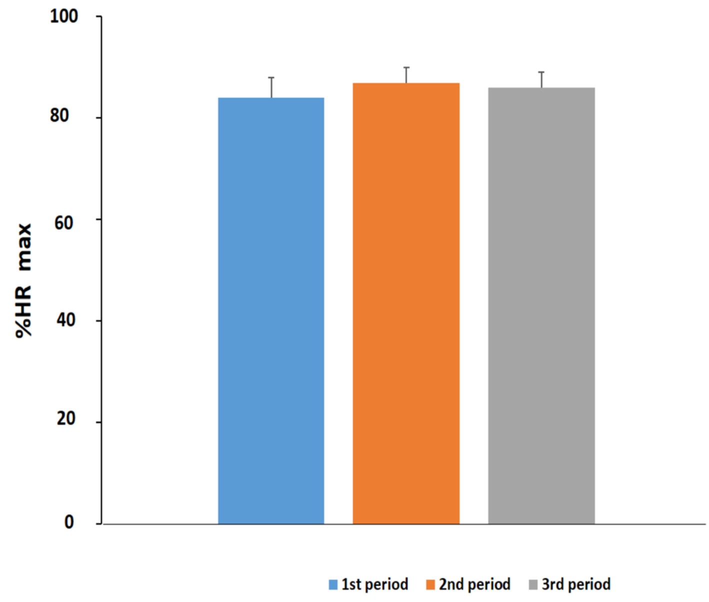

**Figure 1**. Average HR values over the three match periods (3×12min).

ranges of 80-90% and 90-100% of HRmax. (Table 1).
The distance travelled in the 71-80%, 81-90% and >91% ranges were significantly different from the 61-70% range (*P*= .0003, ES: 1.48–1.89). The distance travelled in the different HR ranges was not statistically different in the three match periods. Load assessment by CR-10 Borg Scale showed a value of 8.77±0.26 (a.u.).

**Table 1.** Heart Rate range and distance travelled in a beach soccer official match.

| %HR (range) | Distance (m) | *P* value | Cohens *d* |
|---|---|---|---|
| 0-50 | 65.66 ± 31.85 | | |
| 51-60 | 51.77 ± 13.52 | | |
| 61-70 | 77.46 ± 45.19 | | |
| 71-80 | 368.95 ± 237.77 | .0003[a] | 1.48 |
| 81-90 | 633.18 ± 253.34 | .0003 [a] | 1.76 |
| > 90 | 991.2 ± 246.25 | .0003 [a] | 1.89 |

[a]Significantly different from range 61-70%.

Each young player participated in the competition for 25.06 ± 1.33 min. The total distance covered, and the distance achieved per minute of play were 2185.66±264.22m and 74.15 ± 7.19 m, respectively. The equivalent distance was 2425.19 ± 311.86m. A peak speed of 18.63 ± 1.87 km/h was recorded. The average recorded speed value was 4.39 ± 0.43 km/h. The average metabolic power was 4.87 ± 0.53 W/kg; average metabolic power for the active phases (MPE avg power) and recovery phases (MPE rec avg power) was found to be 17.96 ± 0.45 W/kg and 4.01 ± 0.39 W/kg, respectively. The number of accelerations and decelerations were 10.32 ± 6.31 n and 7.33 ± 2.17 n, respectively. The distance walked (1260.91 ± 98.11 m), low-intensity (846.44 ± 218.10 m), moderate-intensity (72.41 ± 31.51 m) and high-intensity running (7.42 ± 3.33 m) were significantly different. The value of low intensity running distance was significantly different from the distance covered in moderate and high intensity running (*P*= .0002, ES: 1.77-2.36). The three official match periods showed no statistically significant differences for distances covered at different running intensities (Figure 2). The young soccer players ran in the following metabolic power ranges: 1926.70 ± 426.31 m at low power, 224.44 ± 37.23 m at high power, 33.12 ± 13.66 m at very high power, and 2.90 ± 1.81 m at maximum power (Table 2). The values at high power (*P*= .0003, ES: 1.83), at very high power (*P*= .0002, ES: 2.42) and maximum power (*P*= .0002, ES: 2.85) were significantly lower than those at low power.

## Discussion

The main objective of the study was to investigate the main external and internal load parameters measured in young Under-15 soccer players engaged in an official match.
The second aim of the study was to understand how similar or different are the loads imposed by beach soccer and 11-a-side soccer.
Sand is considered a valuable alternative to training on a conventional surface for the soccer player: research states that knee extensors need to increase muscle activity on sand compared to the conventional surface, and sand returns less ground reaction force in the stance phase[11].
The literature provides very useful insights into which areas of intervention and training can take advantage of some specific characteristics of sand[29]. The most specific knowledge concerns training on functional sand to increase jumping performance[6,12,30,31] and return to sport/return to play after injury[7]. Indeed, sand is used in return to play post lower limb injury particularly as a functional surface to activate the foot intrinsic

**Table 2**. External motor load variables.

| Variable | Beach soccer player value | P value | Cohens *d* |
|---|---|---|---|
| Play time for each player (min) | 25.06 ± 1.33 | | |
| Total distance (m) | 2185.6 ± 264.22 | | |
| Distance/min (m) | 74.15 ± 7.19 | | |
| Maximum speed (km/h) | 18.63 ± 1.87 | | |
| Avg speed (km/h) | 4.39 ± 0.43 | | |
| Avg Metabolic power (W/kg) | 4.87 ± 0.53 | | |
| MPE avg power (W/kg) | 17.96 ± 0.45 | | |
| MPE rec avg power (W/kg) | 4.01 ± 0.39 | | |
| Acceleration (n°) | 10.32 ± 6.31 | | |
| Deceleration (n°) | 7.33 ± 2.17 | | |
| Equivalent distance (m) | 2425.19 ± 311.86 | | |
| Walking (m) | 1260.91 ± 98.11 | | |
| Low intensity running (m) | 846.44 ± 218.10 | | |
| Moderate intensity running (m) | 72.41 ± 31.51 | .0002 [a] | 1.77 |
| High intensity running (m) | 7.42 ± 3.33 | .0002 [a] | 2.36 |
| Sprint running (m) | 0 | | |
| Distance low-power (m) | 1926.70 ± 426.31 | | |
| Distance high-power (m) | 224.44 ± 37.23 | .0003[b] | 1.83 |
| Distance very high-power (m) | 33.12 ± 13.66 | .0002[b] | 2.42 |
| Distance maximum power (m) | 2.90 ± 1.81 | .0002[b] | 2.85 |

[a] Significantly different from low intensity running distance.

[b] Significantly different from low-power distance.

muscles[7].
Despite this knowledge, there are very limited studies that have investigated external and internal loading parameters during official sand competitions in young Under-15s. Similarly, comparisons between performance on sand and performance in 11-a-side soccer matches appear very modest. This study was structured to address this knowledge gap.
From the observation of the values obtained during the competition, the beach soccer match is configured as an event of high cardiovascular intensity: comparing distances covered and HR values, it is observed that 75% of the meters covered involved a commitment between 80% and 10°% of HRmax. This engagement is confirmed by the average HR value of about 91%. The young soccer players ran about 45% of the match distance at a HR above 90% of the HRmax. The distances covered in the different HR ranges were not statistically different over the 3 competitive periods: probably the possibility of performing continuous changes during the match allows the effects of fatigue to be counteracted.
The high intensity of the match was confirmed by the RPE values recorded by the participants.
Therefore, it is plausible to define that the internal load observed in an 11-a-side soccer match is significantly lower than what is observed in a beach soccer match for players of the similar age[21,32].
Rather, internal load values seem closer to exercises on small spaces and formats, so-called small-side games, where exercise intensities always reach 90%HRmax: in fact, the 3vs3[33,34] and the 2vs2 format[35] require an exercise intensity higher than 90%HRmax in youth soccer. The distances covered in the different HR ranges are similar to what was obtained in a similar study with U-17 beach soccer players; instead, in the present study RPE values were higher than young beach soccer players[5]. Likely, the different training background of the two observed groups may have affected the fatigue perception.
This higher response compared to conventional surfaces, artificial or natural grasses, is a functional adaptation also observed in young adult soccer players engaged in intermittent

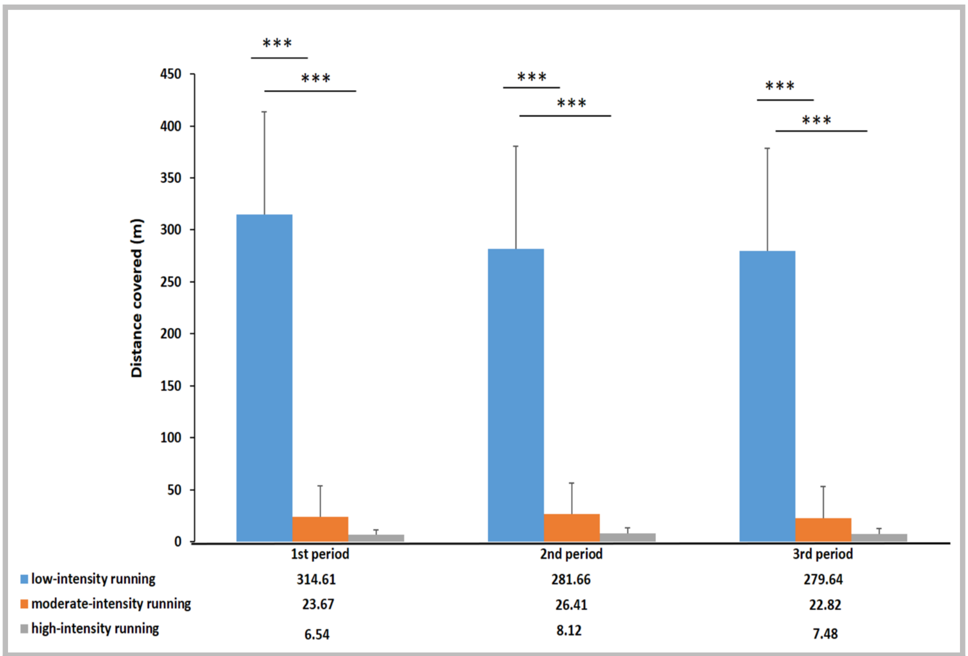


**Figure 2**. Distances covered in the different intensity running ranges during the 3 match periods (3×12min). The distance measured in moderate and high-intensity running was significantly lower than the value of low-intensity running ($P$= .0002). The distance travelled in the different intensity running ranges was not statistically different in the 3 match periods.

running exercise[11].

In achieving a more accurate and precise assessment of a young soccer player's energy expenditure, it is useful to make use of metabolic power measurement: in fact, this evaluative approach allows the "*weight*" of the athlete's speeds, decelerations, accelerations and numerous other mechanical parameters during match performance to be measured with relevance[20,36].

The values recorded in the match show a low metabolic power exercise profile as the running distances are mainly in the lower range: in sum, the sandy surface returns a very modest mechanical load. This interpretation is confirmed by the values observed in the changes in speed, number of accelerations (10.32±6.31 nr) and decelerations (7.33±2.17 nr), which are numerically very limited in this match competition.

Comparing the values of accelerations and decelerations obtained in this study with what was found in another similar study shows a high difference[5].

Likely, the differences in the ages of the two monitored samples may have affected the number of accelerations and decelerations: the stages of maturation allow higher values of muscle strength to be expressed in the 15–17-year-old range[5].

Comparison of beach soccer and 11-a-side soccer values also draws differences for the metabolic power variable: comparing young soccer players of the same age shows that in 11-a-side soccer the values are far higher[36]. Likely, in 11-a-side soccer the performance capitalizes the natural grass surface and larger spatial dimensions and allows for a higher number of speed variations[36].

In addition, sand attenuates the intensity of decelerations and limits the neuromuscular load: the displacement of sand grains seems to be the main reason for lower deceleration intensities and a lower number of velocity changes are observed than in 11-a-side soccer[37,38].

Low-intensity running volumes should not appear to contradict what has been observed: the literature contributes to a better understanding of this analysis because it shows that on sand even low-intensity exercise exhibits a change in muscle activation patterns and running biomechanics[8,39].

Sand creates very small but numerous air voids below the surface that alter the effectiveness of foot stance and subsequent foot thrust[8]: related to this specific characteristic of sand, the high mean metabolic power values obtained in this study can be explained.

The results observed in this study are in agreement with other research that has described the energy cost of sand at low speed (>24% approximately) compared to a more conventional surface[18].

In fact, sand imposes an additional cost on the athlete due to the foot stabilizing action: only after the stabilization of the slipped-slinked foot in the sand can the force be applied to push the lower limb into the running action[8,15].

In addition, differences in sprint performance on different surfaces could depend on the presence of a ball during running performance; it seems to suggests that, in the case of ball movements, the surface may influence sprint speed, inducing appropriate adaptions by players. In particular, hard surfaces allow to reach higher peak speeds than sand surfaces[15]. The type of specific soccer shoe used on the surface can also affect performance, depending on how it affects players' perception of the surface by changing the myoelectric activation of muscles[15].

To this different action of the foot must be added that sand behaves differently from conventional surfaces: it does not return the elastic energy accumulated by the muscle-tendon unit but disperses it in heat[40].

It is for this reason that the athlete must compensate for the deficit presented by the sandy surface with increased foot contact time and additional muscle work[40].

This interpretation is supported by a recent review: comparing sprint performance on sand and natural grass showed that 10- and 20-meter runs are negatively affected by the limitation of elastic reuse of the lower limb[15].

The disadvantageous characteristics of sand in locomotion and body displacement are confirmed by a study conducted on young beach soccer players of the same age as the sample in these studies: young soccer players engaged in broad jumps on grass and sand were observed, and the observation described a performance decline of about 23% on sand[10]; performance differences between about 27% and 33% were also observed in one-leg jumping[10].

Movements using the stretch-shorten cycle are affected by deficits in force production and explain the differences observed in peak velocity and high intensity running values between beach soccer and 11-a-side soccer played on natural and artificial grass[41].

When comparing beach soccer and 11-a-side soccer with players of the same age, differences in peak velocity between 25%[42] and 35%[41,43] emerged.

Both peak speed and average speed value are lower compared to U-17 beach soccer players. Average speed value can be influenced by a higher distance covered by walking, differently from the U-17 beach soccer players study[5].

## Practical applications

Beach soccer imposes different loads than 11-a-side soccer: internal load values are higher while external load values are moderate. It can be argued that two very different performances are required of the young soccer player[11,36,44].

The characteristics of the sand require specific running strategies and movements to respond effectively to the particular surface[11,43,46].

The mechanical load is very limited while the high cardiovascular activity is prominent. For these reasons, beach soccer seems to be a complementary and integrative activity for the training of the Under 15 soccer player.

Moreover, sand is configured as the most suitable surface to limit the reduced load tolerance characteristic of the maturation phase of Under 15 soccer players [4,47].

It is suggested that training on conventional surfaces be integrated with sessions on sand with reference to the phases of the sports season when high training volumes need to be presented to young soccer players.

## Conclusions

Technical staffs may consider beach soccer as a complementary activity in the preseason phase when volumes are very high and young players are deconditioned.

Further studies may investigate whether there are functional responses to playing on the sand in all phases of the soccer season[3,45].

Particular attention should be paid to the Under 15 youth category because they are preparing to participate in the national phases of this sport: understanding the load determined by the beach soccer match allows more effective training sessions to be scheduled.


## Acknowledgments

The author is grateful to all players and sports club for their voluntary and important participation.


## Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

## Ethical Committee approval

Università degli Studi di Foggia n.00149ss/2023.


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## Topic

Sport Performance

## Conflicts of interest

The author declares no conflict of interest.


## Funding

No funding was received for this investigation.


## Author-s contribution

Conceptualization, I.S.; methodology, I.S.; software, I.S..; validation, I.S.; formal analysis, I.S.; investigation, I.S.; resources, I.S.; data curation, I.S.; writing—original draft preparation, I.S.; writing—review and editing, I.S.; visualization, I.S..

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Received: 01.03.2025.
Accepted: 05.03.2025.
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