

Evaluation of the external and internal workload in female futsal players

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ABSTRACT: Match analysis technology has been extensively used in football, but there is limited literature on its use in futsal. Despite its increased popularity, the female futsal game model has never been quantified. The aim of this study was to quantify locomotor and mechanical activities performed during a non-competitive female futsal match, measuring the differences between the first and second half. Sixteen female futsal players of the Italian 2nd division were enrolled (age 27 ± 5 years, height 1.65 ± 0.09 m, body weight 56.9 ± 7.7 kg, BMI 20.9 ± 1.9 , fat mass $21.5 \pm 2.9\%$). Locomotor and mechanical activities were recorded by means of the 10 Hz GPS StatSports system. Games were performed on a 38x18 m synthetic grass outdoor pitch. Significant differences were found between the first and second half in total distance (1424 ± 114 and 1313 ± 113 m, $p < 0.05$), relative velocity (70 ± 6 and 64 ± 6 m min^{-1} , $p < 0.05$), high speed running (28 ± 16 and 22 ± 19 m, $p < 0.05$) and high metabolic distance (80 ± 29 and 69 ± 28 m, $p < 0.05$). The match analysis of female futsal matches provides useful information about its external load demands. Female futsal players decreased the workload in the second half compared to the first one during this non-competitive match. It was found that fatigue impairs the performance in the second part of the game. Coaches and physical trainers can obtain useful information to design training programmes taking into account the quantification of locomotor and mechanical activities performed in this study.

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INTRODUCTION

Futsal is commonly named five-a-side indoor football format. It is played on a field of 40x20 m (range between 38x18 and 42x22 m) with goals of 3x2 m between 2 teams of 5 players (four are outfield players and one is the goalkeeper). Futsal's popularity has improved in recent years, and more than 12 million players in over 100 countries are involved [1]. Despite its popularity, its scientific background in male and especially in female futsal players is limited, compared to the traditional game format in male and female soccer players [2].

Futsal can be defined as a multiple-sprint sport with an intermittent high intensity activity [3]. Male futsal players cover a mean of 4000 m (large range of 601-8040 m due to substitution policies), at mean relative velocity (RV) of $120 \text{ m} \cdot \text{min}^{-1}$ (range 102.7-145.4 m) during official matches [4]. Moreover, Barbero-Alvarez et al. [4] reported that futsal players covered a distance (during official competitions) by walking of 397 m, jogging 1762 m, medium intensity running 1232 m, high intensity running 571 m and at maximum speed 349 m. Understanding the futsal game model and quantifying external load variables as distance covered, relative velocity (RV), number of accelerations, decelerations, and change of directions may be a useful task for the design of suitable training programmes [3,5,6].

Metabolic power is an ecological approach useful to quantify workload during matches and training sessions [7]. The estimation of the metabolic power used the rationale that accelerated running on a flat terrain is energetically analogous to uphill running at constant speed [8]. The metabolic power approach better represents a soccer match model than a speed-based approach [7,8]. Indeed, especially on small pitches, traditional speed categorization may heavily underrate (over 100%) the quantification of high-intensity distance performed by players [9]. Thus, metabolic power variables might be included in external load analysis in order to better understand the actual futsal demands.

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a metabolic power approach in this sport. Therefore, the aim of this study was to quantify the workload in a female non-competitive futsal game, investigating the differences between the first and second half, and taking into account metabolic power as a new parameter in futsal.

MATERIALS AND METHODS

Participants

Sixteen Italian 2nd division female futsal players were enrolled in the study (age 27 ± 5 years, body height 1.65 ± 0.09 m, body mass 56.9 ± 7.7 kg, BMI 20.9 ± 1.9 , fat mass $21.5 \pm 2.9\%$) during season 2014/15. Goalkeepers were excluded from the study. The futsal coach of the team supported the players in every part of the study (i.e. verbal encouragement during the games). Participants signed a written informed consent form and all procedures were approved by the Ethics Committee of the Department of Neurological and Movement Sciences, University of Verona (Italy). All measurements were conducted according to the Declaration of Helsinki for human studies of the World Medical Association.

Procedures

Body fat estimation was determined using a skinfold-based method (skinfold calibre, Gima S.p.A., MI, Italy). Body density was calculated using the Jackson and Pollock equation [21]. We also recorded both body weight (BW), height by stadiometer (Seca, Italy) and BMI. The measures (skinfold, body weight and height) were obtained three times using the average value for the analysis. Each player's HR_{max} was determined by completion of a Yo-Yo intermittent recovery test level 1 (IR1). Heart rate was recorded during IR1 and during matches using Polar RS400D heart rate monitor watches (Polar, Oulu, Finland), and the data were analysed with ProTrainer 5 software at the end of each test [5]. Before every session players performed a traditional warm-up for 12 minutes. In the first phase players did exercises without the ball and in the second part they performed specific exercises with the ball (players were supported by their coach during warm-up activation). Training load parameters were recorded during two friendly matches (composed of two halves of 20 minutes) by means of the 10 Hz GPS system and 100-Hz triaxial accelerometer (STATSports, Ireland). Validity of these GPS units was previously reported [22]. The GPS units were turned on about 10-15 min before the beginning of the test; meanwhile the subjects familiarised themselves with the equipment as well as the procedures and performed a warm up. During the experiments a GPS unit was placed on the back of the participants by means of a harness at the level of the chest. We used the same GPS unit for all participants to avoid inter-unit variability (a possible confounding factor). GPS data were analysed by STATSport Viper Software Version 1.2. Teams played without the opportunity to perform substitutions (5 vs. 5). Substitutions were prohibited in order to reduce the players' match-load variability [4]. Match measurements were performed in two different training sessions in order to avoid the

effect of fatigue. Games were performed on a 38x18 m synthetic outdoor pitch. An outdoor pitch was used to enable the analysis of the GPS technology, as currently GPS technology does not gain a signal indoors to provide all the relevant variables. Total distance covered (TD) measured in metres, high speed running over $14.4 \text{ km} \cdot \text{h}^{-1}$ (HSR), number of accelerations and decelerations performed ($>2 \text{ m} \cdot \text{s}^{-2}$), relative velocity calculated as the ratio between TD and the total time, average metabolic power (MP) and high intensity metabolic power distance over 20 W kg^{-1} (HMD) were measured and analysed [8]. The indirect estimation of the metabolic power used the rationale that accelerated running on a flat terrain is energetically analogous to uphill running at constant speed:

$$\text{EC} (\text{J} \cdot \text{kg}^{-1} \cdot \text{m}^{-1}) = (155.4 \text{ ES5} - 30.4 \text{ ES4} - 43.3 \text{ ES3} + 46.3 \text{ ES2} + 19.5 \text{ ES} + 3.6) \text{ EM}$$

Where EC is the energy cost of accelerated running on grass, EM is the equivalent mass and ES is the equivalent slope [8,10]. This study cannot explain in detail the rationale of this algorithm; thus we invite researchers and sport scientists to read Osgnach 2010 [8].

Further analysis was conducted measuring dynamic body load (DBL) with a 100-Hz triaxial accelerometer. The integration of triaxial accelerometers into GPS devices offers additional information about athletes' physical loads. The triaxial accelerometer summates accelerations in the 3 movement axes (X, Y, and Z planes) to measure a composite magnitude vector (expressed as a Gforce) [11]. This external parameter may be a specific new indicator of mechanical stress. It has demonstrated a good relationship with external (TD, $r=0.70$) and internal (rating of perceived exertion, $r=0.74$) load variables [11]. Body load evaluates every instantaneous variation in training activity, and based on a logical rationale relative to the football and futsal game model it could be a good indicator of players' workload.

Statistical analysis

Statistical analyses were performed using SPSS software version 20 for Windows 7, Chicago, USA. The assumption of normality was verified by the Shapiro-Wilk test. Paired t tests were performed to analyse the differences between the first and second half. Significance was set at $p < 0.05$. Data are presented as mean \pm SD. Cohen's d (ES) was calculated to determine the magnitude of effect by standardizing the coefficients according to the appropriate between-subjects standard deviation and was assessed using the following criteria: small > 0.2 , medium > 0.5 , large > 0.8 [20].

RESULTS

Players covered a distance of 920 ± 164 m during IR1, and they reported an HR_{max} of 194 ± 7 bpm. Several significant differences between GPS parameters for the first and second half were identified, as reported in Table 1. Significant decreases ($p < 0.05$) between the first (time 20 minutes 25 s) and second half (20 min 26 s) were

TABLE 1. Performance variables analysed during friendly futsal matches in female players. Mean \pm SDs, N=16.

Locomotor activity	First half	Second half	Differences (%)	Match
Time (min)	20 min 25 s	20 min 26 s	-	40 min 51 s
TD (m)	1424 \pm 114*	1313 \pm 113	-111 (7.8%)	2737 \pm 207
RV (m \cdot min ⁻¹)	70 \pm 6*	64 \pm 6	-4 (8.6%)	67 \pm 5
HSR (m)	28 \pm 16*	22 \pm 19	-6 (21.4%)	50 \pm 33
HMD (m)	80 \pm 29*	69 \pm 26	-11 (13.7%)	150 \pm 53
No. accelerations	16 \pm 4	16 \pm 4	0 (0%)	31 \pm 6
No. decelerations	21 \pm 6	19 \pm 7	-2 (9.5%)	40 \pm 12
DBL (AU)	49 \pm 26	51 \pm 28	+2 (4.1%)	101 \pm 55
MP (W \cdot kg ⁻¹)	6.2 \pm 0.7 [#]	5.9 \pm 0.7	-0.3 (4.8%)	6.1 \pm 0.6
Mean HR (%Max)	85 \pm 3	81 \pm 4	-4 (4.7%)	83 \pm 3

TD=total distance; RV=relative velocity; HSR=high speed running; HMD=high metabolic distance; DBL= dynamic body load; MP=average metabolic power, HR=heart rate.

Differences are reported as absolute value (percentage of differences).

* = $p < 0.05$ first half compared to second.

[#] = $p = 0.059$ first half compared to second.

found in TD (1424 \pm 114 m and 1313 \pm 113 m, respectively, ES=0.97, large), RV (70 \pm 6 m \cdot min⁻¹ and 64 \pm 6 m \cdot min⁻¹, respectively, ES=1.0, large), HSR (28 \pm 16 m and 22 \pm 19 m, respectively, ES=0.34, small), HMD (80 \pm 29 m and 69 \pm 26 m, respectively, ES=0.39, small), and mean HR (85 \pm 3 % and 81 \pm 4% HRmax, respectively, ES=1.13, large). An effect (ES=0.42, small, $p=0.059$) was found for MP between the first and second half (6.2 \pm 0.7 W \cdot kg⁻¹ and 5.9 \pm 0.7 W \cdot kg⁻¹, respectively). No significant differences between first and second halves in number of accelerations (16 \pm 4 and 16 \pm 4, respectively), number of decelerations (21 \pm 6 and 19 \pm 7, respectively) or DBL (49 \pm 26 arbitrary units (AU) and 51 \pm 28 AU, respectively) were found.

DISCUSSION

To the best of our knowledge, this study is the first to analyse a friendly futsal match in female players. A decrease in many physical parameters in the second half was identified (reported in Table 1). Due to the lack of research in this area, no available comparisons can be made for recorded MP, HMD, DBL, number of accelerations and number of decelerations.

It is generally accepted that changes of speed, accelerations and decelerations are important parameters in team sports [5]. It is known that 'stop and go' actions or high intensity intermittent bouts have higher energy demands than running at constant speed [6]. Significant decreases in physical load parameters were shown between the first and second half, especially in TD and HMD. However, DBL, number of accelerations and number of decelerations did not show a significant difference between halves. The decrease in physical workload that was found is in agreement with previous reports on male futsal players [4,12]. Barbero-Alvarez et al. [4] reported a

significant decrease in high intensity running and RV from 118.4 m \cdot min⁻¹ to 110.5 m \cdot min⁻¹ between the two halves of the match, while De Oliveira et al. [12] found a decrease in RV from 136.6 m \cdot min⁻¹ to 129.2 m \cdot min⁻¹. Physical activity decrease is a phenomenon potentially associated with fatigue [13]. The current study results show that fatigue may affect performance in female futsal players as reported in male players [3]. In this study, players performed the matches without substitutions; thus the onset of fatigue was inevitable during the match and it caused a decrease in performance (external and internal load parameters); this type of match protocol underlines that some substitution strategies (e.g. replace a couple of players every 2-3 minutes) are necessary in order to decrease the negative effect of fatigue. The physiological motivation of fatigue was previously explored in soccer [13]. It was found that after the game about half of the type I and type IIA fibres were almost or completely depleted of muscle glycogen [13]. The current data are in line with previous reports that showed a general performance decrease between the two halves of football of a longer duration (i.e. 45 min each) [13].

As previously stated, the current data cannot be compared to studies that included female samples, although it is possible to perform a brief comparison to male futsal players. On the basis of previous literature, large differences exist between female and male futsal players in match-load parameters, where male professional players performed greater TD (4000 vs. 2737 m) and relative velocity (117 vs. 67 m \cdot min⁻¹) compared to females [4]. These large differences are likely due to the differences in physical conditions between genders (male vs. female) and also league level (professional vs. semi-professional) [14]. Previous analysis of activity profiles of outfield players showed that the TD covered by elite players was

higher than that covered by amateurs (5087 vs. 4528 m, respectively) [14].

This study is the first to our knowledge that compares traditional external loads to metabolic parameters in an outdoor futsal pitch. Futsal is characterised by an intermittent model, where players perform short, powerful actions. Unfortunately, when carrying out these actions, speed remains low, and accordingly is categorised in a lower speed zone as jogging (e.g. speed $<10 \text{ km} \cdot \text{h}^{-1}$). This can grossly underestimate the actual weight of the external load performed. In this study, large differences between distances covered in HSR and HMD categories ($50 \pm 33 \text{ m}$ and $159 \pm 53 \text{ m}$, respectively) were identified. It is suggested that traditional external load parameters based on speed categories may not be suitable to represent the physical activities/demands of a futsal match (game model), and therefore a metabolic power approach may be better suited, due to an increase in the shorter and more powerful actions occurring in a futsal match. Physiological and internal load parameters should be integrated to external load parameters in order to obtain a more accurate analysis of the training load. HR is a useful parameter in order to take into account aerobic metabolism during futsal matches [2]. The present data show limited HSR ($50 \pm 33 \text{ m}$) when compared to the traditional football format ($917 \pm 143 \text{ m}$) [15], which may provide a rationale for the use of HMD in futsal and/or training on small pitches. The difference between HSR ($50 \pm 33 \text{ m}$) and HMD ($150 \pm 53 \text{ m}$) found in this study, as reported in previous studies, may suggest that the use of speed categories in order to analyse training and matches on small pitches may underestimate the high intensity activity performed [7,9]. Thus, it is recommended to disregard the speed categories in a futsal game and training analysis. To date, it is advised to quantify external workload by TD, number of accelerations and number of decelerations [3]. In the current study, analysis of internal (HR) and external load parameters (metabolic power and DBL) underlined the necessity to integrate both the parameters in order to better support training and match load analysis [7]. However, before the integration of these methods in routine evaluations, further analysis in future research has to be conducted. Metabolic power has the potential to differentiate training within futsal, but this approach still has its limitations [16]. In this study, the utilization of DBL during futsal match analysis is reported for the first time. It is a relatively new parameter that records every instantaneous variation of activity, and it can add to the investigation of specific indicators of mechanical stress. Future research may analyse better its use in futsal.

This study is not without its limitations. The futsal matches studied were conducted in friendly matches, and it is possible to argue that an official futsal match could have a greater physiological impact and higher external load than reported in this study. In a futsal match, a team comprises five players, four on-court players and the goalkeeper, with an unlimited number of substitutions. This study did not allow substitutions, and we have to consider it as a limitation. In addition, a larger sample size might be necessary to increase the

knowledge on this topic, as well as on female futsal players generally. In this study players performed matches on a synthetic outdoor field; this was necessary in order to record the data by GPS devices that cannot work indoors. Official futsal matches are played on indoor pitches. In this case, it may be suggested that the limitation is not associated with the pitch location (indoor or outdoor), but rather with the field surface. Synthetic grass was used in the current study, and it has different characteristics to wood or other official surfaces typically used in futsal. However, a large number of teams, especially semi-professional or amateurs (and frequently even professional teams), do not have the availability of indoor facilities, and perform training sessions on artificial grass, so this study may still hold relevance. Moreover, artificial turf pitches are allowed (in exceptional cases) for national competitions (FIFA, Futsal laws of the game 2012/13) [17].

In conclusion, these findings can provide useful information and support to futsal practitioners. This study brings new information on female friendly futsal matches, by the quantification of physical and mechanical activities. Information about mechanical-muscular loads (e.g. TD, MP, HMD, DBL, number of accelerations and decelerations) has critical importance in the design of specific futsal training protocols. Futsal is a very physically intense sport, and its physical demands are important and should be taken into consideration by coaches in applying training for competitions in order to improve maximal performance. Physical demands and aerobic fitness have a link with fatigue, and as reported in our study, female futsal players showed a low aerobic fitness level ($\text{IR1} = 920 \pm 164 \text{ m}$). A previous investigation showed that elite level female futsal players have lower aerobic fitness ($\text{VO}_2\text{max} = 45.3 \pm 5.6 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) than elite and professional female soccer players (from 49 to $58 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) [18]. Coaches and sport scientists can use this new information to plan futsal training sessions, and to quantify the workload more appropriately. Moreover, futsal is used in some countries as a football development tool, to develop young footballers' technical and tactical behaviours, and thus the knowledge about futsal's physical demands might have practical implications in development of young talent. This is also supported by recent analysis on elite and sub-elite females, where professional futsal players achieved better scores than the semi-professional ones in agility and kicking performance during shooting [19]. Future analyses are necessary in order to better understand the futsal game model in female players, and to investigate external load parameters suitable for this sport, as metabolic power and DBL may provide a better understanding.

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