Original Article

Analysis of the energy expenditures by Ukrainian professional futsal players during the preparation and participation in competitions

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Abstract

This study determined the energy expenditure of 60 professional Ukrainian futsal players with different positional roles by taking into account their mass, composition, and body structure. To obtain the necessary data, was used a device that determines the number of calories expended and quantities of fat and muscle components in the body of each athlete. The data on the expenditure of energy was received during competitions and at training sessions during preparation for competitions. The data on the body composition as well as the use of anthropometry, somatoscopy, and the Heath-Carter scheme allowed to determine the types of body structure of the athletes. Professional futsal players have an ectomorphic type of body structure. During a futsal match, the most energy is expended by the defenders, and the expenditure of the pivots are insignificantly larger than those typical for the goalkeepers. During training, the defenders and pivots spend almost the same amount of energy, which is considerably more than that of the goalkeepers, regardless of the content of training programs. The obtained data can be used by trainers, nutritionists, and team doctors to offer players the best time to recover between workouts and provide them with an adequate diet. The results on the peculiarities of the energy expenditure of Ukrainian professional futsal players in different positional roles during preparation for competitions and during training sessions should be considered as a way to achieve better results in competitions. Specifically, these data can be used by trainers, nutritionists, and team doctors to offer players the optimal recovery period between training sessions and provide them with an adequate daily eating ration. This approach will enhance preparation by players for competitions.

Keywords: energy expenditure, anthropometry, futsal different positional roles.

Introduction

Different characteristics of futsal players are manifested through a set of features (Barbero-Alvarez, Soto, & Granda-Vera, 2008; Casamichana, Castellano, & Castagna, 2013; Moore, Bullough, & Edmondson, 2014; Agras, Ferragut, and Abalde, 2016; Almeida, Volossovitch, Duarte, 2017; Aquino, Puggina, Alves, Garganta, 2017). In particular, the value of most of their functional characteristics is different from the values of players with the same sport qualification and positional roles, but specializing in another variety of this sport game, namely soccer (Barbero-Alvarez, & Castagna, 2009; Casamichana, Castellano, 2010; Bueno, & Moura, 2014; Moura, Marche, & Cunha, 2017). Thus, futsal players' running economy is 12.5% bigger. Moreover, it is typical for defenders, wingers, pivots. Also, running economy is positively correlated with oxygen uptake at VT₂ (hereinafter ventilatory threshold 2 - i.e. respiratory compensation point) in both sports and in all positional roles (Santos-Silva, Greve, 2017). In connection with the data obtained, these authors emphasize the need to separately study the functional characteristics of players who specialize in each of the specified types of sports game. The analysis of existing information has shown an unjustifiedly small amount of data on the parameters of various physiological characteristics of professional futsal players. Existing data show that the physiological characteristics of the cardiopulmonary system, namely %HR_{max}, VO_{2max}, blood lactate, of the professional futsal players are significantly higher (at $p < 0.05$) than of the futsal players of amateur group (Makaje, & Yoopat, 2012). The locomotor activity of the former during the match is higher, namely: total distance amounted to 5087±1104 and 4528±1248 m respectively ($p < 0.05$). However, there were no significant differences in the physiological demands and activity profiles between the goalkeepers in the two groups ($p > 0.05$).

According to other data (Barbero-Alvarez, & Castagna, 2009), VO_{2max} may be considered a competitive-level dependent physical variable in futsal; VO_{2max} values or above $60 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ are advisable to play futsal at the professional level. At the same time, these authors note that the value of ventilatory threshold (VT) and running economy (RE, VO_{2max} at $8 \text{ km} \cdot \text{h}^{-1}$) of futsal players from a professional top-ranked second division team and semi-professional top-ranked third division team were almost identical. Milanez et al (2011) indicate that VO_{2max} plays a key role in determining the magnitude of an individual's perceived exertion during futsal training sessions. Between VO_{2max} ($59.6 \pm 2.5 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and overall training load accumulated over the total period was found a significant correlation ($r = -0.75$). Taking into account the given data, it is important to note that the lack of significant decrease in FEV_1 of the examined athletes testifies to sufficient compensatory changes and high respiratory potential of athletes who train for speed, strength and endurance abilities (Castagna, Barbero-Alvarez, 2010; Guba, Skorovich, & Stula, 2014). The above data is important for the trainer, because their consideration ensures an increase in the efficiency of training aimed at training futsal players in competitive activities. There is no exception to the amount of energy spent by players with different positional roles during the competition and preparation for them. In this regard, data on their body weight, composition, and features of the body structure are also important (Carter, Heath, 1990). Considering the above mentioned, it was indicated that at the present stage there is actually no research aimed at establishing the quantitative characteristics of energy expenditure during training and competitive activities of the Ukrainian professional futsal players with different positional roles. Also, there is insufficient data on morphological characteristics of professional futsal players, that determine the amount of consumed energy. This information is very important and necessary to the coaches, primarily because of the choice of optimal parameters of physical activity.

Materials and methods

60 futsal players were used to determine their locomotor activities; the age range of 24.7 ± 3.3 years. All the sportsmen were professional futsal players, although had different positional roles, in particular: 20 goalkeepers, 20 defenders, 20 pivots; they compete in the first League of the championship of the Ukraine. Each athlete was informed about the research design and the requirements, benefits and risks of the study. The research was conducted in compliance with the WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects, 2013. The study protocol was approved by the Ethical Committee of Kamianets-Podilskyi National Ivan Ohienko University. The energy expenditures of the studied athletes were determined during the training process and competitive activity. For this purpose was used the device OMRON HJ-321-E Walking Style One 2.1. This example allows to establish that apart from other (daily distance, daily steps, aerobic mode), also calorie counter. According to the available information the measurement error is very small, namely from 0.5 to 6.9%. It was located in a special inner pocket of sports shorts that was made with this purpose. For adequate analysis of the data on energy expenditures, the body weight of the athletes and its composition was taken into account. The body weight of the athletes was determined using medical scales SMR-250-100 Certus Medical. The percentage of fat and muscle components in the total mass of the athlete's body was established by means of the device BODY COMPOSITION MONITOR OMRON BF-311; the data obtained was transferred to a personal computer. The reliability of the obtained results with the help the used devices is, to some extent, proved by the fact that they were used by the researchers [21], the manufacturer's warranty and a large number of user reviews on its official website on the Internet. At the same time, the method of somatoscopy and names of types of the body structure was used in the scheme of Heath-Carter (1990), in particular: endomorphy, mesomorphy, and ectomorphy. During the analysis of data on energy expenditure of athletes during competitive activity, the most common type of the futsal match was taken into account: during one half of the match the outfield player usually plays 4-5 times for 3-5 minutes and then all four of the players are changed.

Data about the energy expenditure during training sessions included consideration of their specificity. In particular, the expenditure of energy was established during the sessions on increasing technical and tactical preparation of players, training with comprehensive content and training for development of speed endurance. The contents of the first set of trainings supposed using in the preparatory part of aerobic running at a distance of 500 m during 4 minutes, after that - various running exercises with high intensity (maximum and submaximum speed of execution for 6 minutes) and stretching exercises (5 minutes). The preparatory part was completed by the exercises with general development content and moderate intensity for 5 minutes. During the main part, the players performed the task of technical-tactical interaction while possessing the ball in their half of the court (ball control under pressure, 22 minutes). Then there was a match between two teams, which included active pressure throughout the 9 minutes. The next task was to perform: shots on goal (9 minutes), technical and tactical interaction during possession of the ball on the opponent's half of the field (positional attack, 22 minutes), the match of two teams (positional attack, 11 min), playback of standard positions (11 minutes), the game of two teams (playback of competitive activity, 22 minutes). In the final part the players performed aerobic jogging at a distance of 200 m for two minutes and stretching exercises for 4 minutes. Parameters of physical activity assumed that the leading mode of exercise is the aerobic-anaerobic, duration 120 minutes, the mean value was at 136-140 bpm, max HR was 198-200 bpm, and the minimum 62-64 bpm.

Parameters of physical activity during a series of lessons with complex content included the following: mode of exercise was anaerobic alactic, the duration of individual classes - 110 minutes, average HR 132 to 136 bpm, the maximum value 218-222 bpm, the minimum 63-67. At these sessions the speed force was developed and technical-tactical skills of futsal players was improved. To do this, in the preparatory part was used aerobic running at a distance of 500 m within 4 minutes. After that the players were doing the exercises with general development content and moderate intensity for 6 minutes and stretching exercises (6 minutes). In the main part the players first performed low and high shots to prepare goalkeepers for various tasks (3 minutes). Then within 9 minutes, the players performed a set of five exercises for speed development; each exercise was repeated 5 times, with rest between repetitions and exercises. Next task involved the shooting on goal (9 minutes) and transmission in couples through the corridor (6 minutes). In the final part the players performed aerobic running at a distance of 200 m for two minutes and stretching exercises for 4 minutes. Parameters of physical activity during a series of trainings on the development of speed endurance suggested that the mode of exercise is anaerobic glicolic, the duration of individual lessons is 115 minutes, the average value of HR at the level 130-134 bpm, the maximum value HR bpm is 200-204, the minimum - 100-104. In the preparatory part of such training, the players performed aerobic jogging at a distance of 500 m within 4 minutes, then stretching exercises (6 minutes) various running exercises with high intensity (6 minutes), as well as exercises with general development content (7 minutes) and stretching (3 minutes) with moderate intensity. In the main part the players first performed low and high shots to prepare goalkeepers for various tasks (3 minutes). After that all of them performed a complex of exercises for development of speed endurance. This complex included: 4 series 5 min. each; 4 exercises in one series, rest between exercises - 40 seconds, and between series - 2 minutes. After performing such a complex, players again but this time for 9 minutes, performed shots on goal to improve their technical and tactical preparation and goalkeepers. The major part continued with a match of two teams, which included accomplishment of assigned tactical task for 17 minutes and ended with a task of passing the ball in pairs across the corridor for 6 minutes. In the final part the players performed aerobic running at a distance of 200 m for two minutes and stretching exercises for 4 minutes. HR was determined using the BEURER PM 15 device. The accuracy of its measurement is not different from that of an electrocardiograph. The device also allows you to set the upper and lower limits of the required HR, and alerts about their achievement with the sound signal.

All statistical analyses were performed using SPSS Version 21. For each characteristic there were determined average values, standard deviations, and Student criterion for unrelated samples (Thomas, Nelson, & Silverman, 2011).

Results

Morphological characteristics of professional futsal players is given in Table 1. The data showed that the composition of their body was characterized in that development the fat component corresponded

Table 1. Morphological characteristics of professional futsal players (n=60)

Indicator	Mean	SD	Min	Max
Length of body, cm	177.0	4.79	168.0	183.0
Body weight, kg	70.2	5.44	54.8	76.1
Muscular component of body composition, %	44.4	2.14	42.2	47.9
The fat component of body composition, %	13.4	2.72	7.9	17.5

a low level of fat, and the development of the muscular component corresponded to the middle level. Based on these data and the results of somatoscopy, it was determined that the studied athletes had a distinctive ectomorph body structure. During the national championship match, the studied athletes spend an unequal amount of energy. Thus, the biggest expenditures were show by the defenders, somewhat lower by the pivots, and the smallest by the goalkeepers. During the game, the goalkeepers make fewer moves than the field players (Kagawa, Kobata, & Nakamura, 2014; A Guide to Proper Nutrition for Futsal, 2018). Although, as evidenced by the data obtained during the experimental study, the goalkeepers spent a lot of energy (Table 2). However, during the game, the defenders spent 211.2 kcal more energy than the pivots. The defenders spent 243.5 kcal more than the goalkeepers. The statistical significance of this difference corresponded to 0.001 alpha levels of probability ($p < 0.001$). This difference was significant because its statistical significance corresponded to 0.001 alpha levels of probability ($p < 0.001$). During the preparation of

Table 2. Peculiarities of the amount of energy consumed by professional futsal players with different positional roles during a competitive activity

Positional role	Mean $\pm$ SD, kcal	Goalkeepers	Defenders
Goalkeepers (n = 20)	1132 $\pm$ 53.3	–	7.91*($p < 0.001$)
Defenders (n = 20)	1375.5 $\pm$ 65.2	–	–
Pivots (n = 20)	1164.3 $\pm$ 64.7	1.02 ($p > 0.05$)	9.12* ($p < 0.001$)

Note: * - statistically significant difference of the two mean value

the futsal players for the country championship, the energy expenditures were not the same (Table 3). It was determined that during the

Table 3. Amount of energy expended (Mean $\pm$ SD) by the professional futsal players with different positional roles when using training sessions with different contents, *kcal*

Activity features	Goalkeepers (n = 20)	Defenders (n = 20)	Pivots (n = 20)
Preparation for competitions:			
· content of training sessions-1	1142.5 $\pm$ 41.2	1522.4 $\pm$ 58.3	1439.8 $\pm$ 52.7
· content of training sessions-2	1101.3 $\pm$ 46.9	1480.7 $\pm$ 61.6	1397.3 $\pm$ 56.2
· content of training sessions-3	1087.1 $\pm$ 51.7	1469.8 $\pm$ 65.2	1380.4 $\pm$ 59.1

Note: content of training sessions-1 – to increase the technical and tactical preparation of the players; content of training sessions-2 – to create a complex impact on the preparation of the players; content of training sessions-3 – to develop the speed endurance of the players

session-1 training, the goalkeepers spent significantly less energy than the defenders and pivots. The energy expenditures of the latter two were almost identical ($p > 0.05$) because the difference was 82.6 kcal (Table 4).

Table 4. Comparison of the amount of energy expended by the professional futsal players with different positional roles when using training sessions with different contents, *t*

Sports activity	Goalkeepers–Defenders	Goalkeepers–Pivots	Defenders–Pivots
Preparation for competitions:			
· content of training sessions-1	5.32* ($p < 0.001$)	4.45* ($p < 0.001$)	1.05 ($p > 0.05$)
· content of training sessions-2	4.9* ($p < 0.001$)	4.04* ($p < 0.001$)	1.00 ($p > 0.05$)
· content of training sessions-3	4.6* ($p < 0.001$)	3.74* ($p < 0.01$)	1.02 ($p > 0.05$)

Note: * - statistically significant difference of the two mean values

During each training session, when the content of the training sessions-2 was used, the energy expenditures of futsal players with different positional roles were within the range of 1101.3–1480.7 kcal. The comparison of these data showed that the goalkeepers spent significantly less energy than did the defenders and pivots. The energy expenditures of the latter two were almost identical because the difference between their data was only 83.4 kcal ($p > 0.05$). During each training session with a different content aimed at developing the speed endurance of the futsal players (training sessions-3), the players spent the amount of energy in the range of 1087.1–1469.8 kcal. When comparing these data, it was revealed that the goalkeepers spent significantly less energy than did the defenders and pivots because the difference was 382.7 kcal and 293.3 kcal ($p < 0.001$), respectively. The energy expenditure of the defenders and pivots were approximately identical because the difference between the values of the index was only 89.4 kcal, which was not statistically significant ($p > 0.05$). In addition, the use by the goalkeepers, defenders, and pivots of all the options of the content was accompanied by almost the same energy expenditure. Thus, the difference between the values of the indicator, which were obtained after the goalkeepers used content-1 and content-2, was only 41.2 kcal; after the use of content-1 and content-3 – 55.4 kcal; after the use of content-2 and content-3 – 14.2 kcal. A similar result was obtained when comparing the amount of energy expended by the studied defenders and forwards when using content-1, content-2, content-3 during the training sessions when preparing for the country championship (Table 5).

Table 5. Comparison of the amount of energy expended by the professional futsal players with different positional roles when using training sessions with different contents, *t*

Positional role	Content of training sessions 1 and 2	Content of training sessions 1 and 3	Content of training sessions 2 and 3
Goalkeepers	0.66 ($p > 0.05$)	0.84 ($p > 0.05$)	0.2 ($p > 0.05$)
Defenders	0.49 ($p > 0.05$)	0.6 ($p > 0.05$)	0.12 ($p > 0.05$)
Pivots	0.55 ($p > 0.05$)	0.75 ($p > 0.05$)	0.21 ($p > 0.05$)

Discussion

The information about the energy expenditure of each futsal team player has a practical value because it will help trainers with their training activities. Energy expenditure of players is due to many reasons (Kagawa, Kobata, & Nakamura, 2014; Burdukiewicz, Pietraszewska, & Goliński, 2014). Our study showed that all players belonged to the same body type structure, namely ectomorph. This increases the homogeneity of the sample. Thus, in our study, we did not have to consider the body type structure during the analysis of the obtained data (Corrêa, Davids, & Tani, 2014). In addition, the data we received confirmed previous results from other researchers that were related to the peculiarities of the body structure of the futsal players with different positional roles (Burdukiewicz, Pietraszewska, & Goliński, 2014; Iedynak, Galamandjuk, & Chopik, 2017). In addition, during a competitive activity, the largest energy expenditure was exhibited by the defenders, and the pivots and goalkeepers exhibited almost identical energy expenditures. In (Bueno, Caetano, & Moura, 2018), it

is noted that during a game, the goalkeepers make significantly less movements than the outfield players. However, their energy expenditures are large, which was confirmed by the data in our study. The obtained energy expenditures of the goalkeepers can be explained by several reasons. First, the goalkeepers are in the game without a replacement, and thus constantly and with high intensity perform special moves with the ball and without the ball (Corrêa, Davids, & Tani, 2014; Iedynak, Galamandjuk, Koryahin, Blavt, & Gurtova, 2019). However, their competitive activity has a high and almost constant psychological stress (Rabasa, Dickson, 2016; Musculus, and Lobinger, 2018). Therefore, the energy expenditure during these tense moments does not differ from the energy expenditure that accompanies a physical activity (Koryahin, & Cherepovska, 2018).

The research results of P. Wolański et al. (2017) suggest that the mean energy expenditure of a single effort was $16.33 \pm 5.36 \text{ kcal} \cdot \text{min}^{-1}$. As noted by Rodrigues et al. (2011), during an official match, the professional futsal players spend $18 \pm 2.2 \text{ kcal} \cdot \text{min}^{-1}$. That result was explained using various methods to obtain information about the amount of expended energy, ignoring the positional roles of the athletes and the uneven length of data fixation during the match. The following data were obtained about the peculiarities of the energy expenditure by the professional futsal players with different positional roles when using training programs with different contents. Specifically, the highest values of the indicator were shown by the defenders, much smaller – by the pivots, and especially low – by the goalkeepers. This result is partially confirmed by the data of the futsal players with different positional roles about the importance of running economy, which they demonstrate when performing aerobic fitness (Alvarez, D'Ottavio, & Castagna, 2009). In addition, better running economy reduces energy expenditure and accelerates the recovery process of the athletes in terms of the ATP production. This contributes to the effective activity of the futsal players with different positional roles by increasing the efficiency and rational use of energy reserves during a competitive activity. The player with a higher running economy value during the match had more ball possession, which increased their opportunity to influence the outcome of the match (Helgerud, Engen, Wisløff, Hoff, 2001). The lack of differences in the amount of energy expended to accomplish each training program used during the study was associated primarily with similar mechanisms of energy supply of the work performed by the futsal players of high qualification with different positional roles during the training. Specifically, these mechanisms were: aerobic-anaerobic, anaerobic alactatic, and anaerobic lactatic. The leading mechanism of energy supply during all training programs was an anaerobic mechanism. It was associated with a statistically insignificant ($p > 0.05$) discrepancy between the amount of energy spent by the players during the training programs to increase the technical and tactical preparedness with that of the comprehensive content aimed at developing speed endurance. These types of loads are necessary because they meet the requirements of an effective competitive futsal activity (Rodrigues, Ramos, & Condessa, 2011; Makaje, Ruangthai, & Yooapat, 2012; Agras, Ferragut, and Abrales, 2016). Furthermore, these loads induce metabolic changes in the muscle tissue of the athletes, which lead to the adaptation and ability to adequately participate in a particular sport (Wilmore, Costill, Kenney, 2012). In addition, training programs should account for the fact that the fast phase of restitution in efforts at the intensity of approximately 85–87% of HRmax ends after approximately 90 s, and then the slow phase begins (Wolański, Muracki, & Murawska-Ciałowicz, 2017). At the intensity of approximately 90% of HRmax, the fast phase starts after approximately 150 s (1 min later). At the very high level of intensity, a small increase in intensity results in a significant increase of the recovery time. Professional futsal players are characterized by the peculiarities of energy expenditure during a competitive activity and preparation for it. Largely, these characteristics are caused by the positional roles of the athletes because all of them have the same ectomorphic type of the body structure. During the futsal game, the most energy is expended by the defenders, and the expenditure by the pivots is insignificantly larger than that by the goalkeepers. During the training, the defenders and pivots spend almost the same amount of energy but it is considerably more than the amount spent by the goalkeepers. This peculiarity is preserved when these athletes use training programs with aerobic-anaerobic, anaerobic alactatic or lactatic mechanisms of energy supply.

Conclusions

The results on the peculiarities of the energy expenditures of the futsal players of high qualification and different positional roles during preparation for the competitions and training sessions should be considered as an approach to achieve better results in a competitive activity. In particular, these data can be used by the trainers, nutritionists, and team doctors to offer players the optimal recovery parameters between training sessions and an adequate daily ration of eating. Therefore, further research into the energy expenditure and recovery of its supply by the futsal players with high qualification is essential. In particular, this study examined the energy expenditure by the players during competitive futsal matches and preparations for them and accounted for the body structure of the players with different positional roles. Therefore, further studies should include physiological characteristics, including special fitness tests and analysis of blood samples.

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