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ORIGINAL SCIENTIFIC ARTICLE

INFLUENCE OF BODY COMPOSITION PARAMETERS ON ANAEROBIC STRENGTH OF LOWER EXTREMITIES IN FEMALE FOOTBALL PLAYERS

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Abstract

The aim of this study was to investigate the influence of body composition on the anaerobic strength of the lower extremities, as well as the prediction of body composition on the results of anaerobic ability in professional football players.

Materials and Method. The sample of respondents consists of female football players who compete in the highest rank of the competition, the Serbian Super League. The total number of respondents included in the study was 21 female football players (age 19.38 ± 3.69, body height 166.48 ± 6.17 cm, body weight 59.98 ± 7.09 kg). The study is of a transversal nature and testing was done in the pre-competition period. The sample of measuring instruments used in the research are body composition and assessment of anaerobic strength of the lower extremities. Assessment of body composition was performed indoors using a multifrequency bioelectric impedance (Inbody 770). Variables for estimating the anaerobic strength of the lower extremities were obtained using a bicycle ergometer (Monark 839E) in the Wingate Anaerobic Test.

Results. The results of body composition show a statistically significant influence on the prediction of maximum anaerobic strength of the lower extremities in professional female football players ($p < 0.05$), as well as on the overall work in the anaerobic zone and the mean values of anaerobic strength. Regression analysis of the influence of body composition on the parameters of maximum strength in (W / kg) and fatigue rate does not show statistically significant results.

Conclusion. There is a statistically significant influence of body composition, such as: body weight, lean body mass (%), muscle mass in absolute and relative values, on the values of maximum anaerobic strength, mean values of anaerobic strength and overall work in professional female footballers.

Keywords: Wingate Anaerobic Test, lower extremity anaerobic strength, body composition, training plan and program.

Introduction

Today, about 20 million women play football worldwide, which is approximately 10% compared to men (İbrahim, Yaşar, Bayrakdaroğlu, & Yildiz, 2019). However, despite the growing popularity of women's football around the world, studies on women's football are limited. There is also an increased need for specific studies such as the association and impact of body composition on the physical predispositions of female football players, which can help plan and program training units and thus enable female football players to improve and increase their physical abilities (Martínez-Lagunas, Niessen, & Hartmann, 2014). Anaerobic activity is defined as energy consumption that uses anaerobic metabolism (without the use of oxygen) that lasts less than 90 seconds (Wilmore & Costill, 2004). The capacity to perform a variety of activities of high, anaerobic intensity are important for determining player's abilities (Littl & Williams, 2005). Good anaerobic capacity and good aerobic fitness are prerequisites for a successful performance of women's football (Mohr, Krustrup, Andersson, Kirkendal, & Bangsbo, 2008; Sheppard & Young, 2006), to help them perform high-intensity activities and help in recovery (Mohr, Krustrup, & Bangsbo, 2005). Milanović et al., 2017). Football is an activity in which an occasional high-intensity exercise regimen is combined with low-intensity movements (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005; Miller et al., 2007; Vescovi, Brown, & Murray, 2006). In addition to the different requirements in football, there are movements that require maximum effort in a short period of time, such as sprinting, acceleration, agility and jumping (Gunnar & Svein, 2015). Krustrup et al., (2005) found that female football players change different types of activities, such as sprinting, walking, jogging, acceleration, at different intensities from 152 to 186 heart rate per minute, every four seconds. Reilly, Bangsbo, & Franks (2000) said that most movements in a single match are performed without the ball and mainly for this type of activity aerobic capacity is used, while intense anaerobic activities occur during the activity at the end of the game. Body composition is an important indicator of an athlete's physical condition and health (Mala et al., 2015). When it comes to women who play football professionally, Nikolaidis, (2014) concluded that body composition values such as: body fat in% and kg, lean body mass in kg and body mass index are closely related to somatotype and muscle strength of the lower extremities. However, it is not possible to talk about one, isolated property of body composition or ability, which is the decisive factor when talking about anaerobic abilities and their results, values. When talking about the relationship between body composition and anaerobic strength of the lower extremities of women who play football professionally, Nikolaidis (2014) concludes that values for assessing body composition, such as non-fat body mass ($r = 0.84$) and body mass index ($r = 0.70$) , are significantly related to the values of maximum anaerobic strength of the lower extremities as well as the values of body fat ($r = 0.60$) and the percentage of body fat ($r = 0.42$). Küçükkubaş, Günay, Löklüoğlu, & Kakil (2019) found that there is no correlation between the percentage of lean body mass ($r = 0.02$), lean body mass in kg ($r = 0.26$) and the percentage of body fat ($r = -0.02$) with the values of maximum and mean anaerobic strength as well as lower extremity fatigue rates in the Wingate test. Moraru, Grigore, Alexandru-Rare, & Elisabeta (2017) the outcome of their research also does not show a correlation between body mass index ($r = 0.434$) and the values of maximum anaerobic strength in professional football players. The relationship between the parameters for assessing body composition and anaerobic strength of the lower extremities in women, who play football and compete in the highest rank of the competition, remains unclear and requires additional research. Also, previous research has shown contradictory results when it comes to the connection between body composition and anaerobic strength of the lower extremities. When it comes to research, which is based on the physiological and physical characteristics of top female football players, still lagging behind, there is not a sufficient number of papers, compared to research related to their male football colleagues.

The aim of this study was to investigate the influence of body composition on the anaerobic strength of the lower extremities, as well as the prediction of body composition on the results of anaerobic ability in professional football players.

Materials and Method

Study participants

The sample of respondents consists of female football players who compete in the highest rank of the competition, the Serbian Super League. The total number of respondents included in the study was 21 female football players (age 19.38 ± 3.69, body height 166.48 ± 6.17 cm, body weight 59.98 ± 7.09 kg). The study is of a transversal nature and testing was done in the pre-competition period. The criteria for inclusion were: players who joined the first team for at least six months, players who played at least one half-season before testing, that all players went through the preparation period with the team, without injuries in the last six months. Exclusion criteria were: persons in the recovery phase from some form of acute or chronic injuries, persons in the process of rehabilitation and football players who did not complete the entire preparation period. All respondents were first informed about the study, the purpose and goal of the research and possible consequences were explained to them. Also, the procedure and the course of the testing itself were explained to the respondents. Prior to the survey, each respondent signed a consent form to participate. For this research, the consent and approval of the head coach and the president of the club were obtained, and after that, testing was started. The research was approved by the Ethics Commission of the Faculty of Sports and Physical Education, University of Nis in accordance with the Declaration of Helsinki.

Study organization

The sample of measuring instruments used in the research are body composition and assessment of anaerobic strength of the lower extremities. Assessment of body composition and anaerobic strength was determined in the morning (09:30 h). Testing was done after the day of the break that the players had. The day before the examination of the body composition, the examinees had to follow the protocol, which included the requirements not to consume food or drink after 10 pm. Also, in the morning, before the test, the respondents did not consume food and drink. Evaluation of body composition was performed indoors using multifrequency bioelectric impedance (Inbody 770; Biospace Co. Ltd, Seoul, Korea), (Aandstad, Holtberget, Hageberg, Holme, & Anderssen, 2014) at frequencies 1, 5, 50, 250, 500 and 1000 kHz under a controlled temperature of 23-28 ° C. This instrument uses an eight-point tetrapolar tactile electrode system (four in contact with the palm and thumb and the other four in contact with legs) that separately measure the impedance of the arms, trunk and legs. Participants (wearing minimal clothing) placed their bare feet on metal scales and grabbed hand electrodes according to the manufacturer's instructions. Inbody 770 automatically measures total body mass, fat mass, muscle mass and lean (muscle and bone) mass in absolute amount up to the nearest 0.05 kg. Body height was measured using a portable stadiometer (Seca 220, Seca Corporation, Hamburg, Germany) with a degree of 0.1 cm. Values of lean body mass in% were obtained using the formula LBM % = *LBM kg / Body weight kg*. The values of muscle mass in% were obtained using the formula MM % = *MM kg / Body weight kg*. Variables for assessing the anaerobic strength of the lower extremities were obtained using a bicycle ergometer (Monark 839E Sweden) in the Wingate Anaerobic Test (Hachana, Attia, Nassib, Shephard & Chelly, 2012; Beneke, Pollmann, Bleif, Leithäuser & Hütler, 2002). The height of the seat is adjusted so that the subjects can take the optimal cycling position. The Wingate Anaerobic Test began with a five-minute warm-up ride at 50 to 60 rpm. After five minutes of warming up, the subjects continue driving. When the 70 rpm bicycle is reached, the ergometer automatically applies (lowers) the load after which the subjects pedal as fast as possible for the next 30 sec. After 30 sec. the subject has two minutes of light pedaling to restore his heart rate. The load is adjusted on a predefined protocol, 7.5% by body weight. To estimate the anaerobic power of the lower extremities, the variables were: maximum power (PP W), maximum power (PP W / kg), mean power (MP W), mean power (MP W / kg), fatigue rate (FR%) , total work (TW J).

Statistical analysis

The data were processed by the Statistical Package for Social Sciences SPSS (v17.0, SPSS Inc., Chicago, IL, USA). In the first step, the basic descriptive parameters and distribution of variables are determined. They were calculated for all tests central and dispersive parameters: arithmetic mean (Mean), standard deviation (Std. deviation) and Confidence interval for mean (Lower and Upper). The normality of the distribution of the variables was derived through two procedures: the asymmetries of the Skewness results and the homogeneity of the Kurtosis results. Linear regression analysis was applied to determine the influence and prediction of body composition parameters with the results of anaerobic strength of the lower extremities. The statistical significance of the results was $p < 0.05$.

Results

Table 1 shows the basic central and dispersion data on body composition and anaerobic strength of the lower extremities in female football players. The results of skewnwss and kurtosis showed that there is a symmetry of the results and that there is homogeneity of the results, the distribution of the results was normal.

Table 1. Basic central and dispersion parameters of football players (n = 21)

Variables	Mean±SD	95% CI	
		Lower	Upper
TM (kg)	14.07 ± 4.39	12.07	16.07
LBM (kg)	45.91 ± 4.1	44.05	47.78
LBM (%)	76.93 ± 5.02	74.64	79.22
MM (kg)	25.42 ± 2.41	24.33	26.52
MM (%)	42.58 ± 2.87	41.27	43.89
PP (W)	549.65 ± 92.57	507.51	591.79
PP (W/kg)	9.34 ± 1.59	8.61	10.06
MP (W)	198.57 ± 74.37	164.71	232.42
MP (W/kg)	3.31 ± 1.17	2.77	3.84
FR (%)	64.18 ± 12.51	58.49	69.88
TW (J)	11.02 ± 1.51	10.33	11.71

Legend: TM (kg) – body weight; LBM (kg) – lean body mass; LBM (%) – lean body mass; MM (kg) – muscle mass; MM (%) – muscle mass; PP (W) – maximum power; PP (W / kg) – maximum power; MP (W) – mean power value; MP (W / kg) – mean value of power; FR (%) – fatigue rate; TW (J) – total work.

The results of body composition show a statistically significant influence on the maximum anaerobic strength of the lower extremities in professional female football players (Table 2). The statistical values were ($p < 0.05$), while the coefficient of determination which tells how much of the variance of the independent variable explains the model of the dependent variable is 45% ($R^2 = 0.457$).

Regression analysis of the influence of body composition on the parameters of maximum strength in (W / kg) does not show statistically significant results. Also, when it comes to the analysis of individual linear correlation (r) of body composition and PP (W / kg) there is no statistically significant correlation.

The influence of body composition values on the prediction of MP (W) shows statistically significant values ($p < 0.05$). The coefficient of determination of body com-

Table 2. Influence of body composition parameters on anaerobic strength of lower extremities of female football players (n = 21)

Variables	PP (W)		PP (W/kg)		MP (W)		MP (W/kg)		FR (%)		TW (J)	
	r	b	r	b	r	b	r	b	r	b	r	b
TM (kg)	.309*	1.053	-.314	2.037	.392*	-.024	.149	-.606	-.311	1.882	.412*	1.165
LBM (%)	-.135*	.903	.398	1.771	-.264*	3.664	-.057	3.089	.267	-2.177	-.203*	2.316
MM (kg)	.667*	.382	.156	-.382	.563*	.918	.388	.896	-.297	-1.162	.819*	.628
MM (%)	-.071*	.019	.420	.546	-.251*	-3.883	-.059	-3.660	.283	4.159	-.139*	-1.339
R2	.457		.236		.517		.297		.358		.711	

Legend: * p <.05; r – correlation coefficient; b – standardized regression coefficient; R^2 – coefficient of determination; TM (kg) – body weight; LBM (%) – lean body mass; MM (kg) – muscle mass; MM (%) – muscle mass; PP (W) – maximum power; PP (W / kg) – maximum power; MP (W) – mean power value; MP (W / kg) – mean value of power; FR (%) – fatigue rate; TW (J) – total work.

position parameters to the mean value of strength was 51% ($R^2 = 517$). However, the independent variables did not show a statistically significant effect on mean power values (W / kg). The same results were obtained when talking about the influence of body composition on the fatigue rate. It has not been established that there is a significant influence of body composition on the fatigue rate. The results of body composition show a statistically significant influence on the total work in the anaerobic zone (Table 2). Statistical values were ($p < 0.05$), while the coefficient of determination was 71% ($R^2 = 0.711$). Lean body mass (%) indicates the highest contribution to the explanation of the dependent variable (b = 2.316).

Discussion

Changes in modern football have brought with them changes in the intensity and type of movement. There is more and more movement with a change of direction in a small space, jumps, sprints, which requires high intensity. The study by İbrahim et al., (2019) shows that in football, different types of activities, of different intensity, change every four seconds. An anaerobic activity is defined as energy expenditure that uses anaerobic metabolism(without the use of oxygen) that lasts less than 90 seconds,utilizing an exhaustive effort. Two major energy sourcesare required during the WAnT. The first is the adenosinetriphosphate-phosphocreatine (ATP-PCr) system, which lasts for 3 to 15 seconds during maximum effort. The second system is anaerobic glycolysis, which can be sustained for the remainder of the all-out effort. Therefore, the WAnT measures the muscles' ability to work using both the ATP-PCr and glycolytic systems. Many sports including soccer, use anaerobic metabolism extensively during competition (Zupan et al., 2009). The values of body composition in Table 2 show a statistically significant prediction on the parameter of maximum anaerobic strength (W) ($p < 0.05$), while the total variation of the system from the variable predictors and criteria was approximately 45% ($R^2 = 0.457$). Body mass (kg) is the value that most explains the dependent variable (b = 1,053). The results of the study by Moraru et al. (2017) also show a statistically significant correlation between body weight and maximum anaerobic strength of the lower extremities ($p < 0.01$), the correlation strength was strong ($r = 0.733$) and body height and maximum anaerobic strength (W) ($p < 0.01$, $r = 0.612$), however, there is no significant correlation between body mass index and maximum leg strength in female football players. Küçükkubaşet et al. (2019) in top athletes did not get the relationship between lean body mass in absolute and relative values and the percentage of fat did not show a statistically significant correlation with maximum strength (PP (W)). Analyzing the results of the research Nikolaidis (2014), we noticed that the maximum anaerobic strength of the legs was statistically significantly associated ($p < 0.001$) with the body fat index ($r = 0.70$), fat mass ($r = 0.60$) and non-fat body mass ($r = 0.84$).), while the percentage of body fat was statistically related ($p < 0.01$) in values ($r = 0.42$). When it comes to the influence of body composition parameters on maximum strength in (W / kg), the results of our research do not show a correlation of these values. However, Nikolaidis (2014) in his work obtained results in which there is a relationship between maximum strength in (W / kg) and body fat percentage ($p < 0.01$, $r = -0.42$). The results of the mean value of strength (W) show a significant relationship $p < 0.05$) with body composition values. The coefficient of determination was ($R^2 = 0.517$), which means that the set of independent variables, in this case the values of body composition, 51% explains the dependent variable. The strength of the correlation between muscle mass (kg) and the mean value of anaerobic strength of the legs is ($r = 0.563$). The results of the study by Moraru et al. (2017) show a significant correlation ($p < 0.05$, $r = 0.457$) between mean strength (W) and body weight as well as body height and mean strength (W) ($p < 0.05$, $r = 0.416$). Also, Nikolaidis (2014) found that the mean values of anaerobic strength (W) show a significant correlation ($p < 0.001$) with the body mass index ($r = 0.50$) and lean body mass in kg ($r = 0.71$), while fat mass in kg shows a slightly weaker correlation ($p < 0.05$, $r = 0.35$). In the research of the same author, the percentage of body fat does not show a significant correlation with the average value of strength (W). Küçükkubaşet et al. (2019) did not establish a correlation between lean body mass in absolute and relative values and the percentage of fat with the results of the mean value of strength (W). There are differences in the results of our research, when we talk about the influence of body composition parameters on the mean value of strength (W / kg), and the results obtained by Nikolaidis (2014). In our research, we did not obtain and did not determine the influence and connection between body composition and the mean value of strength (W / kg). However, the results of a study conducted by Nikolaidis (2014), suggest that body mass index, body fat percentage, and fat mass in kg are negatively correlated with mean strength (W / kg). Body mass index shows a correlation in value ($p < 0.01$, $r = 0.41$), and the percentage of body fat ($p < 0.001$, $r = 0.63$) and fat mass in kg ($p < 0.001$, $r = 0.63$). Influence of parameters body composition on fatigue rate values (%) in our study do not show a statistically significant correlation and significant effects on the dependent variable. Similar results were obtained by Küçükkubaşet et al. (2019) who did not find a correlation between lean body mass in absolute and relative values and the percentage of fat with fatigue rate results (%). However, the Nikolaidis study (2014) did not find a statistically significant correlation only with lean body mass in kg, while body mass index ($p < 0.05$, $r = 0.36$), body fat percentage ($p < 0.05$, $r = 0.34$) and fat mass in kg ($p < 0.05$, $r = 0.36$) showed a moderate correlation with fatigue rate values (%) in the Wingate Anaerobic Test. Moraru et al. (2017) in whose research the results of the female football player show a correlation ($p < 0.05$) only between body height and fatigue rate (%) in a moderate correlation ($r = 0.474$). The results of body composition show a statistically significant influence on the prediction of total work (J) in the anaerobic zone. Statistical values were ($p < 0.05$). The coefficient of determination that tells how much of the variance of the independent variable explains the model of the dependent variable 71% ($R^2 = 0.711$). The highest contribution to the explanation of the dependent variable is shown by LBM (%) with (b = 2.316).

Conclusion

Based on the obtained results, the following can be concluded:

There is a statistically significant influence of body composition, such as: body mass, lean body mass (%), muscle mass in absolute and relative values, on the values of PP (W), MP (W) and TW (J) in female professional footballers. Based on the obtained results, we can conclude that the parameters of body composition affect the values of anaerobic strength of the lower extremities.

These results should be taken into account in the analysis of the physical fitness of female professional football players. The anaerobic ability of the lower extremities, as one of the important abilities for achieving top results in modern football, has been shown to depend a lot on the value of body composition. The proposal and conclusion of the paper is that in some further research, in order to obtain the most relevant results, more variables for the assessment of body composition should be included, primarily body fat in percentages and lean body mass in kilograms. Also, it is recommended to take other ranks of the competition as a sample of respondents, as well as different age categories.

Conflict of interest

Authors claim no conflict of interest.

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ВПЛИВ ПАРАМЕТРІВ БУДОВИ ТІЛА НА АНАЕРОБНУ СИЛУ НИЖНІХ КІНЦІВОК У ФУТБОЛІСТОК

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 2 табл., 21 джерело

Мета дослідження – визначити вплив складу тіла на анаеробну силу нижніх кінцівок, а також прогнозування впливу складу тіла на результати анаеробних здібностей у професійних футболістів.

Матеріали та методи. Вибірку респондентів складають футболістки-жінки, які змагаються у найвищому рангу змагань, Суперлізі Сербії. Загальна кількість респондентів, які були включені в дослідження, – 21 футболістка (вік 19,38 ± 3,69, зріст тіла 166,48 ± 6,17 см, маса тіла 59,98 ± 7,09 кг). Дослідження носить поперечний характер, і тестування проводилося у підготовчому періоді. Досліджувалися склад тіла та оцінка анаеробної сили нижніх кінцівок. Оцінку складу тіла проводили у приміщенні з використанням багаточастотного біоелектричного імпедансу (Inbody 770). Змінні для оцінки анаеробної сили нижніх кінцівок були отримані за допомогою велоергометра (Monark 839E) в анаеробному тесті Wingate.

Результати. Аналіз будови тіла свідчить про його статистично значущий вплив на прогнозування максимальної анаеробної сили нижніх кінцівок у професійних футболісток ($p < 0,05$), а також на загальну роботу в анаеробній зоні та середні значення анаеробної сили. Регресійний аналіз впливу складу тіла на параметри максимальної сили (Вт / кг) та швидкості втоми не показує статистично значущих результатів.

Висновок. Існує статистично значущий вплив складу тіла (маса тіла, нежирна маса тіла (%), м'язова маса в абсолютних та відносних значеннях) на значення максимальної анаеробної сили, середні значення анаеробної сили та загальні показники роботи в професійних футболісток.

Ключові слова: анаеробний тест Wingate, анаеробна сила нижніх кінцівок, склад тіла, план та програма тренувань.

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