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ORIGINAL ARTICLE

Negative association between quantities of body fat and physical fitness of university football players

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Abstract

The aim of the present study was to assess, analyze and correlate tests of physical abilities (acceleration and maximum speed in 30 m, Balsom agility test and YoYo intermittent test) with anthropometric measures of university football athletes. Twenty athletes were selected from the University of Brasilia football team (20.95 ± 1.84 years; 71.60 ± 11.65 kg; 176.85 ± 7.28 m) in which they participated in a cross-sectional analysis that correlated fat mass (FM), lean mass (LM) and fat-free mass (FFM) by DXA, with the physical capacity tests. The significance level was plotted at 5%. The FM correlated with the initial acceleration (10 m) ($p < 0.05$) and with the YoYo intermittent test ($p < 0.01$); the Balsom correlated with the initial acceleration (10 m) ($p < 0.05$) and with the total acceleration (20 m) ($p < 0.01$). In addition, there was positive correlation of RLM and RFFM with YoYo intermittent test, and negative correlation between RFFM and BAT ($p < 0.05$). Thus, we conclude that the body composition seems to be a determining factor in physical tests of university field football players.

Keywords Athletes · Body composition · Athletic performance · Physical tests · Anthropometry

Introduction

Association football (or simply "soccer" in USA), due to its actions of jumping, accelerating and changing direction, is considered a very complex modality and classified as intermittent due to its sprints with different intensities. In addition to having intermittent characteristics, football requires a lot of the player's aerobic capacity [1, 2].

The aerobic capacity is an important physical fitness way for football players to endure all the playing time, as it ensures a high energy performance throughout the match, and more than 90% of the match is played with aerobic metabolism [2–4]. This aerobic predominance is related to the duration of the match (approximately 90 min) and the high distance covered by the athletes during the games [2, 3]. Thus continuous and interval runs are used in training to improve aerobic capacity [1].

Although most of the football game uses the aerobic pathway, most of its decisive moments are solved by skills such as a sprint, or an agility move [4]. Reilly et al. [5] identified in his study that to compete at a high level, some prerequisites are required in physical and anthropometric tests, such as moderate to high aerobic and anaerobic power, good agility, joint flexibility and be capable of generate high torques during fast movements. Specifically, players must have well-developed aerobic capacity, anaerobic power, coupled with agility and the ability to maintain high power during fast movements throughout the game [5]. Since mass is inversely proportional to acceleration, it is possible that body mass changes performance in physical sprint, velocity and aerobic

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capacity tests, but there are no studies yet that associated the sensitivity of external validity tests with body composition.

The 30 m sprint test and Yo–Yo intermittent recovery level 1 although not gold standard laboratory tests, are widely used because it allows for motor actions close to the football game, respecting specificity, intermittent running, change of direction, game environment with cleats, clothes and temperatures close to the reality of the modality, besides being tests of high external validity. However, we do not know the presence of studies that investigated the influence of body composition on these physical tests [5, 6]. Lago-Penãs et al. [6] showed that elite players had a lower percentage of fat, higher percentage of muscle mass, and that anthropometric and physical characteristics are actually crucial to discriminate talented from non-talented football players.

Similar studies that investigated the correlation between physical performance and anthropometry among football players are limited and results have been inconsistent [6]. Studies such as these in college football athletes are inconclusive [6], as body components were similar in the selected and non-selected players within each playing position. In this sense, the present study aimed to assess, analyze and correlate the physical abilities with the anthropometric measures of university football athletes. Our initial hypothesis is that there will be a negative correlation between body fat and performance in the physical tests (acceleration and maximum speed in 30 m; Balsom agility test and YoYo intermittent test).

Methods

The study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the Ethics Committee of University (number 2.533.743), and the participants signed an informed consent form. Twenty university football players participated in this study and the characteristics of the sample are described in Table 1.

All evaluations were made at the university with a total of 3 days of tests. On the first day, anthropometric and body composition data were collected. On the second day, the 30-m sprint test and the Balsom agility test (BAT) were performed; the latter was made just after the former, that is after the 30-m test was performed by all players, following the order of execution of the athletes, stipulated in the first test, both tests with two attempts using the highest value obtained. On the third day, the YoYo intermittent recovery test was performed.

The anthropometric data were collected through an electronic/digital balance with a resolution of 100 g (Filizola®, "PersonalLine" model) and stadiometer (Country Technology®), with a resolution of one centimeter.

Table 1 Sample characteristics ($n = 20$)

	Median (Q1–Q3)
Weight (kg)	70.22 (65.4–75.8)
Height (cm)	177.00 (171.25–182)
Age (years)	21.00 (19.25–22)
Fat mass (kg)	9.72 (6.43–12.32)
Fat mass/body weight ratio	0.13 (0.09–0.17)
Lean mass (kg)	57.91 (55.08–62.15)
Lean mass/body weight ratio	0.82 (0.78–0.86)
Fat-free mass (kg)	60.80 (58.21–65.67)
Fat-free mass/body weight ratio	0.87 (0.82–0.91)
Initial acceleration 10 m (s)	2.08 (1.96–2.19)
Total acceleration 20 m (s)	3.24 (3.14–3.44)
Maximum speed 30 m (s)	4.51 (4.42–4.73)
Balsom agility test (s)	12.24 (11.96–12.56)
YoYo intermittent recovery test VO_2 maximum (ml/kg/min)	44.46 (43.46–46.82)
YoYo intermittent recovery test vVO_2 maximum (km/h)	15.00 (15–15.5)

Data expressed as median and interquartile ranges [first quartile (25%) and third quartile (75%)]

Q1 first quartile, *Q3* third quartile, *kg* kilograms, *cm* centimeters, *km/h* kilometer per hour, *s* seconds, *ml* milliliters, *min* minutes, *SD* standard deviation

Body composition was measured using the dual energy X-ray absorptiometry (DXA) equipment (GE Eletric Company®, model Lunar), and all measures of body composition were adjusted by the body weight of each athlete, in which the total value was divided by body weight. The measures were lean body mass (RLM) in kg, fat mass (RFM) in kg and fat-free mass (RFFM) in kg. Being that the lean mass is just the muscle mass. Fat-free mass are all lipid-free tissues including water, muscles, bones, connective tissues and organs. Fat-free mass is the sum of muscle mass (lean mass) + bone mass + residual mass. It is all subtracting the weight of essential fat.

The data of the physical tests were collected in the lab of university. The tests were performed in 2 days (Tuesday and Thursday) between 4:00 p.m. to 6:00 p.m. and with a 24-h interval between them. Before the tests started each day, a warm-up was performed (moderate intensity) with a speed of approximately 9 km/h. After the run, some dynamic stretching exercises were performed for the muscles of the lower limbs—gluteus, posterior and anterior thigh and iliopsoas. In addition, as a form of warm-up, four exercises were performed in the agility ladder and coordinating exercises of running: high and low skipping, hop and jump-running.

On the second day, marking cones were used for the course, and chronometers and whistles for the evaluators. On the third day, there were cones for demarcation of the course, amplified sound box, pen drive with sound file in the mp3 extension and individual evaluation cards for each athlete.

Acceleration and maximum speed

The 30-m sprint test was used to measure the parameters of initial acceleration (10 m), total acceleration (20 m) and maximum speed (30 m). The test was performed on the football pitch. There were 3 markings, in the 10 m, 20 m and 30 m which correspond, respectively, to the initial acceleration, total acceleration and maximum speed. It should be noted that the evaluators, equipped with a stopwatch, positioned themselves in each of the three markings [4].

Balsom agility test

The agility test protocol followed the guidelines of Balsom [7]. Such a test is designed for the football player, in which subjects are required to make several changes of directions and two turns.

YoYo intermittent recovery test

The application of the test was performed observing the protocol established by Bangsbo et al. [11]. In this sense, four batteries were carried out with five athletes in each course. Before the beginning of the test, the evaluators guided the athletes regarding the test protocol, alerting them to the importance of reaching the end of the course at the right time, to the sound of the beep. The YoYo IR2 consists of repeated 40 m (2 × 20 m) runs between markers set 20 m apart, at progressively increasing speeds dictated by an audio signal. To calculate the VO_2max (YoYo1) the following formula was used: $VO_2\text{max} = \text{distance traveled (in meters)} \times 0.0084 + 36.4$; in addition, it was possible to verify the speed that it took to reach this VO_2max, vVO_2max (YoYo2) [11].

Statistical analysis

Data were presented as median and interquartile ranges [first quartile (25%) and third quartile (75%)]. Initially, the normality and the homogeneity of the data were verified, through the Shapiro–Wilk and Levene tests, respectively. Due to the size of the sample, the non-parametric tests were used to treat the data. The Spearman test was used to measure the association between the data. The level of significance was plotted at 5% ($p < 0.05$). SPSS software version 22.0 was used for analysis.

Results

Characteristics of the sample are displayed in Table 1 (weight, height, age, relative fat mass, relative lean mass, relative fat-free mass, initial acceleration, total acceleration, maximum speed, balsom agility test and YoYo intermittent recovery test).

There was a significant and regular correlation between RFM and 10 m. Furthermore, RFM showed negative, moderate and significant correlation with YoYo1 and YoYo2. A moderate, positive and significant correlation was found between 10 and 20 m with BAT. The 10 m with 30 m was significant and strongly correlated. However, the same correlation between BAT and the 30 m test was not observed [8]. In addition, there was positive correction of RLM and RFFM with YoYo intermittent test, and negative correlation between RFFM and BAT ($p < 0.05$) (Table 2).

Discussion

The main finding of our study is that there is a negative correlation between RFM and the physical fitness tests used in football university players. Although the athletes have come from a vacation, the results of the physical tests are similar to those of several authors, both in football as in futsal and in the most varied categories, from sub17 to professional [9–12]. It can be inferred that there are approximate values for some physical tests in football, and that the sample of the present study was within such values.

Although YoYo1 is an indirect test for measuring VO_2 maximum, its values approximate with the treadmill test. Due to the limitations of the vast majority of clubs, direct reviews became difficult to use. The same test applied in different terrains caused different metabolic demands and physiological requirements, thus resulting in changes in the final results [1].

Studies correlating the YoYo1 with body composition variables are scarce, this test is more used in the literature to correlate with other variables such as peak speed and speed relative to ventilatory threshold or laboratory tests, however, such a test is less sensitive to changes in performance capacity [3, 10, 13]. A review by Silva et al. [3] mentions the significant and strong correlation between YoYo1 and high-intensity performance (speed > 15 km/h) during field football matches in professional players.

In the present study, it was possible to verify that the higher the RFM, the worse the results of YoYo1 and YoYo2. It is possible that a higher RFM results in worse economy of movement, interfering negatively in the test

Table 2 Matrix correlation of the values of relative fat mass, relative lean mass, relative fat-free mass, 10 m, 20 m, 30 m, BAT, YoYo1, YoYo2 of the studied group

	RFM	RLM	RFFM	10 m	20 m	30 m	BAT	YoYo1	YoYo2
10 m (s)									
ρ	0.49	−0.27	−0.26	–	0.46	0.67	0.48	−0.17	−0.22
p	0.02*	0.25	0.25	–	0.04*	0.001*	0.02*	0.46	0.34
20 m (s)									
ρ	0.14	−0.16	−0.19	–	–	0.33	0.61	0.10	0.006
p	0.56	0.49	0.41	–	–	0.14	0.004*	0.64	0.98
30 m (s)									
ρ	0.33	−0.42	−0.41	–	–	–	0.41	−0.36	−0.19
p	0.14	0.06	0.07	–	–	–	0.06	0.11	0.40
BAT (s)									
ρ	0.38	−0.44	−0.48	–	–	–	–	−0.06	−0.05
p	0.09	0.06	0.03*	–	–	–	–	0.79	0.81
YoYo1 (ml/kg/min)									
ρ	−0.57	0.57	0.55	–	–	–	–	–	0.88
p	0.008*	0.008*	0.012*	–	–	–	–	–	0.0001*
YoYo2 (s)									
ρ	−0.67	0.63	0.62	–	–	–	–	–	–
p	0.001*	0.003*	0.004*	–	–	–	–	–	–

Data expressed as Spearman's coefficient *r* and *p* value

10 m 10 m initial acceleration, *20 m* 20 m total acceleration, *30 m* 30 m maximum speed, *BAT* balsom agility test, *RFM* relative fat mass, *RLM* relative lean mass, *RFFM* relative fat-free mass, *YoYo1* YoYo intermittent recovery test VO_2 maximum, *YoYo2* YoYo intermittent recovery test vVO_2 maximum; ρ Spearman's coefficient, *p* significant

*Significative

results [14], since the mass is inversely proportional to the acceleration [15]. According to BenOunis et al. [16], the higher the physical fitness level (aerobic and anaerobic), the less fatigue felt by the players, which results in a lower quality decrease.

The ability to run short distances in a short period is a characteristic skill of football; the data of the present study of 20 m and 30 m closely resemble those of the first field football players in Tunisia [16]. On the other hand, such a test cannot be used as a fatigue index, Harper et al. [17] performed a study simulating an extra time of a football match and the consumption of gel (carbohydrates) and realized that both the control group and the experimental group did not present significant differences [17]. Some authors use a protocol with different lengths, 5 m, 10 m and 30 m [18, 19].

The results of the tests of 10 m, 20 m, 30 m and BAT when compared to junior teams have a small improvement [18]. This may be due to the anthropometric factors, probably our players have a greater relative lean mass, which generates a greater muscular power, besides having the lungs developed and possessing a greater muscular maturation [15].

The 30-m test and the BAT are correlated to possible injury rates in football players, since such tests show a shortening of the hamstrings, thus causing an injury to the athlete [18]. Probably, these tests did not present significant correlation due to the sample size and/or the statistical tests used (Spearman).

The measurement of the sprint test correlated with each other as expected, but the correlation between 10 and 30 m caught the eye, as did the 10 m with BAT. It is believed that for good agility and good top speed, the initial speed should be high. It can be considered that muscle pre-activation due to a high power "start" can influence agility and maximum speed [15, 20]. However, a major limitation in our study is that speed analyses were not performed from more sensitive methods.

A negative correlation was observed between the RFM and the tests YoYo1, YoYo2 and 10 m. Pareja-Blanco et al. [21] also found such results, leading to the conclusion that adiposity is a factor that negatively influences such tests.

One fact that caught the attention was the RFM did not influence in the 20 m and 30 m. It can be assumed that once the athlete is already in speed, the law of inertia could be applied to it, thus making RFM not have so much influence on the last two measures. However, the findings of Nikolaidis et al. [22] have shown that the main factor for a below-expected performance in adult players is to have a higher percentage of fat.

Our study has some limitations, such as methods to evaluate acceleration, a reduced sample, lack of evaluation of biochemical and molecular factors that could offer additional information in the understanding of this negative relationship between RFM and performance in physical capacity tests. Further studies are suggested with a larger sample and possibly with a wider variety of physical tests, mainly tests that can evaluate, besides the lean mass, the muscular architecture and fiber typing to deepen the answers found.

It was concluded with the present study that there is a negative correlation between RFM and the physical fitness tests used in football university players.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures were carried out according to the resolution 466/2012 of the National Health Council and to the Declaration of Helsinki for experiments to be conducted on humans. After approval of the Human Research Ethics Committee of the University of Brasília (protocol number: 2.533.743), the volunteers received a full explanation about the purposes and procedures of the study and gave a written informed consent.

Informed consent Informed consent was obtained from all the individual participants included in the study.

References

1. Lizana CJR, Belozo F, Lourenço T, Brenzikofer R, Macedo DV, ShoitiMisuta M, Scaglia AJ (2014) Análise da potência aeróbia de futebolistas por meio de teste de campo e teste laboratorial. Revista Brasileira de Medicina do Esporte 20:447–450
2. Impellizzeri FM, Rampinini E, Marcora SM (2005) Physiological assessment of aerobic training in soccer. J Sports Sci 23(6):583–592. https://doi.org/10.1080/02640410400021278
3. Silva JFd, Dittrich N, Guglielmo LGA (2011) Avaliação aeróbia no futebol. Revista Brasileira de Cineantropometria Desempenho Humano 13:384–391
4. Chamari K, Hachana Y, Ahmed Y, Galy O, Sghaier F, Chatard J, Hue O, Wisloff U (2004) Field and laboratory testing in young elite soccer players. Br J Sports Med 38(2):191–196. https://doi.org/10.1136/bjsm.2002.004374
5. Reilly T, Bangsbo J, Franks A (2000) Anthropometric and physiological predispositions for elite soccer. J Sports Sci 18(9):669–683. https://doi.org/10.1080/02640410050120050
6. Lago-Peñas C, Rey E, Casáis L, Gómez-López M (2014) Relationship between performance characteristics and the selection process in youth soccer players. J Hum Kinet 40:189–199. https://doi.org/10.2478/hukin-2014-0021
7. Balsom P (1994) Evaluation of physical performance. Football (soccer). Blackwell Scientific, Oxford
8. Callegari-Jacques SM (2009) Bioestatística: Princípios e aplicações. Artmed Editora, São Paulo
9. Matzenbacher F, Pasquarelli BN, Rabelo FN, Dourado AC, Durigan JZ, Rossi HG, Stanganelli LCR (2016) Adaptations in the physical capacities of U-18 futsal athletes during a competitive season. Revista Brasileira de Cineantropometria Desempenho Humano 18:50–61
10. Ribeiro YS, Balhego LL, Vecchio FBD (2015) Aerobic power and jumps predict performance in intermittent running test in young indoor soccer players. Revista Brasileira de Cineantropometria Desempenho Humano 17:357–366
11. Rey E, Lago-Peñas C, Casáis L, Lago-Ballesteros J (2012) The effect of immediate post-training active and passive recovery interventions on anaerobic performance and lower limb flexibility in professional soccer players. J Hum Kinet 31:121–129. https://doi.org/10.2478/v10078-012-0013-9
12. Rey E, Padrón-Cabo A, Barcala-Furelos R, Mecías-Calvo M (2016) Effect of high and low flexibility levels on physical fitness and neuromuscular properties in professional soccer players. Int J Sports Med 37(11):878–883. https://doi.org/10.1055/s-0042-109268
13. Oliveira RS, Pedro RE, Milanez VF, Bortolotti H, Vitor-Costa M, Nakamura FY (2012) Relação entre variabilidade da frequência cardíaca e aumento no desempenho físico em jogadores de futebol. Revista Brasileira de Cineantropometria Desempenho Humano 14:713–722
14. Silvestre R, West C, Maresh CM, Kraemer WJ (2006) Body composition and physical performance in men's soccer: a study of a National Collegiate Athletic Association Division I team. J Strength Cond Res 20(1):177–183. https://doi.org/10.1519/R-17715.1
15. McArdle WD, Katch FI, Katch VL (2016) Fisiologia do Exercício. Nutrição, Energia e Desempenho Humano, 8 edn. Guanabara Koogan, Rio de Janeiro
16. BenOunis O, BenAbderrahman A, Chamari K, Ajmol A, BenBrahim M, Hammouda A, Hammami M-A, Zouhal H (2013) Association of short-passing ability with athletic performances in youth soccer players. Asian J Sports Med 4(1):41–48
17. Harper LD, Briggs MA, McNamee G, West DJ, Kilduff LP, Stevenson E, Russell M (2016) Physiological and performance effects of carbohydrate gels consumed prior to the extra-time period of prolonged simulated soccer match-play. J Sci Med Sport 19(6):509–514. https://doi.org/10.1016/j.jsams.2015.06.009
18. García-Pinillos F, Ruiz-Ariza A, Moreno del Castillo R, Latorre-Román P (2015) Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. J Sports Sci 33(12):1293–1297. https://doi.org/10.1080/02640414.2015.1022577
19. García-Pinillos F, Martínez-Amat A, Hita-Contreras F, Martínez-López EJ, Latorre-Román PA (2014) Effects of a contrast training program without external load on vertical jump, kicking speed, sprint, and agility of young soccer players. J Strength Cond Res 28(9):2452–2460. https://doi.org/10.1519/jsc.0000000000000452
20. Sekulic D, Spasic M, Mirkov D, Cavar M, Sattler T (2013) Gender-specific influences of balance, speed, and power on agility performance. J Strength Cond Res 27(3):802–811. https://doi.org/10.1519/JSC.0b013e31825c2cb0
21. Pareja-Blanco F, Suarez-Arrones L, Rodríguez-Rosell D, López-Segovia M, Jiménez-Reyes P, Bachero-Mena B, González-Badillo JJ (2016) Evolution of determinant factors of repeated sprint ability. J Hum Kinet 54:115–126. https://doi.org/10.1515/hukin-2016-0040
22. Nikolaidis PT (2015) Can maximal aerobic running speed be predicted from submaximal cycle ergometry in soccer players? The effects of age, anthropometry and positional roles. Adv Biomed Res 4:226. https://doi.org/10.4103/2277-9175.166649