The Relationship between Body Mass Index, Body Fat Percentage, and Dietary Intake with Muscle Fatigue in Adolescent Football Players

by Trias Mahmudiono

Submission date: 03-Feb-2022 10:10AM (UTC+0800)
Submission ID: 1753837407
File name: ARTIKEL_C-14.pdf (507.4K)
Word count: 2142
Character count: 11351

J Nutr Sci Vitaminol, **66**, S134–S136, 2020

The Relationship between Body Mass Index, Body Fat Percentage, and Dietary Intake with Muscle Fatigue in Adolescent Football Players

Mochammad RIZAL, Calista SEGALITA and Trias MAHMUDIONO

Department of Nutrition, Faculty of Public Health, Universitas Airlangga, Indonesia

(Received June 24, 2019)

Summary It is important for football players to maintain muscle strength through the entire match. The aim of this study was to investigate body mass index (BMI), body fat percentage (BF%), dietary intake (energy, carbohydrate, and protein) and its relationship with muscle fatigue among adolescent football players. This was a cross-sectional study involving 26 football players aged 15–17 y. BMI was determined using WHO Anhtro Plus, BF% was analyzed using Bioelectrical Impedance Analysis (BIA) and categorized using bodyfat curves for children, and dietary intake was assessed using 3×24 h dietary recall. Running-Based Anaerobic Sprint Test (RAST) was conducted twice and averaged to identify muscle fatigue. Pearson correlation and multiple-regression analysis were performed to determine the relationship between variables. The results showed that overall participants had healthy weight (17.61 ± 1.82 kg/m^2), good diet pattern (energy 99.08 ± 14.34%, carbohydrate 92.88 ± 9.54% and protein 95.96 ± 23.41%), but low body fat (6.76 ± 2.12%). In pearson test, negative correlations were found in muscle fatigue and BMI ($r=-0.393$, $p=0.047$), as well as BF% ($r=-0.458$, $p=0.019$), but positive between muscle fatigue and energy intake ($r=0.538$, $p=0.005$). Furthermore, multiple-regression analysis only confirmed statistically significant relationship between energy intake and muscle fatigue ($p=0.028$). We conclude that the higher BMI and BF% may lead to greater muscle fatigue, while higher energy intake has significant improvement to reduce muscle fatigue. Hence, it is essential for football players to consume adequate energy, and consider to maintain BMI and BF% at optimal range.

Key Words sport nutrition, football players, muscle fatigue

Football is the most prominent sport worldwide including Indonesia, performed by all layers of society regardless of gender and ages with different degrees of expertise. Nielsen Sports reported that Indonesia is the second highest country with 77% of the people interested in football (*1*). Sport achievement requires optimal performance, and therefore, it is important for football players to be able to maintain muscle strength through the entire match. Without neglecting the importance of aerobic capacity, anaerobic energy metabolism is imperative for underpinning numerous explosive movements and sustaining forceful contraction during a 90-minute game (*2*). Muscle fatigue is one of the major problems often encountered by athletes, which is caused by many factors such as gender, age, Body Mass Index (BMI), Body Fat Percentage (BF%), and dietary intake. A study reviewed that football participants consistently experienced a decline in performance in the second half of the match (*3*). This is because of the high-intensity maneuvers in football involving repeated sprint bouts and long runs with short period of recovery. Hence, it is crucial to apply sport sciences such as technical, tactical, physical, physiological, psychological, and nutrition into practice to support sporting success (*2*, *4*). The aim of this study was to investigate BMI, BF%, dietary intake (energy, carbohydrate, and protein) and its relationship with muscle fatigue among adolescent football players.

E-mail: mochammadrizal01@gmail.com

MATERIALS AND METHODS

This was a cross-sectional study involving 26 male football players aged 15–17 y. The study was carried out in high school students of SMAN 2 and SMAN 3 Jombang, East Java, Indonesia. Participants were chosen if they practice at least 3 times per week for 1 h/session and not consuming any enhancing supplements such as caffeine, creatine, citrulline, arginine, and beta alanine, 1-wk prior recruitment. Participants were excluded if taking medical treatment or being injured. One day prior to the test, participants had to have sufficient sleep for 6–8 h and eat a balanced diet meal consisting of carbohydrate, protein, and vegetables 2–3 h before the test. In addition, they were instructed to wear comfortable clothes and shoes during the test.

Protocol. This study was performed for 8 d. In the first day, we measured participants' height and weight to determine BMI, body composition to analyze BF% using Bioelectrical Impedance Analysis (BIA) (Tanita BC-541), and dietary intake using 24-h dietary recall.

After data completion, Running-Based Anaerobic Sprint Test (RAST) was conducted for the first time. There was a 7 d of washout period to allow ample time for muscle recovery before the second RAST. During washout period, dietary recall was assessed for the second time. RAST was run again in the eighth day, after we interviewed dietary recall for one more time (Fig. 1).

RAST. Participants were required to undertake 6× 35 meter of sprints with 10 s recovery between each sprints. Two timekeepers were involved since one people timed each run of 35 m and the other timed the 10 s recovery period. Muscle fatigue was regarded as Fatigue Index (FI) in unit of percentage. The value is measured by calculating the difference between maximum and minimum power obtained from six sprints, then divided by its maximum power. The lower the value indicates that athletes have better muscle ability to maintain their performance from fatigue, vice versa (Fig. 2, 3).

The nutritional status of the participants was determined using WHO Anhtro Plus. BF% was analyzed using Bioelectrical Impedance Analysis (BIA) and categorized using bodyfat curves for children (5). Dietary intake was randomly assessed using 3×24 h dietary recall and grouped as: severe deficit, moderate deficit, mild deficit, normal, and over (6). Additionally, RAST was conducted twice with 7 d of washout period and averaged to identify muscle fatigue.

Statistical analysis. For all normally-distributed data, we employed pearson to analyze significance relationship between variables, and spearman used if data were not normally-distributed. Furthermore, we also performed multiple-regression analysis using FI as dependent variable and age, BMI, BF%, and dietary intake as independent variables. All data analyses were performed in IBM SPSS Statistics 20 with alpha significance level of 0.05.

Ethical approval. This study was approved by Health Research Ethics Committee of Faculty of Public Health Airlangga University (143-KEPK) and conducted in accordance with the Declaration of Helsinki. All participants signed the informed consent after explanation regarding the study had been delivered. This study obtained the Universal Trial Number (UTN) U1111-1214-6071 and was also registered in the Thai Clinical Trials Registry (TCTR) as TCTR20180614005.

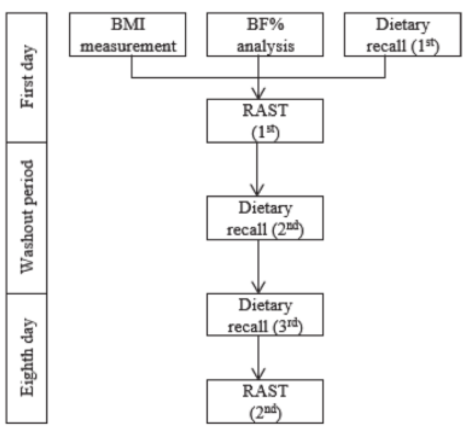

Fig. 1. Study protocol.

$$Power = \frac{subject's\ weight \times distance^2}{time^3}$$

Fig. 2. Power calculation formula.

$$FI = \frac{Power_{max} - Power_{min}}{Power_{max}}$$

Fig. 3. FI calculation formula.

RESULTS

Table 1 depicts that overall participants had healthy weight (17.61±1.82 kg/m^2), good diet pattern (energy 99.08±14.34%, carbohydrate 92.88±9.54%, and protein 95.96±23.41%), but low body fat (6.76±2.12%). As seen in the Table 2 above, negative correlations were found significantly in: muscle fatigue and BMI (r=−0.393, p=0.047), as well as BF% (r=−0.458, p=0.019). Meanwhile, there was significant correlation in energy intake and muscle fatigue (r=0.538, p=0.005). Carbohydrate and protein intake did not show any significant relationship with muscle fatigue however (p>0.05). Further data analysis using multiple-regression analysis in Table 3 only confirmed statistically significant relationship between energy intake and muscle fatigue (p=0.028), but not age, BMI, and BF%.

Table 1. Characteristics of participants.

Variable	n=26				
	Mean	Median	Standard Deviation	Minimum Value	Maximum Value
BMI (kg/m^2)	17.61	17.30	1.82	14.90	22.50
BF%	6.76	6.05	2.12	5.00	14.20
Energy Intake (% of requirement)	99.08	99.50	14.34	73.00	155.00
Carbohydrate Intake (% of requirement)	92.88	93.00	9.54	68.00	116.00
Protein Intake (% of requirement)	95.96	91.50	23.41	71.00	175.00
FI Average (%)	49.65	49	10.35	31.00	76.00

Table 2. Pearson test on characteristics and its relationship with muscle fatigue.

	FI (%)	
	p	*r*
BMI	0.047	−0.393*
BF%	0.019	−0.458*
Energy Intake	0.005	0.538**
Carbohydrate Intake	0.420	0.165
Protein Intake	0.390	0.176

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 3. Multiple-regression test on characteristics and its relationship with muscle fatigue.

	FI (%)	
	t	*p*
Age	0.629	0.536
BMI	−0.662	0.515
BF%	−0.318	0.753
Energy Intake	2.363	0.028

DISCUSSION

This study revealed that BMI and BF% were negatively associated with muscle fatigue, while positive correlation was found between energy intake and muscle fatigue. However, we did not see any significant relationship between carbohydrate and protein intake with muscle fatigue. Muscle fatigue was measured using RAST which requires low-cost equipment, and is a valid, reliable and easy-applied method to measure anaerobic power and capacity (*7*).

It is supported from previous study that higher BMI had greater fatigue compared to those who were non-obese (*8*). It was caused by the greater voluntary torque loss encountered by obese individuals during the fatigue protocols. The opposite interaction between BF% and muscle fatigue is aligned with Vaara et al. (*9*). Athletes have higher muscle fatigue when they have higher BF%. Hulens et al. explained that the higher degree of fat mass (dead weight), the higher the moment of inertia to overcome the weight when accelerated movement is executed (*10*).

In contrast, energy intake was positively correlated with muscle fatigue, and confirmed by multiple-regression analyisis. The result was related with study in judokas athletes which found that caloric restriction led to poorer performance (*11*). Caloric restriction may lead to immune and endocrine function impairment as well as hormonal changes, therefore depressing the overall performance including increased muscle fatigue. Another study explained that inadequate energy intake might induce muscle fatigue by the intracellular acidosis mechanisms (*12*). In which, the key enzymes in glycogenolysis and glycolysis are phosphorylase and phosphofructokinase, respectively. Both of these enzymes are inhibited at low pH in vitro, and hence the rate of ATP supply to energy-requiring processes might be diminished in muscles that become acidic during fatigue.

In conclusion, to reach the highest performance during the game, it is essential for football players to consume adequate energy, and consider to maintain BMI and BF% at optimal range. Our findings add evidence regarding the various factors associated with muscle fatigue.

Disclosure of state of COI

No conflicts of interest to be declared.

Acknowledgments

The authors are grateful to the SMAN 2 and SMAN 3 Jombang for their permission, coaches for their assistance, and participants for their involvement in this study.

REFERENCES

1) Nielsen S. 2014. Global interest in football [Internet]. [cited 2019 Jun 11]. Available from: https://nielsensports.com/global-interest-football/
2) Stølen T, Chamari K, Castagna C, Wisløff U. 2006. Physiology of soccer an update. *Sports Med* **35**(6): 501–536.
3) Alghannam A. 2012. Metabolic limitations of performance and fatigue in football. *Asian J Sports Med* **3**(2): 65–73.
4) Beck KL, Thomson JS, Swift RJ, Hurst PR Von. 2015. Role of nutrition in performance enhancement and postexercise recovery. *J Sports Med* **6**: 259–267.
5) McCarthy HD, Cole TJ, Fry T, Jebb SA, Prentice AM. 2006. Body fat reference curves for children. *Int J Obes* **30**(4): 598–602.
6) Gibson RS. 2005. Principles of Nutritional Assessment Second Edition. Oxford University Press, New York.
7) Zagatto AM, Beck WR, Gobatto CA. 2009. Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. *J Strength Cond Res* **23**(6): 1820–1827.
8) Maffiuletti NA, Jubeau M, Munzinger U, Bizzini M, Agosti F, De Col A, Lafortuna CL, Sartorio A. 2007. Differences in quadriceps muscle strength and fatigue between lean and obese subjects. *Eur J Appl Physiol* **101**: 51–59.
9) Vaara JP, Kyröläinen H, Niemi J, Ohrankämmen O, Häkkinen A, Kocay S, Hakkinen K. 2012. Associations of maximal strength and muscular endurance test scores with cardiorespiratory fitness and body composition. *J Strength Cond Res* **26**: 2078–2086.
10) Hulens M, Vansant G, Lysens R, Claessens AL, Muls E, Brumagne S. 2001. Study of differences in peripheral muscle strength of lean versus obese women : an allometric approach. *Int J Obes Relat Metab Disord* **25**(5): 676–681.
11) Abedelmalek S, Chtourou H, Souissi N, Tabka Z. Caloric restriction effect on proinflammatory cytokines, growth hormone, and steroid hormone concentrations during exercise in judokas. *Oxid Med Cell Longev* **2015**: 1–8.
12) Westerblad H, Allen DG, Lännergren J. Muscle fatigue: lactic acid or inorganic phospate the major cause? *News Physiol Sci* **17**: 17–21.

The Relationship between Body Mass Index, Body Fat Percentage, and Dietary Intake with Muscle Fatigue in Adolescent Football Players

ORIGINALITY REPORT

16%	11%	12%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

4%
★ www.ncbi.nlm.nih.gov
Internet Source

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		