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Original Research Paper

Macronutrients adequacy and body fat percentage among adolescent football athletes

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Abstract
Excess body fat percentage in athlete can affect cardiovascular endurance, body composition, muscle endurance, muscle strength, and flexibility when they was performed. It also, when athletes with a low body fat percentage will have a higher risk of injury. Body fat percentage can be influenced by the adequacy level of macro nutrients (carbohydrates, proteins, fats). This study aimed to analyze the correlation between the adequacy level of macro nutrients and body fat percentage of adolescent football athletes at the PSS Development Center. This study was an observational analytical study with a cross-sectional study design. The sample of this study was 33 adolescent soccer athletes at the PSS Development Center who selected using a purposive sampling technique. The adequacy level of macro nutrient was obtained by a 1x24-hour recall interview method for 2 non-consecutive days. Body fat percentage was measured using a Bioelectrical Impedance Analysis (BIA) scale. Data analysis was performed using the Pearson Product Moment test with a p-value <0.05. The mean adequacy level of carbohydrate, protein, and fat were 70.26%±21.43; 79.66%±23.32 and 84.97%±24.56, respectively. The mean body fat percentage of adolescent athletes was 13.74%±3.61. This study found no correlation between the adequacy level of protein and fat intake with body fat percentage in adolescent football athletes (p=0.0781 and p=0.0783). However, a significant correlation was found between the adequacy level of carbohydrate and body fat percentage in adolescent football athletes (p=0.0042).

Keywords: adolescent; athlete; body fat percentage; football; macro nutrients

1. Introduction

Football has emerged as a prominent sport in contemporary society, particularly among adolescents. It has garnered significant popularity and has begun to garner the attention of the Indonesian populace. Football is a sport that involves a wide range of complex movements, including increasing and decreasing speed, physical contact with opponents, turning around, sprinting, jumping, and grabbing the ball (Slaidins & Fernate, 2021). Achieving optimal performance in football necessitates that athletes maintain a high level of physical fitness. Athletes who possess an anthropometric structure or somatotype that aligns with their sport are likely to demonstrate enhanced sports performance (Widowati, 2015). During the transition to adolescence, athletes undergo a period of substantial change in body composition, which has the potential to impact future performance (Sukmajati, 2015) . As adolescence progresses, both males and females typically undergo an increase in body fat (BF) and a concomitant decrease in lean body mass (LBM). Adolescent athletes must consume sufficient quantities of macronutrients and micronutrients to meet their rapid growth needs (Brown et al., 2017). This is due to the fact that their metabolism functions at a higher rate than that of adult athletes.

Body composition is comprised of three components: body mass index, muscle mass, and fat percentage. Body fat percetage is the amount of body fat stores by comparing total body fat to body weight (Anggitasari et al., 2019). Research conducted by Esco et al. (2018) indicates that average of

body fat percentage in youth soccer player was high (20%). For athletes, excessive body fat percentages can have a detrimental effect on various physiological systems, including the cardiovascular system, endurance, body composition, muscle endurance, muscle strength, and flexibility (Amrinanto, 2016). Another study by Kemper et al. (2015) posits that athletes with low body fat percentages are more susceptible to injury.

According to Nurhasanah (2018), there are several factors that affect body fat percentage such as individual characteristics, lifestyle, fiber intake, and macronutrients adequacy. Research study by Muthmainnah (2019) demonstrated that more than 45% of adolescent football athletes exhibited excessive intake of carbohydrates, protein, and fat, which exceeds the recommended daily intake (RDI) established by the Indonesian Ministry of Health. An excessive intake of nutrients has been demonstrated to result in an increase in body fat percentage. Elevated levels of carbohydrate consumption can precipitate an augmentation and acceleration of sensations of hunger. Moreover, these carbohydrates can undergo a metabolic process that results in their conversion into fat reserves (Andriyani, 2017). Furthermore, protein sources derived from food (particularly those of animal-based) frequently contain substantial amounts of fat, thereby resulting in the accumulation of adipose tissue. It has been established that foods with high fat content contain twice the number of calories as foods with low fat content. Consequently, when individuals consume excess calories, they are stored in the form of fat in the body. Contrary to the findings of Mardiana et al. (2022) and Hariyanto (2022), the studies indicated that the macronutrients intake of football athletes was in the deficit category compared to the recommended daily intake. The findings of these studies suggest that there was no correlation between macro nutrient intake and body fat percentage. In the event of inadequate intake, the potential consequences include increased fatigue and diminished athletic performance. This indicates that the results from previous studies are not entirely consistent.

As demonstrated in the preceding description, the body fat percentage can be influenced by a number of factors, including macronutrients adequacy. However, research related to macronutrients adequacy and body fat percentage in football athelete, especially adolescents, remains scarce. The objective of this study is to analyze the correlation between macronutrients adequacy and body fat percentage in adolescent football athletes at the PSS Development Center.

2. Research Methods

This research is an analytical observational with a cross-sectional study desain that was conducted during June-July 2023. Population in this studi were 40 adolescent football athletes at the PSS Development Center and a sample of 33 adolescent football athletes were obtained. The sampling technique was choosen using purposive sampling. The inclusion criteria were as follow: adolecent athletes who aged 13-17 years old, registered at the PSS Development Center, and willing to become respondents and follow the entire series of research. The exclusion criteria were athletes who manifesting signs and symptoms associated with illness, including fever, dizziness, and weakness. This research was approved by the Research Ethics Commission of 'Aisyiyah University Yogyakarta with number 2793/KEP-UNISA/IV/2023.

Primary data collection of respondent characteristics including their names, age and Body Mass Index (BMI). Adequacy level of macro nutrient data was collected using the 1x24 hour recall interview method conducted for 2 non-consecutive days (weekday and weekend). The instruments used were food photo book and 1x24 hour recall form. The 1x24 hour recall interview data in the form of gram weight was entered into the nutrisurvey to determine the macronutrient intake of each respondent. The results of the data were compared with Indonesian's RDI of macronutrient requirements per day for each athlete and multiplied by 100%. The results of the data were then categorized according to the

Widyakarya Nasional Pangan dan Gizi (WNPG), (2012) into 3: deficit (<80%), adequate (80-110%), and excess (>110%).

Body fat percentage data was conducted by direct measurement with the calibrated Bioelectrical Impedence Analysis (BIA) scale. Body fat percentage was categorized according to Kemenkes RI (2021) for football athletes, including low (<6%), normal (6-18%), or high (>18%). Data collection was carried out with the assistance of 16 enumerators from the Nutrition Study Program, Universitas 'Aisyiyah Yogyakarta. Before data collection, enumerators were given briefing on technical measurement method.

Univariate data analysis was conducted to describe the mean, standard deviation, and frequency. The data normality test used the Shapiro Wilk test and the data was found to be normally distributed. Bivariate data analysis was conducted to determine the correlation between adequacy level of macro nutrient and body fat percentage in athletes using the Pearson Product Moment correlation test with a significance of $p < 0.05$.

3. Results and Discussion

3.1. Characteristics of Respondents

According to the Table 1, a total of 33 adolescent athletes from the PSS Development Center participated in this study. The age range of the participants was from 13 to 17 years old, with 36.36% of the participants were 16 years old. Research conducted on youth soccer athletes PSIS Semarang also demonstrated that the majority of respondents were dominated by 15-year-olds (37.84%) (Wijaya, 2022). Changes in the body fat composition of the human body occur during the developmental stage of adolescence. Concurrent with the aging process, there is an observed increase in body fat percentage. The body fat percentage in men is lower than that of women because men experience additional muscle mass and body tissue (Sholichah et al., 2021).

The mean carbohydrate adequacy level was found to be 70.26% ± 21.43, with 63.64% of respondents falling within the deficit category. A similar trend was observed among youth football athletes from Pertamina Soccer School and Ragunan SHS, with 62.5% of these subjects having a carbohydrate intake that is still less than the recommended amount (Novitayana, 2017). Adequate carbohydrate intake (80-110% of needs) is imperative for athletes because it can be used during high-intensity training, maintain blood sugar, and become muscle glycogen stores (Penggalih et al., 2019). The provision of carbohydrates to an athlete has the objective of replenishing muscle and liver glycogen stores that have been utilized during muscle contraction. As Novitayana (2017) asserts, athletes with limited glycogen stores are prone to fatigue and diminished performance. In the event that the utilization of energy surpasses the intake of nutrients, athletes may encounter fatigue, which can compromise performance.

The mean adequacy level of protein was determined to be 79.66% ± 23.32. Furthermore, it was found that 54.55% of respondents were in the deficit category. Research conducted in PS TIRA PERSIBO also had deficit protein intake, with an average of 63.93% ± 11.43 and 49.6% ± 13.8 (Kuswari et al, 2021). Furthermore, the protein fulfillment in the Aceh PPLP youth athletic group indicates that it remains below the adequate level (<80%) (Penggalih et al., 2019). Insufficient protein intake can have severe consequences. When protein intake is inadequate, the body undergoes a process of protein breakdown, which consumes energy. This process is referred to as "catabolism" (Novitayana, 2017). Furthermore, protein intake is of particular significance due to its role in the production of enzymes and hormones, as well as the repair of tissues that have been damaged by exercise (Penggalih et al., 2019).

Table 1. Characteristics of Respondents

Characteristics of Respondents	Frequency			*n = 33*
	Min	*Max*	*Mean ± SD*	*n (%)*
Age (years old)	13	17	15.21 ± 1.24	
13 year				2 (6.06)
14 year				11 (33.33)
15 year				3 (9.09)
16 year				12 (36.36)
17 year				5 (15.15)
BMI-for-age (z-score)	-1.38	1.12	-0.01 ± 0.57	
Normal	-1.38	0.69	-0.12 ± 0.47	30 (90.91)
Overweight	1.02	1.12	1.06 ± 0.05	3 (9.09)
Carbohydrate Adequacy Level (%)	34	125.9	70.26 ± 21.43	
Deficit	34	79.1	57.81 ± 13.81	21 (63.64)
Adequate	81.2	105.7	88.96 ± 8.28	11 (33.33)
Excess	-	-	-	1 (3.03)
Protein Adequacy Level (%)	33.3	117.3	79.66 ± 23.32	
Deficit	33.3	79.5	63.38 ± 13.67	18 (54.55)
Adequate	85.7	109.7	98.78 ± 8.68	13 (39.39)
Excess	115.9	117.3	116.6 ± 0.99	2 (6.06)
Fat Adequacy Level (%)	30.5	134.6	84.97 ± 24.56	
Deficit	30.5	79.5	60.23 ± 15.16	13 (39.39)
Adequate	83.7	109.7	95.17 ± 8.42	15 (45.45)
Excess	111.4	134.6	118.68 ± 9.32	5 (15.15)
Body Fat Percentage (%)	5.6	19	13.74 ± 3.61	
Low	-	-	-	1 (3.03)
Normal	8	17.7	13.14 ± 2.93	27 (81.82)
High	18.1	19	18.56 ± 0.38	5 (15.15)

The mean adequate level of fat was determined to be 84.97% ± 24.56. This indicates that 45.45% of the respondents were classified as having an adequate level of fat. A study by Rahmah et al, (2020) and Maulida et al., (2023) revealed that the majority of youth athletes in West Sumatra demonstrated sufficient fat intake (76.5% and 84.5%). The intake of fat is imperative for the production of energy, the protection of organs, the provision of body cushioning, and the facilitation of the intake of fat-soluble vitamins and essential fatty acids (Penggalih et al., 2019). It is imperative for athletes to be cognizant of their dietary fat intake to ensure optimal energy levels and body composition, thereby facilitating the enhancement of performance during training and competition (Fink & Mikesky, 2015).

Based on the adequacy level of macro nutrients above, it is known that adequacy level of carbohydrate and protein were inadequate, while adequacy level of fat was adequate. These deficits may be due to a diet consisting of only two to three small meals per day. Furthermore, some respondents had poor eating habits, such as frequently consuming fried foods and rarely eating breakfast due to morning rush hour. The results of research by Wijaya et al. (2022), possible causes of macronutrient imbalance include a lack of nutritional knowledge, misunderstandings about nutrition, and an absence of information about proper dietary guidelines.

Adolescence is a period of significant physiological change, during which the human body undergoes rapid growth and development. This stage requires adequate energy and nutrients to support these processes. Insufficient intake of macronutrients (i.e., protein, fat, and carbohydrates) has been demonstrated to increase the risk of adverse health outcomes. It is imperative to establish optimal energy and nutrient (carbohydrate, protein, fat) adequacy to avert delayed puberty in youth athletes, modify

eating behaviors, and mitigate the heightened risk of injury. This condition has been observed to result in an increase in body fat percentage and a decrease in muscle mass (Purwaningtyas et al., 2021). As posited by Ananda et al. (2022), it is imperative for football athletes to implement meticulous nutritional arrangements to ensure nutritional adequacy. Adherence to proper nutritional implementation is crucial, as inadequate nutrition can impede the training process of athletes. Adequate nutrition is a critical component of athletic performance, as insufficient activity in the absence of proper nourishment can lead to a decline in physical performance.

The measurement of body fat percentage revealed that 81.82% of the respondents were classified as having a normal body fat percentage (13.74% ± 3.61). Research conducted on youth football athletes at PPLP Central Java and PSSG FC had a normal body fat percentage of 85.70%, with an average of 15.59% ± 2.34 (Mardiana et al, 2021; Sunjaya, 2022). For athletes, maintaining a normal to low body fat percentage has been shown to enhance performance. Research has demonstrated a correlation between body fat percentage and fat free mass on performance in youth soccer players, with stronger relationships reported in the former metric (Esco et al., 2018).

3.2. The Correlation Between Adequacy Level of Macro nutrient and Body Fat Percentage

Based on Table 2, there was a correlation between adequacy level of carbohydrate with body fat percentage (p=0.0042). However, there was no correlation between adequacy level of protein and fat with body fat percentage (p=0.0781 and p=0.0783). The correlation between the adequacy level of carbohydrates and body fat percentage exhibited a negative correlation with a coefficient value of r = -0.4853, indicating a weak correlation. Consequently, a reduction in carbohydrate intake was associated with an increase in body fat percentage. This finding contradicts the prevailing theory that posits the conversion of excess carbohydrates into fat, subsequently stored in adipose tissue (Singh et al., 2017).

The results of this research were in line with Macuh et al. (2023) which shows a significant correlation between carbohydrate intake and body fat percentage. This phenomenon is attributable to the fact that one category of carbohydrates is fiber. Fiber present in foodstuffs has been shown to require a greater duration to be digested and subsequently broken down into glucose. This phenomenon is considered to be a means of averting the increase in blood sugar levels that is typically induced by the hormone insulin, a consequence that often ensues after the consumption of simple carbohydrates (Chandel., 2021). Insulin has been demonstrated to function as an inhibitor of lipolysis while concurrently stimulating lipogenesis. It is widely accepted that the ingestion of fiber-type carbohydrates is associated with the process of reducing body fat (He et al., 2022).

This finding contradicts the conclusions of a study by Kuswari et al. (2021) which reported an absence of a correlation between carbohydrate intake and percent body fat in football athletes. In principle, excess carbohydrate intake can lead to increased body fat accumulation, which, in turn, can result in elevated body fat percentages and the development of obesity. In the event that an individual's carbohydrate intake exceeds its expenditure, resulting in a state of imbalanced energy metabolism, a positive energy balance ensues within the body. In circumstances where a positive energy balance (i.e., energy in > energy out) is derived from carbohydrates, the body will store it in the form of glycogen (short term) and adipose fat (long term) (Singh et al., 2017). The ingestion of substantial quantities of carbohydrates on a daily basis by athletes results in comparatively elevated glycogen stores in comparison to those who consume minimal amounts of carbohydrates. In the event that an athlete's glycogen stores are depleted, they will rapidly experience fatigue, which will consequently lead to a decline in sports intensity and performance. Furthermore, it has been demonstrated that insufficient blood glucose levels can disrupt cerebral function, thereby diminishing an athlete's ability to concentrate during competition (Sepriadi, 2019).

Table 2. The Correlation Between Macronutrient Intake and Body Fat Percentage

Variable	Body Fat Percentage	
	r	P-value
Carbohydrate adequacy level	-0.4853	0.0042*
Protein adequacy level	-0.3111	0.0781
Fat adequacy level	-0.3109	0.0783

*significant ($p<0.05$)

The statistical test results showed that there is no significant correlation between adequacy level of protein intake and body fat percentage (p=0.0781). The correlation coefficient value (r = -0.3111) indicates a negative correlation with a weak correlation, suggesting that an increase in protein intake is associated with a decrease in body fat percentage. These results are consistent with the findings of Kuswari et al. (2021) and Macuh et al. (2023), which demonstrated that there was an absence of a significant correlation between protein intake and body fat percentage. This phenomenon can be explained by the fact that, under typical circumstances, protein is not directly converted into energy; rather, it is utilized to facilitate the formation of new tissues or to replace damaged tissues (Williamson et al., 2019). A substantial body of research has demonstrated that elevated protein intake can lead to a reduction in body fat percentage. The peptide hormones present in protein have been demonstrated to induce satiety, thereby prolonging the sensation of fullness and reducing appetite while concomitantly attenuating the increase in body fat (Moon & Koh, 2020).

The results of this study are not in line with the results of Mostafafi & Sulandjari (2021), which says that there is a correlation between protein intake and percent body fat. Protein is one of the sources of energy for the body. Excess protein intake causes the energy that enters the body to be more too. When the energy balance does not occur (energy in > energy out), the body will store the excess energy into adipose fat. If in the long run this situation continues to occur, the body fat will increase, indicated by a high body fat percent and classified as obese. Food sources of protein usually contain high fat (especially animal protein). More protein intake will be followed by high fat intake as well, so that energy balance does not occur and fat accumulation in adipose tissue will increase (Kerksick, 2019).

Protein is a crucial macronutrient for athletes due to their heightened vulnerability to muscle tissue damage, particularly during periods of rigorous sports training and competition. Furthermore, in endurance sports of a protracted nature, a negligible amount of amino acids from protein will be utilized as a source of energy, particularly when glycogen stores are waning (Kerksick, 2019). The absence of correlation in this study may be ascribed to protein consumption that falls short of the body's requirements. However, the respondents' body fat percentage exhibited normal values. This phenomenon may be influenced by the frequency and intensity of training, which increases when preparing for competition. It has been demonstrated that heightened training intensity can exert an influence on athletes' body fat percentage.

Same as the adequacy level of protein, there was no significant correlation between fat intake and body fat percentage in this study (p=0.0783). The statistical test results indicate a negative correlation and a weak correlation (r = -0.3109), which suggests a potential correlation between higher fat intake and a lower percentage of body fat. The findings of this study were consistent with the results of the research conducted by Novitayana (2017) and Kuswari et al. (2021) which reported an absence of correlation between fat intake and the percent body fat of football athletes. As posited by Kerksick (2019), this phenomenon can be attributed to the composition of the fatty acids absorbed by the body. A higher proportion of unsaturated fatty acids has been demonstrated to result in a reduction in body weight when compared to a higher proportion of saturated fatty acids. This phenomenon can be

attributed to the heightened susceptibility of unsaturated fatty acids to oxidation during energy metabolism, thereby preventing their accumulation as fat deposits.

The present study's findings stand in contrast to those of the research conducted by Anwar et al. (2016), which indicated a correlation between fat intake and percent body fat in softball athletes. The prevailing theory posits that an increase in fat intake is concomitant with an increase in percent body fat. Excessive fat consumption will be more easily stored by the body as an energy reserve. The process of fat accumulation is not instantaneous; rather, it is a protracted phenomenon. An excess of body fat is known to lead to its excessive accumulation, a condition referred to as obesity (DeBruyne et al., 2016).

A substantial body of research has demonstrated that the absence of an association between protein and fat intake with body fat percentage was attributable to the presence of other contributing factors. In addition to nutrient intake, individual characteristics such as age are considered. Moreover, the phenomenon may be attributable to the frequency of respondents' training sessions, which occurred three to four times per week and lasted two to three hours. Research has demonstrated a direct correlation between the duration of exercise and energy expenditure; that is, the longer the exercise, the greater the energy expenditure and higher muscle mass.

4. Conclusion

There was a significant correlation was found between the adequacy level of carbohydrate and body fat percentage in adolescent football athletes. In order to facilitate further research, it would be advisable to expand the age range of adolescent football athletes in order to make it more varied and to compare it with other endurance sports.

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