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# Relationship of Energy and Macro Nutrient Intake, Percent Body Fat and Hemoglobin Levels with VO2max of Male Teenage Students Malang City

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***Abstract.*** Football is one of the most popular team sports and is loved by the general public, including teenagers. However, based on FIFA's (2021) records in the last decade, the ranking of Indonesian football for both men and women tends to decline compared to previous years. One of the factors that can affect an athlete's performance is physical fitness, including cardio-respiratory endurance. The quality of cardiorespiratory endurance can be measured by the maximum amount of oxygen (VO2max). Several factors affect cardiorespiratory endurance, including genetics, gender, age, physical exercise, body composition, hemoglobin levels, and food intake. Knowing the relationship between energy intake & macronutrients, percent body fat, and hemoglobin levels with VO2max male student ASIFA (Aji Santoso International Football Academy) in Malang City. The type of research is analytic research with cross-sectional. The sample is 22 people aged 13-15 years. Normality Shapiro Wilk correlation test Pearson-product moment and Spearman-rho with 95% confidence level. Most of the respondents had a moderate level of energy consumption deficit (40.9%), a higher level of protein consumption (50%), a normal level of fat consumption (45.5%), and a severe level of carbohydrate consumption deficit (54.5%). percent of ideal body fat (90.91%), normal hemoglobin levels (95.46%), and less VO2max (45.5%). There is a relationship between energy, protein, and carbohydrate intake with VO2max in ASIFA male adolescent students ($p<0.05$). Meanwhile, fat intake, percent body fat and hemoglobin levels showed no statistical relationship ($p>0.05$) although descriptively there was a trend.

Key-Words: *Cardiorespiratory Endurance (VO2max); Macronutrient Consumption Rate; Percent Body Fat; Hemoglobin Level*

## 1. Introduction

Football is a team sport played by two teams with 11 players on each team, including one goalkeeper (kipper). Football in Indonesia is a very popular sport. Schools (SSB) aim to develop and foster children and youth who have talent and interest in soccer. Football adolescent age. However, in the last decade, the ranking of Indonesian football for both men and women has tended to decline compared to previous years. Indonesian men's football still stands at number 173 of the 210 countries listed in FIFA. While the women's team is ranked 95th out of 167 countries.

One of the factors that can affect the athlete's achievement is physical fitness. The fitness component consists of cardiorespiratory endurance, *muscular endurance*, skeletal *muscle strength*, muscle speed in contraction (*muscular speed*) and flexibility. The quality of cardiorespiratory endurance can be measured by the maximum amount of oxygen (VO2max) that can be utilized by the body per minute of physical activity [2]. The greater the value of VO2max, the endurance and stamina of a person will be better, so that performance will be better. There are several factors that affect cardiorespiratory endurance, including genetics, gender, age, physical exercise, body composition, haemoglobin levels and food intake [3].

Athletes who eat a well-designed diet include the amount and proportion of macronutrients (carbohydrates). Adequate protein, fat and fat) will be able to increase peak performance [2]. Food intake also directly affects the body composition of an athlete. Body composition can be described through the composition of fat in the body in the form of percent body fat. The optimal body fat percentage for children and adolescents is 11-20% for men and 16-25% for women [4]. According to research [5], it is proven that there is a strong negative relationship between maximum oxygen consumption (VO2max) with percent body fat.

Haemoglobin is the main molecule responsible for transporting oxygen from the lungs to the peripheral tissues and transporting carbon dioxide from the peripheral tissues to the lungs. If the haemoglobin status is lower than the normal value, then the amount of oxygen in the blood is also lower. On the other hand, the higher the haemoglobin level, the higher the oxygen level in the blood

## 2. Materials and Methods

This analytical research with *cross-sectional* was conducted at SSB ASIFA (Aji Santoso *International Football Academy*) Malang City in August 2021 (*Pre-season*). A total of 22 students from 83 students were obtained through a *purposive sampling method* with inclusion criteria including men aged 10-19 years, living

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and eating daily in the dormitory, fulfilling the requirements on the fitness test eligibility test form, willing to be a research subject. and not injured. The independent variables in this study were the amount of energy & macronutrient intake (protein, fat and carbohydrates), percent body fat and haemoglobin levels of ASIFA male adolescent students. The dependent variable is the cardiorespiratory endurance (VO2max) of ASIFA male adolescent students.

The level of cardiorespiratory endurance (VO2max) was obtained using the *bleep test* on a 20 m track and the help of the *audio bleep test*. Measurement of the level of energy intake and macronutrients using the *recall* 1 x 24 hour measurement of height using a *microtoise* 200 cm and an accuracy of 0.1, as a requirement before measuring the percent body fat and carried out. Measurement of body fat percentage using *Bioelectrical Impedance Analysis* (BIA) tread type OMRON HBF-362.vein *median cubital* and haemoglobin levels were measured using the *cyanmethemoglobin* using the *Easy Touch* GCHb tool.

The process of measuring the level of energy and macronutrient intake, height, percent body fat and VO2maxwas carried out by researchers and enumerators assisted by ASIFA supervision. Meanwhile, the measurement of haemoglobin levels was carried out by ASIFA medical personnel. The measurement of VO2max was done one week earlier than other variables. Food intake levels, percent body fat and haemoglobin levels were measured at the same time.

The data obtained were processed using computer software, namely Nutri survey 2007 for food intake data and SPSS version 24 for further analysis. Univariate analysis to describe the characteristics of the subjects included age, nutritional status based on BMI/U, VO2max, food intake levels, percent body fat and haemoglobin levels. The bivariate analysis begins with the normality test of the data using *Shapiro-wilk* and linearity test using linear regression. The variables of cardiorespiratory endurance (VO2max), food intake level and percent body fat were normally and linearly distributed so that the *Pearson-product moment*. Variable haemoglobin levels were normally distributed but not linear so the *Spearman rho*. The correlation test was carried out with a 95% confidence level ($\alpha = 0.05$). This research has received an ethics pass certificate from the Health Research Ethics Commission of the Health Polytechnic of the Ministry of Health Malang Reg. No: 226/KEPK-POLKESMA/2021 dated October 4, 2021.

## 3. Results and Discussion

The research subjects were aged between 13-15 years and most of the subjects (95.45%) had good nutritional status (BMI/U).

Table 1. Distribution of Subjects by Age and Nutritional Status (BMI/U)

| Characteristic Subject | n = 22 | |
|---|---|---|
| | n | % |
| **Age** | | |
| 13 | 3 | 13,6 |
| 14 | 9 | 40,9 |
| 15 | 10 | 45,5 |
| **BMI/U** | | |
| Good Nutrition [a] | 21 | 95,45 |
| Overweight | 1 | 4,55 |

[a]Good nutrition: (-2 SD to +1 SD); [b]Overweight: (+1 SD to +2 SD)

Table 2. Distribution of Subjects based on VO2max, Energy and Macro Nutrient Intake Levels, Percent Body Fat and Hemoglobin Levels

| Subject Characteristics | n = 22 | |
|---|---|---|
| | n | % |
| **Cardiorespiratory Resistance (VO2max)** | | |
| Very Less (<35 ml/kgBB/min) | 3 | 13,6 |
| Less 35 – 38.3 ml/kgBB/minute) | 9 | 40,9 |
| Moderate (38.4 – 45.1 ml/kgBB/min) | 5 | 22,7 |
| **Energy Intake** | | |
| Severe deficit (<70%) | 1 | 4,5 |

| Subject Characteristics | n = 22 | |
|---|---|---|
| | n | % |
| Moderate deficit (70 -79%) | 8 | 36,4 |
| Mild deficit (80 – 89%) | 9 | 40,9 |
| Normal (90 – 119%) | 4 | 18,2 |
| **Protein Intake** | | |
| Severe deficit (<70%) | 1 | 4,5 |
| Moderate deficit (70 – 79%) | 1 | 4,5 |
| Mild deficit (80 – 89%) | 2 | 9,1 |
| Normal (90 – 119%) | 7 | 31,8 |
| Over (≥120%) | 11 | 50 |
| **Carbohydrate Intake** | | |
| Severe deficit (<70%) | 12 | 54,5 |
| Moderate deficit (70 – 79%) | 4 | 18,2 |
| Mild deficit (80 – 89%) | 6 | 27,3 |
| **Fat Intake** | | |
| Severe deficit (<70%) | 6 | 27,3 |
| Mild deficit (80 – 89%) | 5 | 22,7 |
| Normal (90 – 119%) | 10 | 45,5 |
| Over (≥120%) | 1 | 4,5 |
| **Bodyfat Percentage** | | |
| Ideal (6 – 18%) | 20 | 90,91 |
| Over (>18%) | 2 | 9,09 |
| **Hemoglobin Levels** | | |
| Moderate Anemia (8 – 10,9 g/dL) | 1 | 4,54 |
| Normal (≥12 g/dL) | 21 | 95,46 |

Table 3. Relationship of Energy and Macro Nutrient Intake, Percent Body Fat, and Hemoglobin Levels with VO2max

| Variable | Cardiorespiratory Resistance (VO2max) | | | p | r |
|---|---|---|---|---|---|
| | Very Less | Less | Moderate | | |
| **Energy Intake** | | | | | |
| Severe deficit | | 1 | | | |
| Moderate deficit | 4 | 3 | 1 | 0,032[a] | 0,457 |
| Mil deficit | 2 | 4 | 3 | | |
| Normal | 1 | 2 | 1 | | |
| **Protein Intake** | | | | | |
| Severe deficit | | 1 | | | |
| Moderate deficit | 1 | | | 0,041[a] | 0,438 |
| Mil deficit | 2 | | | | |
| Normal | 3 | 3 | 1 | | |
| Over | 1 | 6 | 4 | | |
| **Carbohydrate Intake** | | | | | |
| Severe deficit | 6 | 6 | | 0,02[a] | 0,492 |
| Moderate deficit | | 2 | 2 | | |
| Mil deficit | 1 | 2 | 3 | | |
| **Fat Intake** | | | | 0,107[a] | 0,353 |

| Variable | Cardiorespiratory Resistance (VO2max) | | | p | r |
|---|---|---|---|---|---|
| | Very Less | Less | Moderate | | |
| Severe deficit | 4 | 1 | 1 | | |
| Mild deficit | 1 | 4 | | | |
| Normal | 2 | 4 | 4 | | |
| Over | | 1 | | | |
| **Bodyfat Percentage** | | | | | |
| Ideal | 5 | 10 | 5 | 0,141[a] | -0,736 |
| Over | 2 | | | | |
| **Hemoglobin Levels** | | | | | |
| Moderate Anemia | | | 1 | 0,154[b] | -0,315 |
| Normal | 7 | 10 | 4 | | |

[a]*Pearson-product moment*; [b]*Spearman-rho*

3.1 Relationship of Energy Intake to VO2max

There is a significant positive relationship between energy intake and VO2max, indicating that if there is an increase in food energy intake, there will be an increase in cardiorespiratory capacity (VO2max), and vice versa. The results of the same study indicate [7] there is a relationship between energy intake and cardiorespiratory endurance in swimming athletes ($p = 0.033$) with a fairly strong correlation strength ($r = 0.572$) and the direction of the relationship is positive, meaning the higher the energy intake, the better the cardiorespiratory endurance.

Routine exercise during the *Pre-Session* carried out by athletes has a long enough intensity so that it requires a greater energy intake than people in general. Adequate energy intake is an important component in achieving sports success that plays a role in the process of calorie expenditure, improving and increasing strength, endurance, muscle mass, and health [8]. Adequate intake of energy and macronutrients will support fitness and power. cardiorespiratory resistance (VO2max) during exercise [9].

3.2 Relationship between Protein Intake and VO2max

It is known that the higher the level of protein consumption, the higher the VO2max achievement, with a fairly strong correlation. The results of the same study were also found in students in UKM and non UKM football IPB and in adolescent athletes at SSB Harbi that there was a significant relationship between the level of protein consumption and fitness (VO2max) [2,10]. There are several factors that influence protein needs in athletes, including: age, gender, lean body mass, level of physical fitness, training regimen, and competition phase. in the growth process will require a greater amount of protein. Protein is one of the basic ingredients for forming hemoglobin (Hb), which functions as a carrier or transporter of oxygen. Lack of hemoglobin (Hb) is an obstacle to achieving a high VO2max value, as evidenced by an increase in hemoglobin levels in the arteries, indicating an increase in VO2max.

3.3 Relationship between Carbohydrate Intake and VO2max

There is a significant positive relationship between carbohydrate intake and the achievement of cardiorespiratory endurance (VO2max). More carbohydrate intake, more the VO2max achievement value too. The results of previous studies on swimming athletes and adolescent athletes of SSB Harbi also found the same thing, namely that there was a significant relationship ($p < 0.05$) between carbohydrate intake and cardiorespiratory endurance and had a positive direction [2,7]. Cardiorespiratory endurance is supported by an adequate intake of carbohydrates and fats, where carbohydrates act as the main energy source [12]. Adequate carbohydrate intake will be able to replenish muscle glycogen that has been used for muscle contraction. If muscle glycogen is met due to adequate carbohydrate intake, cardiorespiratory endurance during exercise will be good and the duration of exercise can be longer. Therefore, it is important to optimize the athlete's stamina by maintaining carbohydrate intake both in terms of type and amount during exercise.

3.4 Relationship between Fat Intake and VO2max

Table 3 shows that respondents with a heavy deficit consumption level tend to have very less VO2max capacity (18.2%). Respondents with the majority of normal fat consumption levels had better VO2 max capacity, namely in the less (18.2%) and moderate (18.2%) categories. This supports the theory that adequate or normal fat intake supports the cardiorespiratory endurance of athletes. Sports endurance mostly energy formation comes from fat [2]. Fat is stored quite large in adipose tissue in the form of triglycerides during exercise. Stored

triglycerides can be hydrolyzed into glycerol and free fatty acids (FFA). Glycerol and free fatty acids act as energy-producing fuels that support fitness [13].

However, statistically, there is no significant relationship between fat intake and VO2 max achievement of ASIFA male adolescent students (p=0.107, r= 0.353). In addition, the direction of the relationship between the two variables is positive even though the strength of the correlation is low. This indicates that the higher the fat intake, the higher the VO2max achievement. The same result was also obtained in a study conducted on SSB Harbi athletes, [2] that there was no significant relationship between fat intake and physical fitness (VO2max) in a positive direction as well achievement of VO2max was positive, contrary to the existing theory. The metabolic process of breaking down fat into energy requires a lot of oxygen to produce ATP. High-fat food intake is also associated with low glycogen levels which cause decreased cardiorespiratory endurance [7].

The results that are not in accordance with the theory can be caused by several things, including the method of measuring the level of consumption or intake of respondents. In this study, the 24-hour recall method was used for 1 x 24 hours. The weakness of measuring the 24-hour recall method is that the accuracy is very dependent on the respondent's memory and is not able to describe the daily food intake if it is only done once [14]. Therefore, this can be the cause of the bias in the results obtained when tested further.

3.5 Relationship between Body Fat Percent and VO2max

Based on Table 3, it was still found that subjects with body fat percentages exceeded the ideal limit for teenage soccer players and had very low VO2max achievements (9.1%). Excess body fat can reduce cardiac output during physical activity. As a result, the amount of blood pumped becomes less, causing a decrease in oxygen to the muscles that are working. This will affect the decrease in the body's cardiorespiratory resistance (VO2max) [15].

Based on statistical tests, it was found that there was no significant relationship between percent body fat and student VO2max achievement (-0.324) for male ASIFA adolescents and the direction of the relationship was negative, so the higher of bodyfat percentage VO2max will be the lower. Cardiovascular endurance (VO2max) is not only determined by body fat mass, but muscle mass also plays an important role in2athletesMuscle tissue is a tissue that is able to move the body's skeleton and is composed of cells that can produce energy [16]. In adolescent boys generally changes in body composition occur, namely an increase in muscle mass due to an increase in the production of the hormone testosterone which plays a role in the protein synthesis process [3]. The more muscle tissue in the body, the higher the need for oxygen to produce energy. The increase in energy produced will increase the endurance of athletes so that muscle mass is significantly positively related to VO2max [17].

3.6 Relationship between Hemoglobin Levels and VO2max

Most of the subjects had normal hemoglobin levels (95.46%) and had moderate VO2max. Cardiorespiratory endurance is influenced by several factors, including the oxygen-carrying capacity of hemoglobin. Hemoglobin levels that are less than normal can interfere with oxygen transport to tissues and trigger a decrease in maximal oxygen capacity (VO2max). An increase in hemoglobin of 1 gram will increase 3.6 ml/minute VO2max. [3,18].

Different results were obtained in the statistical test of this study. There is no significant relationship between hemoglobin levels and the achievement of VO2max for male adolescent students of ASIFA with the strength of the relationship between the two variables is very low and the direction of the relationship is negative (p = 0.154, r = -0,315). The lower a person's hemoglobin level, the better his VO2max capacity. The direction of the negative relationship is contrary to the results of previous studies and existing theories.

The difference in the results was possible because of the difference in the days of taking hemoglobin data with the bleep test to measure VO2max capacity. The process of forming hemoglobin is very dependent on the formation of red blood cells or erythrocytes. If the spinal cord is functioning properly, the process of erythrocyte formation (erythropoiesis) takes 5-9 days, whereas reticulocyte maturation takes 48-72 hours to be released into circulation [19]. The 7-day gap in this study could be the cause of the bias. The results are there because during that time the hemoglobin level can change in the presence of erythropoiesis, even though the age of hemoglobin and erythrocytes is 120 days until they are denatured from the body.

## 4. Conclusion

1. The intake of energy, protein, and carbohydrates according to the needs will increase VO2max in ASIFA male adolescent students.
2. Adequate fat intake, ideal body fat percent, and normal hemoglobin levels indicated a sufficient trend of VO2max but showed a non-significant relationship.
3. It is hoped that researchers who want to take similar topics can collect data on food consumption and VO2max once in a while, by taking food consumption data at least 2 x 24 hours on non-consecutive days.


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## References

[1] Mubarok MZ, Ramadhan R. ANALISIS TINGKAT VO2MAX PEMAIN SEPAK BOLA DARUL MA'ARIF INDRAMAYU. J Kependidikan Jasm dan Olahraga. 2019;3(1):39–45.
[2] Muthmainnah I, AB I, Prabowo S. Hubungan Asupan Energi Dan Zat Gizi Makro (Protein, Karbohidrat, Lemak) Dengan Kebugaran (VO2max) Pada Atlet Remaja Di Sekolah Sepak Bola (SSB) Harbi. J Kesehat Masy Mulawarman. 2019;1(1):24.
[3] Arum VM, Mulyati T. Hubungan Intensitas Latihan, Persen Lemak Tubuh, Dan Kadar. J Nutr Coll. 2014;3:179–83.
[4] Ramadhanny I. Hubungan Antara Asupan Karbohidrat, Status Gizi dan Persen Lemak Tubuh dengan Tingkat Kebugaran Kardiorespirasi pada Remaja Laki-laki Usia 13 - 15 Tahun di Sekolah Sepakbola Astam Tangerang Selatan. Universitas Pembangunan Nasional "Veteran"; 2019.
[5] Yaaqoub C, Mohamed HZ. The Relationship between Maximum Oxygen Consumption (VO2 Max) and Body Fat Percentage of the Male Secondary School Pupils (15-18 Years). J Heal Sci. 2018;6(4).
[6] Dieny FF, Fitranti DY, Panunggal B, Safitri I. Pengaruh pemberian sari umbi bit (beta vulgaris) terhadap kadar hemoglobin dan performa atlet sepak bola. J Gizi Indones (The Indones J Nutr. 2017;5(2):119–26.
[7] Larasati MD, Yuliana S. Asupan Makanan, Status Gizi Dan Ketahanan Kardiorespirasi Atlet Renang. J Ris Gizi. 2020;8(1):37–43.
[8] Kerksick CM, Kulovitz M. Requirements of Energy, Carbohydrates, Proteins and Fats for Athletes [Internet]. Nutrition and Enhanced Sports Performance: Muscle Building, Endurance, and Strength. Elsevier Inc.; 2014. 355–366 hal. Tersedia pada: http://dx.doi.org/10.1016/B978-0-12-396454-0.00036-9
[9] USADA. Nutritional requirements of Athletes. TrueSport Nutr Guid [Internet]. 2019;29. Tersedia pada: www.TrueSport.org
[10] Ningsih PR. TERHADAP KEMAMPUAN MENENDANG BOLA DALAM PERMAINAN SEPAK BOLA PADA SISWA PUTRA SKRIPSI. 2015;
[11] Mahan, L.K & Raymond JL. Krause's Food & The Nutrition Care Process. 14th editi. St. Louis: Elsevier; 2011. 328–329 hal.
[12] Baranauskas M. Long Term Carbohydrate Intake and the Effect on Endurance Performance in Collegiate Distance Runners. Thesis [Internet]. 2016; Tersedia pada: The University of Akron
[13] Andina Rachmayani S, Kuswari M, Melani V. Hubungan Asupan Zat Gizi dan Status Gizi Remaja Putri di SMK Ciawi Bogor. Indones J Hum Nutr. 2018;5(2):125–30.
[14] Supariasa. Penilaian Status Gizi. Jakarta: Buku Kedokteran EGC; 2002.
[15] Chatterjee, S., Chatterjee P& B. Cardiorespiratory Fitness of Obese Boys. Indian J Physiol Pharmacol. 2015;3(49):353–7.
[16] Latifah NN, Margawati A, Rahadiyanti A. Hubungan komposisi tubuh dengan kesegaran jasmani pada atlet hockey. J Keolahragaan. 2019;7(2):146–54.
[17] Esco MR, Fedewa M V., Cicone ZS, Sinelnikov OA, Sekulic D, Holmes CJ. Field-based performance tests are related to body fat percentage and fat-free mass, but not body mass index, in youth soccer players. Sports. 2018;6(4).
[18] Prommer N, Wachsmuth N, Thieme I, Wachsmuth C, Mancera-Soto EM, Hohmann A, et al. Influence of endurance training during childhood on total hemoglobin mass. Front Physiol. 2018;9(MAR):1–9.
[19] D'Arqom A. Pembentukan Sel Darah Merah (Eritropoiesis). In: Talasemia : Ditinjau dari Segi Medis dan Sosial. Surabaya: Airlangga University Press; 2021. hal. 7–13.