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Correlation between Nutritional Adequacy, Iron, Status, Body Fat Percentage and Muscle Mass Percentage with Physical Fitness

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Abstract: This study aims to determine the correlation between nutritional adequacy, iron status, body fat percentage and muscle mass percentage with physical fitness in football athletes at SSB Terang Bangsa Semarang. Adequacy of nutrients (energy, protein, fat, protein and iron) was obtained with a 2×24 hour recall. The iron status value of Fe was measured using the cyanmethemoglobin method and sTfR was measured using the ELISA method. The percentage of fat and muscle was obtained by using a Bioelectrical Impedance Analysis tool. Physical fitness is measured using the ACSPFT (Asian Committee on Standardization of Physical Fitness Test) test which includes long jumps, pull-ups, sit-ups, sprints or sprints, shuttle run tests, sit and reach and long runs. The bivariate statistical test used was the Pearson and Rank-Spearman correlation test, while the multivariate test used the Linear Regression test. There is a correlation between carbohydrate adequacy and physical fitness (p = 0.008). Physical fitness related to carbohydrate adequacy is agility and hand muscle strength (shuttle run and pull-up). There is no correlation between adequacy of energy, protein, fat, iron, iron status, fat percentage, muscle percentage and physical fitness of athletes. The results of multivariate analysis showed that the most influential on physical fitness was fat adequacy (R_{square}=14,6%).
Keywords: Nutritional Adequacy, Hb, sTfR, Fat Percentage, Protein Percentage, Physical Fitness.

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INTRODUCTION

In football, the physical components or physical fitness needed are Flexibility, Agility, Aerobic Endurance and Anaerobic Endurance, Muscle Strength and Speed. (Ali Akbar and Nanang Indardi 2014; Directorate General of Public Health 2002; Luxbacher J 2004). factors that can affect the physical fitness of athletes is the intake of nutrients, both macronutrients and micronutrients. (Djoko Pekik Irianto 2004; Syafrizar and Wilda W 2009; Thomas Battinelli 2000) One of the micronutrients that affect physical fitness is iron. (Fe). Iron is associated with the formation of hemoglobin, a decrease in the number of red blood cells and hemoglobin levels in athletes will cause interference with oxygen transport, so that it will reduce aerobic work capacity and athletes will easily experience fatigue. (Joanne Adamidou and Jenna A Bell-Wilson 2006).

In addition to the intake of nutrients, the physical fitness of an athlete is also influenced by the physical condition of the athlete himself. The biggest factor that affects the physical condition of an athlete is the condition of body composition. (CJ Caspersen, KE Powell, and GM Christenson 1985) Body composition is one of the determinants of athlete performance and athlete performance is one of the determinants of victory in a match. (Djoko Pekik Irianto 2004), (Hergenroeder AC and Klish WJ 1990) Assessment of body composition is useful for monitoring the effects of exercise and is part of physiological monitoring as part of the assessment of athlete fitness. Body composition can affect aerobic endurance, speed, balance and power of an athlete. (Fink HH and Mikesky AE 2017) The purpose of this study was to determine the correlation between nutritional adequacy, iron status, body

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fat percentage, muscle mass percentage and physical fitness on football athletes at Sekolah Sepakbola Terang Bangsa Semarang.

METHOD

This research is an observational study with a cross sectional approach and analyzed by analytical descriptive. The research was conducted at the Terang Bangsa Football School (SSB) Semarang. Hemoglobin examination and sTfR examination were carried out at the GAKI Laboratory of the Diponegoro National Hospital. The number of samples in this study amounted to 27 respondents. Calculation of the number of samples in this study did not use the sample calculation formula, because when this research was running, the Covid-19 disaster occurred, so the title and method in this study changed, the sample used used a number of samples from previous studies, namely 27 respondents.

Adequacy of nutrients (energy, protein, fat, protein and iron) was obtained with a 2×24 hour recall. The iron status value of Fe was measured using the cyanmethemoglobin method with 3 ml blood collection and sTfR was measured using the ELISA method with 30 ml blood collection. Hemoglobin levels and sTfR values were analyzed at the GAKI Laboratory of the National Hospital of Diponegoro University. The percentage of fat and muscle was obtained using the Omron Karada Scan HBF 375 Bioelectrical Impedance Analysis tool. Physical fitness was measured using the ACSPFT (Asian Committee on Standardization of Physical Fitness Test) test which includes long jumps, pull-ups, sit-ups, sprints or running fast, shuttle run test, sit and reach and long run. Each athlete did a physical fitness test 2 times and the time interval between each test was 5 minutes.

The data will be analyzed by statistical test using SPSS version 22. Each data is analyzed to see normality using the Saphiro Wilk test. Bivariate analysis was used to determine the correlation between the independent variables (hemoglobin level, sTfR value, nutrient adequacy, body fat percentage and muscle mass percentage) and the dependent variable, namely physical fitness. For the distribution of normal data using the Pearson Correlation Test, for the distribution of abnormal data using the Spearman Rank Correlation Test. Multivariate analysis using Linear Regression Test for variables with p values <0.25.

RESULT AND DISCUSSION

This research was conducted at the Terang Bangsa Football School Semarang with a total of 27 respondents. The respondent's characteristic data consisted of Body Mass Index (BMI), physical activity, physical fitness, energy adequacy, protein adequacy, fat adequacy, carbohydrate adequacy, Fe adequacy, iron status, muscle mass percentage and body fat percentage.

Table 1. Karakteristik Responden

Characteristics	N	%	Mean±SD	Min-max
Body Mass Index				
Underweight (<18,5)	4	14,3	21,19 ± 2,52	16,27-25,95
Normal (18,5-22,9)	16	57,1		
Overweight (23-24,9)	5	17,9		
Obesitas 1 (25-29,9)	2	7,1		
Obesitas 2 (≥30)	0	0		
Physical Activity				
Mild (1,0-1,59)	2	7,1	1,71 ± 0,066	1,59-1,87
Moderate (1,6-1,89)	25	89,3		
Severe (1,9-2,49)	0	0		
Physical Fitness				
Pull-up			13,66 ± 6,40	3-30
Sit-up			45,55 ± 7,95	35-60
Sprint			1,36 ± 0,17	1,02-1,75
Long jump			278,69 ± 6,35	268,50-292,50
Long run			3,43 ± 0,56	2,56-4,53
Shuttle Run			10,70 ± 0,43	10,12-11,84
Sit and Reach			23,59 ± 2,30	20-27

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Energy Adequacy				
Severe Deficit (<70%)	1	3,7	83,53 ± 6,47	68,84-93,49
Moderate Deficit (70-79%)	7	25,9		
Mild Deficit (80-89%)	14	51,9		
Normal (90-119%)	5	18,5		
Above Demand Rate (≥120%)	0	0		
Protein Adequacy				
Severe Deficit (<70%)	0	0	118,21 ± 17,41	82,13-148,93
Moderate Deficit (70-79%)	0	0		
Mild Deficit (80-89%)	3	11,1		
Normal (90-119%)	10	37,0		
Above Demand Rate (≥120%)	14	51,9		
Fat Adequacy				
Severe Deficit (<70%)	2	7,4	91,57 ± 13,02	63,63-119,88
Moderate Deficit (70-79%)	2	7,4		
Mild Deficit (80-89%)	7	25,9		
Normal (90-119%)	15	25,9		
Above Demand Rate (≥120%)	1	3,7		
Carbohydrate Adequacy				
Severe Deficit (<70%)	13	48,1	70,30 ± 11,15	46,50-87,77
Moderate Deficit (70-79%)	9	33,3		
Mild Deficit (80-89%)	5	18,5		
Normal (90-119%)	0	0		
Above Demand Rate (≥120%)	0	0		
Iron Adequacy				
Severe Deficit (<70%)	3	11,1	94,04 ± 21,08	50,00-149,09
Moderate Deficit (70-79%)	2	7,4		
Mild Deficit (80-89%)	8	29,6		
Normal (90-119%)	12	44,4		
Above Demand Rate (≥120%)	2	7,4		
Iron Status				
Soluble Transferin Reseptor			14,74 ± 11,29	9,00-62,60
Hemoglobin			14,36 ± 0,81	12,40-16,70
Muscle Mass Percentage			41,88 ± 5,05	29,70-49,50
Body Fat Percentage			13,74 ± 4,91	5,30-24,00

The average nutritional status of the respondents as seen from the Body Mass Index is 21.19 kg/m2 which is included in the normal category. There are only two respondents who have obesity nutritional status and one of them is a goalkeeper. The average value of physical activity that has been calculated by the PAL table is 1.71 which is in the moderate category. Physical activities such as football training were carried out by respondents 3 times a week with a duration of 3 hours. The routine activities carried out are school from 07.00 to 14.30. On other days when not exercising, some respondents did other activities such as resting by relaxing, doing additional exercises and playing volleyball together.

The average result of measuring the strength of the hand muscles with the respondent's pull-up test is 13.66 times, while the average result of the measurement of the abdominal muscle strength of the respondents using the sit-up test is 45.55 times. The average respondent's speed measurement results are 1.36 seconds, the respondent's explosive power measurement using the long jump test is 278.69 meters, the respondent's respiratory endurance measurement is 3.43 minutes, the respondent's agility measurement is 10.70 seconds and the average the respondent's flexibility measurement is 23.59 cm.

Table 1 shows that the average respondent's energy adequacy is 83.53% which is in the category of mild deficit, while the average protein adequacy of the respondents is 118.21% which is in the normal category. The average respondent's fat adequacy is 91.57% in the normal category, the respondent's average carbohydrate adequacy is 70.30% in the moderate deficit category and the respondent's average iron adequacy is 94.04% in the normal category .

The respondent's food intake has been regulated by the school, the system of giving in a day is 3 meals and one snack with a total energy of 1900 calories. Respondents obtained heavy meals in the

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morning before going to school, during the day at school and in the afternoon after training, while snacks were given once during the day in the form of bread or bananas. Respondents were not given additional supplements from school, there was only one respondent who took additional supplements in the form of protein milk.

Iron status is described by the value of Soluble Transferrin Receptor (sTfR) and hemoglobin levels in respondents. The normal sTfR concentration is about 1.0-2.9 g/ml. The limit value for sTfR levels is to indicate an early sign of intracellular iron deficiency if the sTfR level is > 2.5 g/ml. (Abdul Khanis 2010; Ahluwalia N 1998; Bambang S 2006; M. Nur 2014) Other sources say that the normal value of sTfR is 0 ,83-2,76 mg/L. (Schumacher YO et al. 2002) If using Hemoglobin as a parameter to measure iron status, the respondent is declared anemic if the age of 12-14 years the hemoglobin level in the blood is below 12.0 g/dL and if Respondents aged 15 years and over are said to be anemic if the hemoglobin level is below 13.0g/dL. (World Health Organization (WHO) 2011) The Soluble Transferrin Receptor values of respondents in this study were all normal. It was obtained from the results of the study that the lowest value of Soluble Transferrin Receptors in respondents was 9 g/L while the highest value was 62.6 g/L with an average of 14.74 g/L. Hemoglobin Levels Respondents in the study were all normal or not anemic. The respondent's average hemoglobin level was 14.36 g/dL and the lowest respondent's hemoglobin level was 12.40 g/dL.

Body composition measured is percent muscle and percent fat. The categories of body fat percentage for men are athletic (5-10%), good (11-14%), acceptable (15-20%) and obese (>24%).(Jeukendrup A and Gleeson M 2010) Percent category muscle mass in men is high (>44%), normal (40-44%), low (<40%).(Janssen IAN et al. 2000; Latifah Nandita Nury, Ani Margawati, and Ayu Rahadiyanti 2019) From Table 1. It can be concluded that the average percentage of the respondent's muscle mass is 41.88, which is included in the normal category. for the average body fat percentage of respondents is 13.74, in the good category.

Table 2. Correlation of Nutrient Adequacy with Physical Fitness

Variabel	R	Sig.
Energy Adequacy*	-0,238	0,232
Protein Adequacy*	-0,149	0,459
Fat Adequacy*	0,382	0.050
Carbohudrate Adequacy**	-0,499	0,008
Iron Adequacy*	-0,231	0,245

*Pearson Test
**Spearman Rank Test

Based on the table above, it can be concluded that energy adequacy, protein adequacy, fat adequacy and iron adequacy are not related to physical fitness. This is evidenced by the p value> 0.05. A similar study was shown by Cornia (2018), which stated that there was no correlation between energy intake and protein intake with physical fitness in taekwondo athletes. (Intan Galih Cornia and Merryana Adriani 2018) Other studies also state that there is no significant correlation between energy adequacy and physical fitness in swimming athletes. (Karinta Ariani Setiautri, Mohammad Zen Rahfiludin, and Suroto 2017) Based on the results of the analysis of the data obtained, the average energy adequacy of the respondents is a mild level of deficit. Sufficient energy is needed by athletes to maintain body tissue mass, body immune system, reproductive function and to maintain optimal athlete performance. The physical activity that athletes do is heavier. Especially if the athlete is a student, the energy needs are much greater because the athlete is still in his teens which is the period of optimal growth and the most productive phase in the development of the athlete's motor skills. school, taking part in extracurricular activities and other activities outside of school. This high energy requirement is not supported by the availability of sufficient food. The athlete's dormitory provides food with a total of 1900 calories of energy per day. This is one of the causes of the respondent's energy adequacy deficit.

While the adequacy of carbohydrates is related to physical fitness, as evidenced by the value of p <0.05 (p = 0.008) and the value of r = -0.499, which means that there is a negative correlation between carbohydrate adequacy and the respondent's physical fitness. So it can be said that the smaller the percentage of carbohydrate adequacy, the higher the respondent's physical fitness. The correlation

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between carbohydrate adequacy and physical fitness can occur when the body consumes excessive carbohydrate sources without adequate physical activity, so carbohydrates in the body will be stored in the form of fat reserves. Excess fat in the body will be able to increase body mass, which will affect the speed of athletes, besides a high percentage of fat in the body will increase the temperature in the body so that the body will get tired easily. (Refiana Putri Sukmajati 2015)

Based on table 3, it can be seen that there is a correlation between energy adequacy and the shuttle-run as evidenced by the values of p = 0.024 and r = 0.434, which means that there is a positive correlation, namely the better the energy adequacy, the better the shuttle-run score for the respondents. There is also a correlation between carbohydrate adequacy and the shuttle-run as evidenced by the values of p=0.003 and r=0.552, which means that there is a positive correlation, namely the better the carbohydrate adequacy, the better the shuttle-run score for the respondents. There is a correlation between carbohydrate adequacy and pull-ups as evidenced by the value of p = 0.031 and r = -0.416, which means that there is a negative correlation, namely the lower the carbohydrate adequacy, the better the pull-up score on the respondents.

Table 3. Correlation of Nutrient Adequacy with Physical Fitness

Variabel 1	Variabel 2	R	Sig.
Energy Adequacy	***Shuttle run****	**0,434**	**0,024**
	*Pull-up**	-0,240	0,227
	*Sprint**	0,001	0,995
	*Lompat jauh**	-0,033	0,869
	*Sit and reach***	0,190	0,341
	*Sit-up***	-0,202	0,311
	*Lari jauh***	0,075	0,710
Protein Adequacy	*Shuttle run**	0,086	0,669
	*Pull-up**	-0,122	0,543
	*Sprint**	0,002	0,991
	*Lompat jauh**	0,051	0,800
	*Sit and reach***	-0,047	0,814
	*Sit-up***	-0,227	0,256
	*Lari jauh***	0,023	0,909
Fat Adequacy	*Shuttle run**	-0.093	0,644
	*Pull-up**	0,266	0,180
	*Sprint**	-0,168	0,403
	*Lompat jauh**	0,276	0,164
	*Sit and reach***	0,280	0,158
	*Sit-up***	-0,097	0,629
	*Lari jauh***	-0,166	0,408
Carbohydrate Adequacy	***Shuttle run****	**0,552**	**0,003**
	Pull-up*	**-0,416**	**0,031**
	*Sprint***	0,127	0,529
	*Lompat jauh***	-0,268	0,177
	*Sit and reach***	0,022	0,912
	*Sit-up***	-0,043	0,830
	*Lari jauh***	0,232	0,244
Iron Adequacy	*Shuttle run**	0,075	0,709
	*Pull-up**	-0,197	0,324
	*Sprint**	-0,159	0,428
	*Lompat jauh**	0,044	0,829
	*Sit and reach***	0,091	0,651
	*Sit-up***	0,092	0,646
	*Lari jauh***	-0,013	0,950

*Pearson Test
**Spearman Rank Test

Shuttle-run is a test conducted to measure the agility of an athlete. Agility is the ability to move quickly without losing balance. (Ngurah Nala 1998) Agility is closely related to speed, strength, balance and coordination of motion, balance, flexibility and all other athletic abilities. (M Sajoto 1995)

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Pull-ups are tests performed to measure hand muscle strength. Muscle strength is defined as the power or muscle tension to do work repeatedly or continuously against resistance in a maximum effort. (Thomas Battinelli 2000) Adequate energy in athletes is very important to be stored in muscles and liver as glycogen. If the glycogen reserves in the body are low, the athlete will experience fatigue because the energy needed has been exhausted. (Moehji S 2003) Carbohydrates are needed by athletes to produce energy. Carbohydrates are able to produce energy-forming basic molecules in a larger quantity and at a faster rate than fat burning. (Irawan nd) The negative correlation between carbohydrate adequacy and pull-ups (hand muscle strength) is when the body consumes carbohydrate-rich foods. If excessive physical activity is not accompanied by sufficient physical activity, then carbohydrates in the body will be stored in the form of fat reserves. Excess fat in the body will be able to increase body mass, which will affect the speed of athletes, besides a high percentage of fat in the body will increase the temperature in the body so that the body will get tired easily. (Refiana Putri Sukmajati 2015)

Table 4 shows the results of the test of the correlation between iron status and physical fitness, namely that there is no significant correlation between iron status, namely hemoglobin and Soluble Transferrin Receptor levels with physical fitness (hemoglobin level p = 0.295 and sTfR p = 0.399). The results of this study are in line with research conducted by Masithoh (2018) which states that there is no significant correlation between hemoglobin levels and athletes' physical fitness. (Anastasia Masithoh, Galeh S Pontang, and Indri Mulyasari 2018) Also supported by research conducted by Dewi (2017) and Arum (2013) that there is no correlation between hemoglobin levels and the physical fitness of football athletes. Physical fitness of athletes is not only influenced by hemoglobin levels but also other factors, such as motivation and nutritional intake. The absence of a correlation between iron status and physical fitness of the respondents could be due to all respondents having iron status (hemoglobin levels and sTfR values) and good physical fitness. The level of iron adequacy in the respondents was also mostly in the normal category. A good level of iron adequacy is because respondents always consume iron-rich foods in every meal. (Arum VM 2013; Kartika Indaswari Dewi and Bambang Wirjatmadi 2017)

Table 4. Correlation of Iron Status with Physical Fitness

Variabel	R	Sig.
Hemoglobin*	-0,209	0,295
Soluble Transferin Reseptor**	0,169	0,399

*Pearson Test
**Spearman Rank Test

Iron is very influential on the physical fitness of an athlete. Iron is needed in the process of hematopoiesis (blood formation), namely in the synthesis of hemoglobin (Hb). (Gibney MJ et al. 2009) based on Pretty and Muwakhidah's research (2017) hemoglobin levels have an effect of 15.2% on physical fitness. (Pretty A and Muwakhidah 2017) Hemoglobin functions to bind and then carry oxygen to the lungs before being circulated to all body tissues. Oxygen has a role as a fuel that can produce energy to support one's activities. (Gibson R 2005; Ikanov Safitri and Bambang Wirjatmadi 2020)

Tabel 5. Correlation between Body Fat Percentage and Muscle Mass Percentage with Physical Fitness

Variabel	R	Sig.
Body Fat Percentage*	-0,208	0,297
Muscle Mass Percentage**	0,166	0,408

*Pearson Test
**Spearman Rank Test

Based on the test of the correlation between the percentage of body fat and the percentage of muscle mass with physical fitness, it can be concluded that there is no correlation between the percentage of body fat and the percentage of muscle mass with physical fitness. This is indicated by a significance value of more than 0.05 (percentage of body fat p=0.297 and percentage of muscle mass p=0.408). The results of this study are in line with research conducted by Everyutri (2017) which

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states that there is no correlation between body fat percentage and physical fitness in swimming athletes. (Karinta Ariani Setiautri et al. 2017) Supported by other research conducted by Nurwidyastuti (2012) which states that there is no significant correlation between the percentage of body fat and physical fitness. (Dinda Nurwidyastuti 2012) There is no correlation between the percentage of body fat and physical fitness because the percentage of fat in most of the respondents is in the very good category and the overall physical fitness of all respondents is also in the category very good. The correlation between the percentage of fat and physical fitness can occur because excess fat in the body will be able to increase body mass, which will affect the speed of athletes, besides a high percentage of fat in the body will increase the temperature in the body so that the body will get tired easily. (Refiana Putri Sukmajati 2015).

Table 6. Simple Linear Regression Analysis

Variabel	Regresision coef. (B)	R_{square}	Sig.
Energy Adequacy	-0,861	0,057	0,232
Fat Adequacy	0,686	0,146	0,050
Fe Adequacy	-0,257	0,054	0,245
Carbohydrate Adequacy	1,253	0,056	0,007

From the results of multivariate analysis, it was found that the coefficient of determination (R_{square}) of energy adequacy was 0.057, which means 5.7% of physical fitness was influenced by energy adequacy, while the remaining 94.3% of physical fitness was influenced by other variables not examined in the study. The coefficient of determination (R_{square}) of fat adequacy is 0.146, which means that 14.6% of physical fitness is influenced by fat adequacy, while the remaining 85.4% of physical fitness is influenced by other variables not examined in the study. The coefficient of determination (R_{square}) of Fe adequacy is 0.054, which means 5.4% of physical fitness is influenced by Fe adequacy, while the remaining 94.6% of physical fitness is influenced by other variables not examined in the study. The coefficient of determination (R_{square}) of carbohydrate adequacy is 0.056, which means 5.6% of physical fitness is influenced by carbohydrate adequacy, while the remaining 94.4% of physical fitness is influenced by other variables not examined in the study. It can be concluded that the variable that most influences physical fitness is fat adequacy. These results are supported by research conducted by Asmika (2012) and Intan Dwi Sari (2016) which states that there is a relationship between fat adequacy and the physical fitness of football athletes. (Asmika, Nugroho, and Virgianto 2012; Intan Dwi Sari 2016).

However, fat consumption in athletes should be limited because excess fat in the body will increase body mass, which will affect the athlete's speed, besides a high percentage of body fat will increase body temperature so that the body will get tired easily. The recommended consumption of fat in a day is 8% of the total energy requirement which comes from saturated fat and 3-7% from polyunsaturated fat. Fat is used as a source of energy in physical exercise to increase muscle capacity. Increased fat metabolism during endurance sports such as football has the benefit of protecting glycogen use and improving physical endurance. (Djoko Pekik Irianto 2004; Refiana Putri Sukmajati 2015; Rhosidatus Salamah 2019).

CONCLUSION

There is a relationship between carbohydrate adequacy and physical fitness which is indicated by a p value <0.05 (p = 0.008), but there is no relationship between the adequacy of energy, protein, fat and iron with athletes' physical fitness marked by a p value> 0.005 (p energy =0,232, protein p=0,459, fat p=0,050, and iron p=0,245). There was no significant relationship between iron status, namely hemoglobin and sTfR levels with physical fitness, which was indicated by p>0.05 (hemoglobin level p=0.295 and sTfR p=0.399). There is no relationship between the percentage of body fat and the percentage of muscle mass with physical fitness which is indicated by the value of p = 0.297 and p = 0.40. The results of multivariate analysis showed that the most influential on physical fitness was fat adequacy (R_{square}=14,6%).

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