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# Health and fitness study of Semarang soccer players: the role of $VO_2$ max, body mass index, age and length of training

# Estudio de salud y condición física de jugadores de fútbol de Semarang: el papel del VO2 máximo, el índice de masa corporal, la edad y la duración del entrenamiento

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**Abstract.** Physiological factors influence the performance of football players, so a coach must know and analyze these factors. This study explored the relationship between Body Mass Index (BMI) and maximal aerobic capacity ($VO_2$ max) on the health and fitness of soccer players in Semarang. The study involved 41 soccer players from various local clubs, aged 14-16 years, who were evaluated through BMI measurement by measuring height and weight and $VO_2$ max test with Multi-Stage Fitness Test. Data were analyzed using Pearson correlation to identify the strength and direction of the relationship between variables. The analysis results showed that: 1) Age had a moderate positive correlation with $VO_2$ max ($r = 0.366$, $p = 0.018$), indicating that $VO_2$ max values tend to increase with age. However, age showed no significant correlation with the other variables (BMI criteria, BMI, and length of training), 2) BMI criteria had a very high and significant correlation with BMI ($r = 0.785$, $p < 0.001$), confirming that the BMI criteria used were highly correlated with actual BMI values. However, no significant correlation was found between BMI criteria and $VO_2$ max and training duration, 3) BMI showed no significant correlation with $VO_2$ max ($r = 0.191$, $p = 0.232$) nor with training duration ($r = 0.088$, $p = 0.585$), 4) $VO_2$ max had a moderate and significant positive correlation with training duration ($r = 0.639$, $p < 0.001$), suggesting that individuals with longer training duration tend to have higher $VO_2$ Max. This study concludes that there is a significant relationship between age and $VO_2$ max as well as between training duration and $VO_2$ max, indicating the importance of both factors in aerobic capacity improvement programs. In addition, the BMI criteria used proved to be valid in reflecting actual BMI values. These results underscore the importance of considering age and duration of training in football players' fitness programs as well as the validity of the BMI criteria used in the study.
**Keywords:** Body Mass Index; $VO_2$ max; Age; Length of Training; Football

**Resumen**. El rendimiento de los jugadores de fútbol está influido por factores fisiológicos, por lo que un entrenador debe conocer y analizar estos factores. Este estudio tenía como objetivo explorar la relación entre el Índice de Masa Corporal (IMC) y la capacidad aeróbica máxima (VO2 máx) en la salud y la forma física de los jugadores de fútbol en Semarang. En el estudio participaron 41 jugadores de fútbol de varios clubes locales, con edades comprendidas entre los 14 y los 16 años, que fueron evaluados mediante la medición del IMC midiendo la altura y el peso y la prueba de VO2 máx con el Multi-Stage Fitness Test. Los datos se analizaron mediante la correlación de Pearson para identificar la fuerza y la dirección de la relación entre las variables. Los resultados del análisis mostraron que 1) La edad tenía una correlación positiva moderada con el VO2 máx ($r = 0{,}366$, $p = 0{,}018$), lo que indica que los valores de VO2 máx tienden a aumentar con la edad. Sin embargo, la edad no mostró una correlación significativa con las demás variables (criterios de IMC, IMC y duración del entrenamiento), 2) los criterios de IMC tuvieron una correlación muy alta y significativa con el IMC ($r = 0{,}785$, $p < 0{,}001$), lo que confirma que los criterios de IMC utilizados estaban muy correlacionados con los valores reales de IMC. Sin embargo, no se encontró una correlación significativa entre los criterios de IMC y el VO2 máx. y la duración del entrenamiento, 3) el IMC no mostró una correlación significativa con el VO2 máx. ($r = 0{,}191$, $p = 0{,}232$) ni con la duración del entrenamiento ($r = 0{,}088$, $p = 0{,}585$), 4) el VO2 máx. tuvo una correlación positiva moderada y significativa con la duración del entrenamiento ($r = 0{,}639$, $p < 0{,}001$), lo que sugiere que los individuos con una mayor duración del entrenamiento tienden a tener un VO2 máx. más alto. La conclusión de este estudio es que existe una relación significativa entre la edad y el VO2 máx, así como entre la duración del entrenamiento y el VO2 máx, lo que indica la importancia de ambos factores en los programas de mejora de la capacidad aeróbica. Además, los criterios de IMC utilizados demostraron ser válidos a la hora de reflejar los valores reales de IMC. Estos resultados subrayan la importancia de tener en cuenta la edad y la duración del entrenamiento en los programas de acondicionamiento físico de los futbolistas, así como la validez de los criterios de IMC utilizados en el estudio.
**Palabras clave:** Índice de masa corporal; VO2 máx; Edad; Duración del entrenamiento; Fútbol

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## Introduction

Football is one of the sports that characterize physical activity using the aerobic energy system more dominantly coupled with high turnover of the anaerobic system (Boone, Jane et al. 2012). Football players are multi-layer athletes who must have good aerobic and anaerobic abilities (Vasileios et al. 2018). Football players during a match generally cover a distance of 9,500-12,000 meters (Ermanno Rampinini , Franco M. Impellizzeri , Carlo Castagna , Aaron J. Coutts 2009). Knowing this kind of football game activity, health, and physical fitness are crucial for football players to achieve the best performance and reduce the risk of injury. Football players who regularly train with increasing training duration continuously will improve their health and physical fitness (Hammami et al. 2018). Two main indicators often used to assess the physical fitness of an athlete are Body Mass Index (BMI) and $VO_2$ max. BMI measures the ratio between body weight and height, providing an overview of a person's nutritional status. Meanwhile, $VO_2$ max measures maximal aerobic capacity, which reflects the efficiency of the respiratory and

cardiovascular systems in supporting intensive physical activity (Ummy Aisyah Nurhayati 2024). VO2 Max reflects the body's maximum ability to consume oxygen during intense physical activity, which is directly related to physical performance and endurance. By understanding VO2 Max, we can predict one's physical capacity and design more effective exercise programs to improve overall health and fitness (Nunes et al. 2018). An athlete's nutritional status can be assessed through Body Mass Index (BMI), one of the simple indicators to classify weight status. BMI is calculated from body weight divided by height squared and is used to identify whether an athlete is underweight, normal, overweight, or obese (Campa et al. 2021). BMI monitoring is one of the simple ways to know the health condition of an athlete (Wati et al. 2024).

Football players must have a good $VO_2$ max because each player will run, walk, kick, and jump for 45 minutes in each round (Anggara and Subagio 2021). Players with a high $VO_2$ max tend to perform better on the pitch due to their ability to maintain high intensity during matches (Bryantara 2016). Football players with good aerobic capacity ability can recover faster and be ready to continue the match with the maximum ability he has (Etaxas 2021). When football players have high aerobic metabolic strength and capacity, they can perform at the highest level (Boone, et al. 2012). Besides having a good $VO_2$ max, football players must have a normal or ideal body mass index. This is because the body mass index is an important indicator of the physical health and performance potential of football players on the field, guiding their training and nutrition strategies toward achieving optimal performance. Body Mass Index is a measurement that considers a person's weight and height to categorize them into different ranges such as underweight, normal weight, overweight, or obese. A football player with a normal body mass index will easily perform optimally (Hidayat et al. 2022). Football players' balanced body mass index is important to ensure they have enough muscle mass without excess fat that can hinder their movements (Hov et al. 2023). Maintaining an ideal BMI can improve players' agility, speed, and endurance on the field. Players with an ideal BMI tend to move more efficiently, make faster decisions, and reduce the risk of injury during matches. BMI optimization can contribute to injury prevention by ensuring that players have the strength and endurance necessary to withstand the game's physical demands. It also helps reduce strain on joints and muscles, minimizing the chance of injury during matches or training sessions (Dharmajayanti, Negara, and Artini 2023). How to get a normal BMI by paying attention to the nutritional intake consumed by each player and training patterns (Pranata 2023).

In that context, this study aims to explore the relationship between $VO_2$ Max and Body Mass Index with the health and fitness of Semarang football players. Understanding the influence of these two factors is hoped to provide greater insight into efforts to improve athlete performance through a more scientific and measurable approach.

Organisation (WHO), BMI is categorized as follows: Underweight: BMI < 18.5, Normal: BMI 18.5 - 24.9, Overweight: BMI 25 - 29.9, Obese: BMI ≥ 30 (World Health Organization, 2020)

VO2 Max Measurement

VO2 Max was measured using the Bleep Test.

## Materials and Methods

### *Research Design*

This study used a cross-sectional design to evaluate the relationship between Body Mass Index (BMI) and $VO_2$ Max in soccer players in Semarang. The study was conducted over a three-month period, from January to March 2024.

Participants

A total of 41 soccer players from various local clubs in Semarang participated in this study. Inclusion criteria were players who were actively practicing and competing for at least one year, aged between 14-16 years, and willing to follow all study procedures. Participants with a history of serious injury in the past six months or health conditions that could affect the measurement results were excluded from the study.

Body Mass Index (BMI) Measurement

BMI is calculated using the following formula (World Health Organization 2020);

$$BMI = \frac{\text{Body Weight (kg)}}{\text{Height (m)}^2}$$

Body weight measurements were taken using a digital scale with an accuracy of 0.1 kg, while height was measured using a stadiometer with an accuracy of 0.1 cm. Measurements were taken in the morning before training to ensure consistent body condition. According to the commonly used classification by the World Health

### *Research Procedure*

1. Preparation and Counseling: All participants were given complete information regarding the purpose and procedures of the study. Informed consent was obtained from all participants.
2. Baseline Measurement: BMI measurement was done first followed by $VO_2$ Max measurement. Participants were asked not to do strenuous physical activity 24 hours before measurement and to avoid consumption of food or drinks that could affect measurement results such as caffeine and alcohol.
3. Implementation of the Beep Test.

### *Data Analysis*

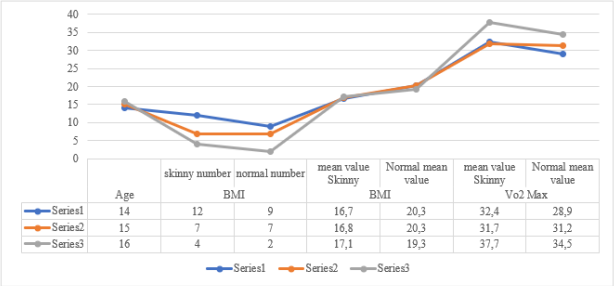
Descriptive analysis was conducted to describe the characteristics of the participants. Kolmogorov-Smirnov Normalization Test to determine whether the data is normally distributed or not, provided that the significant value> 0.05, then the data is normally distributed, but if the significance value <0.05, then the data is not normally distributed. So if the data is normally distributed, it can be

continued with the Pearson correlation test, but if the data is not normally distributed, the test used is the Spearman correlation test (non-parametric). The correlation test was used to test the relationship between VO2 Max, BMI, Age, and Length of Training, with the significance level set at $p < 0.05$.

## Research Results

### *Participant Characteristics*

A total of 41 football players participated in this study. The average age of the participants was 14.6 ± 0.7 years. The average BMI was 18.3 ± 2.1 kg/m² and the average $VO_2$ max was 31.9 ± 7.3 ml/kg/min.




| | Age | BMI: skinny number | BMI: normal number | BMI: mean value Skinny | BMI: Normal mean value | Vo2 Max: mean value Skinny | Vo2 Max: Normal mean value |
|---|---|---|---|---|---|---|---|
| Series1 | 14 | 12 | 9 | 16,7 | 20,3 | 32,4 | 28,9 |
| Series2 | 15 | 7 | 7 | 16,8 | 20,3 | 31,7 | 31,2 |
| Series3 | 16 | 4 | 2 | 17,1 | 19,3 | 37,7 | 34,5 |

Figure 1. Average Value of BMI and $VO_2$ max

Table 1.
Descriptive Statistics

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| BMI | 41 | 18.7017 | 2.10276 | 13.14 | 23.05 |
| VO2_Max | 41 | 40.2024 | 10.64800 | 22.50 | 56.30 |
| Lenght_of_Training | 41 | 3.29 | 1.453 | 1 | 6 |
| Age | 41 | 14.80 | .813 | 14 | 16 |

Furthermore, the results of the research data were tested for normality using the Kolmogorov-Sminrnov normality test to determine whether the data were normally distributed or not. The results of the Kolmogorov-Smirnov normality test are presented in Table 2.

Table 2.
One-Sample Kolmogorov-Smirnov Test

| | | BMI | VO2_Max | Lenght_of_Training | Age |
|---|---|---|---|---|---|
| N | | 41 | 41 | 41 | 41 |
| Normal Parameters | Mean | 18.7017 | 40.2024 | 3.29 | 14.80 |
| | Std. Deviation | 2.10276 | 10.64800 | 1.453 | .813 |
| Most Extreme Differences | Absolute | .134 | .138 | .203 | .278 |
| | Positive | .095 | .110 | .203 | .278 |
| | Negative | -.134 | -.138 | -.138 | -.173 |
| Test Statistic | | .134 | .138 | .203 | .278 |
| Asymp. Sig. (2-tailed) | | .061 | .047 | .000 | .000 |

Based on the data in Table 2, it can be concluded that the data is not normally distributed, this is based on the Sig value. (2-tailed) <0.05, only one variable has a Sig. (2-tailed) >0.05, namely the BMI variable with a Sig value. (2-tailed) 0.061. Based on the results of this Normality Test, the next test uses the Spearman correlation test (non-parametric) to analyze the relationship between several variables, namely VO2 max, BMI, Age, and length of training. The results of the Spearman correlation analysis are presented in Table 3.

Table 3.
Correlations Spearman

| | | | VO2_Max | Age | BMI | Lenght_of_Training |
|---|---|---|---|---|---|---|
| Spearman's rho | VO2_Max | Correlation Coefficient | 1.000 | .451** | .644** | .784** |
| | | Sig. (2-tailed) | . | .003 | .000 | .000 |
| | | N | 41 | 41 | 41 | 41 |
| | Age | Correlation Coefficient | .451** | 1.000 | .348* | .665** |
| | | Sig. (2-tailed) | .003 | . | .026 | .000 |
| | | N | 41 | 41 | 41 | 41 |
| | BMI | Correlation Coefficient | .644** | .348* | 1.000 | .550** |
| | | Sig. (2-tailed) | .000 | .026 | . | .000 |
| | | N | 41 | 41 | 41 | 41 |
| | Lenght_of_Training | Correlation Coefficient | .784** | .665** | .550** | 1.000 |
| | | Sig. (2-tailed) | .000 | .000 | .000 | . |
| | | N | 41 | 41 | 41 | 41 |

The results of the analysis showed that: VO2 max has a moderate positive correlation with Age ($r = 0.451$, $p = 0.003$), which means that as age increases, VO2 max values tend to increase. Likewise, BMI and $VO_2$ max have a strong positive correlation with BMI ($r = 0.644$, $p = 0.000$), which means that VO2 max will tend to improve if BMI touches the Ideal category. This also applies to the length of training, VO2 max has a strong correlation with the length of training ($r = 0.784$, $p = 0.000$), which means that the longer the training is done, the higher the VO2 max value will be.

## Discussion

### *Correlation of Age with $VO_2$ max*

The results showed a significant positive correlation between age and $VO_2$ max ($r = 0.451$, $p = 0.003$). This finding suggests that with increasing age, $VO_2$ max values tend to grow in the analysed sample. This could be due to physiological adaptations that occur with age or level of experience in aerobic exercise. However, other literature often suggests that $VO_2$ max tends to decrease with age due to decreased cardiovascular capacity and respiratory system efficiency. $VO_2$ max tends to peak in your 20s and begins to gradually decline as you get older. This decline is estimated

to be around 1% per year after age 30 to 40 and can reach a 30% decline by age 65 (Kim et al. 2016). $VO_2$ max declines by about 10% per decade after the age of 25–30 years and slightly more at older ages (e.g., older than 60–70 years) (Burtscher et al. 2022). Age is one of the factors of the rise and fall of the $VO_2$ max of football players, at a young age the $VO_2$ max of football players tends to be less until he touches old age, namely the age of 20-29 years and will decrease at the next age until 65 years (Martin-Rincon and Calbet 2020).

***Correlation between BMI and VO2 max***

The strong and significant correlation between BMI and VO2 max ($r = 0.644$, $p = 0.000$) indicates the validity of the BMI criteria used in this study. The high BMI_Creteria indicates that the BMI classification method used accurately reflects the true BMI value. However, there was no significant correlation between BMI_Creteria and $VO_2$ max. Both lean and ideally built players, if they have efficient cardiovascular and respiratory systems, can have similar VO2 max. The capacity of the heart to pump blood, the volume of blood pumped, and the capacity of the lungs to exchange oxygen for carbon dioxide are the main factors that determine VO2 max (Albiach et al. 2021). It is different if a player has an obese BMI classification, this will affect one's fitness. Individuals with a higher BMI tend to have a lower aerobic capacity or VO2 Max, which signifies a decrease in efficiency in physical activity (Akhmad et al. 2024). VO2 max is a measure of a person's aerobic capacity and depends on the body's ability to transport and use oxygen during intense physical activity. Although lower body fat in thinner people can affect total body weight, more important factors are muscle mass and the efficiency of the cardiovascular system (Martin-Rincon and Calbet 2020).

***Correlation between Length_Of_Training and $VO_2$ max***

There was a significant positive correlation between Length_Of_Training and $VO_2$ max ($r = 0.784$, $p = 0.000$), indicating that individuals who train longer tend to have a higher $VO_2$ max. This aligns with the literature stating that long-term aerobic training can improve the body's oxygen capacity and cardiovascular efficiency. For example, a study by Midgley and Larson (2006) showed that an aerobic training program can significantly increase $VO_2$ max. 16-year-old youth football players given 16 weeks of cardiovascular training resulted in a significant increase in their vo2 max compared to 16-year-old youth football players given 4 weeks of training (Calandro, Esposito, And Altavilla 2020). Longer and more intense training sessions provided greater improvements in $VO_2$ max compared to shorter and less intense training sessions (Russomando et al. 2020). Consistent and sustained exercise duration performed for 8 weeks can effectively improve aerobic capacity and cardiovascular endurance in young age groups (Jatmiko et al. 2024).

## Conclusion

The conclusion from the results of this study is that there is a significant relationship between age and $VO_2$ max as well as between training duration and $VO_2$ max. In addition, the BMI criteria used were highly correlated with actual BMI values. However, no significant relationships were found between age and BMI, between BMI criteria and $VO_2$ max, or between BMI and training duration. These results indicate the importance of considering age and length of training in aerobic capacity improvement programs as well as the validity of the BMI criteria used in the study. The analysis provides insight into how these variables interrelate in the context of the given data and their practical relevance in the development of fitness and health programs.

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