



## Analysis of the Relationship Between Vo2Max Level and the Achievement of Tennis Athletes in Semarang City

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### Abstract

**Introduction:** Tennis is an intermittent high-intensity sport that requires optimal aerobic endurance to maintain performance throughout long and demanding matches. **Objectives:** This study aims to determine the relationship between maximum aerobic capacity (VO2Max) and the achievement of KONI tennis athletes in Semarang City. **Method:** This research is a quantitative research with a survey method with a correlational approach. The population in this study is KONI tennis athletes in the age group of 12-18 years. The sampling technique used purposive sampling with a total of 11 athletes. Since the achievement rankings between male and female athletes are different, the data is divided into 2 consisting of 5 male and 6 female athletes. The VO2Max data used is secondary data obtained from the results of the MFT test conducted by KONI Semarang City. Meanwhile, to get data on athletes' achievements on a national scale, using the [www.pelti.org](http://www.pelti.org) website. The data analysis technique used the Pearson Product Moment Correlation Test. **Result:** The results of the study showed: 1. The results of the data analysis of KONI Semarang City men's tennis athletes showed significant values in the variables VO2Max and Achievement, namely  $0.000 < 0.05$  so that the variables VO2Max and Achievement had a relationship or correlation, 2. The results of the data analysis of KONI Semarang City women's tennis athletes showed significant values in the variables VO2Max and Achievement, namely 0.014, meaning  $0.014 < 0.05$  so that the variables VO2Max and Performance are related or correlate. **Conclusion:** Based on the data above, it can be concluded that there is a relationship between VO2Max and the achievements of KONI tennis athletes in Semarang City.

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## INTRODUCTION

In achievement sports, athletes undergo various types of exercises that include technical, tactical, mental, and physical exercises to optimize their abilities and achieve competitive targets (kumar and Devi 2023) Technical and tactical training aims to hone sport-specific skills, while mental training aims to build psychological resilience. Based on Wang et al (2023), among the components above, physical exercise is the main foundation because it facilitates the body's capacity to execute movements efficiently and consistently in high-load conditions. Through a physical exercise program, aspects such as the cardiovascular system, skeletal muscles, and neuromuscular coordination skills are systematically stimulated to increase the potential of athletes in facing the demands of competition (Farley et al. 2020)

Tennis is one of the achievement sports that requires a combination of physical conditions, including: strength, speed, agility, and high aerobic endurance (Ulbricht et al. 2016) Physiologically, tennis is classified as a high-intensity sport. Each point is earned using *sliding*, *sprinting*, and short racket strokes for 5–10 seconds with a break time between points of 10–20 seconds (work-resting ratio 1:1 to 1:4), and 90-2 seconds – 2 minutes for breaks between sets. In each point, players travel an average distance of 8–15 meters through *sliding* and *sprinting* movements, so that the total distance traveled per match can reach several kilometers, this clearly demands optimal endurance of the athlete (Amatori et al. 2020)

The overall duration of a tennis match varies, depending on the match format used (Lisi and Grigoletto 2021) There has been no specific study discussing the format of matches in tennis, but based on Lisi and Grigoletto (2021), for the bestof3 format, the average lasts about 1.5 hours, while in the bestof5 format it can reach 4 hours under certain conditions. Even the match between Novak Djokovic (ND) and Rafael Nadal (RN) in the final of the 2012 Australian Open lasted more than 5 hours (Reid and Duffield 2015) The length of the duration of a tennis match is what makes maximum aerobic capacity (VO<sub>2</sub>Max) a key factor in determining the player's ability to maintain performance throughout the match.

VO<sub>2</sub>max menjadi sangat krusial bagi petenis karena tenis bersifat olahraga *intermittent*, di mana periode usaha intens (rally panjang, servis cepat, pergerakan lateral) bergantian dengan periode pemulihan singkat. Dalam studi yang dilakukan oleh Baiget et al (2015), ditemukan bahwa pemain dengan VO<sub>2</sub>max lebih tinggi cenderung menghabiskan lebih banyak waktu di zona intensitas rendah dan lebih sedikit di zona menengah hingga tinggi, menunjukkan bahwa mereka bisa mengatur beban fisiologis mereka lebih efisien dalam durasi pertandingan yang panjang.

Selain itu, dalam studi yang dilakukan oleh Baiget et al (2015) menyatakan bahwa pemain tenis kompetitif umumnya memiliki VO<sub>2</sub>max antara ~ 44 hingga 69 ml/kg/min, dan banyak yang melebihi 50 ml/kg/min, sebagai syarat penting agar kemampuan aerobik cukup untuk mendukung pemulihan antar rally dan menjaga performa di set akhir. VO<sub>2</sub>max yang tinggi memungkinkan pemain menghadapi akumulasi kelelahan, mempercepat pemulihan

antar usaha intens, dan menjaga kualitas teknis serta taktis di saat pertandingan memanas terutama dalam format pertandingan panjang.

Maximum aerobic capacity (VO2Max) is a key indicator of the body's ability to take up, transport, and utilize oxygen during high-intensity physical activity, and is measured in  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$  (Genevois 2019). In professional tennis athletes, the VO2Max value ranges from 55.0 to 67.4  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$ , with an average of 61.1  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minute}$ . In addition, the minimum recommended standard for tennis athletes is VO2Max > 50  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$  for men and > 42  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$  for women (Genevois 2019)

Based on research conducted by Baiget (2015) has investigated the correlation between VO2Max and tennis performance aspects, with consistent results showing a positive relationship (Baiget et al. 2015) A study conducted by (Baiget et al. 2015) showed a low to moderate correlation ( $r = 0.35\text{--}0.61$ ) between VO2Max and competitive performance variables (technical effectiveness, points earned), and a predictive model that combined VO2Max with ventilatory thresholds (VT<sub>2</sub>) was able to explain up to 55% of match performance variance (Baiget et al. 2015). These findings confirm that aerobic capacity not only contributes to physical endurance, but also affects the technical and tactical aspects during competition.

In Indonesia, VO2Max research on tennis athletes is still limited. A study conducted by Mohammad Zafa Nugraha, Mulyani Surendra, and Rias Gesang Kinanti found that the average VO2Max value of PELTI Malang tennis athletes was 39.4  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$  in men and 35.7  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{minutes}$  in women, the majority of whom are categorized as fair to bad according to general standards (Nugraha, Surendra, and Kinanti 2018). Meanwhile, in Semarang City, the focus of the research tends to be on technical aspects such as the analysis of service success at the POPDA Championship, without highlighting aerobic capacity as a key variable (Hidayat 2018) Studies exploring the correlation between VO2Max and tennis performance in Semarang City have not been found, showing a gap for researchers to fill the gap. Based on this gap, this study aims to determine the correlation between VO2Max levels and the achievements of tennis athletes in Semarang City.

With the existence of VO2Max data and comparing it with achievement data on a national scale, it is hoped that a deep understanding of the extent to which aerobic capacity affects the results of competitions can be obtained. The findings of this study are expected to be a scientific basis for coaches and coaches in designing training programs that focus on increasing VO2Max, so that Semarang tennis athletes can improve endurance, energy efficiency, and competitive performance both at the national and international levels.

## METHOD

The method used in this study is a survey method with a correlational approach. Hartanti (2019) explained that "correlation research is research conducted by researchers to find out the level of relationship between two or more variables without making changes or

manipulations to existing data". The population in this study is Semarang City tennis athletes in the age group of 12-18 years. The selection of samples in the age group of 12-18 years old is because they have been involved in junior competitive matches, have competition experience, and have a more stable ranking. This allows the relationship between physical attributes such as  $VO_2\text{max}$  and real achievements (rankings, wins, technical performance) to be analyzed more validly. The sampling technique used in this study was purposive sampling with a total of 11 athletes. Because the ranking of achievements between male and female athletes is different, so the data is divided into 2 consisting of 5 male athletes and 6 female athletes. The data used is secondary data obtained from the Semarang City KONI. Athletes' achievements are assessed based on the national ranking value by the Indonesian Tennis Association in [www.pelti.org](http://www.pelti.org) website. The data analysis technique uses the Pearson Product Moment Correlation Test ( $r$ ) which aims to determine the degree of tightness of the relationship between variables expressed with ( $r$ ). The type of relationship between variable X ( $VO_2\text{Max}$ ) and variable Y (Achievement) can be positive and negative. The basis for decision-making is as follows: 1) if the Significance value  $< 0.05$  then it is correlated, 2) if the Significance value is  $> 0.05$  then it is not correlated. If the significance value is exactly 0.05, then we can compare the Pearson Correlation Test with the  $r$  table with the following conditions: 1) if the Pearson Correlation Test  $> r$  table then it is related, 2) if the Pearson Correlation Test  $< r$  table then it is not related (Jabnabillah and Margina 2022) The guidelines for the degree of relationship are explained in Table 1 below:

Table 1. Coefficient Interval and Relationship Level

| Interval Cowphysin | Relationship Level |
|--------------------|--------------------|
| 0,00 – 0,199       | Very weak          |
| 0,20 – 0,399       | Weak               |
| 0,40 – 0,599       | Enough             |
| 0,60 – 0,799       | Strong             |
| 0,80 – 1,000       | Very Strong        |

## RESULT AND DISCUSSION

Based on the  $VO_2\text{Max}$  data of KONI Tennis Athletes in Semarang City that has been assessed, the results of the categorization of  $VO_2\text{Max}$  levels can be presented as follows :

Table 2.  $VO_2\text{Max}$  Results Data of KONI Male Tennis Athletes in Semarang City

| $VO_2\text{Max}$ Value | Category |
|------------------------|----------|
| 36,8                   | Less     |
| 36,8                   | Less     |
| 35,8                   | Enough   |
| 44,6                   | Enough   |
| 34,4                   | Less     |

Based on Table 2. The  $VO_2\text{Max}$  Results Data for Male Tennis Athletes KONI Semarang City above stated that there are no athletes who are in the very good or good categories. In the

medium category, there are 2 athletes, while the other 3 athletes are in the less category. There are no athletes in the category very lacking.

Table 3. VO2Max Results Data of KONI Women's Tennis Athletes, Semarang City

| VO2Max Value | Category |
|--------------|----------|
| 29,9         | Less     |
| 35,8         | Enough   |
| 26,8         | Less     |
| 31           | Enough   |
| 31           | Enough   |
| 30,6         | Less     |

Based on Table 3. The data on the VO2Max results of KONI Women's Tennis Athletes in Semarang City above stated that there are no athletes who are in the very good category or the good category. In the medium category, there are 3 athletes, while the other 3 athletes are in the less category. There are no athletes in the category very lacking.

After the data is categorized, the data is then analyzed using the Pearson Product Moment Correlation Test. The results are shown as follows:

Table 4. Results of Correlation Test of Male Athletes

| Correlations |                     | VO2Max  | Prestasi |
|--------------|---------------------|---------|----------|
| VO2Max       | Pearson Correlation | 1       | -,999**  |
|              | Sig. (2-tailed)     |         | ,000     |
|              | N                   | 5       | 5        |
| Rank         | Pearson Correlation | -,999** | 1        |
|              | Sig. (2-tailed)     | ,000    |          |
|              | N                   | 5       | 5        |

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

In Table 4. The results of the Correlation Test for Male Athletes above the significant value on the variables VO2Max and Achievement are 0.000, meaning  $0.000 < 0.05$  thus the variables VO2Max and Achievement have a relationship or correlation. In this table we can also find out that the Pearson Correlation on VO2Max and achievement is -0.999 with the degree of relationship between these two variables which is perfectly correlated and the form of relationship between these two variables is negative which means that the higher the VO2Max of an athlete the smaller the number of rankings. For example, athletes with the initials A with a VO2Max level of 44.6 ml/kg/min are ranked 110, while athletes with the initials RAA with a lower VO2max level of 36.8 ml/kg/min are ranked 156th.

Table 5. Results of Correlation Tests of Female Athletes

| Correlations |                     | VO2Max             | Prestasi           |
|--------------|---------------------|--------------------|--------------------|
| VO2Max       | Pearson Correlation | 1                  | -,901 <sup>*</sup> |
|              | Sig. (2-tailed)     |                    | ,014               |
|              | N                   | 6                  | 6                  |
| Rank         | Pearson Correlation | -,901 <sup>*</sup> | 1                  |
|              | Sig. (2-tailed)     | ,014               |                    |
|              | N                   | 6                  | 6                  |

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

In Table 5. The results of the Correlation Test for Female Athletes above, the significant value on the variables VO2Max and Achievement is 0.014, meaning  $0.014 < 0.05$  thus the variables VO2Max and Achievement have a relationship or correlation. In this table we can also find out that the Pearson Correlation on VO2Max and achievement is -0.901 with the degree of relationship between these two variables which is perfectly correlated and the form of relationship between these two variables is negative which means that the higher the VO2Max of an athlete, the smaller the number of rankings. For example, athletes with the initials VCM with a VO2Max level of 35.8 ml/kg/min are ranked 67th, while athletes with the initials AD with a lower VO2Max level of 26.8 ml/kg/min are ranked 81st.

Based on the results of the data above, it can be suspected that there is a relationship between VO2Max and tennis athletes' achievements. This conjecture is supported by the results of this analysis in accordance with research conducted by Igo (2022) which states that athletes who have a higher VO2Max have a greater chance of achieving compared to athletes with lower VO2Max levels. Research conducted by Baiget (2015) also noted a strong association between VO2Max and the ATP rating of a professional tennis athlete, where an increase in VO2Max was followed by an improvement in ranking. So that the higher the VO2Max level of an athlete, the better the body's ability to maintain performance during the match, which will ultimately support athletes in achieving even higher achievements.

Increased VO<sub>2</sub>max in tennis athletes brings some concrete physical and performance gains. A high VO<sub>2</sub>max means that the body's maximum capacity to take in and utilize oxygen is greater, so that the muscles and cardiovascular system can work more efficiently in high-pressure situations such as long rallies or endurance games. This allows for a decrease in fatigue at the end of a set or match, which is often the determinant of victory.

The increase in VO2Max speeds up recovery between high-intensity intervals in tennis matches. Since tennis is an intermittent sport with a period of high effort followed by a period of relative recovery for example when moving fast, then waiting for the ball, then sprinting again, athletes with high VO<sub>2</sub>max return faster to conditions that support the next maximum effort.

High VO2Max levels also strengthen tolerance to accumulated metabolic fatigue, increasing the ventilatory threshold, allowing athletes to maintain intensity at higher levels before they begin to experience significant performance declines.

Athletes with high VO2Max have greater physiological reserves to adjust to tactical changes or unexpected situations in a match. For example, when the weather is hot and mentally exhausted. With good VO<sub>2</sub>max reserves, technical performance such as movement speed to the ball, long rally, and stroke accuracy tends to be more stable even when the body condition is already declining.

However, the results of the analysis stated that the average VO2Max level of KONI tennis athletes in Semarang City was in the low category. Meanwhile, for competitive tennis athletes, the minimum recommended VO2Max value is more than 50 ml/kg/min for men and >42 ml/kg/min for women (Genevois 2019) Therefore, there needs to be an evaluation of training programs to increase athletes' VO2Max so that they can get good achievements as well.

Based on the results of the discussion above, it is known that research that discusses the relationship between VO2Max levels and athletes' achievements in tennis has not been widely studied, this makes this research one of the empirical novelties in tennis, especially related to KONI tennis athletes in Semarang City which contributes to the development of studies related to the relationship between VO2Max levels and athletes' achievements in tennis.

Judging from the results of the discussion above, the researcher recommends physical condition training, especially in the aspect of endurance. Both aerobic and anaerobic endurance are equally important to increase the VO2Max of KONI tennis athletes in Semarang City. High Intensity Interval Training (HIIT) is highly recommended by researchers because it can significantly increase VO2Max levels if done at the right volume and intensity. Research (Subekti et al. 2023) confirms that HIIT is effective in increasing aerobic capacity and cardiac recovery in athletes by  $2.9 \pm 1.4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  for VO2Max and increased heart rate recovery by  $9.8 \pm 9.1$  beats per minute.

With a proper and structured training program, it is hoped that athletes can increase their VO2Max levels so that the chances of an athlete to achieve glorious achievements are also greater. A systematic and measurable exercise program is an exercise program that can improve in a positive direction (Evenetus, Mulyana, and Ma'mun 2019)

## CONCLUSION

Based on the results of the data analysis that has been discussed in the discussion above, it can be concluded that there is a very strong relationship between VO2Max and the achievements of KONI tennis athletes in Semarang City The results of the study also concluded that KONI tennis athletes in Semarang City have a low level of VO2Max, making it difficult to develop and compete with athletes from other regions. Based on the results of this study, the

researcher recommends to coaches, administrators, and all parties responsible for managing the running of the training program of KONI tennis athletes in Semarang City so that it is used as a basis for evaluation materials, both the evaluation of the training program and the evaluation of nutrition management so that in the future the VO2Max level of KONI tennis athletes in Semarang City can increase so that it can support the improvement of the achievement ranking of KONI athletes in Semarang City also optimally.

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