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Analysis of Maximum Aerobic Capacity (VO2max) of Tulungagung Handball Male Athletes

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ABSTRACT

Maximal aerobic capacity (VO2max) is a key indicator of cardiovascular fitness and an athlete's ability to maintain physical performance in intense sports activities, especially handball. Tulungagung, as one of the regions in East Java that is actively developing handball sports, has excellent potential to produce outstanding athletes. This study aims to describe the VO2max of male handball athletes from Tulungagung. The research subjects were active male handball athletes from Tulungagung, selected through purposive sampling based on the following criteria: aged 18-21 years, with a minimum of two years of competitive experience, and regularly participating in training with a group of 15 people. The research instrument used is the Multistage Fitness Test (MFT), also known as the beep test, to measure VO2max. The results showed that male handball athletes in Tulungagung had an average VO2max of 47.693 ml/kg/min, with the majority, as much as 67% being in the Excellent and Superior categories.

Keywords: VO2max, Handball, Male Athletes, Tulungagung

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INTRODUCTION

Maximal aerobic capacity (VO2max) is a key indicator of cardiovascular fitness and an athlete's ability to maintain physical performance in intense sports activities (Rahadianti, 2023; Rusito et al., 2023; Syamsuryadin et al., 2024). In the sport of handball, which demands a combination of speed, strength and endurance, VO2max has a crucial role in determining the success of athletes (Candra, 2020). Research on VO2max in male handball athletes in Tulungagung is relevant because this sport is increasingly popular (Karim et al., 2023; Nurudin et al., 2023), especially at the regional level, but specific data on the aerobic fitness profile of athletes in this area are still limited. This study aims to fill the gap with a descriptive approach that provides a real picture of the athletes' physical condition.

Handball is a sport that requires high stamina due to its repetitive movements, such as sprinting, jumping, and throwing the ball, over a relatively long match duration (Bauer et al., 2022; Bělka et al., 2023). VO2max as a physiological parameter is an important benchmark for evaluating an athlete's ability to meet energy needs during a match (Ando et al., 2019; Donie et al., 2021). Previous research suggests that athletes with higher VO2max tend to have better endurance (Amirudin & Abdillah, 2020; Paskalis et al., 2022), which in turn improves performance and reduces the risk of fatigue (Haryanto et al., 2024; Triansyah & Haetami, 2020). However, data on VO2max of handball athletes in Indonesia, especially in regions such as Tulungagung, are still rarely found, so this research has novelty value.

Tulungagung, as one of the regions in East Java that actively develops handball sports, has excellent potential to produce outstanding athletes. However, without adequate data on the physical capacity of athletes, coaching and the development of training programs become less directed. This research is important to provide baseline VO2max data that coaches and sports administrators can use to design more effective training strategies. Thus, this research not only contributes to the academic world but also has a practical impact in improving sports achievements in the region.

The novelty of this study lies in its focus on male handball athletes in Tulungagung, a population that has not been widely explored in the context of VO2max. Most VO2max research in Indonesia is often conducted on popular sports, such as soccer or badminton, while handball receives less attention. The unique physical and technical characteristics of handball demand a specific approach in fitness analysis (Lemos et al., 2020; Wei et al., 2024). This research will provide new insights into the VO2max profile of local handball athletes, which can serve as a reference for similar studies in other regions.

The increasing attention to the sport of handball at national and regional levels also supports the importance of this research. With competitions such as the Provincial Sports Week (PORPROV) and National Championships, the need for physiological data that supports athlete development is increasingly urgent (Desbrow, 2021; Söderström et al., 2024). VO2max as an objectively measurable

parameter will assist in athlete selection (Wiecha, Kasiak, Szwed, et al., 2023), performance evaluation (Lee & Zhang, 2021), and the development of scientifically based training programs. This research is expected to contribute to mapping the potential of handball athletes in Tulungagung to compete at a higher level.

Furthermore, this study is relevant in the context of health and injury prevention. Athletes with suboptimal aerobic capacity are at risk of premature fatigue (Chatel et al., 2021), which can increase the likelihood of injury during matches or practice (Benjaminse et al., 2019; Verschueren et al., 2020). By understanding the VO2max level of male handball athletes in Tulungagung, coaches can design training programs that not only improve performance but also minimize the risk of injury (Guerrero-Calderón, 2021). The data from this study can serve as the basis for safer and more effective exercise recommendations.

This study also has novelty value because it uses a descriptive approach that focuses on local characteristics. Each region has environmental factors, training patterns, and genetic characteristics that can affect VO2max (Bafirman et al., 2023). By examining handball athletes in Tulungagung, this study aims to produce specific and contextualized data, which may differ from findings in other regions. This data will enrich the scientific literature on aerobic fitness in handball in Indonesia.

From an academic perspective, this research will enhance the knowledge base in the field of sports science, particularly in exercise physiology. The results of this study can serve as a reference for other researchers who wish to develop further studies, such as training interventions to improve VO2max (Crowley et al., 2022) or a comparison of aerobic capacity among different sports (Souza et al., 2018). Additionally, publication of the study's results in scientific journals will enhance the visibility of Tulungagung as an area actively engaged in sports research.

The importance of this research is also related to its potential application in the development of sports policy at the local level. Sports agencies and local sports organizations can use VO2max data to develop more targeted athlete development programs. By understanding the fitness profile of handball athletes, local governments can allocate resources more efficiently to support the development of

this sport. This research can also catalyze raising awareness of the importance of physiological evaluation in sports (Löllgen & Leyk, 2018; Maunder et al., 2021).

Finally, this study has global relevance as VO2max is a universal parameter used in sports research worldwide (Wiecha, Kasiak, Cieśliński, et al., 2023). By comparing the results of this study with international standards, we can evaluate the position of Tulungagung handball athletes in a global context. It can motivate the improvement of training and coaching quality to achieve international standards. Thus, this study not only has a local impact but also contributes to the broader development of sports science.

METHODS

This study used a quantitative descriptive approach to describe the maximum aerobic capacity (VO2max) in male handball athletes in Tulungagung. This type of descriptive research was chosen because it aims to provide a factual and systematic description of the characteristics of VO2max without intervening or manipulating variables. This approach enables researchers to collect accurate data on the aerobic fitness condition of athletes within a specific population.

The research design employed was a cross-sectional study, in which VO2max measurements were taken at a single point in time without a longitudinal comparison. The research subjects were active male handball athletes from Tulungagung, selected through purposive sampling based on the following criteria: 18-21 years of age, with a minimum of two years of competitive experience, and regularly participating in training. The number of subjects was determined based on the availability of athletes who met the criteria, with a minimum target of 15 people to ensure adequate representation.

The research instrument used is the Multistage Fitness Test (MFT) or beep test to measure VO2max, which is a standard method for evaluating aerobic capacity through running back and forth along 20 meters at a gradually increasing speed (Ariani et al., 2022). This test is conducted on a sports field under controlled conditions to minimize the impact of external factors, such as weather and the track surface. The level and last shuttle data achieved by the subjects were converted to VO2max values using a standardized MFT conversion table.

Table 1. Male VO2max Categories (Widodo et al., 2022)

Category	Value
Very Poor	< 33
Less	33,0 - 36,4
Medium	36,5 - 42,4
Good	42,5 - 46,4
Excellent	46,5 - 52,4
Superior	> 52,4

RESULTS AND DISCUSSION

The results of measurements taken from 15 male handball athletes in Tulungagung are as follows.

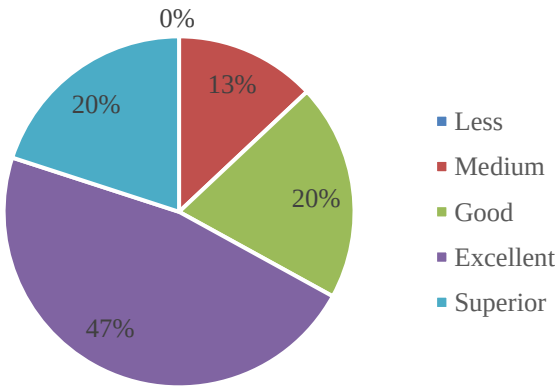

Figure 1. Percentage of VO2max of Tulungagung Handball Athletes

The distribution of maximal aerobic capacity categories showed significant variation. A total of 7 athletes (47%) were in the Excellent category, indicating an excellent level of aerobic fitness to support performance in the sport of handball. In addition, three athletes (20%) fell into the Superior category, reflecting exceptional aerobic capacity, and another three athletes (20%) were in the Good category, signifying adequate fitness levels. Meanwhile, two athletes (13%) were classified in the Moderate category, and no athletes were in the Deficient category (0%). The total number of research subjects was 15, covering 100% of the data distribution.

Table 2. Data Description

Variable	Value
Average	47.693
Highest Value	53.7
Lowest Score	37.4
Data Variation	22.759
Standard Deviation	4.771

The results of VO2max measurements on 15 male handball athletes in Tulungagung using the Multistage Fitness Test (MFT) show an average value of 47.693 ml/kg/min. The highest value achieved was 53.7 ml/kg/min, indicating the presence of athletes with excellent aerobic capacity. In comparison, the lowest value of 37.4 ml/kg/min indicated variations in aerobic ability in this group. The data variation of 22.759 and the standard deviation of 4.771 reflected the heterogeneity in aerobic fitness levels among athletes, although most were in the category that supports competitive performance.

The results showed that the average VO2max of male handball athletes in Tulungagung was 47.693 ml/kg/min, with a category distribution dominated by the Excellent category as much as 47% and Superior as much as 20%) This finding is in line with the theoretical study of Wilmore and Costill (2004), which states that VO2max in the range of 45-55 ml/kg/min is a good indicator of aerobic fitness for team sports such as handball, which requires a combination of endurance and high intensity. These mean values suggest that most athletes in this study have an aerobic capacity that supports competitive performance. However, the lowest value of 37.4 ml/kg/min indicates variations in ability that need to be considered in training programs.

Compared to previous studies, such as the study by Trofin et al. (2021) on male handball athletes in Romania, which reported an average VO2max of 52.77 ml/kg/min, the results of this study are slightly lower but still within the competitive range. This difference could be due to environmental factors, training intensity, or genetic characteristics of the population. The standard deviation of 4.771 in this study indicates a relatively homogeneous distribution of the data, which is consistent with the findings of Trofin et al., who also noted minor variations in the VO2max of handball athletes. It suggests that the training program in Tulungagung has had a positive impact, although there is still room for improvement in enhancing aerobic capacity among athletes with below-average VO2max values.

Theoretical studies by Crowley et al. (2022) confirm that VO2max is influenced by factors such as the frequency, intensity, and duration of aerobic exercise. In the context of this study, the distribution of the Moderate category, at 13%, indicates that some athletes may not have received optimal aerobic exercise.

This finding aligns with the results of a study by Ma et al. (2023), which demonstrated that the improvement of VO2max in handball athletes depends on high-intensity interval training. These findings suggest that coaches in Tulungagung may consider increasing the proportion of interval training to enhance aerobic capacity, particularly in athletes with a VO2max in the Moderate category.

The novelty of this study lies in its focus on male handball athletes in Tulungagung, an issue that has not been widely studied in the context of VO2max in Indonesia. Unlike previous studies that more often explore popular sports such as soccer or badminton, this study provides specific data for handball, specifically aerobic endurance ability, which in this case is represented by VO2max. The finding that 67% of athletes were in either the Excellent or Superior category supports the hypothesis that handball in Tulungagung has good competitive potential. However, the data variation of 22.759 suggests the need for a more specific training approach to improve athlete performance.

Practically, the results of this study can serve as a reference for coaches to design training programs that focus more on increasing VO2max, such as high-intensity cardiovascular exercise or circuit training, as recommended by Rameshkannan & Chittibabu (2024) in their study on handball fitness. Additionally, this data can be used to select athletes who will participate in regional-level competitions by prioritizing those with a VO2max in the Excellent or Superior category. By utilizing these findings, the development of handball sport in Tulungagung can be more focused, while contributing to the scientific literature on exercise physiology in Indonesia.

CONCLUSIONS

This study concludes that male handball athletes in Tulungagung have an average VO2max of 47.693 ml/kg/min, with a majority (67%) in the Excellent and Superior categories, indicating a level of aerobic fitness that supports competitive performance. However, there is variation, with the lowest value of 37.4 ml/kg/min. To improve aerobic capacity, it is recommended that coaches implement high-intensity interval training and a more targeted cardiovascular program, especially for athletes with VO2max in the Moderate category, to minimise performance gaps and maximise higher competitive potential.

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