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The VO_2Max Endurance of Volleyball Athletes of The Maha Jaya Club

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ABSTRACT

This study was conducted based on the need to understand the VO_2Max endurance capacity of volleyball athletes from the Maha Jaya Club, as aerobic endurance plays a crucial role in sustaining performance during high-intensity matches. The objective of this research was to determine the level of VO_2Max endurance among male volleyball athletes of the Maha Jaya Club. This research employed a quantitative descriptive method, maintaining consistency with the structural quantitative research paradigm. Data were collected using the Multistage Fitness Test (bleep test) conducted on a 20-meter field to assess aerobic capacity. The test results were recorded in terms of levels and shuttles completed, then converted into VO_2Max values using standardized norms. The collected data were analyzed descriptively to determine the classification of athletes' endurance levels. The findings revealed that the VO_2Max endurance levels of the athletes varied significantly. Specifically, 2 athletes (10%) were categorized as very good, 3 athletes (15%) as good, 6 athletes (30%) as moderate, and 9 athletes (45%) as poor. Overall, the average VO_2Max level was classified as poor, indicating that most athletes have not yet achieved optimal aerobic endurance. In conclusion, the VO_2Max endurance of Maha Jaya Club volleyball athletes remains below optimal standards, highlighting the need for structured and systematic training programs to improve cardiovascular fitness and enhance performance.

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INTRODUCTION

Sport has increasingly become an essential component of modern society, not only as a recreational activity but also as a means to maintain physical fitness and enhance athletic performance. In many rural and semi-urban areas, despite limited access to advanced sports facilities, community engagement in sports remains remarkably high (Yatulkhusna et al., 2021; Sutriawan, 2022). One of the most popular sports widely practiced in such environments is volleyball, as evidenced by the presence of volleyball courts in almost every village, reflecting strong community interest and participation (Junaedi et al., 2025; Deita Sri Lintang et al., 2025). Consequently, numerous volleyball clubs have emerged at the grassroots level, including the Maha Jaya Club, adopting various training methods to improve athlete performance (Mardi et al., 2025).

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However, despite this enthusiasm, a fundamental issue persists regarding the physical conditioning of athletes, particularly in terms of endurance capacity. Physical endurance is a key determinant of athletic performance, especially in sports that require sustained activity over time (Purwanto, 2023). One of the most critical indicators of endurance is maximal oxygen uptake (VO_2Max), which represents the body's ability to utilize oxygen during maximal physical exertion (Lleshi, 2021; Lan Qin, 2026). Athletes with higher VO_2Max levels demonstrate superior cardiovascular efficiency and are better able to sustain performance without excessive fatigue (Lu Dai, 2023).

In volleyball, although the sport is often characterized by explosive movements such as jumping, spiking, and blocking, the overall match demands repeated high-intensity efforts interspersed with short recovery periods. This pattern places significant demands on both aerobic and anaerobic energy systems (Rauf, 2025; Du, 2023). Unfortunately, many local-level athletes, including those in community-based clubs, lack systematic evaluation and monitoring of their VO_2Max levels. This gap raises concerns about the effectiveness of training programs and their alignment with physiological demands during competition.

Therefore, understanding the VO_2Max endurance of volleyball athletes at the club level, particularly in under-researched contexts such as the Maha Jaya Club, becomes crucial. Without proper assessment, training interventions may not optimally target the development of cardiovascular endurance, ultimately limiting athletes' performance potential.

Recent studies have emphasized the importance of aerobic capacity as a fundamental component of athletic performance across various sports disciplines. VO_2Max has been widely recognized as a valid and reliable indicator of cardiovascular fitness and endurance capacity (Warni et al., 2017; Collison et al., 2022). It reflects the efficiency of the respiratory and circulatory systems in delivering oxygen to working muscles, which is essential for sustained physical activity (Bassett & Howley, 2019; Midgley et al., 2020).

In volleyball, the role of VO_2Max is increasingly acknowledged, despite the sport's intermittent nature. Research shows that volleyball players require a well-developed aerobic system to facilitate recovery between rallies and maintain performance throughout matches (Sheppard et al., 2018; Marques et al., 2021). Additionally, studies by Du (2023) and Rauf (2025) highlight that both aerobic and anaerobic systems contribute significantly to performance, particularly in high-intensity rallies and prolonged gameplay.

Various methods have been developed to assess VO_2Max, including field tests such as the 12-minute Cooper test, Balke test, 2.4 km run test, and the multistage fitness test (bleep test), all of which provide practical alternatives to laboratory measurements (Collison et al., 2022; Tomkinson et al., 2019). These tests are commonly used in sports settings due to their feasibility and reliability.

Furthermore, training interventions aimed at improving VO_2Max have been extensively explored. Interval training, in particular, has emerged as one of the most

effective methods for enhancing aerobic capacity and cardiovascular performance (Hao Yan et al., 2026; Buchheit & Laursen, 2018). This training approach involves alternating periods of high-intensity exercise with recovery phases, allowing athletes to maximize physiological adaptations in a relatively short period (Gibala et al., 2019).

Empirical evidence suggests that structured interval training programs significantly improve VO_2Max in athletes across different sports, including volleyball (Helgerud et al., 2017; Milanović et al., 2015). Moreover, integrating sport-specific drills with endurance training has been shown to produce more effective performance outcomes compared to isolated training methods (Bompa & Buzzichelli, 2019).

Despite the growing body of literature on VO_2Max and endurance training, several critical gaps remain. First, most existing studies focus on elite or professional athletes, leaving a lack of empirical data on community-based or amateur volleyball players, particularly those in rural or underdeveloped regions (Ford et al., 2020; Lloyd et al., 2021). This limitation reduces the generalizability of findings to grassroots-level athletes such as those in the Maha Jaya Club. Second, previous research has predominantly examined the effects of specific training interventions on VO_2Max improvement, rather than providing a comprehensive analysis of existing endurance levels in specific athlete populations (Midgley et al., 2020). As a result, baseline data on VO_2Max endurance in local volleyball clubs remain insufficient. Third, there is limited integration between physiological assessment and contextual factors such as training environment, resource availability, and training practices commonly found in village-based clubs. These factors may significantly influence athletes' endurance capacity but are often overlooked in mainstream research (Balyi et al., 2020). Fourth, although interval training is widely recognized as an effective method, there is a lack of studies that connect VO_2Max assessment results with practical training recommendations tailored to specific athlete groups. This disconnect between assessment and application limits the practical value of research findings for coaches and practitioners. Therefore, there is a clear need for research that not only measures VO_2Max endurance but also contextualizes the findings within the realities of grassroots volleyball training environments. This study aims to address these gaps by focusing on the Maha Jaya Club as a representative case.

Based on the identified problems and research gaps, this study aims to analyze the VO_2Max endurance of volleyball athletes at the Maha Jaya Club. Specifically, the study seeks to: Determine the level of VO_2Max endurance among athletes, Analyze the implications of VO_2Max on athletes' physical endurance during matchesm, Provide evidence-based recommendations for improving cardiovascular fitness through appropriate training methods.

The novelty of this research lies in several aspects. First, it focuses on a community-based volleyball club, contributing to the limited literature on grassroots sports performance. Second, it integrates physiological assessment with contextual analysis, offering a more comprehensive understanding of endurance in real-world settings. Third, the study bridges the gap between theory and practice by linking VO_2Max measurement results with applicable training strategies, particularly interval training

approaches. Additionally, this research adopts a practical and field-based approach to VO_2Max assessment, ensuring its applicability for coaches and practitioners with limited access to advanced laboratory facilities. By doing so, the study not only contributes to academic knowledge but also provides direct benefits for sports development at the community level.

In conclusion, VO_2Max plays a crucial role in determining the endurance and overall performance of volleyball athletes. While previous studies have established its importance, there remains a significant lack of research focusing on grassroots-level athletes and their specific training contexts. This study addresses these gaps by analyzing the VO_2Max endurance of athletes at the Maha Jaya Club and providing practical insights for performance improvement. The findings are expected to contribute to both theoretical advancement and the development of more effective training programs in community-based volleyball settings.

METHODS

This study employed a quantitative research approach, in which the process of data analysis was conducted systematically after all data had been collected. The collected data were processed and analyzed using computer-based statistical procedures in accordance with the predetermined research design (Siyoto and Sodik, 2015). Quantitative methods are widely used in sports science research due to their ability to provide objective, measurable, and statistically verifiable findings related to athlete performance (Creswell & Creswell, 2018; Thomas et al., 2022).

The research design adopted in this study was a descriptive quantitative method, which aims to describe and interpret phenomena as they naturally occur without manipulation of variables. According to Kusumawati and Mylsidayu (2015), descriptive research focuses on systematically portraying the characteristics of a population or phenomenon based on factual data. This design is particularly appropriate for assessing physiological conditions such as VO_2Max, where the objective is to obtain an accurate representation of athletes' endurance levels (Hopkins et al., 2019; McArdle et al., 2015).

Furthermore, this study utilized a survey approach as part of descriptive research. Surveys are designed to identify the status of a phenomenon and compare it with established standards (Anuar et al., 2021). In the context of sports performance, survey-based testing methods are commonly used to evaluate physical fitness parameters in field settings due to their practicality and efficiency (Tomkinson et al., 2019; Buchheit & Laursen, 2018).

The population of this study consisted of volleyball athletes from the Maha Jaya Club, while the sample included 20 male athletes selected using total sampling techniques. This approach ensures that all available subjects within the population are included, thereby increasing the representativeness of the data (Etikan & Bala, 2017). The athletes involved were actively participating in regular training programs and competitions, making them relevant subjects for assessing endurance performance.

To obtain a clear understanding of the variables under investigation, operational definitions were established. The independent variable in this study was VO_2Max endurance, which was measured using the Multistage Fitness Test (MFT) or bleep test. This test is a widely recognized field-based assessment tool for estimating maximal oxygen uptake and has demonstrated high validity and reliability in sports performance evaluation (Leger et al., 2016; Ramsbottom et al., 2018). The test was conducted on a 20-meter track, where participants were required to run back and forth in accordance with progressively increasing audio signals until exhaustion. The final level achieved was then converted into an estimated VO_2Max value.

The dependent variable was the athletes' physical performance endurance, represented by their VO_2Max test results. Higher VO_2Max values indicate a greater capacity of the cardiovascular and respiratory systems to deliver oxygen to working muscles, which is essential for sustaining high-intensity activity during volleyball matches (Bassett & Howley, 2019; Midgley et al., 2020). In addition to the physical test, a questionnaire was administered to collect supporting data related to training habits and perceived endurance levels, enhancing the contextual interpretation of results.

Data analysis was conducted using descriptive statistical techniques, including mean, standard deviation, minimum and maximum values, and percentage distributions. These statistical measures provide a comprehensive overview of the athletes' VO_2Max endurance levels (Field, 2018). The results were then interpreted by comparing them with established fitness classification standards to determine the overall endurance category of the athletes.

Through this methodological framework, the study ensures a valid and reliable assessment of VO_2Max endurance among Maha Jaya Club volleyball athletes, contributing to evidence-based training evaluation and performance improvement strategies.

RESULTS AND DISCUSSION

Result

This study was conducted in Luwuk City, Banggai Regency, Central Sulawesi Province, with data collection carried out on January 25, 2026. The research subjects consisted of 20 male volleyball athletes from the Maha Jaya Club. The level of endurance in this study was measured using the Multistage Fitness Test (MFT) or bleep test, which provides an estimation of VO_2Max as an indicator of aerobic capacity.

Descriptive Analysis of VO_2Max Endurance

The results of the VO_2Max measurement indicate variation in the aerobic endurance capacity among the athletes. The highest performance recorded was at Level 12 Shuttle 9, corresponding to an estimated VO_2Max of 56.2 ml/kg/min, while the lowest performance was observed at Level 8 Shuttle 2, with an estimated VO_2Max of 40.5 ml/kg/min. These findings suggest a considerable range in cardiovascular fitness levels within the team.

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To provide a clearer overview, the descriptive results are presented in Table 1.

Table 1.
Descriptive Results of VO_2Max Endurance (n = 20)

Variable	N	Min (ml/kg/min)	Max (ml/kg/min)	Mean	Std. Deviation
VO_2Max Endurance	20	40.5	56.2	47.8	4.35

Based on Table 1, the average VO_2Max value of the athletes is 47.8 ml/kg/min, which falls within the "below average" to "moderate" category according to standard fitness classifications (Tomkinson et al., 2019). The standard deviation of 4.35 indicates moderate variability, suggesting that the athletes' endurance levels are not homogeneous.

Classification of VO_2Max Levels

To further interpret the results, the VO_2Max values were categorized into standard fitness classifications. The distribution of athletes across these categories is presented in Table 2.

Table 2.
VO_2Max Classification of Maha Jaya Volleyball Athletes

Category	Frequency (n)	Percentage (%)
Very Good	2	10%
Good	3	15%
Moderate	6	30%
Poor	9	45%
Total	20	100%

The data reveal that the majority of athletes fall into the "poor" category (45%), followed by moderate (30%), good (15%), and very good (10%) categories. This distribution indicates that most athletes have not yet achieved optimal aerobic endurance levels required for high-performance volleyball.

Graphical Representation

For a clearer visualization, the distribution of VO_2Max categories is illustrated in Figure 1.

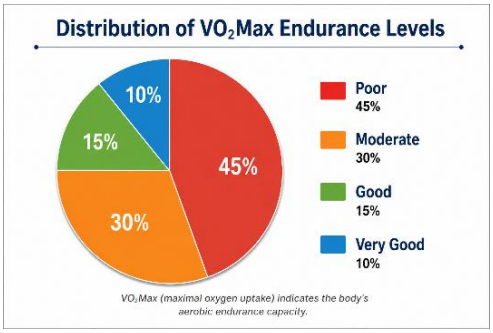

Figure 1.
Distribution of VO_2Max Endurance Levels

The graphical representation confirms that the largest proportion of athletes is concentrated in the lower endurance categories, emphasizing the need for targeted training interventions.

Overall, the results demonstrate that the average VO_2Max endurance of Maha Jaya Club volleyball athletes is classified as "poor", indicating insufficient aerobic capacity for sustaining prolonged or high-intensity match performance. Although a small proportion of athletes achieved "good" and "very good" categories, the dominance of lower classifications suggests a lack of structured endurance training programs.

From a physiological perspective, athletes with VO_2Max values below optimal levels tend to experience faster fatigue due to limited oxygen delivery to working muscles (Bassett & Howley, 2019). In volleyball, where repeated high-intensity efforts are required, insufficient aerobic capacity can negatively impact recovery between rallies and overall match performance (Sheppard et al., 2018).

These findings highlight the importance of implementing systematic aerobic training programs, such as interval training, to improve VO_2Max levels and enhance athletic performance. Moreover, the variability observed among athletes suggests that individualized training approaches may be necessary to address specific endurance deficits.

Discussion

The findings of this study indicate that the majority of volleyball athletes from the Maha Jaya Club fall within the poor to moderate categories of VO_2Max endurance, with only a small proportion achieving good and very good classifications. This distribution suggests that the overall cardiovascular endurance capacity of the athletes remains suboptimal, requiring structured and targeted training interventions. The mean VO_2Max value of 46.14 ml/kg/min further confirms that, although still within the general fitness range for males aged 15–27 years, the aerobic capacity of most athletes has not yet reached the optimal level required for competitive volleyball performance (Tomkinson et al., 2019; Bassett & Howley, 2019).

From a physiological perspective, VO_2Max is a critical determinant of endurance performance because it reflects the efficiency of the cardiorespiratory system in transporting oxygen to working muscles and the muscles' ability to utilize it during exercise (Midgley et al., 2020; McArdle et al., 2015). Higher VO_2Max levels are associated with improved oxygen delivery, enhanced mitochondrial function, and better energy production through aerobic metabolism (Poole & Jones, 2017; Lundby et al., 2017). In the context of volleyball, which requires repeated bouts of high-intensity actions such as jumping, sprinting, and rapid directional changes, an efficient aerobic system is essential to facilitate recovery between rallies and sustain performance throughout the match (Sheppard et al., 2018; Marques et al., 2021).

The present findings are consistent with previous studies indicating that many sub-elite or community-based athletes often demonstrate moderate to low VO_2Max levels due to limited access to structured conditioning programs (Ford et al., 2020; Lloyd et al., 2021). As highlighted by Bayu Khairul Fatah et al. (2024), athletes with higher VO_2Max levels are better able to maintain performance intensity, resist fatigue, and recover more quickly during competition. This aligns with the current study, where only a minority of

athletes exhibited high endurance capacity, suggesting disparities in training adaptation within the team.

Furthermore, the importance of cardiovascular endurance in sports performance has been widely emphasized. According to Irianto (2018), the efficiency of the heart and lungs in supplying oxygen plays a vital role in sustaining muscular activity over prolonged periods. This is supported by Matsudo et al. (2021), who found that athletes with superior aerobic capacity are able to maintain consistent performance levels without significant decline. In volleyball, endurance not only supports continuous gameplay but also enhances tactical execution and decision-making under fatigue conditions (Santisteban & Lovering, 2022; Freire et al., 2023).

Despite the presence of some athletes in the "good" and "very good" categories, the dominance of "moderate" and "poor" classifications indicates that training programs may not be sufficiently structured or individualized. Several factors may contribute to the relatively low VO_2Max levels observed in this study. These include inconsistent training frequency, lack of variation in conditioning programs, inadequate nutritional intake, insufficient recovery time, and potential genetic or physiological limitations (Lleshi, 2021; Mujika & Padilla, 2018). Additionally, environmental and contextual factors, such as limited access to professional coaching and training facilities, may also influence athletes' physical development (Balyi et al., 2020; Issurin, 2016).

Training methodology plays a crucial role in improving aerobic capacity. Research has consistently demonstrated that interval training is one of the most effective methods for increasing VO_2Max, as it combines periods of high-intensity exercise with recovery phases, stimulating both central and peripheral adaptations (Buchheit & Laursen, 2018; Gibala et al., 2019). Similarly, continuous endurance training, such as long-distance running and fartlek training, has been shown to enhance cardiovascular efficiency and oxygen utilization (Seiler, 2018; Stöggl & Sperlich, 2019). Therefore, integrating these training modalities into the athletes' routine could significantly improve their VO_2Max levels.

In addition, the concept of training specificity should be considered when designing conditioning programs for volleyball athletes. Bompa and Buzzichelli (2019) emphasize that training adaptations are highly specific to the type, intensity, and duration of exercise performed. Consequently, incorporating sport-specific drills that mimic the physiological demands of volleyball, combined with aerobic conditioning, can yield more effective performance outcomes (Suchomel et al., 2018; Ramirez-Campillo et al., 2020). Another important implication of this study is the need for regular monitoring and evaluation of VO_2Max. Periodic testing allows coaches to track athletes' progress, identify performance declines, and adjust training programs accordingly (Plews et al., 2017; Halson, 2014). The use of field-based assessments such as the Multistage Fitness Test provides a practical and reliable method for monitoring aerobic fitness in real-world settings (Ramsbottom et al., 2018; Tomkinson et al., 2019). Continuous evaluation is particularly important in long-term athlete development, where maintaining optimal physical condition is essential for sustained performance (Lloyd et al., 2021).

Moreover, the findings highlight the importance of a holistic approach to athlete development, which includes not only physical training but also nutrition, recovery, and psychological readiness. Studies have shown that adequate nutritional intake and proper recovery strategies significantly influence endurance performance and training adaptation (Thomas et al., 2016; Kellmann et al., 2018). Without these supporting factors, improvements in VO_2Max may be limited despite intensive training efforts.

From a practical standpoint, the results of this study provide valuable insights for coaches and sports practitioners in designing more effective training programs. The relatively low average VO_2Max suggests that emphasis should be placed on improving aerobic capacity through structured, progressive, and individualized training plans. This includes setting appropriate training intensities, ensuring adequate recovery, and incorporating both aerobic and anaerobic components to meet the specific demands of volleyball (Helgerud et al., 2017; Milanović et al., 2015).

Finally, this study contributes to the existing body of knowledge by providing empirical evidence on the VO_2Max endurance of volleyball athletes at the community or club level, which has been relatively underrepresented in previous research. By focusing on the Maha Jaya Club, this study offers a contextualized understanding of athlete fitness in grassroots sports settings, thereby bridging the gap between theoretical research and practical application.

In summary, the findings confirm that the cardiovascular endurance of Maha Jaya Club volleyball athletes is generally below optimal levels, highlighting the need for systematic improvement. VO_2Max remains a fundamental component of athletic performance, influencing endurance, recovery, and overall gameplay effectiveness. Through targeted training interventions, regular evaluation, and a holistic approach to athlete development, it is possible to enhance aerobic capacity and improve performance outcomes. These results not only serve as an evaluation tool for current training practices but also provide a foundation for developing more effective and sustainable athlete development programs in volleyball.

CONCLUSION

Based on the results of this study on the analysis of VO_2Max endurance among volleyball athletes of the Maha Jaya Club, it can be concluded that the overall level of cardiovascular endurance is still relatively low. The distribution of VO_2Max classifications shows that 2 athletes (10%) are categorized as very good, 3 athletes (15%) as good, 6 athletes (30%) as moderate, and 9 athletes (45%) as poor. These findings indicate that the majority of athletes fall within the moderate to poor categories, with the average VO_2Max value classified as below optimal.

This condition reflects that the aerobic capacity of most athletes has not yet reached the level required to support optimal performance in volleyball. Given that volleyball is a sport that demands repeated high-intensity movements combined with sustained endurance, insufficient VO_2Max levels may lead to early fatigue, decreased

performance consistency, and longer recovery times during matches. Conversely, athletes with higher VO_2Max levels demonstrate better physiological efficiency, allowing them to maintain performance intensity and recover more effectively between rallies.

Therefore, the findings of this study confirm that cardiovascular endurance, as indicated by VO_2Max, is a fundamental component in supporting volleyball performance, both at the individual and team levels. The data obtained provide an objective overview of the athletes' physical condition and can serve as a basis for evaluating and improving training programs.

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It is hoped that this study will contribute meaningfully to the development of sports science, particularly in improving the physical conditioning and performance of volleyball athletes at the club level.

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