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Comparative Analysis of VO_2 Max between Smokers and Non-Smokers in Football Players: A Study in an Amateur Club

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Abstract

Smoking is a behavioral factor that can reduce athletic fitness, but the comparison of VO_2 max capacity between smokers and non-smokers in soccer players is still rarely studied. This study aims to analyze the differences in VO_2 max between two groups of players at Fortuna FC, Kupang. The study employed a quantitative comparative design involving 20 participants (10 smokers and 10 non-smokers). VO_2 max was measured using the Multistage Fitness Test (Beep Test) and analyzed using an independent sample t-test. The results showed a significant difference between the groups ($t(18) = 8.639$; $p < 0.001$), with a higher average VO_2 max in non-smokers (54.7 mL·kg⁻¹·min⁻¹) compared to smokers (48.9 mL·kg⁻¹·min⁻¹). This difference of 5.8 mL·kg⁻¹·min⁻¹ indicates a decrease in aerobic capacity of approximately 10–12% in smokers. These findings confirm that smoking negatively impacts the cardiorespiratory fitness of amateur soccer players. This study provides relevant empirical evidence for coaches and sports health professionals to promote smoking prevention programs in the development of athletes.

Keywords: *VO_2 max; Smoking and athletic performance; Aerobic capacity.*

Abstrak

Merokok merupakan faktor perilaku yang dapat menurunkan kebugaran atlet, namun perbandingan kapasitas VO_2 max antara pemain sepak bola perokok dan bukan perokok masih jarang diteliti. Penelitian ini bertujuan untuk menganalisis perbedaan VO_2 max antara kedua kelompok pemain di Fortuna FC, Kupang. Desain penelitian menggunakan pendekatan komparatif kuantitatif dengan melibatkan 20 pemain (10 perokok dan 10 bukan perokok). VO_2 max diukur menggunakan Multistage Fitness Test (Beep Test) dan dianalisis dengan uji-t sampel independen. Hasil penelitian menunjukkan perbedaan signifikan antara kelompok ($t(18) = 8{,}639$; $p < 0{,}001$), dengan rata-rata VO_2 max lebih tinggi pada non-perokok (54,7 mL·kg⁻¹·menit⁻¹) dibandingkan perokok (48,9 mL·kg⁻¹·menit⁻¹). Selisih 5,8 mL·kg⁻¹·menit⁻¹ ini menunjukkan penurunan kapasitas aerobik sekitar 10–12% pada pemain perokok. Temuan ini menegaskan bahwa kebiasaan merokok berpengaruh negatif terhadap kebugaran kardiorespirasi pemain sepak bola amatir. Penelitian ini memberikan bukti empiris yang relevan bagi pelatih dan tenaga kesehatan olahraga untuk mendorong program pencegahan merokok dalam pembinaan atlet.

Kata kunci: VO_2 maks; Merokok dan performa atletik; Kapasitas aerobik.

INTRODUCTION

Maximal oxygen consumption capacity (VO_2 max) is a key indicator of cardiorespiratory fitness, determining an athlete's ability to sustain high-intensity physical activity. In modern football, VO_2 max plays a crucial role in a player's ability to maintain game intensity, perform repeated sprints, and accelerate recovery between match phases (Ilias et al., 2023; Modrić et al., 2020). Athletes with a high VO_2 max generally demonstrate more consistent performance throughout a match, primarily because their aerobic capacity optimally supports the aerobic and anaerobic energy systems. Factors such as somatotype, body composition, and training program contribute significantly to variations in VO_2 max values between players (Ghozali et al., 2024). However, several lifestyle factors, such as smoking, can reduce an athlete's aerobic potential, making it an important variable to consider in football performance.

Globally, the prevalence of smoking among athletes is lower than in the general population, but varies significantly across regions and sports (Asar et al., 2025). This suggests that smoking remains a relevant risk factor in sport, particularly at the amateur level, where lifestyle controls are less stringent. In Indonesia, smoking remains high among adolescents and young adults, including among amateur athletes, although specific data on soccer players is limited. This constellation indicates the importance of research examining the impact of smoking on VO_2 max in the local soccer athlete population, a field that has been underreported mainly to date.

Smoking has long been recognized as a factor that can reduce cardiorespiratory fitness through various physiological mechanisms, including decreased oxygen transport capacity, impaired pulmonary ventilation and diffusion, as well as increased oxidative stress and endothelial dysfunction (Araneda et al., 2021; Eeden et al., 2021; Saiphoklang et al., 2020). Decreased lung function and ventilatory efficiency have the potential to reduce the body's ability to sustain intensive aerobic activity, as reported in adolescent smokers (Gp et al., 2023), young athletes (Dewi et al., 2025), and adult and elderly populations (Hung et al., 2023). However, many previous studies have focused solely on lung function or general physiological indicators without directly measuring VO_2 max; thus, the specific consequences of smoking on athletes' maximal aerobic capacity have not been fully elucidated. For example, Pepera & Panagiota (2021) assessed heart rate response and recovery in smoking athletes, but did not measure VO_2 max. Achmad et al. (2022) reviewed general cardiovascular aspects without measuring maximal oxygen consumption. This limitation has resulted in a lack of a comprehensive understanding of the direct relationship between smoking and VO_2 max in athletes, particularly soccer players.

Furthermore, although VO_2 max assessment through Cardiopulmonary Exercise Testing (CPET) is recognized as the gold standard (Allison, 2024; Mazaheri et al., 2021), its application in amateur club settings in Indonesia remains minimal. Therefore, studies using valid field tests such as the Multistage Fitness Test (Beep Test) are an essential alternative for obtaining VO_2 max estimates that can serve as the basis for scientific analysis. Thus, the literature shows that research on smoking and aerobic fitness in athletes has been growing, but has not yet specifically confirmed its impact on VO_2 max in the amateur soccer player population.

Although various solutions in the literature have explained the physiological mechanisms of smoking's impact, significant gaps remain in their empirical implementation in the soccer athlete population. Previous studies have focused primarily on the effects of smoking on lung function, oxidative stress, or ventilation variables, without providing comparative data on VO_2 max, which directly measures maximal aerobic capacity (Araneda et al., 2021; Saiphoklang et al., 2020). Studies related to VO_2 max are more often conducted in non-smoking athletes or the general population (Bahtra et al., 2023; Falces-Prieto et al., 2021), whereas research integrating smoking status variables in athletes remains very limited. Tu et al. (2024) and Baygutalp et al. (2021) note that there is insufficient empirical evidence comparing athletes' VO_2 max based on smoking status, particularly in local and amateur sports communities.

Furthermore, regional variability in athletes' smoking habits, the lack of smoking prevalence data among footballers in Indonesia, and the limited use of VO_2 max measurements in local research reinforce this unfilled gap. Existing research is also rare in amateur club athletes, a population at higher risk of exposure to smoking due to social environmental factors and a lack of behavioral regulation. This situation explains why empirical findings on the impact of tobacco on aerobic performance in football athletes are still limited, despite the extensive physiological theory and mechanistic evidence outlined in the literature. Therefore, there is a need to conduct research based on direct VO_2 max measurements in both smokers and non-smokers to strengthen the scientific foundation of the influence of smoking on sports performance.

Based on this gap, this study was conducted to analyze the differences in VO_2 max capacity between smoking and non-smoking soccer players at Fortuna FC, Kupang. Using the

Multistage Fitness Test, which has been proven valid in estimating VO_2 max in athletes (Senanayake et al., 2024), this study offers a practical yet scientific approach to measuring aerobic differences between the two groups. The novelty of this study lies in its focus on the population of amateur soccer athletes in Indonesia, whose differences in VO_2 max based on smoking status have never been systematically studied. This study also provides added value by directly comparing smoking status within the context of aerobic performance, providing a more specific empirical picture than studies that only assess pulmonary function or general cardiovascular indicators. In terms of scope, this study focuses on a comparative analysis of two groups with similar physical characteristics and training loads, allowing for a more precise interpretation of the impact of smoking on VO_2 max. In addition to contributing to the Indonesian sports physiology literature, this research is also practically relevant for coaches, sports health professionals, and stakeholders in athlete development, particularly in developing educational programs and smoking prevention strategies within football club environments.

METHOD

Research Design

This study used a comparative quantitative approach with a cross-sectional design to compare maximal oxygen uptake capacity (VO_2 max) between smokers and non-smokers in soccer players. This approach was chosen because it allows researchers to assess physiological differences between groups at the same measurement point without manipulating the independent variable. A comparative design is appropriate when the study aims to determine whether there are significant differences between two groups with similar characteristics but differentiated by a single dominant factor, in this case, smoking status. This methodology fills a gap identified in the literature, where there have been no significant reports on differences in VO_2 max based on smoking status in the athlete population (Baygutalp et al., 2021; Saiphoklang et al., 2020; Tu et al., 2024). Therefore, this study has empirical novelty in the context of sports physiology in Indonesia.

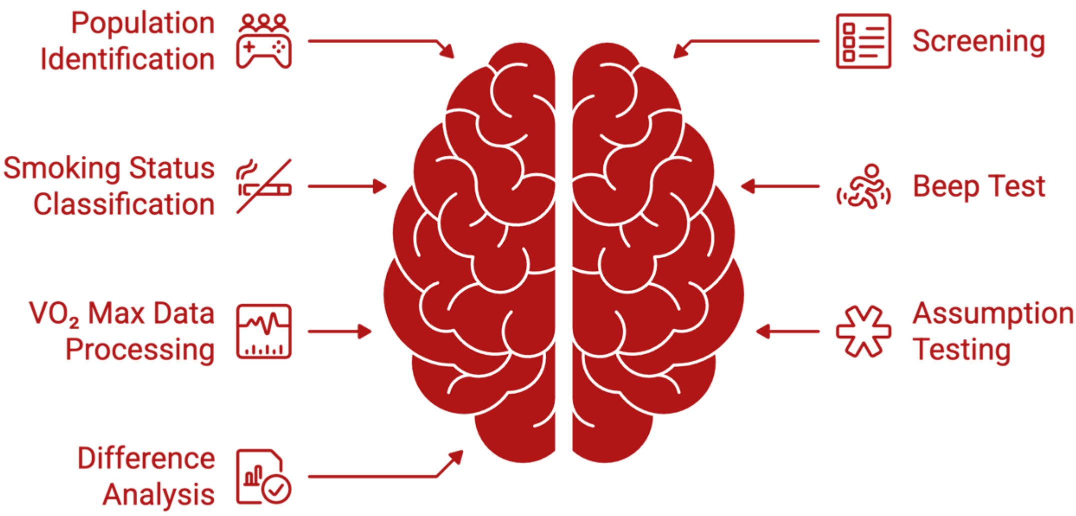

Figure 1. Research Flow Diagram

Population and Research Sample

The population in this study consisted of all soccer players affiliated with Fortuna FC. The total team membership in 2022 was 20, and all were included as part of the total sample due to the small and homogeneous population.

Inclusion criteria were established to ensure physiological homogeneity and reliability of the results:

• Active players aged 20–27 years,
• Participating in training at least 3 times a week for the past 6 months,
• No history of respiratory or cardiovascular disease.

Exclusion criteria included players with injuries or undergoing medications that could affect physical performance. Of the 20 participants, 10 were categorized as active smokers (smoking ≥ five cigarettes per day for ≥1 year) and 10 as nonsmokers (never smoked and not exposed to secondhand smoke).

Measurement Instruments and Validation

VO_2 max was measured using the Multistage Fitness Test (Beep Test). The Beep Test was chosen because it has a proven strong correlation with the gold standard method, Cardiopulmonary Exercise Testing (CPET) ($r \approx 0.60–0.85$), and is widely recommended for measuring VO_2 max in athletes under field conditions (Senanayake et al., 2024; Syahid, 2021). This method was deemed appropriate for the research context due to its practicality, reliability, and applicability to the amateur athlete population. The implementation procedure was carried out uniformly on a 20-meter track, with instructions to stop if the participant failed to reach the line twice consecutively. VO_2 max values were calculated using a standard formula appropriate to the participant's level and final speed.Analisis Data.

The data from the maximal oxygen uptake capacity (VO_2 max) measurements were analyzed using IBM SPSS Statistics version 26 software. All VO_2 max values from the two groups of soccer players, smokers and non-smokers were entered into an SPSS worksheet and systematically processed through three main stages: descriptive analysis, assumption testing, and hypothesis testing. The first stage involved descriptive analysis to obtain the mean, standard deviation, and minimum and maximum values for each group. This analysis provided a general overview of the trends and distribution of aerobic capacity data between groups.

The second stage involved testing statistical assumptions, which included normality and homogeneity tests. The normality test was performed using the Lilliefors method to ensure the distribution of VO_2 max data followed a regular pattern. Data were considered normal if the significance value (p) was >0.05. Next, a homogeneity of variance test was performed using Levene's Test for Equality of Variances in the Independent-Samples T-Test menu in SPSS to verify the equality of variance between groups; data were considered homogeneous if $p > 0.05$. These two tests are essential to ensure that the basic assumptions of the parametric test are met. The third stage involves testing the central hypothesis using an Independent Sample t-test to determine whether there is a significant difference in VO_2 max values between smokers and non-smokers. The test was conducted using the Independent Samples T-Test in SPSS.

Methodological Limitations

This study used the Beep Test as a method for estimating VO_2 max, which, while empirically valid, has a margin of error compared to laboratory CPET measurements. Furthermore, smoking intensity variables (number of cigarettes per day and duration of smoking) were not measured quantitatively (pack-years), so a dose-relationship analysis could not be conducted. However, this limitation aligns with literature findings showing that no studies have directly reported significant differences in VO_2 max based on smoking status in an athlete population (Baygutalp et al., 2021; Saiphoklang et al., 2020; Tu et al., 2024). Therefore, the results of this study provide a significant empirical contribution to strengthening the initial evidence on the relationship between smoking and cardiorespiratory fitness in soccer athletes.

RESULT AND DISCUSSION

This study aims to compare the maximum oxygen uptake capacity (VO_2 max) between smoking and non-smoking football players at the Fortuna FC club, Kupang, using the Multistage

Fitness Test (MFT) method. The MFT method was chosen because it has a sufficiently high validity as a field test to estimate VO_2 max in athletes, although its accuracy varies when compared to direct measurements using Cardiopulmonary Exercise Testing (CPET) (Senanayake et al., 2024). The following table 1 presents the results of the VO_2 max measurement of both groups along with their descriptive statistical values.

Tabel 1. Description of Statistics

Group	Mean	Median	Std. Deviation	Minimum	Maximum
Smokers	48.88	48.45	1.38	47.1	50.8
Tidak Perokok	54.65	54.65	1.63	52.5	57.6

Descriptive statistics show a clear difference between the two groups. The mean VO_2max value of non-smokers (M = 54.65, SD = 1.63) was much higher than that of smokers (M = 48.88, SD = 1.38). This suggests that non-smoking football players show superior aerobic capacity and cardiovascular endurance compared to their smoking counterparts. The relatively low standard deviation values in both groups indicated that the VO_2max performance levels in each group were consistent, with minimal variation among participants.

Tabel 2. Normality Test Results (Shapiro-Wilk)

Kelompok	Statistic	df	Sig.
Perokok	0.878	10	0.125
Tidak Perokok	0.950	10	0.673

Both groups show $p > 0.05$, indicating normally distributed data.

The Shapiro–Wilk test is performed to assess the normality of the data. Both groups, smokers (W = 0.878, p = 0.125) and non-smokers (W = 0.950, p = 0.673), showed p values greater than 0.05. Thus, the assumption of normality is met, which indicates that the VO_2max data is normally distributed. These findings support the use of parametric statistical tests such as independent sample t-tests for further analysis.

Tabel 3. Homogeneity Test Results (Levene's Test)

Levene Statistic	df1	df2	Sig.
0.05	1	18	0.826

$p > 0.05$ indicates equal variances assumed.

The Levene test for variance equivalence shows a Levene statistic of 0.05 with a significance value of p = 0.826, which is greater than the alpha level of 0.05. This implies that the variance in VO_2max scores between groups of smokers and non-smokers is homogeneous. Therefore, the homogeneity assumption of variance is met, which validates the use of standard t-tests with the assumption of equal variance.

Tabel 4. Independent Samples Test

t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Cohen's d
8.56	18	0.000	5.77	0.67	3.83

Significant difference ($p < 0.001$). Large effect size (Cohen's d = 3.83).

Independent sample t-tests showed a statistically significant difference in VO_2max between smokers and non-smokers, t(18) = 8.56, p < 0.001. Non-smokers showed an average VO_2max of 54.65 compared to 48.88 among smokers, resulting in an average difference of 5.77 units. Cohen's calculated d value of 3.83 indicates a very large effect size, which signifies that smoking has a substantial negative impact on aerobic capacity among football players. These results are consistent with physiological evidence showing that exposure to nicotine and carbon monoxide interferes with the efficiency of oxygen transport and utilization, thereby reducing cardiorespiratory fitness. In summary, smoking status is strongly associated with decreased aerobic performance, which emphasizes the detrimental effects of tobacco use on athletes' endurance potential.

This study shows that there is a significant difference in the maximum oxygen uptake capacity (VO_2 max) between smoking and non-smoking football players at the Fortuna FC club, Kupang. Although the numbers and statistical tests are not repeated in this section, the results clearly show that smoking habits are negatively correlated with athletes' aerobic ability. The rationality of these findings can be explained through the basic principles of exercise physiology and the biochemistry of the human body, particularly as it relates to the transport system and oxygen utilization. In sports such as football, VO_2 max describes the body's maximum capacity to transport and use oxygen during high-intensity physical activity. This value is a product of the maximum cardiac output (Qm_{ax}) and the arterial-venous oxygen difference (a–v O_2 difference), which together determine the supply of oxygen to the active muscles. Any disturbance in any of these components, both at the systemic and peripheral levels, will lower the VO_2 max (Shobirin et al., 2023).

Smoking habits have the potential to affect both of these aspects simultaneously. First, the decrease in the quality of hemoglobin (Hb) due to exposure to carbon monoxide (CO) from cigarette smoke reduces the binding capacity of blood oxygen. CO has an affinity to Hb about 200 times higher than oxygen, thus forming carboxyhemoglobin (HbCO) which does not play a role in O_2 transport. As a result, muscle tissue experiences an oxygen deficit during strenuous physical activity (Huang, 2023). Second, cardiovascular system dysfunction due to the effects of nicotine such as peripheral vasoconstriction, increased heart rate, and decreased perfusion efficiency limits the ability of the heart and blood vessels to supply oxygen to the muscles during intense exercise (Eeden et al., 2021).

In addition to impaired oxygen transport, smoking also triggers oxidative stress and chronic inflammation that negatively impacts the respiratory system. Solid particles and free radicals in cigarette smoke cause damage to the alveolar epithelium, decrease lung elasticity, and inhibit gas diffusion capacity (Araneda et al., 2021; Manisalidis et al., 2020). This decrease in ventilation and diffusion ability directly decreases the body's ability to maintain continuous aerobic work. In the context of athletic performance, this condition explains rationally why smoking football players show lower VO_2 max values than their non-smoking counterparts. With disruption of the oxygen transport chain from lung ventilation, alveolar diffusion, Hb binding, to tissue perfusion, aerobic performance becomes limited, endurance decreases, and the recovery process after exercise becomes slower.

This empirical finding is also rational when associated with the concept of oxygen cascade in exercise physiology, which explains that aerobic performance is influenced by the integration of the respiratory, cardiovascular, and muscular systems. Chronic exposure to toxic components in cigarettes progressively hinders the efficiency of each stage in the oxygen transport chain. Thus, the decrease in VO_2 max in smokers is a logical manifestation of a complex physiological disorder process, not simply a result of lifestyle behavior.

The results of this study are generally consistent with the literature on exercise physiology and cardiopulmonary health, which states that smoking decreases aerobic capacity. A number of studies in the last five years support these findings. Saiphoklang et al. (2020) showed that smoking university athletes had lower lung function than non-smoking athletes, especially in forced vital capacity (FVC) and forced expiratory volume (FEV_1), which had direct implications for decreased ventilation efficiency during training. Although the study did not measure VO_2 max directly, the reported decline in lung function was consistent with the physiological mechanisms found in the study.

Research by Caci et al. (2024) further confirms that active smokers have lower VO_2 max than former smokers and non-smokers, with a tendency that quitting smoking can partially restore aerobic capacity. However, longitudinal studies documenting the recovery trajectory of VO_2 max after quitting smoking are still limited (Ho et al., 2021; Patnode et al., 2021a). Most studies stopped at the behavioral aspects and success rates of smoking cessation, rather than on physiological changes that could be objectively measured using CPET. This underscores the importance of advanced research based on longitudinal physiological measurements to understand the extent to which aerobic recovery can occur post-smoking cessation.

On the other hand, the results of this study also show differences with some other studies that report that the association between smoking and VO_2 max is not always significant, especially in healthy young athlete populations. Sharma and Jangra (2024) found that although the VO_2 max in smokers was lower than in non-smokers, the difference was not statistically significant in university athletes. This suggests that factors such as baseline fitness level, duration of smoking habits, age, and exercise volume can act as moderating variables that affect the magnitude of smoking's effects on aerobic capacity.

In addition, in a population with chronic obstructive pulmonary disease (COPD), the negative effects of smoking on aerobic capacity appear much clearer. Soumagne et al. (2020) reported that COPD patients who never smoked had better exercise capacity and ventilation efficiency than COPD patients who were active smokers. This suggests that smoking exacerbates aerobic limitations when a pulmonary pathological condition is already present, supporting the view that the effects of smoking on aerobic performance are cumulative and contextual: the heavier the exposure, the greater the decrease in physiological capacity.

Thus, the results of this study reinforce the general view in sports physiology that smoking is a risk factor that lowers aerobic performance, but also underscores the need for a differential approach in the interpretation of results: the impact of smoking on VO_2 max may be small in healthy athletes with long-term intensive exercise, but it will be more pronounced in individuals with prolonged exposure or degraded physiological conditions. Furthermore, the empirical data gap identified by Tu et al. (2024) and Baygutalp et al. (2021), namely the absence of direct CPET-based evidence measuring the difference in VO_2 max between smokers and non-smokers, suggests that this study makes an important contribution in filling the gap. Using a validated field method (Beep Test) and a controlled comparative approach, this study reinforces the evidence that even in the context of amateur football athletes, smoking habits are sufficient to cause a significant difference in aerobic capacity.

The transport of oxygen to muscle tissue is highly dependent on the concentration of hemoglobin (Hb) and the ability of Hb to bind to oxygen. Exposure to carbon monoxide from cigarette smoke results in the formation of carboxyhemoglobin (HbCO), which decreases Hb's capacity to carry oxygen. Huang et al. (2023) explain that the decline in Hb quality due to chronic exposure to CO can directly inhibit the body's ability to distribute oxygen during strenuous exercise. In the context of athletes, this means a decrease in the availability of oxygen in muscle tissue and increased premature fatigue during high-intensity activity.

The max VO_2 capacity also depends on the maximum cardiac output (Qm_{ax}) and the muscle's ability to extract oxygen (a–v O_2 difference). Smoking can lower both through increased vascular resistance, peripheral vasoconstriction, and nicotine-induced endothelial dysfunction (Eeden et al., 2021). Shobirin et al. (2023) emphasized that this disruption in muscle perfusion leads to a decrease in the tissue's ability to extract oxygen efficiently, thereby lowering the overall VO_2 max value.

Other factors that contribute to the decrease in VO_2 max are the appearance of tissue hypoxia and oxidative stress due to chronic inflammation of the lungs. Baygutalp et al. (2021) explain that cigarette exposure leads to increased activation of the hypoxia-inducible factor 1-alpha (HIF-1α) pathway, which is associated with impaired gas exchange and decreased mitochondrial function. This decrease in mitochondrial efficiency reduces the ability of muscles to produce aerobic energy optimally. The combination of hypoxia and oxidative stress creates unfavorable conditions for athletic performance, as it interferes with the oxidative phosphorylation process that is the basis of aerobic metabolism.

Theoretically, smoking habits can also hinder the process of adaptation to aerobic exercise. Yu et al. (2025) showed that smokers have a lower adaptive response to high-intensity interval training (HIIT) than non-smokers. Nicotine and CO are thought to inhibit the increase in mitochondrial capacity and the efficiency of the autonomic nervous system, thereby reducing the effectiveness of exercise stimuli against increased VO_2 max. This means that even with the same exercise program, smoking athletes are less likely to experience as much improvement in cardiorespiratory fitness as non-smokers.

Although theory and empirical results support a negative association between smoking and VO_2 max, there is no strong longitudinal evidence to date regarding the recovery of VO_2 max capacity after quitting smoking. The studies of Patnode et al. (2021a), Graham et al. (2021), and Ho et al. (2021) focus more on the effectiveness of behavioral interventions and smoking cessation success rates, without including measurements of VO_2 max. Therefore, longitudinal-based CPET research is needed that objectively assesses the dynamics of aerobic capacity recovery in former smokers undergoing exercise or pulmonary rehabilitation. This gap confirms that studies like this Fortuna FC study have fundamental value, as they highlight a direct link between smoking habits and physiological performance that can be measured quantitatively.

CONCLUSION

This study proves that there is a significant difference between the VO_2 max capacity of smoking and non-smoking football players at the Fortuna FC Kupang club. Smokers have lower aerobic capacity than non-smokers, with an average difference of 5.8 $mL \cdot kg^{-1} \cdot min^{-1}$, which physiologically means a decrease of about 10–12% of optimal capacity. This decline is not only statistically significant but also biologically and performatively significant, reflecting disruptions in the oxygen transport system, pulmonary diffusion, and aerobic metabolic efficiency due to exposure to nicotine, carbon monoxide, and free radicals. These three mechanisms work synergistically to reduce the work efficiency of the cardiorespiratory system and adapt exercise to increase aerobic capacity. Academically, this study fills an empirical gap in the Indonesian sports literature that has not studied the difference in aerobic capacity based on smoking status in football athletes. These findings reinforce the theory of sports physiology that asserts that smoking directly decreases cardiorespiratory fitness, while also confirming the importance of lifestyle control in improving athletic performance.

Based on the empirical findings and physiological implications of this study, it is recommended that further research be conducted longitudinally based on Cardiopulmonary Exercise Testing (CPET) to examine the dose-response relationship between intensity, duration, and frequency of smoking to a quantitative decrease in VO_2 max capacity, as well as evaluate the dynamics of aerobic capacity recovery after smoking cessation through a structured exercise program or pulmonary rehabilitation. In the context of athlete coaching, these results confirm the need to integrate smoking hazard education programs into training and fitness curricula, accompanied by club or federation policies that make smoking status part of athlete health screening. A multidisciplinary approach between coaches, sports doctors, nutritionists, and sports psychologists needs to be developed to support smoking cessation interventions that are aligned with improved cardiovascular fitness. Furthermore, in terms of macro policies, the results of this research can be the basis for the creation of national sports health guidelines that emphasize a smoke-free lifestyle as a prerequisite for sustainable athlete development, as well as encourage public health campaigns with the theme "Athletes Without Smoking" to strengthen a culture of healthy performance in the Indonesian sports environment.

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