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Literature Review: VO2max in Active Smokers

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ABSTRACT

Maximal aerobic capacity or maximal oxygen uptake (VO_2max) is a key indicator of the capacity of the cardiovascular and respiratory systems to deliver oxygen to body tissues during intense physical activity. Smoking is known to negatively impact lung function and oxygen circulation, leading to a decrease in VO_2max. This study aims to systematically review the results of previous studies on the effect of smoking on VO_2max in active smokers. The method used is a descriptive literature study by analyzing various national and international scientific articles published between 2010 and 2024. The results show that active smokers have significantly lower VO_2max values than non-smokers. Chemicals in cigarettes such as nicotine and carbon monoxide cause a decrease in oxygen-binding capacity in the blood, impaired pulmonary ventilation, and decreased cardiac efficiency. The higher the frequency and duration of smoking, the greater the decrease in aerobic capacity. In conclusion, smoking directly contributes to a decrease in VO_2max, thus negatively impacting an individual's physical fitness and physical performance.

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B. Acquisition of data;
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INTRODUCTION

Physical fitness plays a crucial role in supporting a person's health and physical performance. Adriani and Fadilah (2023) state that physical fitness is the body's ability to perform daily activities efficiently without experiencing excessive fatigue and to maintain energy reserves for additional activities. Physical fitness reflects the optimal function of the cardiovascular, respiratory, and musculoskeletal systems, which coordinate with each other to support physical performance. Good fitness not only impacts physical capacity and athletic performance but also contributes to the prevention of non-communicable diseases such as hypertension, diabetes mellitus, and heart disease.

Aerobic capacity is a key component of physical fitness, indicating the body's ability to utilize oxygen effectively during physical activity. This capacity can be measured using the Volume of Oxygen Maximum (VO2Max), a physiological indicator that reflects the effectiveness of the heart, lungs, and circulatory system in delivering oxygen to the muscles. Individuals with a high VO2Max tend to have better physical endurance, slower

fatigue rates, and faster recovery after exercise. VO2Max measurements serve as a tool for assessing physical fitness levels, monitoring physical development, and providing a basis for planning exercise programs tailored to individual capacity.

An unhealthy lifestyle, particularly smoking, negatively impacts aerobic capacity. Cigarettes contain more than 4,000 harmful chemicals that can damage various body systems. According to Sundari et al. (2015), harmful substances such as tar, nicotine, lead, and carbon monoxide negatively impact the respiratory and cardiovascular systems. Tar settles in the lungs and damages the alveoli, while nicotine is addictive and causes blood vessel constriction, which increases blood pressure. Carbon monoxide binds to hemoglobin more strongly than oxygen, thus inhibiting oxygen distribution to body tissues. The accumulation of these effects leads to decreased lung function, impaired circulation, and decreased efficiency of oxygen use during activity, ultimately resulting in low VO2Max values in active smokers.

Empirical findings indicate a negative correlation between smoking and aerobic capacity. According to Zein (2017), active smokers have lower VO2Max values than nonsmokers, even with equivalent levels of physical activity. This decrease is related to physiological disturbances caused by exposure to nicotine, tar, and carbon monoxide, which reduce the blood's ability to bind oxygen and inhibit energy metabolism in muscles. Several studies also show that both active smokers and vapers experience decreased aerobic capacity, with the impact being greater in conventional smokers. However, regular aerobic exercise has been shown to increase VO2Max through physiological adaptations such as increased cardiac stroke volume, muscle capillary count, and oxygen diffusion efficiency in the lungs.

Cigarettes contain more than 4,000 harmful chemicals, including nicotine, tar, and carbon monoxide. These substances can disrupt the function of the respiratory and cardiovascular systems (WHO, 2022). Carbon monoxide competes with oxygen for binding to hemoglobin, thereby reducing the blood's capacity to transport oxygen to muscle tissue (Gordon et al., 2010). Furthermore, nicotine causes vasoconstriction, which inhibits blood flow to active muscles during exercise.

In Indonesia, the prevalence of active smoking remains high, especially among the productive age group. Basic Health Research (Riskesdas, 2021) data shows that more than 33% of the Indonesian population aged 15 years and above are active smokers. This is concerning given the high oxygen demand and aerobic capacity required to support productivity and public health.

Most research on the relationship between smoking and VO2Max is limited to young subjects or athletes, with simple research designs. Variables such as smoking duration, frequency of nicotine consumption, and lifestyle have not been widely considered. Based on these conditions, this study was structured as a literature review aimed at analyzing and integrating various previous research findings regarding the relationship between smoking habits and aerobic capacity. This study is expected to enrich understanding of the physiological impact of smoking on VO2Max values, which can improve physical fitness, particularly for active smokers.

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METHODS

This study is a literature review aimed at describing the condition of Maximum Oxygen Volume (VO2Max) in active smokers. The research method used in this study is a literature study. Data collection techniques were carried out by exploring various scientific sources relevant to the research topic. Article searches were conducted through the Google Scholar database with the keyword "VO2Max in active smokers." From the search results, three scientific articles published between 2017 and 2021 were obtained, and they met the criteria of relevance to the focus of this study. These three articles were then analyzed in depth to examine the results, methods, and empirical findings related to the effect of smoking habits on aerobic capacity.

RESULTS AND DISCUSSION

Result

The first research article conducted by Renni Hidayati Zein (2017) has been reviewed and the results are presented in the table below:

Table 1.
Results of the Literature Study for Article 2

Article title	Results	Conclusion
The Effect of Aerobic Exercise on Increasing the Percentage of VO2Max Levels in Active Smokers at Baiturrahim Jambi Health College. Renni Hidayati Zein, SSt.FT (2017).	Light and moderate intensity aerobic exercise performed four times a week for eight weeks, with a duration of 30 minutes per session, has been shown to increase VO2Max in active smokers. The paired t-test results showed a p-value of 0.000, indicating a significant effect of both exercise intensities on increasing VO2Max, although there was no significant difference between the two.	Regular light-to-moderate intensity aerobic exercise for eight weeks has been shown to increase VO2Max levels in active smokers. Aerobic activity has a significant positive impact on physical capacity, especially for smokers who generally experience decreased oxygen uptake.

The article (Zein, 2017) entitled "The Effect of Aerobic Exercise on Increasing the Percentage of VO2Max Levels in Active Smokers at Baiturrahim Jambi Health College" examines the extent to which aerobic exercise can increase aerobic capacity in active smokers. This study used a pre-experimental design with two treatment groups, namely light and moderate intensity aerobic exercise, which was carried out four times a week for eight weeks with a duration of 30 minutes per session. The results of the analysis using a paired t-test obtained a p value = 0.000 which indicated that both types of exercise had a significant effect on increasing VO2Max. However, there was no significant difference between light and moderate intensity exercise in increasing aerobic capacity. These findings indicate that regular aerobic exercise, both with light and moderate intensity, can improve heart and lung function, increase the efficiency of oxygen distribution, and be an effective form of intervention in maintaining physical fitness in active smokers.

The second research article by Kuncoro and Wibowo (2021) has been reviewed and contains results, which are presented in the table below:

Table 2.
Results of Literature Study Article 2

Article title	Results	Conclusion
Cardiorespiratory Endurance of Smokers and Non-Smokers. Mochammad Uwais Kuncoro, Sapto Wibowo (2021).	Student smokers had an average VO2Max of 32.76–39.19 ml/kg/min, which is considered low, while nonsmokers showed higher values. Twenty percent of active smokers who exercised had low cardiorespiratory endurance compared to 6.7 percent of nonsmokers, and only 40 percent of smokers were in the good category compared to 66.7 percent of nonsmokers.	Research findings indicate that smoking reduces students' VO2Max and cardiorespiratory endurance. Toxic substances such as nicotine and carbon monoxide inhibit oxygen distribution and utilization, thereby reducing aerobic capacity in active smokers. Therefore, smoking is a significant factor in reducing fitness and increasing the risk of chronic disease.

The results of the second research article by Mochammad Uwais Kuncoro and Sapto Wibowo (2021) show that smoking significantly contributes to decreased cardiorespiratory endurance and VO2Max values. Active smokers have a lower aerobic capacity than nonsmokers due to impaired lung and heart function caused by the toxic substances in cigarettes. This impairment reduces the efficiency of oxygen distribution to body tissues, thereby impairing the function of the cardiovascular and respiratory systems. These findings confirm that smoking is a major factor in decreasing physical fitness and increasing the risk of cardiovascular disorders and other chronic diseases.

The third research article by Zuhdi and Yuliastrid (2017) has been reviewed and contains the results, which are presented in the table below:

Table 3.
Results of Literature Study Article 3

Article title	Results	Conclusion
The Relationship between Smoking Habits and Maximum Oxygen Volume (VO2Max) in Students of the Health Education Department of Unesa, Class of 2015. Alex Jakfar Zuhdi and Dita Yuliastrid (2017).	The results showed that the average score of students' smoking habits was 41.27, with a distribution of 33.33% in the mild category, 56.67% in the moderate category, and 10% in the severe category. The average VO2Max value was recorded at 36.88, consisting of 33.33% in the poor category, 50% in the moderate category, and 16.67% in the good category. The results of the correlation analysis showed a coefficient of -0.45, which indicates a negative relationship with a moderate level of strength between smoking habits and VO2Max. This means that smoking habits have an effect on reducing VO2Max by 20.25%.	This study concluded that smoking negatively impacts students' aerobic capacity. The higher the smoking intensity, the lower the VO2Max value. A correlation value of -0.45 indicates a moderate negative relationship, contributing to a 20.25% decrease in VO2Max. Therefore, smoking reduces cardiorespiratory endurance and physical fitness.

Based on a study conducted by Alex Jakfar Zuhdi and Dita Yuliastrid (2017) entitled "The Relationship between Smoking Habits and Maximum Oxygen Volume (VO2Max) in Students of the 2015 Class of UNESA Health Department", the results of the study showed that the average score of students' smoking habits reached 41.27, with the majority being in the moderate smoker category (56.67%). The average VO2Max value was recorded at 36.88, with

50% of respondents being classified as moderate and 33.33% being in the low category. The correlation test showed a value of r = -0.45, indicating a negative relationship with a moderate level of strength between smoking habits and VO2Max. This means that the higher the intensity of smoking, the lower a person's aerobic capacity. Smoking habits also contributed 20.25% to the decrease in VO2Max. The results of this study confirm that smoking habits have a significant effect on decreasing cardiorespiratory endurance and can disrupt the function of the heart and lungs of students.

Discussion

According to Zuhdi and Yuliastrid (2017), VO2Max is the maximum amount of oxygen the human body can use during high-intensity physical activity. This value indicates how efficiently the respiratory system, heart, and blood vessels deliver oxygen to working muscles. The higher a person's VO2Max, the more optimal their body's ability to maintain physical performance and endurance during high-intensity activity. According to Barus (2020), the VO2Max level is a person's capacity to utilize and release oxygen optimally during physical activity. This ability reflects the efficiency of the cardiovascular and respiratory systems in providing the oxygen the body needs. A high VO2Max indicates better endurance and physical performance, because the body can produce more energy optimally and delay fatigue during heavy activity or intense exercise. According to Candra (2020), VO2Max is one of the main factors that plays a role in preventing fatigue due to the accumulation of lactic acid in the body. The higher a person's VO2Max capacity, the more optimal the body's ability to deliver oxygen to working muscles, thereby minimizing the accumulation of lactic acid. Therefore, individuals with a high VO2Max are typically able to perform high-intensity activities or exercise for longer periods without fatigue. According to Candra (2020), VO2Max serves to continuously improve the capacity and endurance of the heart and lungs. According to Zuhdi and Yuliastrid (2017), VO2Max is the maximum amount of oxygen the human body can process during high-intensity physical activity. This value indicates how efficiently the respiratory system, heart, and blood vessels function in delivering oxygen throughout the body, especially to working muscles. The higher a person's VO2Max, the more optimal their body's ability to produce energy and maintain physical performance during exercise and high-intensity activity.

According to the authors, VO2Max is a key indicator of the body's maximum ability to utilize oxygen during high-intensity physical activity. This term describes the efficiency of the cardiovascular and respiratory systems in delivering oxygen to working muscles. An increase in VO2Max indicates an increased body capacity to produce energy, maintain endurance, and reduce fatigue due to lactic acid accumulation. Thus VO2Max is not only a measure of aerobic fitness but also contributes to the continuous improvement of heart and lung function, which ultimately improves physical performance and endurance during strenuous activity.

A person can be considered an active smoker if they have a daily smoking habit for at least six months of their life and continue smoking at the time of the study (Sundari

et al., 2015). Smokers are divided into three categories based on the number of cigarettes consumed per day: light smokers who smoke between one and ten cigarettes per day, moderate smokers who smoke 11 to 20 cigarettes per day, and heavy smokers who smoke more than 20 cigarettes per day (WHO). According to Sundari et al., (2015), cigarettes contain thousands of hazardous chemicals that can harm health, such as tar, nicotine, lead, and carbon monoxide.

Cigarettes contain various hazardous chemicals such as nicotine, carbon monoxide (CO), and tar. CO has an affinity for hemoglobin 200 times stronger than oxygen, causing the formation of carboxyhemoglobin, which reduces the blood's capacity to transport oxygen to body tissues (Sundari et al., 2015). This condition results in muscles not receiving an adequate oxygen supply during physical activity, ultimately lowering VO_2max.

Furthermore, long-term exposure to cigarette smoke causes damage to the lung alveoli and a reduction in the surface area for oxygen diffusion. A study by Tantisuwat et al. (2014) showed that active smokers experienced a 15–20% decrease in FEV_1 and FVC compared to non-smokers, indicating reduced pulmonary ventilation capacity (Sundari et al., 2015). This decline in lung function directly impacts the limited oxygen uptake capacity during intense physical exercise.

The nicotine in cigarettes is a stimulant that triggers the release of adrenaline, increasing heart rate, blood pressure, and peripheral vascular resistance. This increased cardiac workload is not accompanied by an increase in oxygen delivery capacity, resulting in decreased cardiac efficiency. Over the long term, this can lead to thickening of the artery walls and reduced blood vessel elasticity, further impairing cardiovascular endurance.

According to the authors, a person is considered an active smoker if they have smoked daily for at least six months and are still smoking at the time of the study. Based on the number of cigarettes smoked per day, smokers are categorized into three levels: light smokers who smoke between one and ten cigarettes per day, moderate smokers who smoke eleven to twenty cigarettes per day, and heavy smokers who smoke more than twenty cigarettes per day. Cigarettes contain various toxic chemicals that are harmful to health, including tar, nicotine, lead, and carbon monoxide. These harmful substances can disrupt organ function, reduce the efficiency of the respiratory system, and increase the risk of chronic disease.

CONCLUSION

Based on research findings, regular light- or moderate-intensity aerobic exercise significantly increases VO2Max levels in active smokers. The average VO2Max value in active smokers is lower than in nonsmokers, with a moderate negative correlation ($r = -0.45$) between smoking and VO2Max levels. These results indicate that the more frequently a person smokes, the lower the body's ability to utilize oxygen optimally. Therefore, it can be concluded that active smokers have lower aerobic fitness levels due

to decreased cardiovascular and respiratory system efficiency due to exposure to toxic substances from cigarettes.

Overall, the results of the literature study indicate a strong negative relationship between smoking and VO2Max values. The longer and more severe the smoking habit, the lower the VO2Max value obtained. This confirms that smoking is a major risk factor inhibiting improvements in physical fitness, particularly in aspects of cardiovascular endurance and respiratory efficiency.

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