JURNAL STAMINA
P-ISSN 2655-1802
E-ISSN 2655-2515
http://stamina.ppj.unp.ac.id

THE ROLE OF PULMONARY VITAL CAPACITY, HEMOGLOBIN LEVELS AND BODY MASS INDEX IN DETERMINING MAXIMUM OXYGEN VOLUME IN NON-ATHLETE STUDENTS

Tendy Roy[1], Eri Barlian[2], Donie[3]

[1]Universitas Negeri Padang, Ilmu Keolahragaan, Padang, Indonesia
[2]Universitas Negeri Padang, Kepelatihan Olahraga, Padang, Indonesia
[3]Universitas Negeri Padang, Kepelatihan Olahraga, Padang, Indonesia

*Coressponding Author. Email: tendyroy1234@gmail.com
*Email Author: tendyroy1234@gmail.com, erybarlian@fik.unp.ac.id.,donie@fik.unp.ac.id.

Received: July 2025, Revised: August 2025, Accepted: September 2025

Abstract
This study aims to examine the relationship between lung vital capacity, haemoglobin levels, and body mass index (BMI) in determining the maximum capacity of oxygen volume (VO2Max) in non-athlete students. The study used a correlational method involving 103 non-athlete students who attended exercise physiology courses, with an average age of ± 20 years. VO2Max was measured using the Multistage Fitness Test, lung vital capacity was measured using a spirometer, while BMI was calculated based on height and weight. Measurement of haemoglobin level was done using Easy Touch Omron device. Data analysis was conducted using the regression method. The results showed a weak correlation between lung vital capacity and VO2Max ($R = 0.378$). Haemoglobin levels also showed a weak correlation with VO2Max ($R = 0.248$), while the relationship between BMI and VO2Max was very low ($R = 0.127$). This study shows that lung vital capacity has a positive but weak relationship with VO2Max in non-athlete students. Haemoglobin levels also showed a weak association, while BMI had very little influence on cardiorespiratory fitness. These findings indicate that other factors may have a more dominant role in determining fitness levels in this population. The implications of this study may provide further insight into the factors that influence cardiorespiratory fitness in non-athlete university students.
Keywords: Lung vital capacity, haemoglobin, body mass index, maximal oxygen volume

INTRODUCTION

The body's physiological abilities play an important role in supporting sports performance. The efficiency of body functions, such as heart, lungs, hemoglobin levels, and body mass, is key in maintaining performance stability during high-intensity physical activity (Tangkudung et al., 2020). The vital capacity of the lungs reflects the ability of the lungs to carry out oxygen exchange, which is in line with the amount of oxygen that can be distributed throughout the body. Individuals with ideal weight tend to have higher lung vital capacity compared to individuals who have a higher body weight (Pinzon, 1998).

In addition, hemoglobin levels play an important role in supporting the oxygen transport capacity in the body. The main role of hemoglobin is to bind oxygen in the lungs and release it into the tissues, a process that is affected by its concentration in the blood. Oxygen transport capacity can be defined as a function of hemoglobin content and cardiac output, with the equation of oxygen content in the blood being an important aspect of this relationship. Specifically, the oxygen transport capacity is determined by the result of the hemoglobin concentration and the amount of oxygen that each gram of hemoglobin can carry, which is about 1.34 mL O2 per gram of Hb(Döbele et al., 2010). BMI also has an indirect influence on cardiorespiratory fitness. Body Mass Index serves as a simple index of weight to height that is commonly used to classify underweight, overweight, and obesity in adults and children.

Although BMI is a useful screening tool, it does not directly measure body fat or account for muscle mass, which can lead to misleading interpretations of a person's fitness level. Research shows that a higher BMI is often associated with lower levels of cardiorespiratory fitness, but this relationship is influenced by additional factors such as physical activity and body composition (Döbele et al., 2010;Oller et al., 2019). However, the extent to which these three variables are interrelated and affect VO2Max in non-athlete populations still requires further research. Based on this, this study aims to answer the following questions: 1) Is there a relationship between lung vital capacity and VO2Max in non-athlete students? 2) How does hemoglobin levels relate to VO2Max in this population? 3) To what extent does BMI correlate with VO2Max in non-athlete students? This study is expected to provide a deeper understanding of the interactions between pulmonary vital capacity, hemoglobin levels, BMI, and VO2Max in the non-athlete student population.

METHODOLOGY

This study uses a quantitative approach, the research design uses correlation. 103 participants were involved in this study who were students in the 5th semester sports physiology course. The average age of the participants was ±20 years, consisting of non-athlete male sex. Data collection techniques with tests and measurements. The instrument used is a Multistage fitness test used to see the ability of VO2 Max, a Spirometer is used to see the vital capacity of the lungs. Weight and height measurements were carried out to obtain BMI, while to obtain Haemoglobin data the Easy Touch Omron tool was used.

Table 1. Research instruments

No	Variabel	Instruments
1	VO2Max	Multistage fitness test
2	Pulmonary Vital Capacity	Spirometer (Sugianto & Nanang Indardi, 2007: 639)
3	IMT	Height and Weight

4	Haemoglobin	Easy Touch Omron

Source: Norma HB (BILLETT, 1990)

RESULTS

Classification of research data

Table 2. Classification of Pulmonary Vital Capacity Data

Klasifikasi	Interval			Frequency
Less Than Once	0	≤	2470	20
Less	2480	-	3040	30
Keep	3050	-	3900	44
Good	3910	-	4470	7
Very good		≥	4480	2
				103

This distribution illustrates that the majority of individuals are in the Moderate category, while only a few have the vital capacity of the lungs that are in the Very Good category.

Table 3. Classification of Hemoglobin Data

Klasifikasi	Interval	Frequency
Low	≤13	18
Normal	14-18	85
Tall	≥19	0
		103

Data can be concluded that most individuals have normal hemoglobin levels, while only a small percentage are in the low category, and there are no individuals with high hemoglobin levels.

Table 4. Classification of Body Mass Index Data

Klasifikasi	Interval	Frequency
Underweight (Underweight)	<18,5	16
Normal weight	18,5-22,9	62
Overweight with risk	23-24,9	17
Obesity	25-29,9	4
Obesity 2	≥30	4
		103

From this data, the majority of individuals are of normal weight, while obesity and obesity category 2 have the same number of individuals, namely 4 people each. The Overweight category is quite significant with 17 people, and underweight individuals reach 16 people.

Table 5. Classification of Maximum Oxygen Volume Data

Klasifikasi	Interval	Frequency
Excellent	>60	0
Good	52-60	2
Above Average	47-51	9
Average	42-46	22
Below Average	37-41	28
Bad	30-36	32
Very Bad	<30	10
		103

Of these distributions, most individuals fall into the Below Average and Poor categories, suggesting that the majority have below-average pulmonary vital capacity. Only a few are in the Good category, and no individual is in the Excelent category.

Table 6. Data description

	Vital Capacity Of The Lungs	HB	IMT	VO2MAKS
Min	1600	8,6	16,02	23
max	4900	18,3	33,86	59,8
Average	3079,13	14,82	21,24	38,77
N	103	103	103	103
Range	3300	9,7	17,83	36,8
Class	7,48	7,48	7,48	7,48
Class Length	700	1,30	2,38	4,92
Stedev	657,85	1,82	3,28	6,61

Based on table 7 of the Model Summary, the following values are obtained:

Table 7. Summary model correlation between independent variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.436a	.190	.165	6.03747
a. Predictors: (Constant), IMT, Kapasitas_Vital_Paru, HB				

R of 0.436 indicates a moderate correlation between the independent variables (BMI, Pulmonary Vital Capacity, and HB) and the bound variable (VO2 Max). R Square of 19% means that the variation in VO2 Max can be explained by a combination of the variables BMI, Pulmonary Vital Capacity, and HB. Because the Sig. F Change value < 0.05, the relationship between variables is statistically significant.

Table 9. Coefficients Regeresi

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.398	7.359		3.859	.000
	Pulmonary Vital Capacity	.004	.001	.380	3.909	.000
	HB	.376	.362	.104	1.039	.301
	BMI	-.327	.197	-.162	-1.656	.101
a. Dependent Variable: VO2_Max						

Based on the table above, it shows that 1) The Pulmonary Vital Capacity Variable (X1) is significant ($p < 0.05$) with a positive coefficient of 0.004, which means that the greater the vital capacity of the lungs, the higher the Max VO2 value. 2) The variables HB (X2) and BMI (X3) were not statistically significant ($p > 0.05$) and did not have a significant influence on VO2 Max. 3) BMI has a negative coefficient, indicating an inverse relationship with VO2 Max, although it is not significant.

Based on the results of the study, it was shown that: 1) Correlation between Lung Vital Capacity (X1) and VO2 Max (Y) with a value of $r = 0.378$ (moderate positive correlation) with Sig. = 0.000, showed a significant relationship. 2) Correlation between HB (X2) and VO2 Max (Y) with a value of $r = 0.248$ (weak positive correlation) with Sig. = 0.011, shows a significant relationship.

3) Correlation between BMI (X3) and VO2 Max (Y) with a value of $r = -0.127$ (a very weak negative correlation) with Sig. = 0.202, so it is not statistically significant.

DISCUSSION

Correlation between Lung Vital Capacity (X1) and Max VO2 (Y)

The higher the Pulmonary Vital Capacity, the higher the VO2 Max value of a person. This can be explained because the vital capacity of the lungs plays an important role in the body's ability to absorb oxygen during physical activity. Good lung capacity allows for more effective distribution of oxygen to body tissues, thereby improving aerobic performance yang diukur melalui VO2 Maks. For example, Jayaputra highlights that physical exercise causes significant changes to the cardiorespiratory system, including an increase in total lung capacity, which is strongly correlated with VO2 max levels (Jayaputra, 2024). This is further supported by research showing that lung function parameters, such as forced vital capacity (FVC) and forced expiratory volume (FEV1), are important indicators of exercise capacity and overall health (Bar-Yoseph et al., 2019). This suggests that as the vital capacity of the lungs increases, so does the maximum aerobic capacity, underscoring the importance of lung function in athletic performance. Similarly, the findings of Rusanov et al. emphasize that lung function tests (PFTs) provide valuable prognostic information regarding exercise tolerance and oxygen consumption, which further links lung capacity to VO2 max (Rusanov et al., 2008). Pulmonary Vital Capacity variables can be considered an important factor that affects VO2 Max, so lung capacity-building programs, such as breathing exercises or aerobic physical activity, can help improve a person's aerobic ability.

Correlation between HB (X2) and VO2 Max (Y)

Although the relationship between Hemoglobin (HB) levels and Max VO2 is weak, this significant correlation suggests that increased HB may contribute positively to Max VO2. This happens because hemoglobin functions as an oxygen binder in the blood and transports it throughout the body. With optimal HB levels, oxygen supply to the muscles during physical activity becomes more efficient.

First, it's important to note that VO2 max is affected by many factors, including cardiovascular fitness, muscle mass, and overall physical condition, not just by hemoglobin levels. For example, Nopiyanto emphasizes that genetic factors can account for 25-40% of a person's VO2 max, suggesting that other physiological aspects play an important role in determining aerobic capacity (Nopiyanto, 2023). This suggests that although hemoglobin contributes to oxygen transport, it is not the only determinant of VO2 max. In addition, Khairani et al. highlight that differences in VO2 max can be significantly attributed to variations in body composition, especially in elderly populations, where muscle mass tends to decrease and fat mass increases. This demographic shift may mask the influence of hemoglobin levels on VO2 max (Khairani et al., 2021). In older women, for example, low VO2 max was more closely related to decreased muscle tissue compared to hemoglobin concentration alone. In addition, Hada et al. discuss how factors such as testosterone levels can affect hemoglobin levels, particularly in men, which can lead to the misleading assumption that higher hemoglobin is directly correlated with higher max VO2 (Hada et al., 2013). However, this relationship is complicated by the fact that VO2 max is also affected by cardiovascular training and adaptation status, which can vary independently of hemoglobin levels. Although HB's effect on VO2 Max is not very strong, monitoring hemoglobin levels is still important in an effort to increase aerobic capacity, especially in individuals with certain conditions such as anemia.

Correlation between BMI (X3) and VO2 Max (Y)

The negative relationship between Body Mass Index (BMI) and VO2 Max suggests that increased BMI tends to be inversely proportional to VO2 Max, but this relationship is very weak and insignificant. This means that BMI was not a factor that directly affected aerobic ability in this study. Research by Das et al. showed a significant negative correlation between BMI and VO2 max in a sample of obese and non-obese individuals aged 20-25 years, suggesting that a higher BMI is associated with lower maximum oxygen absorption, reinforcing the notion that increased body fat negatively impacts aerobic performance (Das, 2023). Similarly Setty et al. corroborate this relationship, given that in obese individuals, an increase in type II muscle fibers and a decrease in type I muscle fibers can significantly interfere with oxygen absorption, further suggesting that a higher BMI leads to functional impairments in aerobic capacity (Setty et al., 2013). In addition, research by Crump et al. emphasized that low aerobic capacity is a long-term risk factor for type 2 diabetes, even among individuals with normal BMIs. This suggests that while BMI is an important factor, BMI is not the only determinant of aerobic fitness; however, the negative relationship between increased BMI and max VO2 is still evident (Crump et al., 2016). Tan et al. also support this view, suggesting that adverse changes in aerobic capacity are observed even in individuals who are classified as having a normal BMI but having a high percentage of body fat (Tan et al., 2022). This highlights the complexity of the relationship, where body composition may play a more important role than BMI alone. Furthermore, Mahar et al. found an insignificant correlation of -0.18 between BMI and max VO2 measurements in adolescent samples. This suggests that despite trends, the association may not be as strong in younger populations (Mahar et al., 2018). However, this does not negate the overall trend observed in the adult population where an increase in BMI is consistently correlated with a decrease in aerobic capacity. In addition, a systematic review by

Kelley et al. showed that exercise interventions can effectively reduce BMI and improve aerobic fitness in overweight and obese children and adolescents, which further supports the idea that managing weight is essential for increasing VO2 max (Kelley et al., 2015). This relationship is also reflected in the findings of Martin et al., who report that obesity negatively impacts the increase in aerobic capacity after cardiac rehabilitation, thus emphasizing the importance of weight management in improving aerobic fitness (Martin et al., 2012). Lowering BMI may not directly increase Max VO2, but maintaining a balanced weight is important in supporting overall physical performance.

CONCLUSION

Based on the results of the study, it can be concluded that 1) Pulmonary Vital Capacity is a significant predictor of VO2 Max with a positive relationship. 2) The HB and BMI variables did not have a significant effect on VO2 Max in this model. 3) Correlation shows that Pulmonary Vital Capacity has the strongest relationship with VO2 Max compared to other variables, although in the moderate relationship category. Thus, the focus on increasing Pulmonary Vital Capacity and maintaining optimal HB levels is more relevant to increasing Max VO2 in the studied population.

REFERENCE

Bar-Yoseph, R., Ilivitzki, A., Gur, M., Mainzer, G., Hakim, F., Livnat, G., Schnapp, Z., Shalloufeh, G., Zucker-Toledano, M., Subar, Y., & Bentur, L. (2019). Exercise Capacity In Patients With Cystic Fibrosis Vs. Non-Cystic Fibrosis Bronchiectasis. *Plos One*, *14*(6), E0217491. Https://Doi.Org/10.1371/Journal.Pone.0217491

BILLETT, H. H. (1990). Hemoglobin And Hematocrit . In *Clinical Methods: The History, Physical, And Laboratory Examinations. 3rd Edition*. Https://Doi.Org/10.5120/Ijca2016910339

Crump, C., Sundquist, J., Winkleby, M. A., Sieh, W., & Sundquist, K. (2016). Physical Fitness Among Swedish Military Conscripts And Long-Term Risk For Type 2 Diabetes Mellitus. *Annals Of Internal Medicine*, *164*(9), 577. Https://Doi.Org/10.7326/M15-2002

Das, D. (2023). Exercise Capability With Total Body Fat Percent &Amp; Skeletal Muscle Percent In Male Students Aged 18 - 25 Years: A Correlational Study. *JRTDD*. Https://Doi.Org/10.53555/Jrtdd.V6i9s.2635

Döbele, T., Schwirtz, G., Gahl, B., & Eckstein, F. S. (2010). Mini ECC Vs. Conventional ECC: An Examination Of Venous Oxygen Saturation, Haemoglobin, Haematocrit, Flow, Cardiac Index And Oxygen Delivery. *Perfusion*, *25*(3), 125–131. Https://Doi.Org/10.1177/0267659110369852

Hada, S. L., S, A., & Gautam, K. (2013). Cardiopulmonary Fitness Test Among Nepalese Students. *Janaki Medical College Journal Of Medical Science*, *1*(1), 3–8. Https://Doi.Org/10.3126/Jmcjms.V1i1.7879

Jayaputra, V. M. B. (2024). Effect Of Chocolate Milk Consumption On Cardiorespiratory Endurance Of Central Java BPPLOP Games Athletes. *Amerta Nutrition*, *8*(2), 295–304. Https://Doi.Org/10.20473/Amnt.V8i2.2024.295-304

Kelley, G. A., Kelley, K. S., & Pate, R. R. (2015). Exercise And BMI In Overweight And Obese Children And Adolescents: A Systematic Review And Trial Sequential Meta-Analysis. *Biomed Research International*, *2015*, 1–17. Https://Doi.Org/10.1155/2015/704539

Khairani, R., Adriani, D., & Amani, P. (2021). Obesity Is The Most Influential Risk Factor Of Cardiopulmonary Endurance In Older Women. *Zinc Supplementation Improves Heme Biosynthesis In Rats Exposed To Lead*, *40*(3), 254–262. Https://Doi.Org/10.18051/Univmed.2021.V40.254-262

Mahar, M. T., Welk, G. J., & Rowe, D. (2018). Estimation Of Aerobic Fitness From PACER Performance With And Without Body Mass Index. *Measurement In Physical Education And Exercise Science*, *22*(3), 239–249. Https://Doi.Org/10.1080/1091367x.2018.1427590

Martin, B.-J., Aggarwal, S., Stone, J. A., Hauer, T., Austford, L. D., Knudtson, M. L., & Arena, R. (2012). Obesity Negatively Impacts Aerobic Capacity Improvements Both Acutely And 1-Year Following Cardiac Rehabilitation. *Obesity*, *20*(12), 2377–2383. Https://Doi.Org/10.1038/Oby.2012.119

Nopiyanto, Y. E. (2023). VO2Max Level Of Convicted Students At Special Prisons For Child Development Institution (LPKA) Class II Bengkulu. *Kinestetik Jurnal Ilmiah Pendidikan Jasmani*, *7*(4), 2015–2024. Https://Doi.Org/10.33369/Jk.V7i4.29781

Oller, L., Dyer, W. B., Santamaría, L., Largo, C., Javidroozi, M., & Shander, A. (2019). The Effect Of A Novel Intravenous Fluid (Oxsealife®) On Recovery From Haemorrhagic Shock In Pigs. *Anaesthesia*, *74*(6), 765–777. Https://Doi.Org/10.1111/Anae.14627

Pinzon, R. (1998). Hubungan Indeks Massa Tubuh Dengan Kapasitas Vital Paru-Paru Golongan Usia Muda. *Bul. Penelit. Kesehatan*.

Rusanov, V., Shitrit, D., Fox, B. D., Amital, A., Peled, N., & Kramer, M. R. (2008). Use Of The 15-Steps Climbing Exercise Oximetry Test In Patients With Idiopathic Pulmonary Fibrosis. *Respiratory Medicine*, *102*(7), 1080–1088. Https://Doi.Org/10.1016/J.Rmed.2007.12.031

Setty, P. V, Bv, P., & Doddamani, B. R. (2013). Correlation Between Obesity And Cardio Respiratory Fitness. *International Journal Of Medical Science And Public Health*, *2*(2), 300. Https://Doi.Org/10.5455/Ijmsph.2013.2.298-302

Tan, Y. H., Lim, J. P., Lim, W. S., Gao, F., Teo, L., Ewe, S. H., Keng, B. M., Tan, R. S., Koh, W., & Koh, A. S. (2022). Obesity In Older Adults And Associations With Cardiovascular Structure And Function. *Obesity Facts*, *15*(3), 336–343. Https://Doi.Org/10.1159/000521729

Tangkudung, J., Haqiyah, A., Puspitorini, W., Tangkudung, A. W. A., & Riyadi, D. N. (2020). The Effect Of Body Mass Index And Haemoglobin On Cardiorespiratory Endurance. *International Journal Of Innovation, Creativity And Change*.