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RELATIONSHIP OF HEMOGLOBIN CONCENTRATION AND LUNG VITAL CAPACITY WITH MAXIMAL AEROBIC CAPACITY (VO_2 MAX) AT INDONESIAN NATIONAL ATHLETES

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Abstract

The objectives of this research are to obtain information the relationship of hemoglobin concentration and lung vital capacity with VO_2 max at Indonesian national athletes either separately or together. This study was conducted at Indonesian national athletes by using survey method with regression and correlation techniques analysis. The number of 50 athletes from 550 populations as a sample is selected purposive random sampling, The research findings there are 1). There is a relationship of hemoglobin concentration with VO_2 max, equation of regression $\hat{Y} = -18{,}76 + 4{,}2X_1$, used T test (α= 0,05), t_{value} = 10,25, t_{table} = 2,00, correlation coefficient ; rxy_1=0,719 and determinant coefficient (r^2) = 0,517, 2). There is a relationship of lung vital capacity with VO_2 max, equation of regression $\hat{Y} = 7{,}16 - 8{,}98\,X_2$, used T test (α= 0,05), t_{value} = 7,48, t_{table} = 2,00, correlation coefficient; rxy_2=0,733 and determinant coefficient (r^2) = 0,538 , 3). There are a relationship of hemoglobin concentration and lung vital capacity are together with VO_2 max, equation of regression $\hat{Y} = 11{,}53 + 0{,}35\,X_1 - 1{,}88\,X_2$, used T test (α= 0,05), t_{value} = 87,28, t_{table} =1,59, correlation coefficient ry_{1-2} = 0,734 and determinant coefficient(ry_{1-2}) = 0,539

***Keywords**; Hemoglobin concentration, lung vital capacity and VO_2 max*

Achievement an athlete cannot be separated from physical fitness. Excellent physical fitness is generally directly related to the high achievements of an athlete. Some physical fitness components that must be owned by an athlete, including muscular strength, muscular endurance, flexibility, body composition, speed, reaction time, explosive power, coordination, balance and cardio respiratory endurance or maximal aerobic capacity.

VO_2 max is a significant factor in the performance of prolonged activities. This stems from the fact that the aerobic system supplies the majority of energy required of these types of exercises. In aerobic exercise or cardio endurance exercise, oxygen is brought to the tissues with the role of hemoglobin. Therefore, sufficient hemoglobin concentration will have an impact on the amount of oxygen in the tissues. Other than that, because maximal aerobic capacity is defined as maximal rate at which oxygen can be consumed in the tissues, then the amount of oxygen in the lung will have an impact with the amount of oxygen in the tissues.

Many athletes who do not know the role of Hemoglobin and lung vital capacity in support the increase VO_2 max. Some research on this has been done but unfortunately gives mixed results. Therefore, the researcher want to do research on the relationship of hemoglobin and lung vital capacity with VO_2 max at Indonesia national athlete, so the athlete can know how big the role hemoglobin and lung vital capacity in support of the support the increase VO_2 max. .

The VO_2 max is defined as the maximal rate at which oxygen can be consumed. The higher an athlete's VO_2 max, more successfully he or she will perform in endurance events, provided all other factors that contribute to championship performance are present. Cardio respiratory endurance is the ability to perform activities of mild to sub maximal intensity level involving large groups of muscles are continuously. Good cardio respiratory endurance is reflected in the high VO_2 Max. Typically the cardio respiratory endurance is described as a percentage of one's maximal aerobic capacity (%_VO_2max). Traditionally it has been accepted that the maximal aerobic capacity or VO_2max is the best physiological indicator of the oxygen transport system's capability when taxed maximally. Maximal aerobic capacity or $V0_2$ Max, is a reproducible measure of the capacity of the cardiovascular system to deliver oxygenated blood to a large muscle mass involved in dynamic work

The rate of maximal oxygen uptake, where the $V0_2$ represents volume of oxygen consumed, usually in liters or milliliters, and the dot over the V is a notation that tells us that this volume is to be expressed per unit of time, usually per minute. Thus, the expression, $V0_2$ max = 3 L/min, means that a person can maximally consume oxygen at a rate of 3 liters per minute.

It is not unusual for oxygen uptake to increase about 10 until 20 times when one passes from a condition of rest. to heavy endurance exercise. There is a fairly broad range of values for maximal oxygen uptake, depending on such factors as state of physical training, age, and sex. Because oxygen is used by all the body tissues, a larger individual has a greater oxygen uptake than a smaller one both at rest and during exercise.

The means of transport and delivery of oxygen and carbon dioxide through the cardiovascular and pulmonary circulatory systems vary based on several factors, such as the individual solubility of the gases in solution, the partial pressure of the gases in the blood, and the presence of hemoglobin in the blood. The two means of oxygen transport in the blood are:1) dissolved in the plasma and (2) bound to hemoglobin

Hemoglobin is an oxygen binding protein on the red blood cell. Roughly 98.5% of oxygen in the blood is bound to and transported by hemoglobin, and the presence of this protein increases the total blood oxygen capacity 70 times. It helps to understand the basic characteristics of hemoglobin. It is made up of an iron containing compound called heme, which is directly involved in the oxygen binding process, and a protein structure called globin. There are approximately 250 million hemoglobin molecules on each red blood cell, and there are 20 to 30 trillion red blood cells in the blood. That is a lot of hemoglobin. The characteristics of the blood are very important for endurance exercise. Since hemoglobin in the red blood cells oxygen, it is obvious that the numbers of red blood cells amount of hemoglobin in those cells are important in determining how much oxygen can be transported to the working muscles. Hemoglobin, or 'Hb', is a protein found in the red blood cells that carries oxygen around the body and gives blood its red colour. Red blood cells are able to carry oxygen so efficiently because of a special protein inside them: hemoglobin. In fact, it is the hemoglobin that is responsible for the colour of the red blood cell.

There are two lungs in the body, a right and a left lung, each located within the thoracic cavity. The lungs are separated by the heart, and enclosed and supported by the rib cage and respiratory muscles. Each lung is a cone-shaped organ composed primarily of a light, spongy tissue that contains hundreds of millions of microscopic air-filled sacs called alveoli. The weight of one lung is relatively small, averaging approximately 1 kg (2.2 lb) in a 70-kg (154 lb) adult. The right lung is subdivided into three lobes, (upper, middle, and lower) and is larger than the left lung, which contains only two lobes (upper and lower). The left lung is marginally smaller than the right lung because the heart protrudes into the left side of the thoracic cavity. Thus, the right lung is not as obstructed by the heart and represents approximately 55% of total lung volume. Connected to the base of the lungs is the diaphragm, a fatigue-resistant skeletal muscle that directs inspiration.

Mathematically, the VC is the sum of IRV, VT, and ERV. Physiologically, VC is the maximum amount of air that can be expired following a maximal inspiration. Thus, a person must exhale as large a breath as possible into a spirometer to get an accurate assessment of VC. Because VC is a general indicator of lung size, it is logical to suggest that larger and taller individuals will have a higher VC.

METHOD

The objectives of this research are to obtain information the relationship of hemoglobin concentration and lung vital capacity with VO_2 max at Indonesian national athletes either separately or together. This study was conducted at Indonesian national athletes by using survey method with regression and correlation techniques analysis. The number of 50 athletes from 550 populations as a sample is selected purposive random sampling.

RESULT

Data Description

Data description of this research include; the lowest value, highest value, average, standard deviation and varian of each variable X_1, X_2 as well variable Y, read more below :

Table. 1. Data Description

Variable	Hb (X_1)	Vital capacity (X_2)	VO_2 Max (Y)
Lowest value	11	2,28	24
Highest value	16,1	4,94	53,7
Average	13,88	3,74	40,77
Std deviation	1,29	0,63	7,69

Table 2. Frequent Distribution of Hemoglobin Concentration (X_1)

No	Interval class	Median	Absolute frequent	Relative frequent
1	11 - 11.7	11.35	4	8%
2	11.8 - 12.5	12.15	6	12%
3	12.6 - 13.3	12.95	10	20%
4	13.4 - 14.1	13.75	9	18%
5	14.2 - 14.9	14.55	10	20%
6	15.0 - 15.7	15.35	6	12%
7	15.8 - 16.5	16.15	5	10%
	Total		50	100%

Based on tables 1 and 2, highest value of Hb 16,1 and lowest value 11 with average 13,8 and standard deviation 1,29. Athletes who have a Hb below average 20 or 40%, while athletes who have Hb above average 30 or 60%

Table. 3. Frequent Distribution of lung vital capacity (X_2)

No	Interval class	Median	Absolute frequent	Relative frequent
1	2.28 - 2.66	2.47	4	8%
2	2.67 - 3.05	2.86	4	8%
3	3.06 - 3.44	3.25	6	12%
4	3.45 - 3.83	3.64	11	22%
5	3.84 - 4.22	4.03	12	24%
6	4.23 - 4.61	4.42	11	22%
7	4.62 - 5.00	4.81	2	4%
	Total		50	100%

Based on tables 1 and 3, highest value of lung vital capacity 4,94 and lowest value 2,28 with average 3,74 and standard deviation 0,63. Athletes who have a lung vital capacity below average 17 or 34%, while athletes who have lung vital capacity above average 33 or 66%.

Table. 4. Frequent Distribution of VO_2 max (Y)

No	Interval class	Median	Absolute frequent	Relative frequent
1	24 - 28.2	26.1	4	8%
2	28.3 - 32.5	30.4	5	10%
3	32.6 - 36.8	34.7	9	18%
4	36.9 - 41.1	39	8	16%
5	41.2 - 45.4	43.3	8	16%
6	45.5 - 49.7	47.6	9	18%
7	49.8 - 54	51.9	7	14%
	Total		50	100%

Based on tables 1 and 4, highest value of VO_2 max 53,7 and lowest value 24 with average 40,77 and standard deviation 7,69. Athletes who have a VO_2 max below average 20 or 40%, while athletes who have VO_2 max above average 30 or 60%

Hypothesis

1. Relationship of Hb and VO_2max

Relationship of hemoglobin concentration with maximal aerobic capacity with regression $\hat{Y} = -18{,}76 + 4{,}2X_1$. There is increase value of X_1 (Hemoglobin concentration) will increase value of Y (Maximal aerobic capacity) and contrarily there is decrease value of X_1 will decrease value of Y.

Relationship degree of hemoglobin concentration (X_1) with maximal aerobic capacity (Y) is showed by value correlation coefficient as rxy_1=0,719, to know significance degree of correlation coefficient used T test with error degree 0,05 ($\alpha = 0{,}05$). The correlation coefficient can be seen in the following table :

Table. 5. Correlation Coefficient test X_1 and Y

Correlation Coefficient	Determinant Coefficient	T_{value}	t_{table}
0,719	0,517	10,25	2,00

Correlation Coefficient test X_1 and Y find t_{value} = 10,25 more than t_{table}= 2.00 Meaning correlation coefficient rx_1y = 0,719 is significance. Thus the hypothesis that there is a positive relationship (proportional) between hemoglobin concentration with maximal aerobic capacity is supported by research data

2. Relationship of Lung Vital Capacity and VO_2max

Relationship of Lung Vital Capacity with maximal aerobic capacity with regression $\hat{Y} = 7{,}16 - 8{,}98\, X_2$. There is increase value of X_2 (Lung vital capacity) will increase value of Y (Maximal aerobic capacity) and contrarily there is decrease value of X_2 will decrease value of Y.

Relationship degree of Lung vital capacity (X_2) with maximal aerobic capacity (Y) is showed by value correlation coefficient as rxy_2= 0,733, to know significance degree of correlation coefficient used T test with error degree 0,05 ($\alpha = 0{,}05$). The correlation coefficient can be seen in the following table :

Table.6. Correlation Coefficient test X_2 and Y

Correlation Coefficient	Determinant Coefficient	T_{value}	T_{table}
0,733	0,538	7,48	2,00

Correlation Coefficient test X_2 and Y find t_{value} = 7,48 more than t_{table}= 2.00 Meaning correlation coefficient rx_2y = 0,733 is significance. Thus the hypothesis that there is a positive relationship (proportional) between lung vital capacity with maximal aerobic capacity is supported by research data.

1. **Relationship of Hb and Lung Vital Capacity with VO_2 max**

Relationship of Hb and lung vital capacity with maximal aerobic capacity with regression $\hat{Y} = 11{,}53 + 0{,}35X_1 - 1{,}88X_2$. There is increase value of X_1 (hemoglobin concentration) and X_2 (lung vital capacity) are together will increase value of Y (maximal aerobic capacity) and contrarily there is decrease value of X_1 and X_2 together will decrease value of Y.

Relationship degree of Hb (X_1) and lung vital capacity (X_2) with maximal aerobic capacity (Y) is showed by value correlation coefficient as $ry_{1\text{-}2}$= 0,734, to know significance degree of correlation coefficient used T test with error degree 0,05 (α = 0,05). The correlation coefficient can be seen in the following table :

Table.7. Multiple Correlation Coefficient test X_1 and X_2 with Y

Correlation Coefficient	Determinant Coefficient	F_{value}	F_{table}
0,734	0,539	87,28	1,59

Correlation Coefficient test X_1 and X_2 with Y find F_{value} = 87,28 more than F_{table}= 1,59. Meaning correlation coefficient $rx_{1X2}y$ = 0,734 is significance. Thus the hypothesis that there is a positive relationship (proportional) between hemoglobin concentration with maximal aerobic capacity is supported by research data.

Determinant coefficient is ($ry_{1\text{-}2}$) = 0,539, meaning that 53,9% of VO_2 max is determined by Hb and lung vital capacity are together.

DISCUSSION

As described earlier that VO_2 max is defined as the maximal rate at which oxygen can be consumed. The higher an athlete's VO_2 max, more successfully he or she will perform in endurance events, provided all other factors that contribute to championship performance are present. The Basketball athlete has VO_2 max 40-60 ml/Kg BW/min, cycling athlete has VO_2 max 62-74 ml/Kg BW/min, canoeing athlete has VO_2 max 55-67 ml/Kg BW/min, rowing athlete has VO_2 max 60-72 ml/Kg BW/min, tennis athlete has VO_2 max 55-62 ml/Kg BW/min, soccer athlete has VO_2 max 54-64 ml/Kg BW/min, weightlifting athlete has VO_2 max 38-52 ml/Kg BW/min and wrestling athlete has VO_2 max 52-65 ml/Kg BW/min.

The factors affecting VO_2 max are often divided into supply and demand. Supply is the transport of oxygen from the lungs to the mitochondria, including lung diffusion, stroke volume, blood volume, and capillary density of the skeletal muscle. VO_2 max is generally influenced by genetic, age, sex, fitness and training, changes in altitude and action of the ventilatory muscles.

Cardiac output, vital capacity, pulmonary diffusion capacity, oxygen carrying capacity especially hemoglobin concentration and other peripheral limitations like muscle diffusion capacity, mitochondrial enzymes, and capillary density are all examples of VO_2 max determinants.

Vital capacity refers to the maximum amount of air the person is capable of expelling from their lungs after maximum inhalation. This is equal to the sum of inspiratory reserve volume, expiratory reserve volume and tidal volume. Normal adults have a vital capacity between 3-5L. The vital capacity an individual exhibits will vary based on their height, weight, sex, age and aerobic and resistance training. The various type of training that can be done athlete to improve vital capacity. Cardio-endurance training is the best way to improve vital capacity.

1. Relationship of Vital Capacity with VO_2 maximal

Cardio-endurance training is included in the physical exercise type. If athlete does cardio-endurance regularly, it influences the vital capacity because cardio-endurance training is an exercise that needs oxygen to form its energy persistently and rhythmically. It's assumed that the athlete that does several activities with intensity aerobic target zone that being systematically has good lungs.

A variety of sports require the athlete to take in a large amount of air to be successful. There are methods that can be used to increase the amount of air the lungs take in and the efficiency of capturing oxygen. Practicing these training daily can increase vital capacity over time.

The biggest change of athlete respiratory system during a moderate to vigorous-intensity workout is probably the number of breaths per minute. The muscles need more oxygen when they are working, which will cause an increase in they are breathing rate. While at rest, respiratory rate may take about 15 breaths per minute, but when they are work out, that rate more than doubles to between 40 and 50 breaths in a minute's time. As athlete exercise harder and harder, their breathing rate and heart rate will increase to a certain point and then won't go any higher. The point at which their body can no longer use any more oxygen is called your VO_2 max.

Any form of cardio-endurance training, including treadmill, rowing machine, swimming and running, is a critical component of a healthy lifestyle. Cardio-endurance training expands lung capacity and improves heart efficiency by raising heart rate.

a. Treadmill

The treadmill is one of the most basic machines available for cardio-endurance training. Cardio-endurance training requires heart to pump blood which carries oxygen throughout the body. When athletes run or walk fast, the heart pumps blood more quickly, thereby improving the amount of oxygen circulating to different vital organs and their extremities. Running as fast during twenty minutes three until five times a week is a great way to improve vital capacity. The better their cardiovascular endurance, the more efficient the body is at using oxygen, thus improving their vital capacity. Oxygen enters the blood through the lungs. The heart pumps that blood to the muscles and organs, where it is used by the cells and tissues as part of a complicated process to produce energy for the body to use during daily activities as well as during moments of more intense physical activity. Although the lungs cannot expand in size, cardio-endurance training can improve vital capacity by adding the number of active alveolar then helps the body make the process of breathing and holding oxygen in lungs more efficient.

b. Rowing machine

The rowing machine is another cardio machine that boosts vital capacity. It also trains the heart to pump blood faster, thereby distributing oxygen throughout the body efficiently. Rowing also requires athlete to breathe quickly and deeply and so it improves vital capacity. Athlete can practice doing different types of breathing while rowing to determine which will best suit the body. Row for 20 to 30 minutes and 3 until 5 times a week for best results.

c. Running

Running is a common form of cardio-endurance training because of the few barriers to entry to engage in the activity. With proper running shoes, one can run almost anywhere. Through running, the body improves its cardiovascular endurance and builds muscles, particularly in the lower body, including the hips, thighs, calves and feet. As the lungs improve their capacity to hold oxygen, the heart will efficiently send oxygen-rich blood to muscles, especially the ones doing work in the lower body.

d. Swimming

Swimming laps or swimming for fun for a prolonged period of time will improve the lung capacity and cardiovascular endurance. Any cardio training should be done at three until five times a week for 30 or more minutes. Cardiovascular system begins to adapt to this regimen, the lungs will increase the capacity of oxygen taken with each breath, thus sending more oxygen to the blood. Swimming engages muscles in both the upper and lower body, so requires the heart must send oxygen rich blood to muscles in both extremities**.**

Beside of cardio endurance training, vital capacity can be enhanced by strength training of the respiratory muscle especially abdominal muscles. Strengthening of the respiratory muscles can be done with weight training or breathing exercise. Many kinds of breathing exercise that can perform athletes, among others:

e. Counted Breathing

The athlete hold his breath and slowly relax the muscles in the face and abdomen, then count to 100 in his heat and let his breath out when they cannot hold it any longer. Each time you perform this technique try to hit a higher number, using his previous progress as a benchmark. Take 3-4 breaths, exhaling slowly and then repeat the exercise. Then repeat the exercise 3-4 more times. Performing this technique regularly can help to increase long term vital capacity.

f. Breathing Techniques

Breathing deeply can help the lungs absorb more air over time. To perform this technique, inhale deeply, allowing the lungs to fill around 85 percent. Do not puff out the cheeks, but keep the face loose and relax to force the diaphragm and stomach muscles to work. Exhale slowly until the lungs are emptied. It may take some practice to complete this technique successfully. Allow the diaphragm to descend, relaxing the abdominal muscles so the lungs are expanded. Widen the arms and hold them away from the body to open the chest and take in a deep breath.

g. Lungs and High Altitudes

The air pressure inside the lungs decreases when they go to high altitudes. Their heart then pumps blood faster to distribute oxygen more effectively to the vital organs and other parts that need it the most. Training-induced hypoxemia is a great way to increase lung capacity. Nevertheless they should alternate training in water, high altitudes and normal surfaces to allow their body to adapt better.

Working out at higher elevations means there will be less oxygen available, forcing the lungs to work more efficiently to get the amount of oxygen their body needs to function. High altitude training at around 8000 feet (2,500 m) above sea level will force the lungs to work much harder, a condition that their body will be able to maintain as they move back down to lower elevated areas. This will increase their vital capacity over time.

2. Relationship of Hemoglobin with $_{VO2}$ maximal

Hemoglobin is an iron-rich protein present in red blood cells. This protein is responsible for carrying oxygen throughout the body. It also transports carbon dioxide out of cells and back to lungs to be exhaled.

a. Training

If the athlete does moderate to high intensity workouts cause the body produces more hemoglobin to meet the increasing demand for oxygen throughout the body. The right kind of physical activity can also help. Cardio endurance training promote blood cell formation, a process known as hematopoesis. And when athlete has more blood cells, they will has more hemoglobin.

As cardio endurance training, walking or brisk and fast movements are best. The movements will encourage blood cell production and hemoglobin. Jogging or running as cardio endurance training will make they break a sweat while protecting the heart. Better yet, they'll make more blood cells and increase hemoglobin. Biking or cycling is another training that increases hemoglobin. Swimming is another low-impact activity that will increase heart rate and build endurance. As they move around, their body will make more blood cells.

b. Diet

Eating a balanced diet is the best way to ensure athlete get a daily supply of all essential nutrients for increase your hemoglobin count. If the athlete need to raise their hemoglobin level by a lot, they may need to take oral iron supplements. I recommend that male athlete get up to 8 mg of iron per day, while female athlete should get up to 18 mg per day. The top iron rich foods include green leafy vegetables like spinach, tofu, asparagus, chicken liver, whole egg, oysters, apple, pomegranate, apricot, watermelon, prunes, pumpkin seeds, dates, almonds, raisins.

Increase Vitamin C intake. It is important to have a combination of both iron and vitamin C as the latter is a carrier rich molecule that can be used for better absorption of iron. Eat foods rich in Vitamin C such as oranges, lemon, strawberries, papaya, bell peppers, broccoli, grapefruit and tomatoes.

Folic acid, a B-complex vitamin, is required to make red blood cells. Some good food sources of folic acid are green leafy vegetables, sprouts, dried beans, wheat germ, bananas, broccoli and chicken liver. "Beetroot is also highly recommended to increase the body's red blood cell count as it is high in folic acid as well as iron, potassium and fiber. As conclusion if the athlete wants their VO_2 maximal are high then they should increase lung vital capacity and Hemoglobin concentration.

CONCLUSION

There is a relationship between hemoglobin and lung vital capacity at Indonesia national athlete. When hemoglobin and or lung vital capacity increase either alone or simultaneously it will be followed by increase VO_2 max. Contrarily when hemoglobin and or lung vital capacity decrease either alone or simultaneously it will be followed by decrease VO_2 max.

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