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EFFECT OF 8 WEEKS OF MODERATE-INTENSITY AEROBIC EXERCISE ON INCREASING ERYTOCYTE CELL MEMBRANE ENDURANCE AND ERYTROCYTE CELL COUNT

Moch. Yunus
Universitas Negeri Malang, East Java, Indonesia
Email: moch.yunus.fik@um.ac.id

Abstract

The purpose of this study was to examine and analyze the effect of 8 weeks of moderate-intensity aerobic exercise on increasing the endurance of erythrocyte cell membranes and the number of erythrocyte cells. This research is apseudo-experimental research with a quantitative approach, and uses pretest and posttest design. The population in this study was students majoring in PKO FIK UM, with sampling techniques using purposive sampling, and the number of samples was 20 people. The independent variable in this study was moderate-intensity aerobic exercise. Exercise is done with a frequency of 3 times per week, for 8 weeks and the duration of exercise is 30 minutes. The dependent variables are: 1) the durability of erythrocyte cell membranes, and 2) the number of erythrocyte cells. Pretest and posttest dependent variable data were collected by venous blood checking techniques carried out in the Bromo Malang Diagnostic clinical laboratory. Data analysis using the paired sample t test technique using α 0.05. The results of the analysis of research data showed that Osmotic Fragility as a variable indicator of erythrocyte cell membrane durability Pretest 0.46±0.04% and postest 0.43±0.06%, P-value 0.028 < α (0.05) while variable number of erythrocyte cells pretest 5.4590 ± 0.223 million / uL and postest 5.6270± 0.142 million / uL,. P-value 0.022 < α (0.05). It can be concluded the effect of 8 weeks of moderate intensity aerobic exercise can increase significantly on increasing the endurance of erythrocyte cell membranes and the number of erythrocyte cells.

Keywords: membrane endurance; erythrocyte cell count; 8 weeks exercise.

INTRODUCTION

The response and adaptation of exercise to erythrocytes has been a hot topic in sports medicine studies in recent decades. Most previous studies have centered on 'sports anemia' (Hu & Lin, 2012). Research conducted to determine the adaptation of exercise to the erythrocyte system results vary. This is influenced by many factors, such as differences in exercise programs, types of cells measured, research subjects and measurement methods. Differences in exercise programs cause different results, this is related to the intensity and duration of exercise and the length of the exercise program (Lee et al., 2021).

Medeiros et al.,(2017) obtained research findings Findings that increased stiffness of erythrocyte membranes caused by acute exercise can result in increased oxidative damage to lipids caused by exogenously produced ROS.

The results of Hu & Lin, (2012) study, concluded that exercise stimulates erythropoiesis and increases hemoglobin (Hb) levels and red cell mass, which increases oxygen transport capacity. Different things were obtained from the results of research conducted by Rønnestad et al., (2021) showed the results of reducing hemoglobin levels after aerobic exercise for eight weeks in 13 female athletes. This is in line with the results of research by Putra et al., (2017) that the High Intensity Interval Training exercise method can increase VO2max but does not increase the value of hemoglobin, erythrocytes and hematocrit.

Osmotic frichity of erythrocytes is one way of examination to describe the durability of erythrocyte cell membranes in maintaining the survival of erythrocyte cells (damaged). Adi & Fathoni, (2020) concluded that physical activity carried out for 8 weeks was not enough to provide the body's adaptation to erythrocyte osmotic fracicity. Different results obtained from the results of research Chou et al., (2016), moderate intensity exercise can improve aggregation, osmotic fringivity and reduce erythrocyte cell damage. Moderate-intensity aerobic exercise has been shown to improve body function. Yuniana, (2020),concluded Aerobic exercise can reduce body fat by 4.651% and increase lung vital capacity. Aerobic exercise can increase cardiorespiratory ability as an effect of air pressure on the physiology of the athlete's body, Nasrulloh et al., (2021). To get optimal results due to aerobic exercise should pay attention to: (1) exercise intensity is expected to reach the training zone, (2) the length of exercise, (3) the frequency of exercise, and (4) the duration of the exercise program (Listyarini, 2012; Nasrulloh et al., 2021)

Aerobic exercise can also cause the formation of free radicals, this is because aerobic exercise can increase oxygen consumption up to 20 times, even in muscles can reach 100 times. Aerobic exercise results in the process of ischemia-perfusion, at the time of aerobic exercise there is also temporary hypoxia in the tissues of some inactive organs such as the kidneys, liver and intestines. High-intensity aerobic exercise with a pulse rate of 80- 85% of the maximum pulse rate, muscle fibers become hypoxic, because at the moment when the muscles contract strongly, squeezing intramuscular blood vessels in the active part of the muscle, as a result of which there is a decrease in blood flow to the active muscle. After finishing the exercise, the blood quickly returns to various organs that lack blood flow, resulting in reperfusion that can cause a number of free radicals to participate in circulation (Kawamura, 2018). Excessive production of free radicals in the body will trigger a condition called oxidative stress. Malondialdehyde (MDA) is an end product of fat peroxidation that is used as a biological biomarker of fat peroxidation and can describe the degree of oxidative stress. While the SOD enzyme is the main endogenous antioxidant enzyme that has an important role directly protects cells from free radical interference, and indirectly maintains a toxic oxygen balance (Rahmawati et al., 2018). Erythrocytes are body cells that are very vital function, erythrocytes are also one of the body cells that are very vulnerable to free radicals. Kruk et al., (2019) concluded that physical activity response can increase oxidative stress and adaptation to regular physical exercise can reduce oxidative stress. Based on the above, this study aims to examine and analyze the increase in the durability of erythrocyte cell membranes and the number of erythrocyte cells due to moderate-intensity aerobic exercise.

RESEARCH METHODS

This study is a pseudo-experimental study, with a randomized group pre-test and post-test design. The variables in this study consisted of treatment variables, namely moderate-intensity aerobic exercise (70-80% of maximum pulse rate), with a frequency of 3x / week, for 8 weeks, exercise duration of 30 minutes. The dependent variable consists of the durability of erythrocyte cell membranes, with indicators of erythrocyte osmotic fragility examination results and the number of erythrocyte cells. Venous blood sampling is carried out before treatment and after the end of treatment after 24 hours of physical activity. Venous blood sampling and examination are carried out at the Bromo Malang diagnostic laboratory which is carried out by skilled and trained personnel. The procedure for laboratory examination of osmotic fraciality is by using 12 tubes with varying levels of concentration of NaCl solution. The next procedure adds 0.05 ml of blood to each tube. Then put the tube at room temperature for 30 minutes then centrifuge for 5 minutes at 3000 rpm. The supernatant is transferred to the cuvette and read using a spectrophotometer with a wavelength of 540 nm. Joyce, (2008) While the examination of the number of erythrocyte cells using the results of a complete blood examination with the Sysmex XP 100 Hematology Analyzer method.

The population of this study is students of the PKO FIK UM Department, class of 2019 which amounted to 98 people. The study sample was taken by purposive sampling, with the following criteria: (a) Male gender, (b) Age 18-20 years, (c) Normal Body Mass Index, (d) No smoking. The number of research samples was 20 male students. The data were analyzed by paired sample t test using α 0.05. The analysis requirements of the t-test technique include data normality tests (Shapiro–Wilk technique test).

RESULT AND DISCUSSION

Description of pretest and posttest data from Osmotic Fagility (FO) research results as an indicator of erythrocyte cell membrane durability and the number of erythrocyte cells are described as follows:

Table 1. Analysis Results of Bound Variable Data Description

Variable	Pretest	Postest	Delta
Erythrocyte Membrane Durability (FO%)	0.46±0.04	0.43±0.06	-0.03±0.03
Erythrocyte intercalation (million/uL)	5.4590 ± 0.223	5.6270± 0.142	0.1650± 0.057

In Table 1 above, the average posttest data (0.43±0.06%) on the variable osmotic fragility of erythrocytes (FO) decreased, this shows the occurrence of lysis in erythrocyte cells at lower NaCl concentrations. This illustrates the increased resistance of erythrocyte cell membranes. The number of erytocyte cells in the postest was 5.6270± 0.142 million/uL, which indicates greater than the number of pretest erythrocyte cells. This shows an increase in the number of erythrocyte cells.

Table 2.
Results of the Dependent Variable Normality Test Analysis (Shapiro-Wilk Test)

Variable		Sig	Status
Erythrocyte Cell Membrane Durability	Pretest	0,765	Normal Distribution
	Postest	0,813	Normal Distribution
Number of erythrocyte cells	Pretest	0,097	Normal Distribution
	Postest	0,059	Normal Distribution

Based on Table 2 above, the sig value on all variables, both pretest and posttest, shows p results >0.05. This means that all variables are normally distributed.

Table 3. Results of Dependent Variable Difference Test Analysis

Variable	Sig	Information
Pair FO Pre-Post	0.028	Significant
Erythrocyte Pair Pre-Post	0.022	Significant

Based on Table 3, the results of all dependent variable components between pretest and posttest differ significantly (p< 0.05). This means that as a result of moderate-intensity aerobic exercise there is a significant difference between the average pretest and posttest in all dependent variable components.

This research is one type of pseudo-experimental research using pre-test and post-test design. Sampling of this study by Purposive Randomized Sampling with a sample of 20 people. The sample criteria used include: male, aged between 18-20 years, nirmal body mass index and not smoking. It is expected that the more variables that are controlled, the more dependent variables change because of their independent variable factors. The independent variable in this study was moderate-intensity aerobic exercise, with a frequency of 3 times per week, for 8 weeks, and a duration of exercise of 30 minutes. It is hoped that with this treatment there will be adaptation due to training. The dependent variables in this study are: 1) osmotic fraciality of erythrocytes as an indicator of erythrocyte cell membrane durability, and 2) number of erythrocyte cells. The dependent variable is measured through venous blood sampling. While venous blood sampling is carried out before and after the exercise program, venous blood samples are taken 24 hours after physical activity. This is in accordance with what Evans & Omaye, (2017) did in their research report also revealed for blood sample examination carried out 24 hours after physical activity.

Sports practice is a modulator of biological functions that can have a broad impact both positive impacts (improving, repairing), and negative impacts (inhibiting, damaging). Sports practice is an important part of life, because sports practice can maintain and increase the degree of health of the body, and will be able to result in an increase in physical performance of the body and can also prevent premature aging. Regular exercise practice is a stimulation to all body systems so that the body will be able to maintain the body remains in a healthy state. Sports training also aims for education, recreation, as well as to achieve an achievement in a championship (Rajšp & Fister Jr, 2020). Aerobic exercise will result in an increase.

The body's metabolism, especially in the skeletal muscles, this increase in metabolism aims to increase energy production (ATP) to meet energy needs for these activities. This increase in metabolism is followed by an increase in the need for O2, to meet the needs of O2 and the expenditure of CO2 and heat requires the integrated work of various cardiovascular and respiratory mechanisms. Changes in circulation will increase blood flow to muscles, while adequate circulation to other tissues must be maintained (Lepe et al., 2021).

Exercise must be done by paying attention to the dose of exercise with the principle of FIT or frequency, intensity, and tempo in order to obtain maximum results (Mayasari & Resley, 2020). Frequency is the amount of exercise in one week of exercise performed in order to give the effect of exercise. The ideal frequency of exercise is 3-5 times a week. Exercise less than 3 times a week does not indicate adaptation of exercise, while exercise more than 5 times a week does not provide a chance for the body to recover. Intensity is the weight of the training load given. Aerobic exercise is performed with light to moderate intensity. Exercise is enough to increase the ability of the heart when given a load between 60-80% or with a heart rate rule between 70-85% of the maximum heart rate. The team represents the duration of the exercise. Research shows the length of exercise between 20-30 minutes is enough to give an increase in ability as much as 35% when done 3 times a week within a period of one and a half months.

Aerobic exercise performed using the correct exercise principles will provide a good biological influence and adaptation to the body. If an exercise is done according to its basic principles, it will improve physical quality. Changes that occur in the body, including chemical changes, an increase in cup volume, a minute increase in volume, an increase in blood and haemoglobin volume, an influence at the cellular level, increasing the number and diameter of mitochondria, increasing various enzyme activities needed for the Kreb cycle and electron transfer (Warburton & Bredin, 2017). Exercises can be done with different durations and intensities. Exercise duration is the length of time an exercise lasts in a single training session, expressed in units of time. Meanwhile, the intensity of exercise is principally the light weight of the exercise or the workload of the exercise. The intensity of exercise can be expressed in absolute and relative terms. In absolute terms, exercise intensity can be judged by the expenditure of energy used per unit time in units of kcal or joules per minute. While relatively speaking, exercise intensity can be assessed, among others, by calculating the training pulse what percentage of the maximum heart rate (%HR) or calculating oxygen use, what percentage of maximum oxygen consumption (VO2 max) in units of ml / kg / minute (McArdle et al., 2010). Physiologically, exercise exerts physical stress on the body that can produce an adaptive response. The recommended physical exercise is as long as the body is able to adapt to the excessive load on the body (overload principle). Training at a high enough intensity can induce specific adaptations that allow the body to function more efficiently (McArdle et al., 2010). Wang et al., (2023) concluded that there is a relationship between exercise intensity and increased hemolysis. This shows that heavy intensity exercise will reduce the resistance of erythrocyte cell membranes.

The main function of erythrocyte cells is the transport of O2 to cells and tissues and the return of CO2 from cells and tissues to the lungs. Erythrocytes are flexible and biconcave, this is useful for passing through capillaries or microcirculation that is Ø 3.5µ, as well as keeping hemoglobin in a reduced state, as well as to maintain osmotic balance even though there is a high concentration of protein in cells (Shouval et al., 2021). The oxygen condition of cells and tissues is the basis for the formation of erythrocytes. The functional ability of cells to transport oxygen to cells and tissues in conjunction with tissue oxygen demand regulates the speed of erythrocyte formation. Any circumstances that cause the amount of oxygen transported to tissues to decrease will increase the speed of erythrocyte production.

Continuous physical activity will cause a hypoxic state in the body, at the cellular level this hypoxic state will trigger the transcription factor HIF-1 (hypoxia induced factor-1) which plays a role in tissue adaptation to low-oxygen conditions, HIF-1 in tissues in the kidneys and liver will trigger the encryption of erythropoietin genes so that erythropoietin will be produced which will be released into the blood circulation (Kibble, 2021). This theory is also supported by research that describes individuals living in lowlands with low-oxygen conditions at high altitudes, these continuous hypoxic conditions are found to increase hemoglobin levels significantly (Calbet & MacLean, 2002).

Adaptation to exercise training is also known to increase the production of antioxidants, such as Catalase (CAT), Superoxide Dismutase (SOD), and Gluthathion Sulfur Hydroxyl (GSH) (Elbassuoni and Abdel Hafez, 2019; Guerreiro et al., 2016). Antioxidant defense is very necessary for a cell, because cells will continuously form oxygen free radicals reactive oxygen species (ROS) during the process of respiration and inflammatory conditions (Ore and Akinloye, 2019). Excessive production of free radicals in the body will trigger a condition called oxidative stress. Malondialdehyde (MDA) is an end product of fat peroxidation that is used as a biological biomarker of fat peroxidation and can describe the degree of oxidative stress. Meanwhile, SOD enzyme is the main endogenous antioxidant enzyme that has an important role in directly protecting cells from free radical interference, and indirectly maintaining toxic oxygen balance (Costa et al., 2021).

Erythrocytes are body cells that are very vital function, erythrocytes are also one of the body cells that are very vulnerable to free radicals. The oxidants formed inside erythrocytes are superoxide (O.2-), hydrogen peroxide (H2O2), peroxyl radicals (ROOD.). Sources of free radicals due to exercise can come from 1) increased autooxidation process of Haemoglobin (Hb) to methemoglobin, 2) increased electron transport system in mitochondria, 3) lactic acid buildup, 4) increased xanthine oxidase (XO), and 5) increased cathecolamine production (W. Wang et al., 2021).

Discussion of erythrocyte cell membrane durability

The process of hematopoiesis occurs in the bone marrow. Reticulocytes, which are premature forms of erythrocytes, will maturate and form erythrocytes that are 8 µm in diameter, biconcave disc-shaped with a cell age of 120 days (Pasini et al., 2006). Erythrocytes are a major component of blood after leukocytes, platelets and plasma (Liu et al., 2020). The erythrocyte membrane is permeable to water molecules (H2O). This is due to the AQP1 protein transport (Shao et al., 2018). Erythrocytes introduced in a hypertonic solution will experience cell shrinkage because more water comes out of the cell than it enters. Conversely, if erythrocytes are in a hypotonic environment, osmosis will occur from the outside into the cell which will cause the cell to bulge. If the plasma membrane cannot withstand the high intracellular pressure due to the achievement of critical volume, the cell will rupture and hemoglobin will be released (Pornprasert et al., 2018).

The erythrocyte osmotic fracicity test assesses the incidence of erythrocyte lysis due to osmotic stress. The degree of osmotic fragility of erythrocytes is influenced by the ratio of cell surface area to cell volume. Increased osmotic fragility can also be influenced by free radicals. Free radicals are also one of the causes of erythrocyte damage. Versteeg et al., (2020), said free radicals have a role in the osmotic fragility of erythrocytes. During physical activity there is mechanical trauma to erythrocytes caused by muscle contractions during physical activity, in addition during physical activity there is an increase in body temperature, lack of body fluids, hemoconcentration and oxidation stress which are the causes of erythrocyte hymolysis during exercise and during the recovery period (Guest et al., 2021). Mattiuzzi & Lippi, (2019) found that the life span of erythrocytes in runners is about 40% shorter than sedentary controls. Direct mechanical injury caused by strong ground contact, repetitive muscle contractile activity or vasoconstriction of internal organs are three potential sources of exercise-induced hemolysis, while metabolic abnormalities develop during exercise (e.g., hyperthermia, dehydration, hypotonic shock, hypoxia, lactic acidosis, shearing). stress, oxidative damage, proteolysis, increased concentrations of catecholamines and lysolecithin) can actively contribute to triggering, accelerating or amplifying this phenomenon.

The burden of physical activity carried out regularly provides the body's adaptation to the ability to produce anti-free radicals and the ability to ward off free radicals caused by physical activity (Kruk et al., 2021). Paraiso et al., (2017) concluded that acute exercise has resulted in a decrease in the osmotic stability of erythrocytes, possibly associated with exacerbations of oxidative processes during intense exercise, chronic exercise for 18 weeks resulting in increased osmotic stability of erythrocytes, possibly by modulation in membrane cholesterol content by low and high density lipoproteins. The results of research by Hu & Lin, (2012) cycling interval training, 5 days / week, 30 minutes, an average intensity of 60% VO2Max, for 5 weeks can improve aggregation, osmotic fragility and reduce erythrocyte cell damage. Hashida et al., (2021) also examined moderate cotinous traning (MCT). After exercise 5 times / week, for 5 weeks obtained the results of an increase in VO2Max and a decrease in osmotic fragility of erythrocytes which means an increase in the resistance of erythrocyte membranes. The results of a study conducted by Noor et al. (2021), showed that the results of moderate-intensity aerobic exercise increased the osmotic resistance of erytorcytes. Tsukiyama et al., (2017) Moderate intensity running exercise in wistar rats, every day, 30 minutes, for 4 weeks resulted in decreased muscle cell damage and increased osmotic resistance of erythrocytes. Alfan et al., (2021) concluded that aerobic activity has the potential for osmotic fragility of erythrocytes. So to prevent physical activity must use the right dose and pay attention to nutritional aspects, especially those that contain anti-free radical substances, such as containing vitamin C, and vitamin E.

Research shows the results of the effect of moderate-intensity aerobic exercise on osmotic fringivity (FO) as a marker of erythrocyte membrane resistance, the test results between pretest and posttest osmotic fraciality obtained a significant difference ($p < 0.05$). This shows that there is a significant difference between the average pretest results and the results on the erythrocyte osmotic fragigility variable posttest. It can be concluded that there is a significant effect of moderate intensity aerobic exercise on the increase in the endurance of erythrocyte cell membranes. In this study the average posttest osmotic fragility of erythrocytes decreased, this means that in the osmotic fragility test erythrocytes with a decrease in fluid concentration (hypotonic) are still able not to rupture. Because the osmotic frigility test assesses the incidence of erythrocyte lysis due to osmotic stress. This means that if erythrocytes are in a hypotonic environment, osmosis will occur from the outside into the cell which will cause the cell to bulge. If the plasma membrane cannot withstand the high intracellular pressure due to the achievement of critical volume, the cell will rupture. In this study the osmotic fringivity of erythrocytes decreased by -0.03±0.03 (6.52%), this means that moderate-intensity aerobic exercise was effective in increasing the endurance of erythrocyte membranes by 6.52%.

Discussion of erythrocyte cell count results

Physiological adaptation due to exercise requires sufficient exercise intensity to stimulate aerobic excitatory threshold values. Aerobic exercise results in an increase in body metabolism, especially in the musculoscletal system. This increase in metabolism is useful for increasing ATP production, so that energy needs for activity can be met. This increased metabolism will certainly be followed by an increase in O2 needs, to meet the needs of O2 and CO2 expenditure and heat requires integrated work of various cardiovascular and respiratory mechanisms. Changes in the cardiorespiratory system during aerobic exercise will increase blood flow to muscles, while adequate circulation to other tissues must be maintained (Versteeg et al., 2020).

Aerobic exercise that is carried out continuously with moderate intensity will cause a state of hypoxia in the body. Hypoxia at the cellular level is a transcription factor for hypoxia induced factor-1 (HIF-1) which plays a role in the response of cells and tissues to low oxygen conditions. HIF-1 in the kidneys and liver will trigger the encryption of erythropoietin genes so that erythropoietin hormone will be produced which will be released into the blood circulation (Means Jr et al., 2023) . This hypoxic condition theory is also supported by Research that exposed individuals living at high altitudes with low oxygen concentrations. This hypoxic condition that occurs continuously can increase hemoglobin levels significantly (Calbet & MacLean, 2002). Erythropoeitin hormone, a hormone in the circulatory system, will pass through the hematopoetic bone marrow (red marrow) and bind to its receptors in the cell system, this bond will trigger the maturation of stem cells into erythroid precursor cells that will undergo a maturation process through a series of reactions with cytokines such as stem cell factor, interleukin-3, interleukin-11, granulocyte-macrophage colony stimulating factor and thromopoietin.

Increased production and number of erythrocyte cells due to aerobic exercise will increase hemoglobin levels in the blood, this increase in hemoglobin levels will increase maximum oxygen capacity although other hematological parameters do not change much. In this study it has been proven that moderate intensity aerobic exercise can result in a significant increase in the number of erythrocyte cells. This is because when doing exercises our body experiences hypoxic conditions. Hypoxic conditions are the main factor in our body forming the hormone erythropoiein. The hormone erythropoetin will trigger the bone marrow to produce more erythrocyte cells.

The results of this study can be shown in Table 3. From the pretest and posttest t tests, the number of erythrocytes obtained p 0.022 ($p < 0.05$). This shows that there is a significant difference between pretest and posttest in the variable number of erythrocyte cells. So it can be concluded that moderate intensity aerobic exercise, frequency 3x / week, and duration of exercise for 8 weeks can significantly increase the number of erythrocyte cells. This is in accordance with the results of Hu & Lin, (2012) study, exercise stimulates erythropoiesis and increases Hb levels and red cell mass, which improves oxygen transport. The underlying mechanisms are mainly in the bone marrow, including stimulating erythropoiesis with hyperplasia of the hematopoietic bone marrow, exercise-induced hematopoietic microenvironment enhancement, and erythropoietic hormones and cytokines accelerating erythropoiesis. Ammar et al., (2020) stated that aerobic and anerobic exercise have an effect on increasing the number of erythrocyte cells. Likewise, the results of research by Dalmazzo & Ramírez, (2019) concluded that there is a significant effect of interval training on the increase in the number of erythrocyte cells, and the increase in VO2max. Different results were obtained from the results of Putra's research (2017), that the high intensity interval training exercise method can increase VO2max but does not increase the value of hemoglobin, erythrocytes and hematocrit.

CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the effect of 8 weeks of moderate-intensity aerobic exercise can significantly increase the endurance of erythrocyte cell membranes and the number of erythrocyte cells.

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