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The Effectiveness of Physical Exercise on Changes in Vo2max, Muscle Endurance, and Blood hemoglobin levels in athletes

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ABSTRACT

Athletes' physical fitness, especially VO2max and muscle endurance, must be increased or maintained because it determines the ability of an athlete to carry out their activities. Physical fitness needs special attention because it is an important element in almost all sports. To determine the effect of physical exercise on changes in VO2max, muscle endurance, and hemoglobin in athletes. This research is a quasi-experimental research with a pre and post-test one-group design with two measurements, before exercise, and after exercise. A total of 40 samples were recruited to participate in this study with predetermined inclusion and exclusion criteria. Physical exercise was given 3 times a week for 2 months. VO2max with bleep test, muscle endurance with half squat jump, and Hemoglobin with routine blood test Results. Physical exercise is very effective on athlete's muscle endurance but is not effective for increasing VO2max and hemoglobin of athletes at the Makassar Student Sports Education and Training Center (PPLP).

1. Introduction

Exercise is one of the physical activities that can improve physical fitness. The exercise involves several systems other than the skeletal muscle system, such as the cardiovascular system, respiratory system, nervous system, excretory system, and several other systems. This system can affect the increase in VO2max, muscle endurance, and hemoglobin levels in the blood. Lack of muscle endurance, VO2max, and hemoglobin in the blood as factors that cause problems with athletes' activity abilities. During the long-term developmental stage of athletes, endurance training is an important means of stimulating athletic development, tolerating long-term demands of training and competition, and promoting strong long-term health-promoting effects over time and continuing into adulthood [1]. With physical condition training, the athlete's physical fitness can be improved or maintained. Physical fitness greatly determines the ability of an athlete in carrying out their activities. The physical condition needs special attention because it is an important element in almost all sports. VO2max is defined as the maximum capacity of the cardiovascular, pulmonary, and muscular systems to utilize and deliver oxygen, which is an indication of cardiorespiratory fitness [2- 4]. VO2max measurement provides important information about physical performance and

overall health [2], it is often used by professional and amateur athletes to measure their aerobic capacity [5].

Many studies have shown that VO2 max is strongly related to endurance performance. This association is based largely on studies of heterogeneous samples, and when the relationship between VO2 max and marathon performance is examined in a homogeneous group of highly trained runners (with the same performance and timing) there appears to be little relationship between VO2 max and performance. Well-developed aerobic capacity (VO2 max) is a prerequisite for endurance performance. So VO2 max is important in determining endurance performance, especially for everyone. Muscular endurance is the ability of a muscle or group of muscles to sustain repeated contractions against a resistance for a long period [6]. High Vo2 Max must be supported by optimal hemoglobin levels. Athletes have higher hemoglobin than untrained people. The benefits of regular exercise are well known to the general public, such as increased aerobic capacity and muscle strength, both of which are important for the ability to lead an active life and for good health [7].

The average human body contains 2 liters of oxygen, which consists of 1 liter in HB 0.5 liters in the air in the lungs, 0.3 liters stored in muscles called myoglobin, and 0.25 liters in the body. This shows that hemoglobin is the highest oxygen storage place in the human body. Hemoglobin carries oxygen from the lungs to all body tissues and carries carbon dioxide from all over the body back to the lungs. It is important to understand that hemoglobin is a determinant of maximal oxygen uptake [8]. To be successful, an athlete must have a high VO2max, good muscle endurance, and optimal hemoglobin levels. Many efforts have been made to overcome the problem of muscle endurance, VO2max, and hemoglobin levels, but so far it has not been optimally addressed, therefore researchers offer efforts in the form of providing physical exercise to increase muscle endurance, VO2max, and hemoglobin levels. Because physical activity is important in increasing muscle endurance, VO2max, and hemoglobin levels to prevent cardiovascular and neuromusculoskeletal system disorders, this research is necessary.

2. Materials and Methods

2.1 Subject

This research is a quasi-experimental study with a pre and post-test one-group design with two measurements, before and after exercise. The subjects of this study were 40 people from 43 athletes of the Makassar Student Sports Education and Training Center (PPLP) at the time of the study using a random sampling technique. The inclusion criteria in this study were all PPLP athletes, not injured, who did not take the pre-test or post-test. The Makassar Health Polytechnic ethics committee approved the research protocol number 128/KEPK-PTKMS/IV/2022.

2.2 Outcome Results

Vo2 max with bleep test, muscle endurance with half squat jump, and hemoglobin with routine blood test assessed at baseline, and after exercise 3 times a week for 2 months.

2.3 Statistic analysis

The data were found to be normally distributed according to the normality test. Paired sample t-test was used to compare baseline data on Vo2 max, muscle endurance, and hemoglobin after exercising 3 times a week for 2 months.

3. Findings and Discussion

Physical exercise that is done regularly for 8-12 weeks will increase a person's vo2max with an increase that

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varies between 15-20%. Some people experience an increase of 20-30%, but some experience an increase in VO2max of less than 15%. After 12 weeks of training, Vo2max tended to be flat or experienced an insignificant increase. This study used 40 subjects and was carried out for 2 months. The results of this study are presented in tabular and narrative form using univariate and bivariate analysis. the most sport is takraw with 10 subjects (25%).

Table 1 Analysis of the characteristics of the subject according to age, gender, and sport

Subject Characteristics	n	%
Age (years)		
13 – 15	17	42.5
16 – 18	23	57.5
Total	40	100
Gender		
Male	23	57,5
Female	17	42,5
Total	40	100
Sports		
Athletics	6	15,0
Rowing	5	12,5
Karate	8	20,0
Pencak silat	7	17,5
Takraw	10	25,0
Boxing	4	10,0
Total	40	100

Age greatly determines muscle maturation, as one of the factors that determine a person's ability to carry out activities to increase VO2max capacity, muscle endurance, and hemoglobin levels in the blood. The age of the research subjects, the majority of whom are 16-18 years, is the ideal age to increase VO2max capacity, muscle endurance, and repair of hemoglobin in the blood. Increasing the age of a person will reduce the ability to do activities. This is in line with the results of research which states that increasing age will affect muscles and bones [9]. Likewise, the results of research state that increasing age will cause a decrease in muscle mass and function [10]. Likewise for gender, where the male gender is more than the female the activity ability of the research subject is greater. Gender is very decisive in activities so that differences can be obtained in obtaining muscle endurance, VO2max, and hemoglobin levels. Gender differences cause differences in body composition as an impact on muscle endurance, VO2max and hemoglobin levels [11], [12]. In addition, muscle endurance is also influenced by the ability of mitochondria to oxidize, ATP synthesis, muscle fibers, and vascularization [13]. Likewise, the types of sports that are carried out daily, where takraw is the most sports activity that requires movements that require energy such as jumping, somersaults, and smashes, to increase the ability of muscle endurance, VO2max, and adequate hemoglobin.

Table 2 Vo2max analysis of athletes before and after training
To determine the athlete's VO2max ability, measurements were taken before and after being given physical exercise 3 times a week for 2 months

VO2max athlete	n	Mean	SD	p-value

Before exercise	40	42.877	5.9857	0.369*
After exercise	40	43.381	5.5856	

The results of the analysis using the paired t-test showed that the average VO2max was 42.877 + 5.9857 before giving physical exercise, and the average VO2max after physical exercise was 43.381+ 5.5856 with p-value = 0.369 > 0.05, which means there is an increase in VO2max is not significant. Thus, physical exercise does not affect the athlete's VO2max. This is because the athlete in question is used to high-intensity training and is at the peak of his performance, so the improvement is not very noticeable. According to Kisner et.al (2017) "VO2max is the main factor to determine exercise intensity or step speed that can be done continuously. VO2max is usually expressed in body weight, in milliliters of oxygen consumed per kilogram per minute (mL/kg per minute) VO2max depends on oxygen transport, oxygen binding capacity in the blood, heart function, oxygen diffusion ability, and oxidative potential in muscles. With an endurance training program, more oxygen can be delivered and consumed so untrained people can experience an average VO2max increase of 20% or more after joining the training program". This is in line with the results of research which states that exercise with a treadmill provides a gradual increase in VO2max and is higher in the group that does exercise [14]. VO2max can be influenced by the form of exercise and cardiorespiratory fitness [15]. Likewise, interval training has shown insufficient evidence to increase the VO2max of trained runners [16].

Table 3 Analysis of athlete's muscle endurance before and after exercise
To determine the ability of the athlete's muscle endurance, measurements were taken before and after being given physical exercise 3 times a week for 2 months

Muscular endurance athlete	n	Mean	SD	p-value
Before exercise	40	75.73	13.938	0.001*
After exercise	40	85.33	16.239	

The results of the analysis using a paired t-test showed that the average muscle endurance of the subject before giving physical exercise was 75.73 + 13,938, and the average muscle endurance after physical exercise was 85.33 + 16,239 with a p-value = 0.001 < 0 0.05, which means there is a significant increase in VO2max. Thus it can be concluded that physical exercise given 3 times a week for 2 months can increase the endurance of the athlete's muscles. There is an increase in the number and size of mitochondria in muscles so that it can increase the capacity of muscles to produce ATP aerobically. In addition, there is an increase in the concentration of myoglobin in the muscles which can increase the speed of oxygen transport and the rate of oxygen diffusion in the mitochondria. The change that occurs is a decrease in the rate of muscle glycogen depletion at a submaximal level of work. This is due to an increase in the capacity to mobilize and oxidize fat, an increase in fat mobilization and metabolic enzymes, a decrease in lactic acid levels in the blood, and a decrease in phosphocreatine and ATP in skeletal muscle. This will be followed by an increase in the ability to oxidize carbohydrates due to an increase in oxidative potential in mitochondria and an increase in glycogen stores in muscles. The ability of muscle contraction depends on the energy provided by ATP. The amount of ATP available in muscles, even in trained muscles, is only sufficient to maintain maximum muscle strength for about 3 seconds. For this reason, a metabolic system is needed so that ATP is still formed [13], [17], [18].

Table 4 Analysis of athlete's hemoglobin level before and after exercise
To determine the hemoglobin level in the athlete's blood, measurements were taken before and after being given physical exercise 3 times a week for 2 months.

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Hemoglobin athlete	n	Mean	SD	p-value
Before exercise	40	14.128	1.392	0.550*
After exercise	40	14.202	5.985	

The results of the analysis using a paired t-test showed that the average hemoglobin level of athletes before physical exercise was 14,128 + 1,392, and the average hemoglobin level of athletes after physical exercise was 14,202 + 5,985 with a p-value = 0,550 > 0,05, which means there is no significant difference. This means that physical exercise does not affect increasing the athlete's blood hemoglobin level. Hemoglobin levels that are above and below the optimal value will disrupt homeostasis. Therefore, the body responds to maintain a relatively stable internal environment (homeostasis) including the body's efforts to optimize blood hemoglobin levels that are not optimal. When an athlete performs the physical exercise, there is an approximately 85% increase in blood flow to skeletal muscles. This increased blood flow causes red blood cells to break down because they are pinched against body tissues (such as the soles of the feet) when they come into contact with hard body surfaces. Physical exercise or techniques that are carried out for a long time will cause more red blood cells to be damaged. Damage to red blood cells results in a decrease in iron stores in the body which are stored in the form of ferritin. The decrease in iron reserves in the body requires iron input from outside. So, if there is an iron imbalance, the hemoglobin level in the blood will decrease. Strenuous physical exercise also causes a relative decrease in blood supply, iron, and ischemic changes in the intestinal mucosa that cause microscopic blood to flow [19]. The results of another study showed that during exercise deoxy (Hb + Mb) did not change [20].

4. Conclusion

Physical exercise is very effective for increasing an athlete's muscle endurance, but not effective for increasing an athlete's VO2max and hemoglobin.

5. References

[1] U. Granacher et al., “Effects of resistance training in youth athletes on muscular fitness and athletic performance: A conceptual model for long-term athlete development,” Front. Physiol., vol. 7, no. MAY, 2016, DOI: 10.3389/fphys.2016.00164.

[2] T. Brink-Elfegoun, L. Kaijser, T. Gustafsson, and B. Ekblom, “Maximal oxygen uptake is not limited by a central nervous system governor,” J. Appl. Physiol., vol. 102, no. 2, pp. 781–786, 2007, DOI: 10.1152/japplphysiol.00566.2006.

[3] B. D. Levine, "V̇O2: What do we know, and what do we still need to know?" J. Physiol., vol. 586, no. 1, pp. 25–34, 2008, DOI: 10.1113/jphysiol.2007.147629.

[4] B. K. Pedersen and B. Saltin, “Exercise as medicine - Evidence for prescribing exercise as therapy in 26 different chronic diseases,” Scand. J. Med. Sci. Sport., vol. 25, pp. 1–72, 2015, DOI: 10.1111/sms.12581.

[5] H. Petot, R. Meilland, L. Le Moyes, L. Mille-Hamard, and V. L. Billat, "A new incremental test for VO2max accurate measurement by increasing VO2max plateau duration, allowing the investigation of its limiting factors," Eur. J. Appl. Physiol., vol. 112, no. 6, pp. 2267–2276, 2012, DOI: 10.1007/s00421-011-2196-5.

[6] R. T. Kell, G. Bell, and A. Quinney, “Musculoskeletal fitness, health outcomes and quality of life,”

Sport. Med., vol. 31, no. 12, pp. 863–873, 2001, DOI: 10.2165/00007256-200131120-00003.

[7] X. Sui et al., “Cardiorespiratory fitness and adiposity as mortality predictors in older adults,” J. Am. Med. Assoc., vol. 298, no. 21, pp. 2507–2516, 2007, doi: 10.1001/jama.298.21.2507.

[8] J. Malczewska-Lenczowska, D. Sitkowski, J. Orysiak, A. Pokrywka, and Z. Szygula, “Total haemoglobin mass, blood volume and morphological indices among athletes from different sport disciplines,” Arch. Med. Sci., vol. 9, no. 5, pp. 780–787, 2013, doi: 10.5114/aoms.2013.36926.

[9] L. Bonewald, “Use It or Lose It to Age: A Review of Bone and Muscle Communication,” Physiol. Behav., vol. 176, no. 1, pp. 139–148, 2016, DOI: 10.1016/j.bone.2018.11.002.Use.

[10] V. Santilli, A. Bernetti, M. Mangone, and M. Paoloni, “Clinical definition of sarcopenia,” Clin. Cases Miner. Bone Metab., vol. 11, no. 3, pp. 177–180, 2014, DOI: 10.11138/combo/2014.11.3.177.

[11] Y. Yaprak and N. Küçükkubaş, “Gender-related differences on physical fitness parameters after core training exercises: A comparative study,” Prog. Nutr., vol. 22, no. 3, 2020, doi: 10.23751/pn.v22i3.9334.

[12] S. G. H. Sara Pourheydari, Rahman Sheikhhoseini, “Correlation Between the Functional Movement Screen (FMS) Test with Dynamic Balance and Core Endurance in Male and Female Volleyball Players in Kerman Province,” Syria Stud., vol. 7, no. 1, pp. 37–72, 2015, [Online]. Available: https://www.researchgate.net/publication/269107473_What_is_governance/link/548173090cf22525dcb61443/download%0Ahttp://www.econ.upf.edu/~reynal/Civil wars_12December2010.pdf%0Ahttps://think-asia.org/handle/11540/8282%0Ahttps://www.jstor.org/stable/41857625.

[13] N. A. H. Octavia, M. Ichwan, and P. C. Eyanoer, “Correlation between Hemoglobin Levels and Muscular Endurance in Soccer Athletes,” Indones. J. Med., vol. 3, no. 3, pp. 168–172, 2018, doi: 10.26911/theijmed.2018.03.03.07.

[14] N. Prommer et al., “Influence of endurance training during childhood on total hemoglobin mass,” Front. Physiol., vol. 9, no. MAR, pp. 1–9, 2018, DOI: 10.3389/fphys.2018.00251.

[15] J. Lee and X. L. Zhang, “Physiological determinants of VO2max and the methods to evaluate it: A critical review,” Sci. Sport., vol. 36, no. 4, pp. 259–271, 2021, doi: 10.1016/j.scispo.2020.11.006.

[16] A. Parmar, T. W. Jones, and P. R. Hayes, “The dose-response relationship between interval-training and VO2max in well-trained endurance runners: A systematic review,” J. Sports Sci., vol. 39, no. 12, pp. 1410–1427, 2021, DOI: 10.1080/02640414.2021.1876313.

[17] M. Hargreaves and L. L. Spriet, “Skeletal muscle energy metabolism during exercise,” Nat. Metab., vol. 2, no. 9, pp. 817–828, 2020, DOI: 10.1038/s42255-020-0251-4.

[18] R. Wibom, E. Hultman, M. Johansson, K. Mather, D. Constantin-Teodosiu, and P. G. Schantz, "Adaptation of mitochondrial ATP production in human skeletal muscle to endurance training and detraining," J. Appl. Physiol., vol. 73, no. 5, pp. 2004–2010, 1992, DOI: 10.1152/jappl.1992.73.5.2004.

ISSN: 0005-2523
Volume 62, Issue 06, August, 2022

[19] V. Novack, A. S. Finestone, N. Constantini, O. Shpilberg, S. Weitzman, and D. Mertel, "The prevalence of low hemoglobin values among new infantry recruits and nonlinear relationship between hemoglobin concentration and physical fitness," Am. J. Hematol., vol. 82, no. 2, pp. 128–133, 2007, DOI: 10.1002/ajh.20791.

[20] J. F. Reis et al., "Tissue oxygenation in response to different relative levels of blood-flow restricted exercise," Front. Physiol., vol. 10, no. APR, pp. 1–9, 2019, DOI: 10.3389/fphys.2019.00407.