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EFFECTIVENESS OF JOGING AND SWIMMING TRAINING ON MAXIMUM OXYGEN VOLUME IMPROVEMENT (VO_2 MAX) IN ADOLESCENT MEN

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Abstract

Objective: *To determine the effectiveness of exercise jogging and swimming to increase the maximum volume of oxygen (VO_2 max) on adolescents.* ***Methods*** *: This study is an experimental study to determine the effects of interventions to research object. The sample consisted of 24 students (adolescents aged 17-25 years), and are selected based on purposive sampling technique to use your table parq assessment tests (Physical Activity Readiness Questionnaire) available. Samples were divided into two treatment groups, ie the first treatment group consisted of 12 people with a given practice jogging, while the treatment group II consisted of 12 people with a given swimming.* ***Results*** *: hypothesis testing in treatment I mean before it was 36,093 ± 0,518, after the average was 39,876 ± 0,544 with related t-test p value = 0,001 which means jogging exercise can improve VO_2 max on adolescents. On average before treatment II was 36,160 ± 0,580, after the average was 40,820 ± 0,434 with related t-test p value = 0,001 which means the swimming exercises can improve VO_2 max on adolescents. III hypothesis testing I mean treatment was 3,796 ± 0,193, mean treatment II was 4,743 ± 0,364 with independent t-test showed the value of 0,187, which means there are differences increase VO_2 max on adolescents.* ***Conclusions*** *: Exercise jogging and swimming are effective in improving VO_2 max on adolescents. However, swimming exercises better in improving VO_2 max on adolescents.*

Keywords *: Jogging, Swimming, VO_2 max.*

Backgroud

In the development of health science at this time, efforts in the health sector have experienced development. Not limited to curative efforts, but also promotive, preventive and rehabilitative efforts. Sport has gained a place in the world of health as an important factor in disease prevention efforts. With exercise it is also proven to increase the degree of health and physical fitness level. A person who has excellent physical fitness can perform daily activities optimally and not get tired quickly, and still have energy reserves to be able to do other activities. According Ekowarni (2001) among adolescents as a result of lack of physical activity and lifestyle of adolescents who do not pay attention to health so that the impact will affect health and fitness factors, which will arise problems related to health and fitness. One of them, namely regarding the endurance of the heart and lungs. These problems can have an impact on the decreased ability to meet the needs of oxygen uptake (O_2) to the maximum or many affected by heart disease and other problems that will later have an impact on fitness and health in the body (Girwijoyo & Dikdik, 2013).

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VO_2 max is defined as taking the maximum volume of oxygen that can be utilized in one minute, during the maximum activity or exercise which is calculated in units of mL / kg / Bb (Quinn, 2014). A person's physical fitness can be influenced by several factors, namely internal and external factors. Internal factors, including age, gender, genetic makeup, and race. External factors themselves, for example, forms of exercise, lifestyle (alcohol, smoking, do not like sports, etc.), body composition, height, and geographical location.

Cardiac and Lung Physiology of Aerobic Exercise

The effects of cardiovascular physiology when the body performs physical activity, namely stimulation of myelinated and unmelinated fibers in skeletal muscle so that it involves the response of the sympathetic nervous system, while the central pathway is unknown. Sympathetic nervous system responses generally include peripheral vasoconstriction in the muscles when exercising and increased cardiac contractility, increased heart rate, increased systolic blood pressure. This causes a marked increase in cardiac output distribution. The level of response is the same as muscle mass depending on the intensity of the exercise. An increase in cardiac output is caused by an increase in contractility in the heart muscle, an increase in stroke volume, an increase in blood flow through the working aorta, and an increase in peripheral venous pressure.

Respiratory changes occur quickly, even before gas exchange during exercise, (O_2 & CO_2) increases across the alveolar membrane and capillaries during the first breath or second breath. Increased muscle metabolism during additional exercise results in increased venous PCO PC and H +, increased body temperature, increased epinephrine, increased stimulation of joint and muscle receptors. From these factors can stimulate the respiratory system. Reflex baroreceptors, protective reflexes, pain, emotions, can contribute to increased respiration. Ventilation frequency increases every minute following an increase in tidal volume. In alveolar ventilation, gas diffusion occurs across the alveolar capillary membrane, increasing 10-20 times during physical activity or strenuous exercise, to supply the additional O2 needed and release excessive CO_2 (Kisner, 2007).

Jogging Training:

According to Sheehan (2011), quoted by Prisandika, in her book defines that jogging is an activity with speeds below 6 miles / hour, or equal to 9.7 km / hour.

Biomechanics of Jogging Exercises

According to Guo et al (2006) the jogging process is known to have two phases, namely the stepping phase and the swing phase. Some added another phase, the two-foot phase on the floor (double support) that lasted a short time. This double support phase will get shorter if the speed of the road increases, even in the running phase, the double support is completely gone, and it actually occurs in a phase where both feet do not step on the floor. The tread phase (40%) starts from heel strike or heel on, foot flat, mid stance, heel off and ends with toe off or ball off. While the swinging phase (60%) starts from toe off, swing and ends with heel strike. This functional classification of the road phase, which is divided into the tread phase (initial contact, loading response, midstance, terminal stance and preswing) and the swinging phase (initial swing, midswing and terminal swing). The muscles that work when someone does jogging exercises, namely there are three types of muscles, among others: primary (primery), supporting (supporting), and additional (auxiliary). Primary muscles consist of m. quadrisep femoris, m. hamstring, m. gluteus maximus, m. iliopsoas, m. gastrocnemius, and m. soleus. Supporting muscles include m. biscep brachii, m. diaphragm and m. abdomen. While the additional muscles include m. external intercostals and m. internal intercostals (Barnet, 2010).

Heart and Lung Work Against Jogging Exercises

When jogging, changes in the cardiovascular system and respiration occur. Changes that occur in the cardiovascular system, namely an increase in heart size, decreased heart rate, increased stroke volume (SV), increased blood volume and hemoglobin, and increased VO_2 max. While the changes that occur in the work system of respiration, namely increased ventilation a minute, increased tidal volume, increased respiratory frequency, increased ventilator efficiency, increased lung volume, and increased lung diffusion capacity. (Shiel, 2015).

Effects of Jogging Exercises on Increasing VO_2 Max

Jogging exercise is a sport that more involves lower limbs and some other supporting muscles, namely m. quadrisep femoris, m. hamstring, m. gluteus maximus, m. iliopsoas, m. gastrocnemius, and m. soleus. Supporting muscles include m. biscep brachii, m. diaphragm and m. abdomen. While the additional muscles include m. external

intercostals and m. internal intercostals. The muscles work continuously without stopping during the jogging phase. The workings of these muscles are caused by metabolic processes.
Metabolic process in question, namely the breakdown of ATP into ADP. ATP is a high-energy phosphate compound that stores energy for the body. ATP is formed from the adenosine nucleitide coupled with phosphate groups in high-energy bonds. ATP hydrolysis releases one phosphate into ADP and releases energy. The release of phosphate will then become AMP releasing a lot of energy. The energy released from food catabolism is used by ADP to form ATP as energy storage. The ADP ATP system is the main way of transferring energy in cells. If one phosphate compound is released from ATP, it will release energy of 7-12 cal. Energy from the breakdown of ATP is one of which will be used as energy for muscle contraction. Muscle contraction is caused by aerobic exercise such as jogging mixed from a variety of movements that cause large amounts of muscle so that at any time the activity of the body's muscles occurs by about 40% (Giriwijoyo & Didik, 2013).
One of the sources of ATP is oxygen system from the oxidation process of carbohydrates and beta oxidation from fatty acids and proteins. In oxygen systems undergo oxidation reactions through the Krebs cycle (Pearce, 2013). If the greater the muscle contraction, the work of ATP is also getting bigger to produce a lot of energy. If more energy is needed, oxidation, beta oxidation from fats and proteins from the oxygen system occur, thereby increasing oxygen supply. If the need for oxygen supply increases, the working system of the heart and lungs will also increase because they have to pump blood throughout the body. With the improvement of the working system of the heart and lungs will increase VO_2 max (Kravitz & Lance, 2002).

Exercise or exercise can increase the average VO_2 max consumption is ± 38 mL / kg / min in healthy men who are active and ± 29 mL / kg / min in healthy and active women. At the time of exercise, the muscles use oxygen about 10-20 times more than at rest. This increase in O_2 also affects the muscles that are active with two mechanisms, namely (1) vasodilation of blood vessels in the muscles that are at work, (2) vasoconstriction of blood vessels to reduce blood flow and then followed by widening of blood vessels to increase blood flow. Exercise can also increase the number of capillaries, this is because the distribution of blood to muscle fibers is smoother. The level of performance of the individual who is doing exercise depends on the ability of the heart's performance, because the heart is the most limiting relationship of adequate oxygen transport to the muscles that are active. To reach cells, O_2 must pass through, (1) the lungs (respiratory system), (2) hemoglobin carries oxygen in the blood, (3) passes through the heart which is then pumped to the cells through the blood vessels. Blood flow to muscles will increase 25-fold maximum during the most strenuous training, this is due to the result of intramuscular vasodilation caused by a direct effect of an increase in muscle metabolism (Wiarto, 2013).

Jogging Exercise Procedure
a. Exercise Dosage
According to a journal published by the Journal of the American College of Cardiology cited by Curfman (2015), that the most beneficial exercise, which is a combination of slow or moderate jogging exercises 2-3 times a week, for a total of 60-145 minutes or 20 minutes every practice times with an intensity of 65-80% of HR max (220 - age), exercise time of 20-30 minutes.
b. Warming up
The warm-up motion is done to prevent muscle cramps as well as to gradually increase body temperature and heart rate. To warm up can be started by extending the lower limbs such as the limbs and upper limbs such as the arms for 5-10 minutes. Then rest for 30 seconds before doing the core set.
c. Core Training
Do jogging in the field with progressive methods for 5 minutes each set at week 1, week 2, week 3, week 4, week 5, and so on until week 6 of each repetition, then rest for 30 seconds
d. Cooling down
Cool down after jogging so that body temperature and heart rate do not decrease dramatically by walking at a slow pace for 5-10 minutes (Giriwijoyo & Didik, 2013).

Swimming Exercise
Swimming is one of the sports activities with aerobic type of exercise that aims to improve the function of the cardiorespiratory system (Kisner, 2007).

Biomechanics Swimming Training

The swimming process involves the upper and lower limbs, which consist of several movements in the limbs. The upper limb consists of movements (pronation and supination) arm, (flexion and extension) elbow, (flexion, extension, abduction, adduction, internal rotation and external rotation) shoulder. In the lower limbs consists of movements (internal rotation and external rotation) hip and pelvic, (flexion and extension) knee, and (plantar flexion) ankle. Besides the swimming process also involves several additional movements, namely the movement (rotation) neck and head, (scapular upwar rotation, scapular adduction, and scapular retracation, trunk flexion, lateral flexion, rotation) back and abdomen (Mantici & Mike, 2015). The muscles that work when someone does swimming exercises, which is almost most of the muscles from head to foot (Marion, 2010).

These muscles include the hand and wrist joint (flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor digitorum superficialis, flexor digttorum profundus, and flexor pollicis longus) , elbow joint (m. biceps brachii short head, brachialis, m. brachioradialis, m. pronator teres, m. triceps brachii long head, m. triceps brachii lateral head, m. triceps brachii medial head, m. aconeus), shoulder joint. (deltoid middle fibers, posterior posterior fibers, latissimus dorsi, infraspinatus, and teres minor, pectoralis major lower fibers, subscapularis, latissimusdortion, teres major) infraspinatus, teres minor, pectoralis major upper fibers, pectoralis major lower fibers coracobrachialis deltoid anterior fibers, pectoralis major upper fibers and deltoid anterior fibers).

Neck muscles that work, namely m. sternocleidomastoid, whereas on the back muscles that work during shoulder adduction, scapular retraction and upward rotation of the scapula, m. trapezius middle fibers, m. trapezius lower fibers, m.rhomboid, m. serratus anterior, m. trapezius upper fibers and m. trapezius middle fibers. In the core muscles (core muscle) and abdominal muscles that work, namely m. external and internal obliques, m. transverseabdominis, and the muscles that work on the hip joint and pelvic, namely m. gracilis, m. semitehdinosus, m. semimembranosus, m.illiacus, m. psoas major and m. minor, m. pectineus, m. biceps rhetorical, m. gluteus maximus, m. piriformis, m. gemellus superior, m. gemellus inferior, m. obturator internus, m. obturatorexternus, and m. quadratus femoris. Muscles that work on the knee joint, namely m. biceps femoris, m. popliteus, m. semimembranosus, m. semitendinosus, m. rectus femoris, m. vastus intermedialis, m. vastus lateralis, and m. vastus medialis, while the foot and ankle joint muscles that work, namely m. gastrocnemius, m. soleus, m. tibial posterior, m. flexor digitorum longus, m. flexor hallucis longus, m. peroneus longus, and m. peroneus brevis (Mantici & Mike, 2015).

In addition to the muscles of the limbs, the muscles of the chest cavity also work during the swimming process. These muscles, namely external and internal intercostals, and diaphragm muscles, (Mantici & Mike, 2015).

Heart and Lung Work Against Swimming Exercise

When swimming, changes in the cardiovascular system and respiration occur. Changes that occur in the cardiovascular system, namely an increase in heart size, decreased heart rate, increased stroke volume (SV), increased blood volume and hemoglobin, and increased VO_2 max. While the changes that occur in the work system of respiration, namely increased ventilation a minute, increased tidal volume, increased respiratory frequency, increased ventilator efficiency, increased lung volume, and increased lung diffusion capacity (Wiarto, 2013).

The Effect of Swimming Exercise On Increasing VO_2 Max

According to Harriman (2011) that in swimming training itself consists of various swimming styles which include, freestyle, butterfly style, breaststroke, and backstroke. With these various swimming styles, swimming exercises involve most of the work of muscle groups in the body. If jogging exercises use the muscles of the lower limbs, then another thing with swimming exercises that use the muscles of the lower and upper limbs.

When someone does swimming exercises, spur the work of various muscle groups both upper and lower extremities, neck muscles, back muscles, and muscles of the chest cavity, according to Giriwijoyo & Didik (2013). In fact, almost all the back muscles such as the trapezius, latissimus dorsi, serratus posterior, serratus anterior, etc., while the work of the muscles of the lower limbs include calf muscle, m. hamstring, m. quadriceps femoris, m. tensor fascia latae, gluteus, and hip abductor and hip adductor, while the muscles of the chest cavity, namely diaphragm, internal and external intercostals (Pearce, 2013). The muscles work continuously without stopping during the swimming phase. The workings of these muscles are caused by metabolic processes.

Metabolic process in question, namely the breakdown of ATP into ADP. ATP is a high-energy phosphate compound that stores energy for the body. ATP is formed from the adenosine nucleotide plus phosphate groups in high-energy bonds. ATP hydrolysis releases one phosphate into ADP and releases energy. The release of phosphate will then become AMP releasing a lot of energy. The energy released from food catabolism is used by ADP to form ATP as energy storage. The ADP ATP system is the main way of transferring energy in cells. If one phosphate compound is released from ATP, it will release energy of 7-12 cal. Energy from the breakdown of ATP is one of which is used as energy for muscle contraction. Muscle contraction is caused by aerobic exercise such as swimming mixed from a variety of movements that cause a large number of muscle groups so that at any time the activity of the body's muscles occurs by about 40% (Giriwijoyo & Didik, 2013).

One of the sources of ATP is oxygen system from the oxidation process of carbohydrates and beta oxidation from fatty acids and proteins. In oxygen systems undergo oxidation reactions through the Krebs cycle (Pearce, 2013). In this swimming exercise, in addition to the muscles of the working limbs, the diaphragm muscles also contract (work), because they have to take and hold O_2 in the lungs while in the water. The cause of the diaphragm muscles to contract, because there is an inspiration phase, so that the muscles between the ribs (external intercostal muscles) contract, the ribs will be lifted (flat position), the lungs expand, the air pressure in the lungs becomes smaller compared to the outside air pressure, thus the outside air will enter the lungs. If the air is still in the lungs after inspiration for a long time, the breathing muscles will work harder to hold the air in the lungs, before the air is expelled, thus the work of the heart and lung endurance will increased. When the muscles of the limbs and the muscles are contracted (working), the work of ATP will increase to produce a lot of energy. If more energy is needed, oxidation, beta oxidation from fats and proteins from the oxygen system occur, thereby increasing oxygen supply. If the need for oxygen supply increases, the heart (CO) and lung (TV, IRV and ERV) work system will also increase, and the heart and lung endurance will also increase, because they must take as much O_2 as possible before entering the water and holding O_2 in water, and pump blood throughout the body. With the improvement of the working system of the heart and lungs will increase VO_2 max (Kravitz & Lance, 2002).

Exercise or exercise can increase the average VO_2 max consumption is ± 38 mL / kg / min in healthy men who are active and ± 29 mL / kg / min in healthy and active women. At the time of exercise, the muscles use oxygen about 10-20 times more than at rest. This increase in O_2 also affects the muscles that are active with two mechanisms, namely (1) vasodilation of blood vessels in the muscles that are at work, (2) vasoconstriction of blood vessels to reduce blood flow and then followed by widening of blood vessels to increase blood flow. Exercise can also increase the number of capillaries, this is because the distribution of blood to muscle fibers is smoother. The level of performance of the individual who is exercising depends on the ability of the heart's performance, because the heart is the most limiting relationship of adequate oxygen transport to the muscles that are active. To reach cells, O_2 must pass through, (1) the lungs (respiratory system), (2) hemoglobin carries oxygen in the blood, (3) passes through the heart which is then pumped to the cells through the blood vessels. Blood flow to muscles will increase 25-fold maximum during the most strenuous training, this is due to the result of intramuscular vasodilation caused by a direct effect of an increase in muscle metabolism (Wiarto, 2013).

Swimming Exercise Procedure

a. Exercise Dosage

For exercise dose, frequency 3-5 times a week, intensity 65-80% of HR max (220 - age), exercise time is 20-30 minutes

b. Warming up

Walk around the pool 1-2 laps, then start by stretching (from head to foot) for 5-10 minutes, then rest for 30 seconds to prepare for the core exercise.

This warm-up aims to prevent muscle cramps while also functioning to gradually increase body temperature and heart rate.

c. Core Training

Do swimming with progressive methods for 5 minutes each set in week 1, week 2, week 3, week 4, week 5 and so on until week 6 of each repetition, then rest for 30 seconds (Giriwijoyo & Didik, 2013).

d. Cooling down

Cool down after swimming so that body temperature and heart rate do not decrease dramatically by walking at a slow pace for 5-10 minutes (Giriwijoyo & Didik, 2013).

Research methods

This is a quasi-experimental study to see the effectiveness of jogging and swimming exercises on increasing VO_2 max in the treatment group I (jogging exercise) and treatment group II (swimming exercise).

The sample size can be calculated using the pocock formula (2008), in previous studies according to Retired Adi W & Adeka Sangtraga H, with the title research on developing VO persamaan max equation and evaluating HR max (initial study on male workers), which obtained a value of $\mu 1 = 2.778$, the value of $\mu 2 = 2.788$ and SD = 0.28.

The sample size is determined by the Pocock formula (2008):

$$N = \frac{2(\sigma)^2}{(\mu 2-\mu 1)^2} \text{ x f } (\alpha,\beta)$$

σ = standard deviation
α = error rate I
β = error level II
$\mu 1$ = mean pre test score
$\mu 2$ = mean post test score
f (α, β) = values in the table (0,05,0,1)

$$N= \frac{2\ (0{,}28)^2}{(2{,}788-2{,}778)^2} \text{ x } 7{,}9$$

N= 12,3 rounded up to 12 people
So the number of samples needed is 24 people.
The value of VO_2max increase was measured and evaluated using a Balke test which then the results would be analyzed between treatment group I and treatment group II before and after treatment. In total, there were 24 samples as follows:

Treatment Group I
In the treatment group I, before being given a jogging exercise, the sample was measured using a Balke test to get preliminary data on VO_2max as a value before being given treatment, then this treatment group was given a jogging exercise for 18 times in a period of 1.5 months (6 weeks), with a frequency of 3 times jogging in a week. Then at the end of the study an evaluation was carried out by measuring again using the Balke test to see the results of an increase in VO_2max reception.

Treatment Group II
In the treatment group II, before being given swimming training, the sample was measured using a Balke test to get preliminary data on VO_2 max as a value before being given treatment, then this treatment group was given swimming training for 18 times in a period of 1.5 months (6 weeks), with a frequency of 3 times swimming in a week. Then at the end of the study an evaluation was carried out by measuring again using the Balke test to see the results of an increase in VO_2max reception.

Discussion result
As for the data taken from the futsal court and swimming pool fitness center Pola Bugar Kedoya, Jakarta.
Based on table 1 above it can be seen that the sample in treatment group I consisted of 6 people aged 17-18 years (50%), and 1 person aged 19-20 years (8%), 0 people aged 21-22 years (0%) , 2 people aged 23-22 (17%), and 3 people aged 25 years (25%). With the highest frequency in sample distribution according to age at the age of 17-18 years with a frequency of 6 (50%). Whereas in the treatment group II consisted of 5 people aged 17-18 years (42%), 1 person aged 19-20 years (8%), 1 person aged 21-22 years (8%), 2 people with ages 23-24 years (17%), and 3 people aged 25 years (25%). From the explanation of the above table can be illustrated with graph 4.1 in the treatment group I and treatment group II below:

Table 1
Distribution of Samples by Age

Age	Treatment Group I		Treatment Group II	
Year	Frekuensi	%	Frekuensi	%
17-18	6	50	5	42
19-20	1	8	1	8
21-22	0	0	1	8
23-24	2	17	2	17
25	3	25	3	25
Amount	12	100	12	100

Table 2
Sample Distribution According to Height

Height	Treatment Group I		Treatment Group II	
Cm	Frekuensi	%	Frekuensi	%
155-160	2	28	5	31
161-165	2	28	4	25
166-170	2	28	1	6
171-175	6	16	2	38
Amount	12	100	12	100

Table 3
Distribution of Samples by Weight

Weight	Treatment Group I		Treatment Group II	
cm	Frekuensi	%	Frekuensi	%
55-60	5	42	5	38
61-65	1	8	3	23
66-70	2	20	1	8
71-75	4	30	3	31
Amount	12	100	12	100

Table 4
VO_2 max value in the treatment I

Sampel	Treatment Group I		
	Before	After	Variance
1	35,44	39,08	3,64
2	35,39	39,25	3,86
3	36,02	40,04	4,02
4	36,53	40,27	3,74
5	35,56	39,19	3,63
6	35,92	39,36	3,44
7	36,58	40,32	3,74
8	35,91	39,98	4,07
9	36,75	40,44	3,87
10	36,13	40,21	4,08
11	35,91	39,70	3,79
12	36,98	40,68	3,68
Mean	36,093	39,876	3,796
SD	0,158	0,544	0,193

Table 5
VO_2 max value in the treatment I

Sampel	treatment I		
	Before	After	Variance
1	36,13	40,80	3,64
2	36,03	40,77	3,86
3	36,07	40,72	4,02
4	37,04	41,97	3,74
5	36,87	40,80	3,63
6	35,90	41,06	3,44
7	35,96	40,74	3,74

8	35,44	40,04	4,07
9	35,51	40,66	3,87
10	36,58	40,90	4,08
11	36,96	40,75	3,79
12	35,43	40,63	3,68
Mean	36,160	40,820	4,743
SD	0,580	0,434	0,364

Based on tables 4 and 5 above with a sample of 12 groups each, the mean VO_2 max value before treatment I was 36.093 with a standard deviation value of 0.518, and the mean value after treatment I increased to 39.887 with a standard deviation value of 0.544, while the treatment group II, the mean VO_2 max value before treatment II was 36,160 with a standard deviation value of 0.580 and the mean value after treatment II decreased to 40.820 with a standard deviation of 0.434. With the independent t-test, the results obtained a significant level = 0.187 ($P> 0.05$) so that Ho is rejected. This means that there are significant differences in the provision of jogging and swimming exercises to the increase in VO terhadap max of teenage men.

Hypothesis testing

Based on test results with Test

independent t-test above, it can be concluded that in the different test between treatment group I and treatment group II there was a significant difference in the provision of jogging and swimming exercises to increase VO_2 max. This can be seen from a very significant increase between before and after giving

exercise for increasing VO_2 max. But swimming exercises are better at increasing VO_2 max than jogging exercises.

Conclusion

From the results and discussion above, it can be concluded that: jogging and swimming exercises are effective in increasing VO_2 max in teenage men. But swimming exercises are better at increasing VO_2 max in teenage men.

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