Original Research

The Effect of Resistance Training on Cardiorespiratory Fitness on Healthy Male in Surabaya

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ABSTRACT

Low fitness levels have long been the cause of various diseases that are often experienced by humans. Although the process of a disease is something that is related to many factors, it cannot be denied that lack of physical fitness is one of the biggest. Based on data from the NIH (National Institute of Health), lack of physical fitness can cause various diseases, including diabetes, heart disease, and cancer. Low fitness can be associated with long-term mortality with the greatest risk exceeding the risk of smoking, diabetes and hypertension. In theory, the results of the VO2Max test will increase due to several mechanisms including increased respiratory muscle strength and increased cardiac output. Based on this theory, this study was conducted to see the impact of resistance training on cardiorespiratory fitness. This study used a quasi-experiment design with a pre-post test with a total sample of 16 people and was divided into 2 groups, treatment and control. Treatment is the group given a resistance training regimen and control is the group that is not given. Data were obtained by testing the YMCA Ergometry Cycle Test, then processed with SPSS with the Shapiro-Wilk test and Levene test and then a paired t-test was carried out. The results of this study indicate the effect of providing resistance training with a p value = 0.01 which shows significant results. Resistance training increases cardiorespiratory fitness with quite significant results and can improve fitness, but it is still recommended for each individual to balance this resistance training with endurance training for optimal body fitness.

Keywords: *resistance training, cardiorespiratory fitness, healthy lifestyle, good health and well-being, physical medicine and rehabilitation*

INTRODUCTION

Low levels of fitness, specifically cardiorespiratory fitness, have long been the cause of various diseases that humans often experience. Although the process of a disease is related to many factors, it cannot be denied that lack of physical fitness is one of the biggest. Ever since the emergence of the Covid-19 pandemic which forced us all to stay at home and isolate ourselves, there has been a rapid decline in the fitness of each individual after the incident, starting from young people who have high phone screen time or spend a lot of time in front of the computer screen, to the elderly whose physical abilities have decreased[1]. The increase in physical inactivity and sedentary behavior during the Covid-19 pandemic can be explained by two important reasons. The first is related to the fact that there were already existing cases of physical inactivity before the pandemic, and the second is the increasing cases caused by the isolation which involved a long time staying at home, Therefore, several strategies can be adopted to inhibit physical inactivity and reduce sedentary behavior during the Covid-19 pandemic, in order to minimize the risk of chronic and degenerative diseases, as well as of morbidity and mortality.[2]

This decrease in physical fitness is proven with a study done in 2021 which measures the effect of long term movement free period of time during Covid-19, where 126 adolescents were sampled and tested for the cardiorespiratory fitness using VO_2Max before and after isolation. After excluding 29 samples for having a disease that can cause damage on their health, it was found that out of 89 samples there was a decrease of VO_2Max which is about 0.5 mL/kg/min for average. The samples are divided in four groups according to age and gender with the highest decrease among the four group being the-14 year-old girls with decrease as high as 1,5 mL/kg/min, followed by 12-year-old boys with 1.2 mL/kg/min, 12-year-old girls with only 0.3 mL/kg/min decrease and also 14-year-old boys with a slight increase of 0.4 mL/kg/min.[3]

Other data from the World Health Organization (WHO) say nearly one third

(31%) of adults around the world, which is about 1.8 billion people, did not meet the recommended levels of physical activity in 2022. This number is concerning because comparing with the data from a research in 2010, it is found that there is an increase by 5%, and it is predicted that this trend will only increase further in 2030 with 35%of inactivity among adults.

This is a concerning finding as there is a lot of benefit that can be gained from having a good cardiorespiratory fitness, and, vice versa, there are a lot of dangers that can happen from having low level of cardiorespiratory fitness.

A research done in 2022 listed a lot of the benefits, which include: actively maintaining mitochondrial health and function which is vital to reduce age-related sarcopenia and the decrease of muscle function and efficiency; this is done by increasing the intensity of exercise and muscle contraction rate which in turn causes mitochondria to work more in order to precisely match the needed energy of myocytes, provided that oxygen delivery is adequate. Normally, mitochondria will try its best to match the exact needed energy by the cell, but as with any other component of the cell, it can age and can accrue molecular injury over time. But mitochondria will maintain itself by a process of biogenesis (de novo formation) and fusion also fission and mitophagy. When mitochondria are defective, damaged or aged, it can fuse with another one of its kind, preserve functional regions and then eliminate the damaged part. Mitochondria can also split itself into two independent organelles through a fission process. Mitophagy is a process of destruction of mitochondria that is deemed dysfunctional by the cell. These processes will keep the balance of mitochondria. In case of aging and inactivation, the processes will shift into fission and mitophagy which causes sarcopenia and reduced tissue responsiveness to energy demands.[4]

Sedentary behavior or physical inactivity will increase the risk of many health problems happening, including obesity, bone density reduction, cardiovascular alteration and mental health problems. An

imbalance of energy intake and expenditure will cause body fat accumulation, resulting in obesity. Obese children may develop cognitive problems, such as depression and anxiety, as they tend to become the object of bullying. Alteration in the cardiovascular system occurs by increasing blood pressure, cholesterol level and risk of heart disease[5]. A link between fitness and mortality rate has been long established considering age, sex, race and comorbidities[6]. Lower levels of CRF are associated with reduced life expectancy, increased healthcare costs and worse clinical outcomes[7]. To date, many studies have found that individuals that are more physically active have a lower incidence of cardiovascular (CV) disease (CVD) and all-cause mortality compared to those who are comparatively sedentary. Overall, the individuals that have minimum level of physical activity according to guidelines have a far lower mortality rate, that is about 20% to 50%lower than those with physical activity below recommended guideline levels.[8]

According to the US Department of Health and Human Service on "Physical Activity Guideline for Americans," fitness can be branched into different component, which are: cardiorespiratory fitness, musculoskeletal fitness, flexibility, balance and speed.[9]

Cardiorespiratory fitness is the capacity of respiratory and circulation system in giving supply of oxygen to muscle cells' mitochondria in order to produce energy needed during exercise or a physical activity[10]. The level of CRF is dependent on many organ processes that form a chain and which includes pulmonary ventilation, diffusion and pulmonary vascular function, ventricular function, ventricular arterial coupling, vascular capacity to accommodate and transport blood from heart to the body to fulfil oxygen needs, the ability of muscle cell to use the oxygen and the ability of the neural system to recruit muscle fibers. In general, CRF is related to the integration of human body function under physiological stress conditions, and it quantifies the functional.

capacity of an individual, reflecting body function and general health.[11]

Resistance training, on other hand, is a form of training usually done in order to form muscle mass and cause muscle hypertrophy, usually done by people who wish to increase strength because of its correlation with muscle strengthening[12]. There are a lot of known benefits in doing resistance training; strengthening the muscle is only a part of it but it is already vital enough, as, even without any chronic diseases, the aging process will eventually cause biological changes that can contribute to decreases in skeletal muscle mass, strength, and function, leading to decrease in physiological resilience. The decreasing physiological resilience often causes physical disability, mobility impairment, falls, and decreased independence and quality of life in the older adults, not even considering illnesses that may occur in later years. Age-related changes in skeletal muscle mass, strength, and function may be attributable to a variety of mechanisms, including disuse, impaired protein synthesis, and chronic inflammation. In regard to muscle disuse, individuals who are physically inactive have been found to have double the risk of future mobility limitation compared with those who meet the US Surgeon General's recommendations for physical activity. Seeing the unfavorable consequences of aging, it is needed that people, not only the older adults, do something in order to counter those. Among the three main reasons, which are protein synthesis, muscle disuse, and chronic inflammation, muscle disuse is the most preventable factor, as such resistance training is heavily recommended for everyone as it is an effective way to increase muscle mass, Currently, people usually think that only endurance training can actually make an increase in cardiorespiratory fitness, but the truth can be different from people’s theory, thus this research is made.

The research conducted aims to determine the extent to which the physical ability of the sample can be increased in performing cardiorespiratory fitness tests after resistance training and a comparison will be made between before the intervention and

eight weeks after the intervention and the control group. This topic was raised because some people, especially office workers or students, will find it difficult to find time to do endurance training, which has a time component in its implementation, while resistance training focuses more on intensity and repetition so that it will be easier to do in a short time. However, an individual should do both types of training, as recommended by ACSM, so that fitness improvements will be more optimal.

Resistance training used will be body weight resistance training which are push-ups, sit ups, back-ups, and lunges. Those kinds of training are used because most of the people in Indonesia, where the study takes place, do not have access to a gym nor all the fancy gym equipment, and, as such, these trainings will be more of use to the wider masses of Indonesians or anyone who does not want to go to the gym in general. According to a study done on 2015, comparing doing bench presses and push-ups, it is found that there is no significant difference between the two kinds of training on deltoid and pectoral muscle activation.[14]

There are many means to count an individual fitness of cardiorespiratory system, such as maximum heart rate (HRMAX) which is usually used on High-intensity Interval Training. Usually it is about 220 – age, which will decrease by 0.7 bpm each year[15]. Aside from HRMAX, there is also VO_2Max which is the capacity of oxygen volume which can be taken, transported and used by your body as you exercise.[16]

METHOD

Before conducting the study, all 16 subjects were selected based on inclusion criteria, which are: aged between 19-23, having no health issues, with normal heart rate, blood pressure and oxygen saturation, not consuming any specific medication, does not have any injury is mentally able, having no depression, anxiety, etc.

The exclusion The exclusion criteria for this study are: having injury that complicates training, having illness that deters continuation, choosing to quit, and being

uncooperative during training or hard to reach for testing.

They are then asked to fill out an attendance list, then given a questionnaire on their personal health, and an explanation about the activity that will be done during the research process, possible side effects of this study, informed consent, research protocol and ensuring that the subjects met the inclusion and exclusion criteria of the study. Then the respondents were divided into two groups: control and intervention. Then both groups were directed to do the YMCA ergometer cycle test. At the implementation stage, the intervention group was directed to do training with online supervision via the Zoom application while the control group did normal activities. To make sure that the training was uniform, the first three meetings were done offline with the eight weeks, participants were tested again using the YMCA ergometer cycle test method. Participants are as follows:

Table 1. Participant characteristics

INTERVENTION				CONTROL			
AGE	N			AGE	N		
		20	±1,83			19,86	±1,57
WEIGHT	N			WEIGHT	N		
		65,43	±13,64			70,57	±14,3
HEIGHT	N			HEIGHT	N		
		170,57	±5,35			169,43	±5,88

The training regime is focused on training the muscles which entails push-ups, sit-ups, back-ups, and lunges and directed to training arms, chest, abdomen, back and legs.

The YMCA ergometer cycle test is done using an ergocycle in which the participant cycles in accordance to a metronome set on 100 bpm. At first the load is only 150 kgm/min or about 0.5 kg weight. The person cycles for three minutes in which at minutes two and three they will be recorded and compare; if the difference does not go past 5bpm then we can move to next load. This will continue until the heart rate reaches 85% of the age-predicted maximum heart rate (image 1). And after that, the result will be plotted in a graph (image 2).

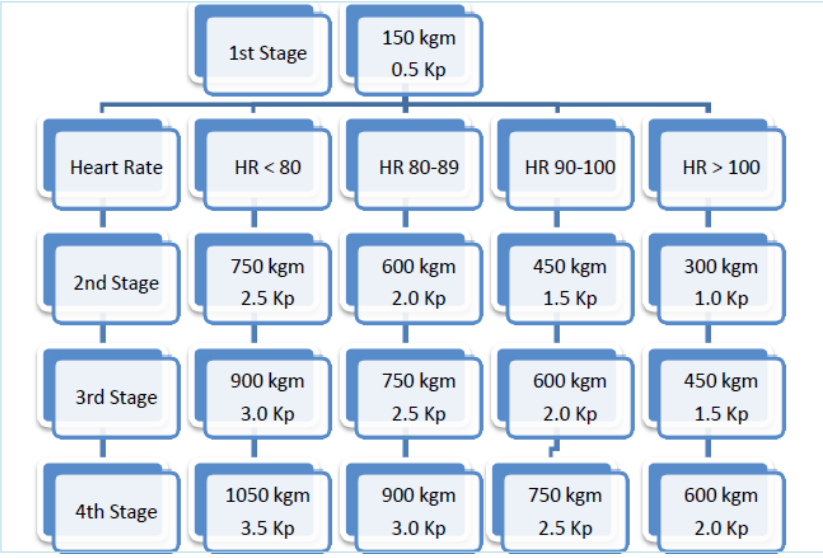

Image 1. Load increase algorithm

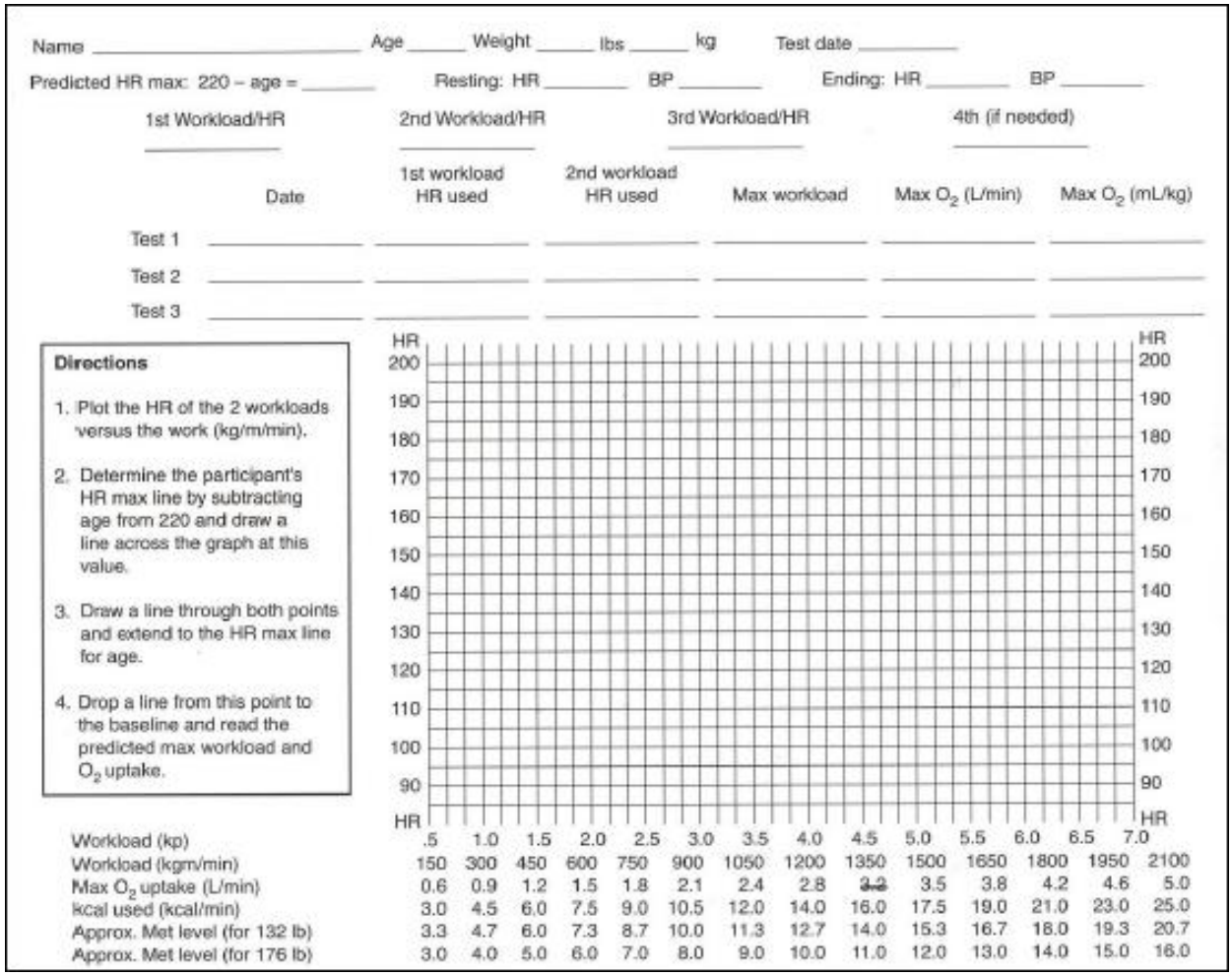

Image 2. YMCA ergometer cycle graph

The results of the examination will be compiled in the SPSS Statistics application and the Shapiro-Wilk normality test, Levene's homogeneity test and paired-t test will be carried out to see the significance of the pre and post tests and the independent t-test to see the significance of the difference in the means of the two groups.

RESULTS AND DISCUSSION

Results

Out of 16 people that joined, two were excluded due to uncooperation, one for not continuing training and the other for not attending test. To make sure that only the participants that followed through, every session of training is included.

After the pre-test and post-test were conducted, the data of VO_2Max obtained were recorded and analyzed as explained. The following table presents the examination results.

Table 2. Pre-test Results

	Treatment	Control
Average	64 ± 12.80 mL/Kg/Min	45 ± 19.32 mL/Kg/Min

Table 3. Post-test Results

	Treatment	Control
Average	70±10.08 mL/Kg/Min	43.33±18.45 mL/Kg/Min

Table 4. Mean Difference

	Treatment	Control
Average	8.36±6.21 mL/Kg/Min	4.85±4 mL/Kg/Min

Discussion

VO_2Max before intervention

Respondents in both intervention and control groups were pretested with YMCA ergometry cycle test and found various VO2Max test results; some had below good fitness levels and some were very good. The lower limit of good VO2Max is around 46.7 mL/kg/min with a standard deviation of 11.5.[17]

VO_2Max after intervention

The respondent group that was given an intervention in the form of resistance training for eight weeks and was evaluated using the VO_2Max examination using the ergometry cycle test examination method obtained results showing a significant

increase in VO_2Max (6 mL/kg/min); this is the difference between pre-test and post-test meanwhile in each individual, we found that the rate of increase varies but falls within (8.36±6.21 mL/kg/min). This was not found in the control group, where the control group actually experienced a decrease in VO_2Max due to lack of physical activity.

Data Analysis

The results of the VO_2Max examination were compiled, then a data homogeneity test was carried out and the results showed homogeneous data; the results of the significance value in the Levene test were >0.05. The VO_2Max of both groups was then tested for the normality of data distribution using the Shapiro-Wilk test and the results of the significance were >0.05 which showed normally distributed data so that a paired t-test could be carried out on both groups to see the magnitude of the impact given by resistance training.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VO2MAX_PRE_KONTROL	.158	7	.200*	.947	7	.698
VO2MAX POST K	.145	7	.200*	.977	7	.943
VO2MAX PRE PERLAKUAN	.211	7	.200*	.885	7	.247
VO2MAX POST PERLAKUAN	.162	7	.200*	.954	7	.767

Image 3. Normality test result

Paired Samples Correlations

		N	Correlation	Significance One-Sided p	Significance Two-Sided p
Pair 1	VO2MAX_PRE_KONTROL & VO2MAX POST K	7	.979	<.001	<.001
Pair 2	VO2MAX PRE PERLAKUAN & VO2MAX POST PERLAKUAN	7	.879	.005	.009

Image 4. T-test result

The effect of resistance training on cardiorespiratory fitness

The results of the ergometry cycle test fitness examination were recorded and then processed with homogeneity and normality tests, then a significance test was carried out using the paired t-test and the results obtained were a significance level below 0.05, which means that resistance training has an effect on increasing VO_2Max so that it is in accordance with the research hypothesis that has been made that resistance training can affect the increase in VO_2Max. In the control group, VO_2Max did not experience significant changes.

The relationship between resistance training and cardiorespiratory fitness

Regular and standardized exercise causes stimulus which causes an increase in the need for oxygen supply required by the entire body. The heart must follow up to this demand while also keeping maintaining blood pressure and adequate perfusion to the organs. Upon initiation of exercise, input from the higher brain centers descend into medullary heart centers, resetting the arterial baroreflex to a higher operating point, leading to a rapid heart rate increase which is mediated by reducing cardiac parasympathetic neural activity. As exercise intensity increases further, progressive baroreflex resetting as well as afferent feedback from muscle metaboreceptors trigger further cardiac parasympathetic withdrawal and sympathetic activation.[18]

In strength training athletes, concentric ventricular hypertrophy is often found due to increased systolic and diastolic pressure followed by increased cardiac output, heart rate, and oxygen consumption. Increased afterload causes increased intraventricular pressure, both of which cause increased wall stress; in response, the heart adds sarcomeres in addition to existing sarcomeres, causing wall thickening. However, the wall thickening rarely exceeds the normal range (<12 mm). In addition, research conducted by Pluim et al. found that in strength training athletes there was also an increase in the diameter of the left ventricle of the heart.[19]

During an exercise, the body needs more oxygen; as such, the heart together with lungs works harder in order to fulfil the demand of oxygen. In the short term, there is not much significant difference but in the long term, it is found that powerlifters have stronger muscles that help with breathing, which will in turn increase VO_2Max.[20]

Another possible theory on how the increase of cardiorespiratory fitness happens is because of the release and action of myokines. Myokines in the muscle cause local changes by regulating muscle development and also enhancing muscle function.[7]

According to the American Heart Association in a 2023 journal, another possible mechanism is that resistance training appears to confer small to moderate beneficial increases in cardiorespiratory fitness through mechanisms such as increased leg strength, improvements in oxidative enzymes, and increased type II muscle fibers.[21]

Thus, based on the data obtained, resistance training can indeed increase VO_2Max; however, it will be more optimal if resistance training is combined with endurance training to improve individual fitness.

Study Limitation

This study was done on 14 (excluding 2 participants) people, which affects how this study can be generalized in the wider community.

CONCLUSION AND SUGGESTIONS

Conclusion

Based on the results of the research, we can make a conclusion about the effectiveness of resistance training. It is found that there is a significant increase in cardiopulmonary fitness. The results obtained are as follows:

1. The results of the fitness test before the intervention in the treatment group showed a fitness test result with an average of 64 ± 12.80 mL / kg / min and after the intervention the results were 70 ± 10.08 mL / kg / min. From the description of the data results, it can be concluded that there was a significant change in the form of an increase in VO_2Max.
2. The fitness test results after intervention in the control group were 45 ± 19.32 ml / kg / min and after eight weeks the results were 43.33 ± 18.45 mL / kg / min. It can be concluded that there was no significant change in the VO_2Max test results of the control group.
3. The differences and results of the data analysis obtained showed very good results and were in accordance with the initial hypothesis of the study, namely that significant changes were obtained from the pre and post-tests in the treatment group and a fairly large difference was also obtained

from the difference between the two groups so that it can be concluded that this study was successful and positive.

Suggestion

For writers

Future researchers can use more varied movements and more complex research variables.

For health service institutions and health education institutions

Based on the results of this research, it can be seen that resistance training is not only beneficial for muscle building, it can also increase a person's fitness level so it will be very useful if applied to health workers and academics to increase their respective productivity. But to further maximize the effect of the training, combining the two types of training, resistance training and endurance training, should be done.

For Further Research

For further research, more varied movements should be used and stricter monitoring of the lifestyle and nutrition consumed by respondents on a daily basis is needed.

For the Public

For lay people who read this research, they can apply this training method with appropriate standards and do not force it; , do not forget to give yourself time to rest and consume sufficient nutrition and maintain a healthy lifestyle. The authors hope that this study will be of great benefit to many people in the future as doing exercise following the recommended frequency can help increase people's health.

DISCLOSURES

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Conflict of Interest

There is no conflicting interest between all authors of this research.

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Ethical Clearance

No. 229/EC/KEPK/FKUA/2023 given by KEPK FK UNAIR on 24 of August 2023.

Authors' Contribution

All authors have contributed to all processes in this research, including preparation, data gathering and analysis, drafting and approval for publication of this manuscript.

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