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**Review Article**
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# Effects of physical activity to cardiorespiratory changes

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**Abstract.** Cardiorespiratory endurance is associated with the development of cardiovascular and respiratory systems' ability to maintain and deliver oxygen to the engaged muscles during long-term physical activity, as well as the muscle ability to obtain required energy through aerobic processes. Physical activities of aerobic character give best results when performed 3-5 times a week. Training duration should be within 50-60 minutes. This way of exercising will surely lead to positive cardiorespiratory changes in both males and females. This paper uses introspection method to review relevant scientific literature concerning our topic of interest. We emphasize that physical activity has a significant influence on cardiorespiratory abilities, that is, it increases maximum oxygen uptake and personal fitness index, both of which are associated with the increased cardiorespiratory ability. Arterial blood pressure is significantly corrected; however, it is necessary to start engaging in physical activities on time for prevention purposes. Due to greater body engagement, physical activities represent one puzzle piece of crucial importance in maintaining cardiorespiratory health.

**Keywords.** Blood pressure, HR, intensity, $VO_2$max.

## Introduction

Physical activity (PA) is defined as any kind of physical movement generated by the skeletal muscles, and for which energy expenditure is required (WHO, 2019). Such physical movements cause a noticeable change in cardiovascular function and show a great potential in prevention and rehabilitation of cardiovascular diseases, which can gravely affect the quality of life (WHO, 2019; Jakovljevic, 2018). Beneficial effects of physical exercise on cardiovascular diseases can be seen in: the improvement of aerobic capacities and metabolic functions, the amplification of the lipid profile, insulin sensitivity of the immune system, the increase of myocardial perfusion and fibrinolytic activity, the decrease of thrombocyte adherence due to increased prostaglandin PGI2 synthesis, the increase in energy consumption (important for maintaining ideal body mass), prevention and treatment of diabetes, and stress control (Bidde et al., 1999). Epidemiological studies have found a positive association between the increased energy consumption caused by physical activity and the reduction in lipid parameters and body mass when combined with dieting and physical exercise (Baxter-Jones & Maffulli, 2003). Physical activity, by altering chemistry and lipoprotein metabolism, slows down the degree of atherosclerosis in coronary arteries in individuals who exercise regularly (Clark et al., 2005). When it comes to prevention and reduction of cardiovascular risk, aerobic physical exercises (jogging, swimming, riding a bike) by the intensity of the medium load training (65% of mean respiratory volume) have a positive effect. The best kind of physical

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activity is the one where endurance and strength are in the focus (Hu et al., 2000). While having a positive effect on body composition, physical activity also positively influences the reduction in fat deposits and maintains healthy body mass (Blair et al., 2004; Haskell et al., 2007; Garber et al., 2011; Golubic et al., 2012; Can et al., 2014; Rosa et al., 2014; Clark, 2015; Liu et al., 2018; Can et al., 2019). Regular PA lead to not only increased aerobic, but also anaerobic parameters (Pilch et al., 2017), decreases the negative effects of diabetes in diabetic patients (Lynch et al., 1996; Gregg et al., 2003), helps those with cardiovascular disorders (Ewing, 2011; Nystoriak & Bhatnagar, 2018; Matthew & Aruni, 2018; Pinckard et al., 2019), increases bone density and reduces osteoporotic changes (Warburton et al., 2001; Carter & Hinton, 2014).

Cardiorespiratory endurance or aerobic endurance is whole body's capability to maintain long-term physical activity and it involves relatively large muscle groups (Petrovic-Oggiano et al., 2010). Cardiorespiratory endurance is closely tied with the development of cardiovascular and respiratory ability to maintain oxygen delivery to the muscles engaged in long-term physical activity, as well as with the muscle ability to acquire needed energy through aerobic processes. A lot of scientist who study PA take maximal oxygen uptake ($VO_2$max), also known as maximal aerobic power or maximal aerobic capacity, as the most objective laboratory parameter for cardiorespiratory endurance (Gianuzzi et al., 2003). Maximal oxygen uptake $VO_2$max refers to the highest amount of oxygen an individual can use or spend during one minute of maximum intensity loading. $VO_2$max values can be directly measured or estimated based on technical characteristics of the used equipment, test protocol, and time and load duration (Armstrong, Welsman, &, Winsley, 1996). When estimating maximum oxygen uptake, where the test ends at submaximal load level with extrapolation of the results to the maximum values, the term highest value or peak oxygen uptake ($VO_2$peak). To obtain this $VO_2$peak value, through the process of progressive overload, it is required to achieve the intensity which allows for minimal duration of 3-5 minutes, when oxygen uptake would reach its plateau. The endurance training can deliver and uptake more oxygen in active muscles. That improvement allows individuals to do a physical activity for which higher intensity endurance is needed, while also improving the physical ability.

Based on physical review, it is recommended that aerobic activities should last 12-16 weeks, 3-5 times a week. Training duration should be approximately 50-60 minutes. This principle greatly influences cardiorespiratory changes in both male and female test subjects. This kind of physical training gives considerably better results that the trainings that last 20-40 minutes (Hsiao et al., 1998; Amiril et al., 2013).

**The effects of physical activity on arterial blood pressure**

Exercise is the key therapeutic component for early prevention and treatment of hypertension. Multiple studies have shown how exercise benefits hypertension by reducing systolic and diastolic blood pressure for at least 5-7 mmHg in hypertension patients (Diaz & Shimbo, 2013; Pescatello et al., 2004; Carlson et al., 2014). Environment factors, including sedentary lifestyle, have been the most prominent as risk factors for hypertension development. While standard antihypertensive therapy exists, physical exercise should also be included due to its positive impact on hypertension and cardiovascular disease prevention (Diaz & Shimbo, 2013; Rossi et al., 2012). Based on this, changing one's lifestyle and being physically active are two very important components of both the European and American World Health Organization guidelines on antihypertensive treatment (James et al., 2014; Mendis, 2014). Differences in workout regime, environment as well as genetic factors can account for major differences and variabilities in blood pressure in response to exercise among different studies

(Members, 2013; Ash et al., 2013). In one study, 20-25% of individuals diagnosed with hypertension did not have a positive reaction and their exercise did not result in blood pressure reduction (Pescatello et al., 2008). Other studies show that blood pressure can be reduced through exercise (Chobanian et al., 2003; Pontes et al., 2008). However, studies that look into blood pressure reduction, as a consequence of chronic exercise, can neglect the acute results after the exercise, and what can be lost in time (Cornelissen & Fagard, 2005). Although the mean value of systolic and diastolic pressure during 24h period is approximately 3.2 mmHg and 1.8mmHg respectively, the reduction is greater during first couple of hours after the exercise, to such extent that even some participants diagnosed with hypertension reach normal blood pressure values (Pescatello & Kulikowich, 2001). Previous studies show that aerobic program increases $VO_2$max, however, it is more important to note that it reduces both heart rate and blood pressure (Astorino et al., 2012). To conclude, irrespective of exercise characteristics, or load intensity, blood pressure is most commonly corrected after acute exercise. If you become physically active, you can reduce your systolic blood pressure - the largest number in blood pressure reading – on average 4-9mmHg, which is as good as certain antihypertensive medications.

In order to reduce the need for antihypertensive medication, some people only need to introduce regular exercise in their daily routine (Flint, 2019). The deparment for health and social services recommends at least 150 minutes of medium intensity aerobic activity or 75 minutes of high intensity aerobic activity per week or a combination of the two. It is also recommended to include at least 30 minutes of aerobic activity on a daily basis during the week. If this is not possible to implement in one's schedule, the workout plan can be broken down into smaller units as these can be extremely useful. Training could be divided into three 10-minutes long aerobic exercise sessions and have the same advantages as one 30-minute long session (Bhatt, 2016; Beddhu et al., 2018).

**The effects of physical activity on $VO_2$max increase**

The benefits of PA are countless, but here we will point out the improvements in aerobic state of the organism (Myers et al., 2002; McGinnis & Foege, 1993). Donnelly et al. (2009) assert that load intensity during workout needs to be at least 50% of maximum heart rate and to have a corresponding duration, so it could result in beneficial changes with maximum oxygen uptake, The degree of cardiorespiratory ability varies depending on the overall state of respiratory, cardiovascular and musculoskeletal systems, and its estimate is important as it is connected to the overall health status of an individual. Multiple studies show that recreational workout and continuous exercise plans can significantly improve cardiovascular system (Kostić & Zagorc, 2005; Basset & Howley, 2000). Some studies show that programs of aerobic character can influence the cardiorespiratory fitness by enhancing the degree of respiratory abilities (Wilmore & Costill, 1999; Pantelić et al., 2007; Grant et al., 2002; Kingwell & Jennings; 1993; Kostić & Zagorc, 2005; Thomsen & Ballor,1991). Bad cardiorespiratory ability increases the degree of many risk factors and can cause premature death. Improving cardiorespiratory abilities is associated with a lower chance of premature death (Kalyani et al., 2007; Myers et al., 2002). Physical fitness is a measure of cardiorespiratory, endocrine and metabolic functions (Castillo-Garzón et al., 2006).

With age, $VO_2$max is decreased by nearly 10% between 25 and 30 years of age in adults of both sexes, irrespective of activity levels (Bortz & Bortz, 1996; Citation et al., 2016; Eskurza et al., 2002; Fitzgerald et al., 1997; Heath et al., 1981; Degens et al., 2013; Pimentel et al., 2003). On average, men have a higher $VO_2$max than women, which comes as a consequence of greater ventricle push, exit volume,

hemoglobin concentration, muscle mass composition and lower body fat (Cheuvront et al., 2003). The main function of the cardiovascular and respiratory systems is to supply enough oxygen and nutrition to the body, release the $CO_2$ and regulate metabolism (Wilmore & Costill, 2005). PA influences health improvement, improves the cardiorespiratory condition, body composition and also benefits psychosocial being. Besides, PA is an important segment in prevention and treatment of diabetes (Kelley & Kelley, 2013; Bae et al., 2015; Yong et al., 2014; Lee et al., 2015; Boström et al., 2012; Alberga et al., 2011). Previous studies researched $VO_2$max changes after interventions with certain experimental treatment of aerobic characteristics at a given time span (Shim et al., 2010; Askarabadi et al., 2012; Rezaimanesh & Amiri-Farsani, 2011; Osei-Tutu & Campagna, 2005). Some studies even compared a few aerobic programs of different load intensity, continuous aerobic exercise controlled for total scope of activities and energy consumption during workout. Research shows that aerobic capacity is significantly higher in groups that experienced higher intensity load (Braith et al., 1994; Burke & Franks, 1975; Crouse et al., 1997; Duncan et al., 1991; Gossard et al., 1986; Gutin et al., 2002; Kang et al., 2002; O'Donovan et al., 2005; Savage et al., 1986).

Endurance training with the intensity of 60% $VO_2$max is equally as efficient, or even more, as the intensity of 70% $VO_2$max for the improvement of aerobic fitness in older population. In other words, healthy seniors, adults with sedentary lifestyle can see a major improvement in their aerobic fitness through aerobic exercise with the intensity of approximately 60% $VO_2$max (Huang et al., 2005). Unfortunately, these studies did not adequatelly discuss the relationship between intensity and load dosage with exercise-induced $VO_2$max increase. Although many studies have tried to explain the relationship between high and low intensity exercise intensity to improve $VO_2$max, it remains unclear whether there is an optimal intensity training for $VO_2$max increase (Daussin et al., 2008). Finding this relationship represents the critical unknown link and an adequate explanation on $VO_2$max increase (Gormley et al., 2008).

**The effects of physical activity on heart rate**

The effects of physical exercise on human body has been a major research interest in the last couple of decades (Nottin et al., 2002; Ekblom et al., 1986), and many have been identified as a response to eg. higher cardiac work in the beginning of workout or training adjustments. According to the American Heart Association (AHA) normal resting heart rate for adults should be 60-100 beats per minute. Tachycardia is high resting heart rate, defined as higher than 100 beats per minute. Bradycardia is low resting heart rate, defined as lower than 60 beats per minute. During sleep, reduced heart rate of approximately 40-50 beats per minute are considered normal. If heart is not pumping at a consistent rate, it is called arrythmia. Heart rate abnormalities can be an important indicator of the presence of a disease (American Heart Association, 2017), which is why regular exercise comes as highly recommended. Based on AHA recommendations, physical activity and exercise should be conducted regularly, preferably every day of the week for at least 30 minutes with medium to high intensity, based on individual's physical ability (Pearson et al., 2002). One of the possible explanations as to why regular PA and exercise increase lifespan, could be the mediating effect of resting heart rate. Regular PA decreases resting heart rate

Huang et al. (2005), Zheng et al. (2015), Cramer et al. (2014); lower resting heart rate seems to be inversely proportional with the expected lifespan (Hartaigh et al., 2014) and is positively correlated to the cardiovascular system (Aune et al., 2017). Aerobic activities are recommended as the best option. The most common exercises are: jogging, swimming, bicycling, climbing, walking, and many other sports that require increased work of the

cardiovascular and respiratory systems. The effects of correctly dosed exercise are the improvements in general body fitness and increased endurance (Kuper, 1971). Decreased resting heart rate is common among sportsmen (Boutcher et al., 1998; Shin et al., 1997).

Aerobic exercise can lead to increased heart rate in individuals who had previously led sedentary lifestyle (Schuit et al., 1999; Levy et al., 1998). Hagginbotham et al. (1986) have shown that men are more likely to have lower HA than women, when doing identical intensity exercise. Furthermore, Rennie et al. (2003) showed that increased rate of medium intensity PA significantly lowered men's resting heart rate, but the same effect was not found in women. Low heart rate, at least partially, is a result of increased parasympathetic tonus and can be linked with PA-induced improvements in sympathetic control of the vasomotor tonus (Shin et al., 1997; Yataco et al., 1997). However, others note that parasympathetic tonus can increase high intensity activity, eg. jogging, but not medium intensity activity (Schuit et al., 1999). In the begining of exercise, heart rate increases due to the inhibition of vagus activity, which not only increases the atrium contractility, but also the transmission speed of ventricle depolarization wave (Clausen, 1977), unrelated to the level of activity's intensity (Baum et al., 1992; Araújo, 1985) or aerobic abilities of healthy individuals (Araújo et al., 1989; Borst et al., 1982). Under the influence of PA, heart rate slows down.

### Conclusion

Physical activity represents a very important segment in protection and improvement of our health. Research shows that regular PA provides multiple health benefits and reduces mortality related to any cause. Based on numerous research and reviews, we can conclude that: PA has a major impact on cardiorespiratory abilities, it increases maximum oxygen uptake and personal fitness index. Arterial blood pressure is significantly improved however, it is advisable to start exercising on time for the sake of early prevention. Due to increased body engagement, PA works to decrease heart rate and optimize cardiac work. Physical activity represents an important segment in the overall improvement of cardiorespiratory functions.

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### Declaration of interest

The authors report no conflict of interest.

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