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The Effect of Buteyko Breathing Technique in Improving Cardiorespiratory Endurance

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Abstract

Cardiorespiratory endurance is one of the main aspects required in sports. Cardiorespiratory endurance is influenced by the function of cardiorespiratory system and body oxygenation system. Improving body oxygenation system is just as important as improving cardiorespiratory system to achieve a higher cardiorespiratory endurance. Performing a strenuous activity requires more oxygen to produce the energy. Ironically, our body adapts to a strenuous activity by increasing number of ventilation rate (hyperventilation), which leads to a decreased efficiency of body oxygenation process. Hyper-ventilation reduces carbon dioxide levels by exhaling more carbon dioxide instead of producing it. The carbon dioxide has a main role in maintaining acid-base balance. Altered pH balance causes less oxygen to be released into the tissues. Buteyko Breathing Technique is one of many breathing exercises aimed at improving body oxygenation system. It focuses on decreasing number of ventilation rate and increasing carbon dioxide levels to optimize body oxygenation process. The purpose of this research was to determine the effects of Buteyko Breathing Technique in improving cardiorespiratory endurance. 22 males aged 15-17 were involved to fulfill the objective of the study. This research used parametric test to analyze the data and to observe significant differences in $VO_{2\ max}$ improvement between the two groups.

Keywords: Buteyko Breathing Technique, Cardiorespiratory Endurance, Body Oxygenation.

1. Introduction

Endurance (a measure of fitness) is the ability to work for prolonged periods of time and the ability to resist fatigue. It includes muscular endurance and cardiovascular endurance. Cardiovascular endurance refers to the ability to perform large muscle dynamic exercise, such as walking, swimming, and/or biking for long periods of time. Fitness level is often based on measurement of body's maximum oxygen consumption $VO_{2\ max}$ (Kisner & Colby, 2012).

Endurance depends on such factors as the ability of the lungs to deliver oxygen from the environment to the bloodstream, the capacity of the heart to pump the blood, the ability of the nervous system and blood vessels to regulate blood flow, and the capability of cells chemical system to use oxygen and process fuels for exercise and rest (Fahey, Insel, Roth, & Insel, 2015). Meanwhile, according to Kisner & Colby (2012), endurance depends on the transport of oxygen, the oxygen-binding capacity of the blood, cardiac function, oxygen extraction capabilities, and muscular oxidative potential.

Cardiorespiratory endurance can be developed through activities that involve continues, rhythmic movement of large muscle groups such as walking, jogging, cycling, and group aerobics. Developing cardiorespiratory endurance leads to an adaptation to our body. Furthermore, short term adaptation increases heart beat and stroke volume (the amount of blood pumped by the heart with each beat), and increase pulmonary ventilation. During a rest and light activity, cardiorespiratory system functions at a fairly steady pace. The heart beats at a rate about 50-90 beats per minute, and ventilation rate about 12-20 breaths per minute (Fahey, Insel, Roth, & Insel, 2015).

The amount of air volume exhaled from the lungs at rest is about 5 liters per minute. Meanwhile, when performing a strenuous activity, such as sports, the amount of air volume exhaled may increase up to 100 liters per minute (Anggriawan, 2015). Hyperventilation is defined as breathing more than metabolic requirements of the body and can be further defined as an increase in the alveolar ventilation more than the level required to maintain the blood gas homeostasis, resulting in a fall in carbon dioxide partial pressure and the development in respiratory alkalosis (Robson, 2017).

Buteyko Breathing Technique is a series of simple breathing exercises based on a principle that is mechanically different from any other breathing exercises. It is generally aimed at improving diaphragmatic breathing and focused on decreasing the amount of ventilation rate. Proper ventilation rate by decreasing the amount of ventilation rate leads to the rise of carbon dioxide levels thus optimizing body oxygenation process (Agustiningsih, Kafi, & Junaidi, 2007).

Furthermore, this technique is distinctive in which people are asked to breathe less rather than more and not to breathe or hold the breath is considered as important as breathing. Generally, the Buteyko method has two major techniques, namely reduced breathing and breath holding. Reduced breathing is a technique to reduce the amount of air entering the lungs. Meanwhile, breath holding is a technique to hold the breath aimed at increasing carbon dioxide levels in the lungs (Courtney, 2008).

Rakhimov (2013) stated that control pause and diaphragmatic breathing retraining are required to mastering Buteyko Breathing Technique. Control pause is a part of breath holding technique that can be used to determine which kind of activity that can be combined with Buteyko method. While, diaphragmatic breathing retraining is required to regulate the efficiency of oxygen delivery and (partial) carbon dioxide elimination.

2. Methods

This research was using Quasi Experimental with pre test – post test control group design. The study was conducted in Indonesia for four weeks of training program. The population of the subjects was 49 high school basketball players in Central Java and West Kalimantan. As many as 22 subjects were selected by using purposive sampling method based on several criteria. They must be male aged 15-17 years, non-obesity, have no record of cardiovascular disorder, migraines, and panic attack, health (not injured), and have daily or weekly training routine besides the basketball training routine. The subjects would be eliminated from this study if he could not attend one of the training program sessions.

The subjects were divided into two groups, including 11 students as the experimental group and 11 students as the control group. The groups were given different training program in which the experimental group was given the training program combined with Buteyko Breathing Technique and the control was given the training program only. The training program used to improve cardiorespiratory endurance in this study was a circuit-interval training “the Triangle Run”. Triangle run is a combination of walking, jogging, and sprint in a triangle shaped track with the size of 20 m x 12 m x 8 m on each side. The training program was conducted twice a week and the training intensity was gradually increased in every week as shown in table 2.1.

Table 2.1 Triangle Run Intensity

	Week 1	Week 2	Week 3	Week 4
Set	2	2	3	2
Laps	8	10	8	14

There was two minutes rest periods between two sets. One minute of the rest period was used to measure the subject’s heart rate and the subjects should reach the target 75% of maximal

heart rate during the training program. Subjects were required to increase the speed on sprint track if the heart rate was below the target, and on the contrary, to decrease the speed on sprint track if the heart rate was above the target.
The techniques of Buteyko method applied in the training program were reduced breathing, breath holding, and diaphragmatic breathing retraining. The subjects learned to breathe less by extending the duration of exhalation instead of the duration of inhalation. The subjects were also taught to perform nasal breathing only during the training program. Breath holding technique was applied on the sprint track in which the subjects should hold their breath while running along the sprint track. The subjects were using a belt placed on the lower rib cage (in the middle of trunk) during the training program to restrict chest breathing as shown in figure 2.1.

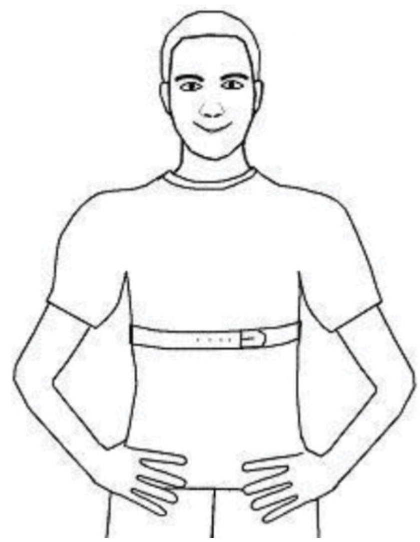

Figure 2.1 Belt placement.

This study was aimed to compare the improvement of cardiorespiratory endurance between the two groups. The measurement was the 20 meter Multistage Fitness Test to determine the $VO_{2\ max}$ score before and after the given training program. The test was conducted once before the training program and once after the training program was completed. Statistical analysis on this study used Shapiro-Wilk test to determine the distribution of the data, Wilcoxon signed-rank test to determine the difference of $VO_{2\ max}$ before and after the training program, and Mann-Whitney U test to compare the $VO_{2\ max}$ significant difference between two independent groups. The dependent variable of this study was cardiorespiratory endurance improvement and the independent variable of this study was the Buteyko Breathing Technique. However, the hypothesis of this research was the training program combined with Buteyko Breathing Technique would achieve a higher $VO_{2\ max}$ improvement than the implementation of single training program.

3. Results

After four weeks of the study, we obtained $VO_{2\ max}$ improvement as shown in table 3.1 and table 3.2.

Table 3.1 Experimental group

Subject No.	Pre Test		Post Test		Improvement
	MFT (Level-Shuttles)	$VO_{2\ max}$ (ml/Kg/min)	MFT (Level-Shuttles)	$VO_{2\ max}$ (ml/Kg/min)	
1.	11-1	53.82	13-1	60.94	13.23%
2.	8-4	44.38	9-10	49.64	11.85%
3.	11-2	54.11	12-6	58.71	8.49%
4.	8-10	46.26	10-7	52.04	12.50%
5.	8-4	44.38	10-8	52.34	17.93%
6.	5-2	33.60	6-4	37.61	11.93%
7.	8-5	44.70	9-2	47.19	5.58%
8.	7-9	42.48	11-8	55.85	31.49%
9.	7-8	42.16	9-2	47.19	11.94%
10.	8-4	44.38	9-3	47.50	7.02%
11.	7-9	42.48	9-4	47.81	12.54%
Mean		44.80		50.62	13.14%
Max		54.11		60.94	31.49%
Min		33.60		37.61	5.58%

Table 3.2 Control group

Subject No.	Pre Test		Post Test		Improvement
	MFT (Level-Shuttles)	VO2 max (ml/Kg/min)	MFT (Level-Shuttles)	VO2 max (ml/Kg/min)	
1.	10-5	51.45	11-3	54.40	5.75%
2.	10-11	51.75	12-1	59.27	7.79%
3.	11-5	54.99	12-8	57.29	10.71%
4.	11-7	55.57	13-8	62.85	13.11%
5.	7-5	41.20	8-6	45.01	9.26%
6.	9-1	46.88	9-11	49.94	6.53%
7.	10-5	51.45	11-7	55.57	8.01%
8.	8-9	45.95	9-4	47.81	4.04%
9.	7-4	40.87	7-6	41.52	1.58%
10.	11-4	54.69	12-7	58.99	7.85%
11.	11-4	54.69	11-12	57.00	4.22%
Mean		49.95		53.60	7.17%
Max		55.57		62.85	13.11%
Min		40.87		41.52	1.58%

Table 3.1 and 3.2 show that the $VO_{2\ max}$ improvement in the experimental group was higher (13.14%) than the control group (7.17%). The highest $VO_{2\ max}$ improvement (31.49%) was achieved by the experimental group.

Table 3.3 Shapiro-Wilk Test

Variable	Category	Statistic	df	Sig.*

$VO_{2\ max}$	Good	0.332	7	0.032
	Excellent	0.231	5	0.258
	Superior	0.219	7	0.557

*Normal at ≥ 0.05.

Table 3.3 shows the normality test using Shapiro-Wilk test. The *p* value of $VO_{2\ max}$ on good category was 0.032 while the *p* value of $VO_{2\ max}$ on excellent and superior category was 0.258 and 0.557, respectively. Because one of the *p* value of $VO_{2\ max}$ category was < 0.05, the data distribution was abnormal.

Table 3.4 Wilcoxon Test on Experimental Group

$VO_{2\ max}$	N	Mean	SD	*p* value*
Pre Test	11	44.795	5.602	0.003
Post Test	11	50.620	6.447	

*Significant at ≤ 0.05.

Table 3.4 shows the $VO_{2\ max}$ average score between pre and post test in the experimental group. The pre test (44.795) mean score in the experimental group was lower than the post test (50.620) mean score, which means the subjects have a $VO_{2\ max}$ improvement after given the training program. Furthermore, Wilcoxon test with 0.05 margin of error revealed that there is a significant difference (p=0.003) on $VO_{2\ max}$ average score before and after given the training program in the experimental group.

Table 3.5 Wilcoxon Test on Control Group

$VO_{2\ max}$	N	Mean	SD	*p* value*
Pre Test	11	49.953	5.423	0.003
Post Test	11	53.604	6.656	

*Significant at ≤ 0.05.

Table 3.5 shows the $VO_{2\ max}$ average score between pre and post test in the control group. The pre test (49.953) mean score in the control groups was lower than the post test (53.604) mean score, which means the subjects have a $VO_{2\ max}$ improvement after practicing the training program. Using Wilcoxon test with 0.05 margin of error, it was revealed that there is a significant difference (p=0.003) on $VO_{2\ max}$ average score before and after given the training program in the control group.

Table 3.6 Mann-Whitney Test

$VO_{2\ max}$	N	Mean	*p* value*
Experimental Control	22	4.738	0.039

*Significant at ≤ 0.05.

Table 3.6 shows the $VO_{2\ max}$ differences between both experimental and control groups. The mean score of $VO_{2\ max}$ differences between both groups was 4.738. Using Mann-Whitney Test with 0.05 margin of error, it was revealed that there is a significant difference (p=0.039) on $VO_{2\ max}$ average score between both experimental and control group before and after given the training program.

4. Discussion

The aim of this study was to determine the effects of Buteyko Breathing Technique in improving cardiorespiratory endurance. Statistical analysis using Wilcoxon signed-rank test shows that both groups were having an improvement in $VO_{2\ max}$ score after given the training program. However, the experimental group shows a higher $VO_{2\ max}$ improvement (13.14%) than the control group (7.17%). Statistical analysis using Mann-Whitney U test shows that there was a significant difference in $VO_{2\ max}$ improvement between both experimental and control group, which means that the combination of training program and Buteyko Breathing Technique was more effective in improving cardiorespiratory endurance.

Buteyko Breathing Technique is aimed to reduce pulmonary ventilation which will increase the carbon dioxide levels in human body. The increase of carbon dioxide levels is leading to an increase in the oxygen partial pressure that forces the oxygen to be released from the hemoglobin (the Bohr Effect). In other words, it will increase the oxygen delivery into the tissues and cells (Guyton & Hall, 2007).

Increased oxygen in the blood tends to emit the carbon dioxide from the blood (the Haldane effect). When entering the lungs, the partial pressure of carbon dioxide decreases while the partial pressure of oxygen increases. Hence, the Haldane effect duplicates the number of carbon dioxide released from the blood into the lungs and increases the carbon dioxide uptakes from the tissues (Guyton & Hall, 2007).

Practicing reduced breathing and breath holding during intensive types of exercise (such as jogging) greatly amplifies the effects of physical exercise. However, intensive physical activity offers some additional positive conditions, such as higher heart rates, perspiration and muscular work. These conditions facilitate the adaptation of human body to a higher carbon dioxide levels. As a result of repetitive breath holds with reduced breathing, the carbon dioxide levels remain high all the time (Rakhimov, 2013).

It is known that increased carbon dioxide levels affect many systems of the body. Increased level of carbon dioxide reduces the blood pH, leads to improvement of the synthesis of proteins, peptides, nucleic acids, lipid and carbohydrates, and increases the formation of ATP. Increased carbon dioxide level reduces the blood pH. It affects the oxygen-hemoglobin dissociation curve shifting to the right and thus reducing the affinity of hemoglobin for oxygen, thereby causing more oxygen to be released into the tissues (Bruton & Lewith, 2005).

Buteyko Breathing Technique also includes advice and training on the benefits of nasal breathing over oral breathing. The nose does not only warm, filter and humidify the inspired air, but also produce nitric oxide – a potent bronchodilator (Bruton & Lewith, 2005). One possible biochemical mechanism of Buteyko method may be through its influence on nitric oxide. Nitric oxide is involved in a large number of physiological responses including bronchodilation, vasodilatation, tissue permeability, immune response, oxygen transport, neurotransmission, insulin response, memory, mood, and learning (Courtney, 2008).

Buteyko Breathing Technique is an exercise to breathe through diaphragmatic breathing instead of chest breathing. The upper (7%) part of the lungs delivers 4 ml oxygen per minute, while the lower (13%) part of the lungs delivers 60 ml oxygen per minute. Therefore, the lower part of the lungs is about seven times more productive in oxygen transport. It provides hemoglobin in arterial blood with up to 98-99% oxygen saturation (Rakhimov, 2013).

During a long breath holding, one can see oxygen saturation dropping and then often reaching maximum saturation of 100% when the first breath is taken. One effect of long breath holding is that it enables the body to reverse carbon dioxide gas exchange so that the body reabsorbs carbon dioxide. Repeated use of extended breath holding increases the body's production of endogenous antioxidants and raises the anaerobic threshold, thus increasing capacity to exercise at higher levels of exertion, an effect similar to altitude or hypoxic training (Courtney, 2008).

5. Conclusion

The result obtained in this study revealed that the combination of Buteyko Breathing Technique and endurance training program is more effective than only using the single endurance-training program. This study was an experimental research based on Kisner & Colby (2012), a report that stated endurance depends on the factors of the transport of oxygen, the oxygen-binding capacity of the blood, cardiac function, oxygen extraction capabilities, and muscular oxidative potential. Developing cardiorespiratory endurance should not be merely focused on improving physiological adaptation, such as improving the ability of the cardiovascular and respiration system. However, improving body oxygenation system should be considered as an important aspect in developing cardiorespiratory endurance. The result of this study proves that improving body oxygenation system has the capabilities to improve cardiorespiratory endurance by comparing the difference of $VO_{2\ max}$ improvement in both groups. Further study to investigate specific aspects of how the mechanism of body oxygenation system may affect the cardiorespiratory endurance is required.

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