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Initial Comparison Of Difference Of Type Warm Up Exercise On Pulmonary Function

Byung-seob Kim[1], Su-bin Park[2], Nam-hyun Jeon[3], Dong-Yeop Lee[4], Ji-Heon Hong[5], Jae-Ho Yu[6], Jin-seop Kim*[7]

[1,2,3] Student, Department of Physical Therapy, SunMoon University, South Korea

*[4,5,6,*7] Professor, Department of Physical Therapy, SunMoon University, South Korea*

kbs7140@naver.com[1], sohahs1@naver.com[2], nh5356@naver.com[3], kan717@hanmail.net [4],

hgh1020@sunmoon.ac.kr[5], naresa@sunmoon.ac.kr[6], *skylove3373*@sunmoon.ac.kr*[7]

Corresponding author : mobilie Phone: +82-10-9062-3373

Abstract

Background/Objectives: *The purpose of this study is to find out how passive and active pre-treadmill exercise affect pulmonary capacity.*

Method/Statistical analysis: *This study was conducted with 20 healthy male university students in their 20s and they were randomly placed in each group. Spirometer (Pony FX, Italy), Ambu-bag (Mow Medical, Korea) and Ultrabreathe (Aqus, UK) were used. Comparisons were made between and inside groups.*

Findings: *Compared with the group before and after, the mean value of active inspiratory muscle warm-up group decreased in all factors, but there were significant differences in maximal oxygen consumption(VO_2max), expiratory minute volume(VE), metabolism(METs)($p<.05$). In the passive inspiratory muscle warm-up group, the mean value increased in all factors except respiratory exchange ratio(RER), but there was no significant difference($p>.05$). In comparison between the groups, the passive inspiratory muscle warm-up group increased no significantly in all items than the active inspiratory muscle warm-up group($p>.05$).*

Improvements/Applications: *Active inspiratory muscle warm-up exercise is thought to negative effects on some pulmonary function in a short time than active inspiratory muscle warm-up exercise.*

Keywords: *Ultrabreathe, Ambu bag, Inspiratory muscle, pulmonary function, Warm up.*

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1. INTRODUCTION

Recently, the fine particles concentration has increased, and the duration of such increased has continued for an extensive period, social interest in the effects of fine particles on the human body is growing rapidly[1]. Increased fine dust causes not only blurred vision and discomfort but also causes serious diseases such as conjunctivitis, paranasal sinusitis, otitis media, bronchitis, asthma and worsened chronic obstructive pulmonary diseases, pneumonia, angina, myocardial infarction and lung cancer[2]. Moreover, changes in air pollutant concentrations have had a severe effect on the pulmonary function of those who are healthy[3].

Respiratory function is a vital function in humans. For smooth breathing, oxygen is inhaled and transported by the blood flow. Carbon dioxide is expelled by expiration after being used by the body[4]. There are two types of muscles related to breathing; the inspiratory muscle and the expiratory muscle. The main muscles involved in the inspiration include the diaphragm and external intercostal muscles, which are used in tidal breathing. The major muscles involved in the expiration are mostly inactive in breathing. The collateral muscles have rectus abdominis, transversus abdominis, internal and external oblique abdominal muscle and Intercostal muscles and take part in deep or intense breathing[5,6].

In recent years, interest in the relationship between breathing muscle training has been increased with the aim of improving respiratory muscle function and lung capacity[7]. It was noted that, although the amount of exercise time is the same, respiratory muscle capacity training significantly reduced the diaphragmatic and abdominal fatigue after respiratory muscle training[8]. It was noted that 40 percent of maximal inspiratory mouth pressure (MIP) inspiratory muscle warm-up exercise could strengthen the inspiratory muscle muscles (8.5±1.8%)[9]. Inspiratory muscle strengthening is related to positive changes in lactic acid levels[10]. Manual hyperinflation showed improvement in the alveolar recruitment of atelectasis patients[11]. It is observed that the Intermittent positive pressure breathing (IPPB) increases the tidal volume, which shows minute ventilation and leads to a rise in arterial blood gas[12,13].

Previous studies show that passive breathing exercises help the pulmonary expansion and improve ventilation. They acknowledge that the breathing muscle capacity training reduces the increase in muscle fatigue and helps to reinforce the muscle strength of the respiratory muscles.

However, there were no studies that classified the inspiratory muscle into two types, passive and active, at MIP40% intensity and applied the training prior to the start of the protocol. Therefore, we would like to compare the active and passive inspiratory muscle training to identify which inspiratory muscle training has a more positive effect on lung capacity at the MIP40% level. Thus, in this study, the pre-post test is applied to the men in their 20s who are randomly classified into the passive and active form of inspiratory muscle training groups before starting the protocol. We will then compare what type of inspiratory muscle training has a more positive effect on lung function during this exercise and suggest whether it has contributed to the development of a new respiratory training program and the improvement of pulmonary function in the study subjects so that it serves as a new guideline in the clinical practice.

2. METHODS

2.1. Participants

Table 1. General characteristics in subjects

Division	Ambu-bag	Ultrabreathe	t	Significance
Age(year)	20.40 ± 1.84	20.90 ± 3.14	-.434	NS
Height(cm)	174.50 ± 4.65	173.50 ± 6.57	.393	NS
Weight(kg)	70.90 ± 6.69	71.10 ± 6.44	-.068	NS

All values are mean ± Standard Deviation(SD)

* *p* <.05

The subjects of our experiment were selected upon the following criteria: 20 healthy male university students attending S university in A city in their 20s who are physically and mentally sound who agreed to participate in the experiment. The exclusion criteria for the experiment are as follows: those with chest pain, those with lung-related surgical history within three months, those with pain or discomfort caused by motions such as walking or running, those with recent orthopedic problems on parts including but not limited to ankle or knee, and those with abnormal blood pressure ranges. This study was approved by the Institute of Review Board (SM-201904-036-1) of Sunmoon University. Participants were informed of the exercise method in advance through prior practice, and their characteristics are as shown in [Table 1].

2.2. Experimental Procedure

After the experimenter explained the purpose of the study; the research method; information on precautions; and safety education to the subject, the actual research method was demonstrated before the measurement, making both the experimenter and the subject familiar with the contents of the study and the research methods. In addition, the 20 subjects were randomly divided into two groups; 10 Ambu-bag (Mow Medical, Korea) training group and 10 Ultrabreathe (Aqus, UK) training group. Both the Ambu-Bag (Mow Medical, Korea) and the Ultrabreite (Aqus, UK) training groups performed measurements for baseline value without any intervention in the first measurement, and then the second measurement was conducted, followed by a single intervention. Assessment items measured were VO_2max, TIME, Respiratory rate (RR), RER, VE, and METs. In addition, the MIPs of both exercise groups were measured using the Spirometer (Pony FX, Italy) before the intervention. Then both groups were fully trained with 40 percent intensity of measured MIP. This is to make the subject to inhale with 40 percent intensity of MIP during inspiration using Ultreabreathe (Aqus, UK) and Ambu-bag (Mow Medical, Korea) [Figure 1, 2, 3, 4].

2.3. Intervention

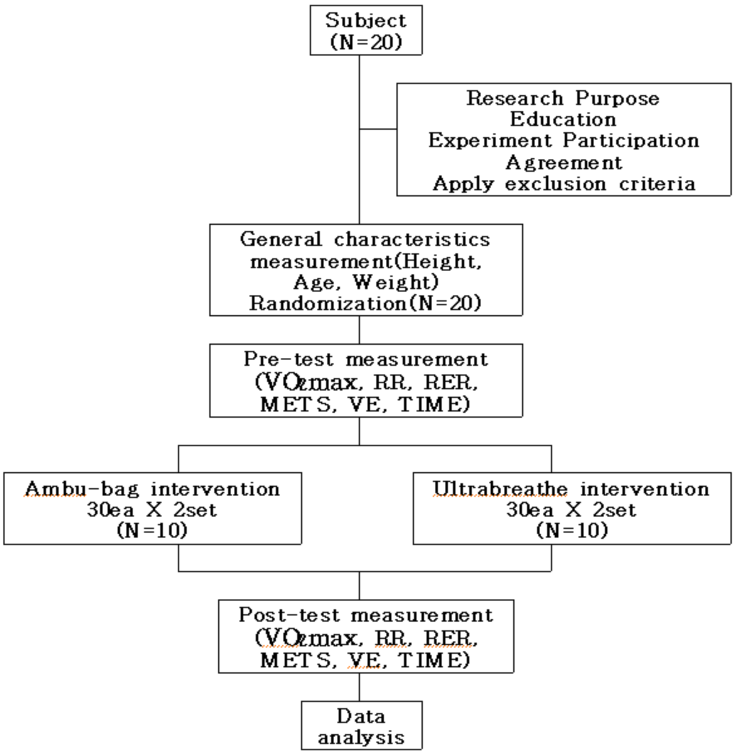
2.3.1. Group of passive inspiratory muscle warm-up (Ambu-bag)

Treadmill exercise was conducted without any prior intervention to measure the value for a baseline of the study. The intensity of the research was set according to the Bruce protocol established in the gas analyzer and Cardiac Stress Testing System. The Criteria for Termination were set to either rating of perceived exertion(RPE) 13 or RER 1.0, which is 60% of the maximum exercise capacity[14].

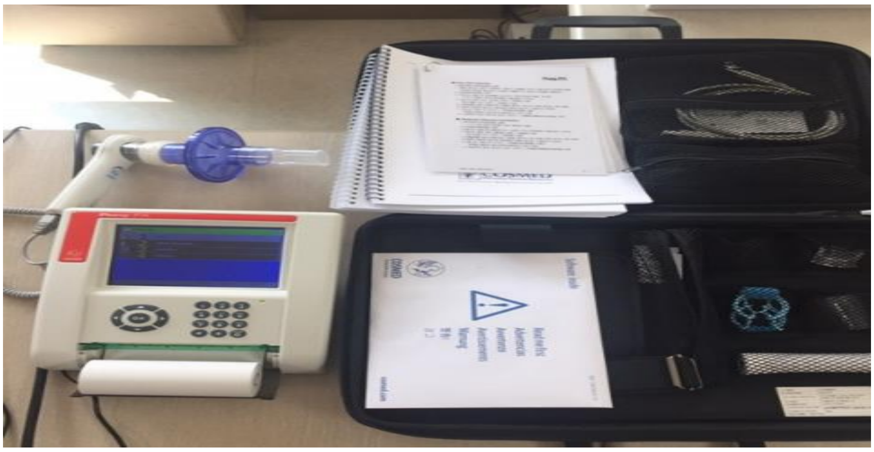
The items measured are VO_2max, TIME, RR, RER, METs, and VE. After measuring the values for the baseline, sufficient rest was given for a week to avoid affecting the values of the baseline. Following the sufficient rest, the amount of inspiration was calculated at the MIP 40%. The calculated capacity was applied manually for two sets of 30 reps via Ambu-bag and measured with gas analysis & cardiac stress testing system(Q-stress TM55, USA). [Figure 5, 6].

2.3.2. Group of active inspiratory muscle warm-up (Ultrabreathe)

In order to measure the value for a baseline of the study, a treadmill exercise was conducted without any prior intervention. The intensity of the research was set according to the Bruce protocol established in the gas analyzer and Cardiac Stress Testing System. The criteria for termination were set to either rating of perceived exertion(RPE) 13 or RER 1.0, which is 60% of the maximum exercise capacity[14]. The items measured are VO_2max, TIME, RR, RER, METs, and VE. After measuring the values for the baseline, sufficient rest was given for a week to avoid affecting the values of the baseline. Following the sufficient rest, Ultrabreathe set at MIP 40% was carried out for two sets of 30 reps and measured with a gas analysis & cardiac stress testing system. [Figure 5, 6].



[Figure 1] Experiment protocol flow chart

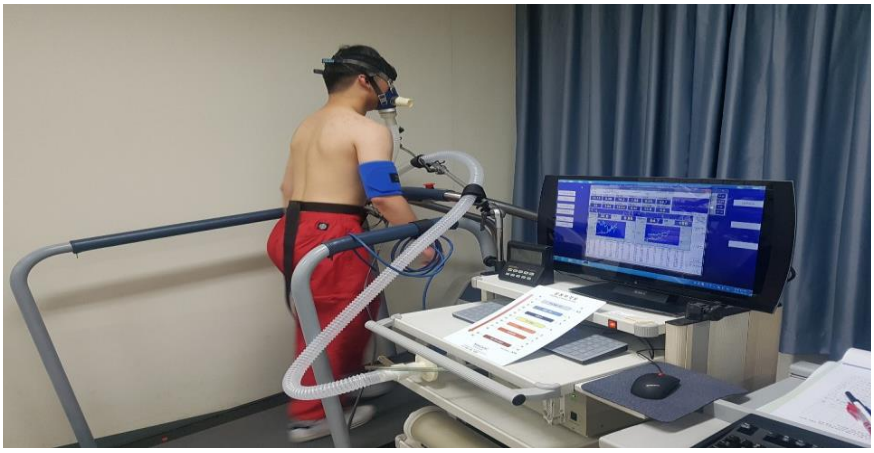


[Figure 2] Spirometer(Pony FX, Italy)

[Figure 3] Ambu-bag (Mowmedical, Korea)

[Figure 4] Ultrabreathe (Aqus, UK)

[Figure 5] Intervention method of each group



[Figure 6] Measurement method with pulmonary exercise test system.

2.4. Measurement Equipment

Prior to the pulmonary function test using a gas analysis & cardiac stress testing system, the purpose, method, and the precautions of the test were explained to the subjects, followed by a demonstration of the actual test method by the experimenter. After providing a sufficient amount of explanation, the measurement pad was attached to the chest to measure the subject's electrocardiogram. Afterwards a gas measuring mask was worn with the head strap adjusted to prevent air escaping from the mask. VO_2max, TIME, RR, RER, METs, and VE were measured according to the increasing intensity of the exercise in accordance with the Bruce protocol set in the tester. The Criteria for Termination were set to either rating of perceived exertion(RPE) 13 or RER 1.0, which is 60% of the maximum exercise capacity[14].

2.5. Data Analysis

All statistical analyses were conducted under the SPSS 22.0 version program. An independent sample T-test was applied to test the pre-post differences between the groups. In order to test the significance of the group, the paired t-test was conducted. All statistical levels of significance (*p*) were below .05.

3. RESULTS

Table 2. Comparison between abmu bag and ultrareathe on warm up

Division		Ambu bag	Ultrabreathe	t
VO_2max (ml/kg/min)	pre	2.51 ± .31	2.77 ± .54	
	post	2.75 ± .77	2.42 ± .37	
	post-pre	0.24 ± .74	-0.58 ± .80	2.372*
TIME (min)	pre	8.68 ± 1.56	8.95 ± 1.24	
	post	8.78 ± 1.42	8.69 ± 1.12	
	post-pre	0.99 ± 1.59	-0.26 ± 1.18	.571
RR (BPM)	pre	9.97 ± 11.51	7.66 ± 5.98	
	post	12.64 ± 8.60	5.87 ± 7.88	
	post-pre	2.51 ± 6.93	-1.79 ± 8.35	1.299
RER	pre	8.59 ± 1.69	8.85 ± 1.32	
	post	7.56 ± 3.40	8.69 ± 1.12	
	post-pre	-1.02 ± 2.99	-0.16 ± 1.13	-.855
METs (ml/kg/min)	pre	10.16 ± 1.52	11.10 ± 1.82	
	post	11.10 ± 3.23	9.71 ± 1.08	
	post-pre	0.94 ± 2.99	-1.39 ± 1.37	2.243*
VE (L/min)	pre	60.05 ± 15.71	66.49 ± 19.23	
	post	68.65 ± 25.74	58.01 ± 8.90	
	post-pre	8.60 ± 20.38	-8.48 ± 11.20	2.322*

All values are mean ± Standard Deviation(SD)

* *p* <.05

3.1. Differences in lung functions between passive and active inspiratory muscle warm-up

When comparing the items of pulmonary capacity measurement between the two groups, the average values of passive showed more increase in both pre-post tests than that of active. However, among the six items, significant differences were shown only in VO_2max, METs, and VE (p <.05), while TIME, RR, and RER did not show any significant differences (p >.05) [Table 2].

3.2. Differences in lung function before and after active inspiratory muscle warm-up.

The average value of the pre-post pulmonary capacity in the active inspiratory muscle warm-up group was decreased in all categories, with the biggest decrease in pre-post changes of the VE value, among other items. However, significant differences were shown only in VO_2max, METs, and VE (p <.05), while TIME, RR, and RER did not show any significant differences (p >.05) [Table 3].

3.3. Differences in lung function before and after passive inspiratory muscle warm-up.

The average value of the pre-post pulmonary capacity in the passive inspiratory muscle warm-up group was decreased only in RER, among other items, including VO_2max, TIME, RR, RER, METs, and VE. The value in VO_2max, TIME, RR, METs, and VE increased, with the biggest increase in the VE. However, there was no significant difference between the pre-post changes in all the measured items (p >.05) [Table 3].

Table 3. Comparison with in groups

Division		Ambu bag	Ultrabreathe
VO_2max (ml/kg/min)	pre	2.51 ± .31	2.77 ± .54
	post	2.75 ± .77	2.42 ± .37
	post-pre	.24 ± .74	-.58 ± .80
	t	-1.013	3.098*
TIME (min)	pre	8.68 ± 1.56	8.95 ± 1.24
	post	8.78 ± 1.42	8.69 ± 1.12
	post-pre	.99 ± 1.59	-.26 ± 1.18
	t	-.196	.696
RR (BPM)	pre	9.97 ± 11.51	7.66 ± 5.98
	post	12.64 ± 8.60	5.87 ± 7.88
	post-pre	2.51 ± 6.93	-1.79 ± 8.35
	t	-1.218	.677
RER	pre	8.59 ± 1.69	8.85 ± 1.32
	post	7.56 ± 3.40	8.69 ± 1.12
	post-pre	-1.02 ± 2.99	-.16 ± 1.13

	t	1.079	.441
METs (ml/kg/min)	pre	10.16 ± 1.52	11.10 ± 1.82
	post	11.10 ± 3.23	9.71 ± 1.08
	post-pre	.94 ± 2.99	-1.39 ± 1.37
	t	-0.996	3.219*
VE (L/min)	pre	60.05 ± 15.71	66.49 ± 19.23
	post	68.65 ± 25.74	58.01 ± 8.90
	post-pre	8.60 ± 20.38	-8.48 ± 11.20
	t	-1.334	2.393*

All values are mean ± Standard Deviation(SD), * p <.05

4. DISCUSSION

Respiratory function is a vital function in humans. The muscles related to breathing can be categorized into two types; the inspiratory muscle and the expiratory muscle. The main muscles involved in the inspiration include the diaphragm and external intercostal muscles, which are used in tidal breathing. The major muscles involved in the expiration are mostly inactive in breathing.

In recent years, interest in the relationship between breathing muscle training has been increased to improve respiratory muscle function and lung capacity[7]. It was noted that, although the amount of exercise time is the same, the diaphragmatic and abdominal fatigue reduced significantly after the respiratory muscle capacity training. Inspiratory muscle strengthening is related to positive changes in lactic acid levels[10]. Manual hyperinflation showed improvement in the alveolar recruitment of atelectasis patients[11]. It is observed that the Intermittent positive pressure breathing (IPPB) increases the tidal volume, which shows minute ventilation and leads to a rise in arterial blood gas[12,13].

Previous studies show that passive breathing exercises help pulmonary expansion and improve ventilation. They acknowledge that the breathing muscle capacity training reduces the increase in muscle fatigue and helps to reinforce the muscle strength of the respiratory muscles. However, there were no studies that classified the inspiratory muscle into two types, passive and active, at MIP40% intensity and applied the training before starting the protocol.

This study would like to compare the active and passive inspiratory muscle training to identify which inspiratory muscle training has a more positive effect on lung capacity at the MIP40% level. In order to figure out the effect each warm-up exercise has on the lung capacity, 20 physically and mentally sound male subjects with good lung capacity were randomly divided into two groups; 10 passive inspiratory muscle warm-up group and 10 active inspiratory muscle warm-up group, prior to the treadmill exercise.

It is reported that regarding the post – pre value between groups, the significant increases in VO_2max, METs, and VE of the passive respiratory muscle warm-ups are linked to the Intermittent positive pressure ventilation (IPPV), which is relevant to the increase of forced inspiratory vital capacity[15]. The application of IPPB in a supine position to neuromuscular patients increases ventilation in the anterior portion of the lung[16]. It is also reported that the significant decrease in VO_2max, METs, and VE of active respiratory muscle warm-ups indicates fatigue development in the respiratory muscles, which results in decreased maximum force or pulmonary functions. The development of muscle fatigue is generally quantified as a decrease in maximum force or power capacity[17]. We consider these as the reason for obtaining the results as mentioned above.

We conducted a paired t-test between the groups to verify that the same results were found in the variation within the group, which can confirm the reliability of the results regarding the variation difference between the groups shown above.

Results from the comparison between post – pre value within the group showed that the average value of VO_2max, TIME, RR, METs, and VE in the passive inspiratory muscle warm-up group, while the average value of RER decreased. But, none of them showed significant differences. However, considering the prior dissertation, which indicates improvement in alveolar recruitment after conducting 20 minutes of manual hyperinflation three times a day for five days with 8 to 13 breath/min speeds, it is safe to assume that applying passive inspiration for a long period can result in positive outcome[11]. Therefore, the results of significant increases in the value of VO_2max, METs and, VE shown in the passive inspiratory muscle warm-up group regarding the comparison between groups appear to be unreliable.

Comparing post – pre values in the active group of inspiratory muscle warm-up, the average value of VO_2max, TIME, RR, METs, VE, and RER all decreased, but the significant differences were shown only in VO_2max, METs and VE values. In the pilot study, when applying four weeks of training with two sets of 30 reps in power-breathe (with MIP50% and increases weekly by 5%), there was a distinct increase in MIP, MEP, FVC, MVV, SVC, and IC[18]. This study conducted the exercise for a short-term, and the measurement variables were VO_2max, TIME, RR, RER, METs, and VE. Perhaps, these differences in the period and the measurement variables produced opposite results. Therefore, passive inspiratory muscle warm-ups for a short period of time does not affect changes in the pulmonary function. It can also be said that active inspiratory muscle warm-ups for four weeks or more indicate an increase in the pulmonary capacity, whereas the active inspiratory muscle warm-ups for a short period of time indicate increases in the strength of the inspiratory muscle but decreases in the pulmonary function variables VO_2max, METs, and VE. It is safe to assume that a one-time warm-up exercise, unlike that of 4 weeks or more, is ineffective.

The limitations of this study are that it was impossible to control the daily activities of the subjects other than exercise time, and it was difficult to generalize the research result to various age groups since the research was conducted with a small number of subject in a relatively young group of college students. In the pilot study, rowing athletes and patients were selected as the research subjects. However, in this study, the research was conducted on the college students in their 20s, so it would be difficult to compare the effects of this study with the pilot. Moreover, the variables measured in the pilot study are different from those measured in this study, which makes accurate comparison very challenging. In the case of the prior dissertation that measured single-component intervention, it is essential not to disregard the changes from the development or the advancement in measuring devices. Through complement and Modification of these limitations and conducting researches from various aspects, this study will contribute to the studies on passive inspiratory muscle warm-up exercises, where not many resources or studies have been reported.

5. CONCLUSION

This study was conducted by classifying the warm-up exercises for inspiratory muscle into two groups, the passive warm-up exercise group and the active warm-up exercise group, prior to the treadmill exercise. Active warm-up exercise for the inspiratory muscle over a short period can increase the muscle strength of the inspiratory muscle, but it can also have a negative effect on some pulmonary functions due to the declined performance from muscle fatigue.

REFERENCES

[1] Pagan I, Costa DL, McGee JK, Richards JH, Dye JA. Metals mimic airway epithelial injury induced by in vitro exposure to utah valley ambient particulate matter extracts. J Toxicol Environ Health A. 2003 Jun 27;66(12):1087-112.

[2] Ristovski ZD, Miljevic B, Surawski NC, Morawska L, Fong KM, Goh F, et al. Respiratory health effects of diesel particulate matter. Respirology. 2012 Feb;17(2):201-12. 10.1111 / j.1440-1843.2011.02109.x.

[3] Yoda Y, Takagi H, Wakamatsu J, Ito T, Nakatsubo R, Horie Y, et al. Acute effects of air pollutants on pulmonary function among students: a panel study in an isolated island. Environ Health Prev Med. 2017; 22: 33. 10.1186 / s12199-017-0646-3.

[4] Roh H, Lee D. Respiratory fnction of university students living at high altitude. J Phys Ther Sci. 2014. 26(9):1489-92. 10.1589 / jpts.26.1489.

[5] Kisner C, Colby LA, Borstad J. Therapeutic exercise: Foundations and techniques. Philadelphia: FA Davis; 2002. p. 995-6.

[6] Cameron MH, Monroe LG. Physical rehabilitation: Evidence-based examination. New York: Physical Therapy; 2008. p. 973.

[7] Mozaffarian D, Kumanyika SK, Lemaitre RN, Olson JL, Burke GL, Siscovick DS. Cereal, fruit, and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. JAMA. 2003 Apr 2;289(13):1659-66. 10.1001/jama.289.13.1659.

[8] Verges S, Lenherr O, Haner AC, Schulz C, Spengler CM. Increased fatigue resistance of respiratory muscles during exercise after respiratory muscle endurance training. Am J Physiol Regul Integr Comp Physiol. 2007. Mar;292(3):R1246-53. 10.1152/ajpregu.00409.2006.

[9] Volianitis S, McConnell AK, Koutedakis Y, Jones DA. The influence of prior activity upon inspiratory muscle strength in rowers and non-rowers. Int J Sports Med 1999 Nov;20(8):542-7. 10.1055/s-1999-9464.

[10] Spengler CM, Roos M, Laube SM, Boutellier U. Decreased exercise blood lactate concentrations after respiratory endurance training in humans. Eur J Appl Physiol Occup Physiol. 1999 Mar;79(4):299-305. 10.1007 / s004210050511.

[11] Maa SH, Hung TJ, Hsu KH, Hsieh YI, Wang KY, Wang CH, et al. Manual hyperinflation improves

alveolar recruitment in difficult-to-wean patients. Chest. 2005 Oct;128(4):2714-21. 10.1378/chest.128.4.2714.

[12] Emmanuel GE, Smith WM, Briscoe WA. The effect of intermittent positive pressure breathing and voluntary hyperventilation upon the distribution of ventilation and pulmonary blood flow to the lung in chronic obstructive lung disease. J Clin Invest. 1966 Jul;45(7):1221-33. 10.1172 / JCI105428.

[13] Torres G. Lyons Ha. Emerson P. The effects of intermittent positive pressure breathing on the intrapulmonary distribution of inspired air. Am J Med. 1960 Dec;29:946-54. 10.1016 / 0002-9343 (60) 90075-9.

[14] Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JM, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American heart association exercise, cardiac rehabilitation, and prevention committee, the council on clinical cardiology; the councils on cardiovascular nursing, epidemiology and prevention, and nutrition, physical activity, and metabolism; and the american association of cardiovascular and pulmonary rehabilitation. Circulation. 2007 May 22;115(20):2675-82. 10.1161 / CIRCULATIONAHA.106.180945.

[15] Dohna-Schwake C, Ragette R, Teschler H, Voit T, Mellies U. IPPB-assisted coughing in neuromuscular disorders. Pediatr Pulmonol. 2006 Jun;41(6):551-7. 10.1002 / ppul.20406.

[16] Guérin C, Vincent B, Petitjean T, Lecam P, Luizet C, Rabilloud M, et al. The short-term effects of intermittent positive pressure breathing treatments on ventilation in patients with neuromuscular disease. Respir Care. 2010 Jul;55(7):866-72.

[17] Enoka RM, Duchateau J. Muscle fatigue: what, why and how it influences muscle function. J Physiol. 2008 Jan 1;586(1):11-23. 10.1113/jphysiol.2007.139477.

[18] Bostanci Ö, Mayda H, Yılmaz C, Kabadayı M, Yılmaz AK, Özdal M. Inspiratory muscle training improves pulmonary functions and respiratory muscle strength in healthy male smokers. Respir Physiol Neurobiol. 2019 Jun;264:28-32. 10.1016/j.resp.2019.04.001.