Comparative Study Between Inspiratory Muscle Training and Resisted Diaphragmatic Exercises on Lung Function in General Population

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Abstract:

Muscle fatigue has a major role in affecting exercise tolerance among general population. Respiratory muscle strengthening plays an important role in daily living to minimize fatigability. A total number of 124 subjects were approached from which only 80 were recruited by convenient sampling method. Participant were assessed for lung function using IMT device and peak flow meter.In a study, we distributed subjects in group A (n=40) and group B (n=40) and assessed. Result shows, values were pre (25.2±5.72) & (25.55±7.2) and post (35.64±5.09) &(34.32±102.10)shows significant improvement ($p<0.0001$). We also calculated peak expiratory flow rate with the average values of A (535.5±98.13) & (635.75±102.10) and the average values of group B (508±123.52) and (607.25±120.89) pre and post respectively($p<0.0001$).The study concluded that, inspiratory muscle training or resisted diaphragmatic exercises have equal effect on lung function in general population.

Keywords:

Inspiratory muscle training, Resisted diaphragmatic exercises, Lung function

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Introduction:

Respiratory system works to balance the production of carbon dioxide and consumption of oxygen within the pulmonary circulation to maintain homeostasis and minimize disturbances such as exercise intolerance and hypoxia [1].Diaphragm is the main respiratory muscle of the respiratory system, it acts like barrier between thoracic and abdominal cavities and have important role in expanding the thorax, by retracting towards the abdominal cavity during inspiration. In addition, it leads the movement of the lower ribs upwards and forwards [2].

This process will create negative pressure which increases thoracic volume. Diaphragm is only respiratory muscle which strongly resists the fatigue because of its continuous function. The mechanism of fatigue is usually managed by inspiratory and expiratory muscles by expanding the thorax maximally and increasing minute ventilation [3]. Muscle fatigue has a major role in affecting exercise tolerance among general population. Therefore, muscular strengthening plays a very important role in muscle activities. Some tests are used to assess strength of respiratory muscles; these tests are as follows- pulmonary function test (PFT) Inspiratory muscle training (IMT).

Spirometry

Spirometry is the common office test used to assess working of lungs by measuring air inhaled and exhaled and how quick air is exhaled.

Pulmonary function test (PFT)

A test that is designed to measure working of lung and efficiency of the exchange of oxygen and carbon dioxide between the blood and air within the lungs.

Inspiratory Muscle Training (IMT)

Inspiratory muscle training is defined as a course of therapy consisting of a series of breathing exercises that aim to strengthen the respiratory muscle.

The inspiratory muscles including diaphragm are morphologically and functionally skeletal muscles and therefore should be respond in the training in the same way as would any loco motor muscle if applied appropriate physiological load is applied, diaphragm increases its thickness when resistance is applied during the training, Inspiratory muscle training (IMT) has been extensively used to improve inspiratory muscle strength [4]. Respiratory muscle training devices enhances respiratory muscle strength, endurance and exercise capacity. IMT devices improve muscle strength of inspiratory muscles. In contrast, EMT devices improvethe strength of the expiratory muscle.

IMT devices have twodifferent modes, each for a specific use**.**

A) Voluntary isocapnichyperpnea which enhances the inspiratory muscle endurance.

B)Resistive inspiratory muscle training which enhances the inspiratorymuscle strength.

This mode is divided into two types.

(1) Pressure resistive IMT devices (PR-IMT) and flow resistive devices.

(2) Pressure resistive IMT devices are usually hand-held devices with a spring load that is impeded with different intensities.

These intensities can be adjusted by the resistive load knob (varying from low to high). In addition, the normal mechanism of PR-IMT devices requires the initiation of a negative pressure (breath) done by the subjects to overcome the load resistance. The effectiveness of these devices has been proved in which stated that the PR-IMT devices work on improving the maximal inspiratory pressure (MIP) [5]. There are several types of PR-IMT such as (power breath) and (Threshold IMT), which has wide ranges of features for instance; muscle strengthen, endurance training and improvement in perception of breathing. Such devices can be used with different intensitieslike high, moderate and low intensities. Flow resistive devices are of two types, passive and dynamic. Passive flow resistive devices require Inhaling through a fixed orifice which can be changed to increase training load and the smaller the diameter, the higher the load is. However, one of the disadvantages the flow resistive devices have, that they are affected by the inspiratory flow which is initiated by the subjects. Thus, breathing patterns should be monitored during training when using these devices. While, dynamic flow resistive devices require to inhale through a variable orifice within the breath, which makes the dynamic flow resistive devices superior than passive flow resistive devices [6].

For pressure resistive IMT devices, high intensity exercise in general results in improving maximum oxygen uptake (VO_2 max) and aerobic performance in healthy subjects. High intensities that ranged between (80%-90%) of MIP in PR-IMT devices, improve the respiratory muscle strength, work capacity, power output and lung volumes but this range of intensities is difficult to be maintained for a long period of time. PRIMT devices are safe for healthy adults, at the same time, high intensities will not induce diaphragmatic fatigue and muscle damage, but they may cause inspiratory muscles soreness. In addition, proved that PR-IMT positively affects both maximal inspiratory and expiratory pressures, in comparison to EMT devices which affect maximal expiratory pressure [7]. Low and moderate intensities that ranged between (40%-60%) have no effect on lung volumes. 60% of MIP improves muscle strength, work capacity and power output. While, 40% of MIP improves muscle strength, work capacity and power output.

The inspiratory muscles, including the diaphragm are morphologically and functionally skeletal muscles and therefore should respond to training in the same way as would any locomotors muscle if an appropriate physiological load is applied. In support of this theory, it has been documented that the diaphragm increases its thickness when resistance is applied during weight training. During whole body workout there increase in metabolic rate and the respiratory rate which results in increase in pumping action of the heart to circulate the blood and oxygen to the other parts of the body. In this process there is rapid exchange in oxygen and carbon dioxide.

The functional capacity of the healthy human respiratory system including the lung, chest wall, and neural control systems, exceeds the demands placed upon it during heavy exercises. This is an impressive feat considering the major challenges the respiratory system must face during intense exercise. For example, the healthy respiratory system faces the major challenges of regulating alveolar partial pressure of oxygen and carbon-dioxide through a considerable increase in alveolar ventilation (VA) that often exceeds resting levels by more than 20 times. The ability for the healthy respiratory system to overcome these challenges, but there are exceptions when the respiratory system becomes limited during the exercises. Resisted Diaphragmatic Exercises are used to increase the strength and mobility of diaphragm. In resisted diaphragmatic exercises participants lie in incline position and about 1pound that is 0.5 grams of weight is placed on the diaphragm. Individuals take deep breath and exhales this procedure is done for 15 repetitions then 12 repetitions and then 8 repetitions.Respiratory muscle training enhances respiratory muscle strength, endurance and exercise capacity. In which, Inspiratory muscle training have different modes, each for a specific use. Resistive inspiratory muscle training which enhances the inspiratory muscle strength. And also, to mark the individuals who are more prone to get affected to lung diseases. Hence, there is need to find out different modes of strengthening training which will helpful to improve pulmonary function in general population.

Materials And Methodology:

Permission for the project was taken from institutional ethical committee. Samples were selected using simple random sampling method on the basis of inclusion and exclusion criteria. Aims, objectives and methodology were explained to the participants and sign on the consent form was taken. Participants were divided into two groups (n = 80). Group A contained 40 participants and Group B contained 40 participants. For the assessment of lung function two devices were used

Peak Flow Meter (PFM) and Inspiratory Muscle Trainer (IMT). After the assessment participants were randomly distributed into two groups for 4 weeks exercise program. Half of the participants were under resistive diaphragmatic exercises and half of the participants were trained under Inspiratory Muscle Trainer (IMT). After 4 weeks again post training readings were taken.

Mini-Bell Peak Flow Meter (PFM)

The mini bell peak flow meter provides an objective measurement of Peak Expiratory Flow (PEF) and is valuable information of lung function. Make sure red pointer is at zero. Hold the peak flow in a horizontal position, as illustrated and take deep breath to draw air into the lungs. Place your lips tightly on the mouthpiece and blow as fast as you can. Your exhaled breath will move the indicator up the scale. Reset the pointer to the bottom of the scale and repeat the above procedure for twice or thrice and you will get higher readings.

Inspiratory Muscle Trainer (IMT)

An inspiratory muscle trainer is used to check strength of inspiratory muscles and lungs. It consists of a mouthpiece, a scale ranging from (0-41), a spring to increase or decrease the resistance; participants were asked to inhale deep and as fast as possible with a nose clip placed on the nose. Participants were instructed to repeat the procedure for 2 to 3 times (repetition maximum) was taken during assessment, during exercise program and post exercise program to check the strength of inspiratory muscles. Participants were instructed to repeat the procedure for 15times then for 10 times and at last for 8times. Again 3 RM was taken to spot the difference.Then data was statically analysed using Microsoft excel and instat software.

Results:

1 Repetition maximum	*Pre-Training (mean ± S.D)*	*Post-Training (mean ± S.D)*	*p -Value*
Group A	*25.2±5.72*	*35.67±5.09*	*< 0.0001*
Group B	*25.55±7.2*	*35.32±102.10*	

Table 1: Distribution of subjects according to 1 Repetition maximum

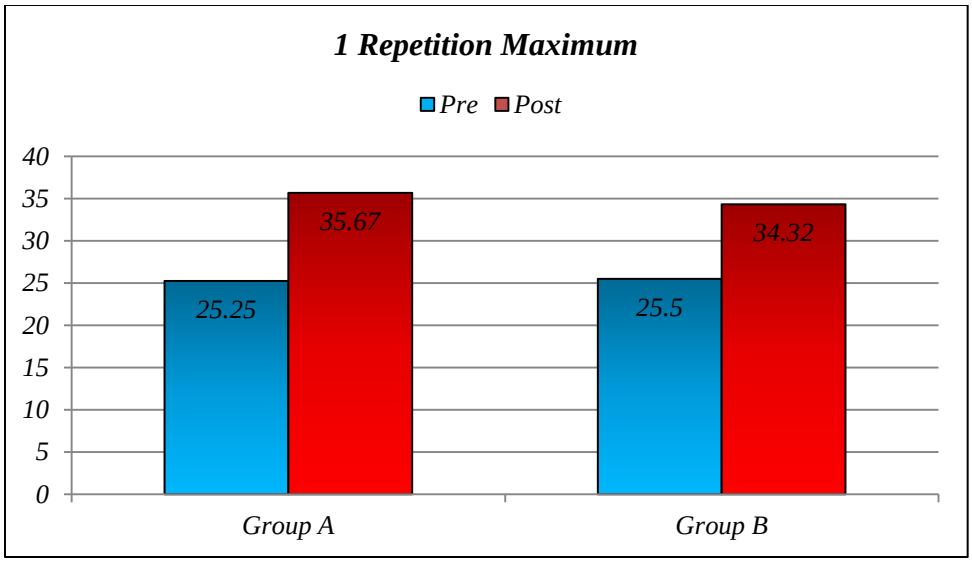

Figure 1: Above graph shows, significant improvement in both inspiratory muscle training and resisted diaphragmatic training on 1RM, post treatment ($p<0.0001$) in general population.

Peak expiratory flow rate	*Pre-Training (mean ± S.D)*	*Post-Training (mean ± S.D)*	*p -Value*
Group A	*535.5±98.13*	*635.75±102.10*	*< 0.0001*
Group B	*508±123.52*	*607.25±120.89*	

Table 2: Distribution of subjects according to Peak expiratory flow rate

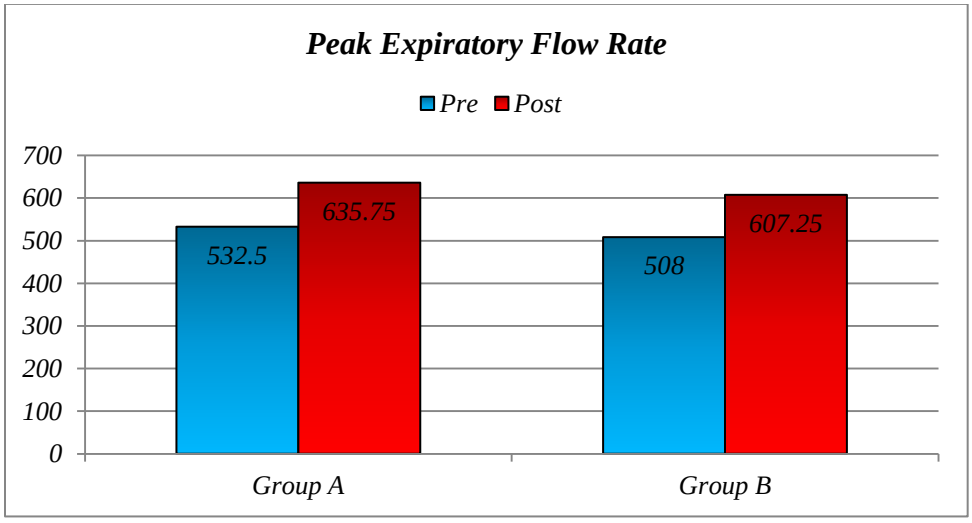

Figure 2: Above graph shows significant improvement in both inspiratory muscle training and resisted diaphragmatic training on peak expiratory flow rate, post treatment ($p<0.0001$) general population.

Discussion:

Respiratory system works to balance the production of carbon dioxide and consumption of oxygen within the pulmonary circulation to maintain homeostasis and minimize disturbances such as exercise intolerance and hypoxia. Diaphragm is the main respiratory muscle of the respiratory system, it acts like barrier between thoracic and abdominal cavities and have important role in expanding the thorax, by retracting towards the abdominal cavity during inspiration. In addition it leads the movement of the lower ribs upwards and forwards. This process will create negative pressure which increases thoracic volume. Diaphragm is only respiratory muscle which strongly resists the fatigue because of its continuous function. The mechanism of fatigue is usually managed by inspiratory and expiratory muscles by expanding the thorax maximally and increasing minute ventilation [8].

Our study was random sample based in the population of 80. So, there was huge difference in the participation of gender. As you can see there is male dominance more than female. The participation of male individuals was 66 as compared to female individuals were only 14.

We also calculated Body Mass Index (BMI) of our participants. From our analysis we came to the conclusion that very few were under the category of underweight that is only 03 individuals were between the range of 15-18kg/m^2, only 04 individuals were under the category of grade 1 obese that is between the range 30-35kg/m^2, only 02 individuals were under the category of grade 3 obese that is between the range of 36-40kg/m^2, most of the population was having good Body Mass Index (BMI) 71individuals were between the range of 19-29kg/m^2.

RajendraPradeepa in his studies of prevalence of generalized & abdominal obesity in urban & rural India stated that prevalence was significantly higher among the urban residence as compared to rural residents in all four regions studied. The National Family Health Survey-3 also reported that in India obesity ($\geq$ 25kg/m^2.) in urban population as compared to rural population [9]. In our study we distributed our subjects into two groups each group contained 40 participants. Group A (n=40) Group B (n=40) were assessed by using Phillips inspiratory muscle trainer device (IMT) and mini-bell peak expiratory flow meter (PEFM) in both the devices three readings were taken and best from the three readings was considered. Group A were trained with Phillips inspiratory muscle trainer device (IMT) and Group B were trained with resisted diaphragmatic exercises. Figure 1shows distribution of population pre and post training by

inspiratory muscle trainer and resisted diaphragmatic exercises, the average values were pre (25.2 ± 5.72) (P=0.0001) which is extremely significant of group A and the average values of group B were pre (25.55±7.2) and post were (35.325±5.806) (p<0.0001). As you can see participants of both the groups show significant improvements post treatment.

Nora Sulaiman in his study,a comparison between two types of resistive inspiratory muscle training devices in normal subjects in regards to pulmonary functions stated that MIP was improved significantly in both, TG and PG (p<0.005 and p<0.006, respectively), while no change was noticed in CG. For MEP, both TG and PG improved significantly with a p-value of (p<0.034 and p<0.208, respectively) while no improvements were observed in CG. PEFR proved to be significantly increased in PG (p<0.012), while there was no improvement in TG and CG. MVV showed improvement in both, TG and PG (p<0.023 and p<0.006, respectively), while no change was noticed in CG. Regarding MNOVA test, Threshold IMT Device shows to be superior to power breath-plus in increasing MIP significantly (p<0.000) [10].

We also calculated Peak Expiratory Flow Rate (PEFR) of our individual's figure 2 shows, the distribution of population according to peak expiratory flow rate. The average values of group A trained with inspiratory muscle training before treatment were (535.5 ± 98.13) and post treatment was (635.75± 102.10). And the average values of group B trained with resisted diaphragmatic exercises before treatment were (508 ± 123.52) and post treatment were (607.25 ± 120.89) p value was (p<=0.0001). As you can see both the groups showed significant improvement after the treatment. We also compared group A and group B by using unpaired t-test mean values of group A trained with Inspiratory muscle training (1RM) was (35.67± 5.09) and group B trained under resisted diaphragmatic exercises values were (35.32 ± 5.80) p value of both the groups were (P<0.77) which was not significant.

We also compared group A and group B of Peak expiratory flow rate (PEFR) by using unpaired t- test. The mean values of group A were (635.75 ± 102.10), group B was (607.25 ± 120.89) and p value was (p<0.25) which was not significant. Paul M in his study Heart Rate Variability Biofeedback Increases Baroreflex Gain and Peak Expiratory Flow stated that,there is an acute increase in low-frequency and total spectrum heart rate variability, and in vagal Baroreflex gain, correlated with slow breathing during biofeedback periods. Increased baseline Baroreflex gain

also occurred across sessions in the biofeedback group, independent of respiratory changes, and peak expiratory flow increased in this group, independently of cardiovascular changes. Biofeedback was accompanied by fewer adverse relaxation side effects than the control condition. And he concluded that: Heart rate variability biofeedback had strong long-term influences on resting baroreflex gain and pulmonary function. It should be examined as a method for treating cardiovascular and pulmonary diseases. Also, this study demonstrates neuroplasticity of the baroreflex.

Conclusion:

The study concluded that inspiratory muscle training or resisted diaphragmatic exercises have equally effective on lung function in general population.

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