International Journal of Health Sciences and Research
Vol.12; Issue: 10; October 2022
Website: www.ijhsr.org
ISSN: 2249-9571

Original Research Article

Effect of Respiratory Muscle Training in Improving the Exercise Tolerance in Normal Individuals

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DOI: https://doi.org/10.52403/ijhsr.20221009

ABSTRACT

Background and objective: Nowadays in normal individuals, decrease in tolerance is very common due to age physical functional decline, which influences respiratory performance. One of the physical changes associated with age is reduction in muscle strength and power. Respiratory muscle training by using cycle ergometer peak flow meter and incentive spirometer can improve the exercise tolerance thereby increasing the muscle strength and power. This study aims at finding the effect of respiratory muscle training in improving the Rate Pressure Product (RPP), Rate of Perceived Exertion (RPE) & Six Minute Walk Distance Test (6MWD) in normal individuals.
Methods: 50 normal individuals aged 30 to 40 volunteered for this study. All the individuals underwent pre evaluation to exclude any cardiopulmonary disease. They were given training with incentive spirometer, peak flow meter and cycle ergo meter. The training was given for 50mins in session twice daily 5 days in a week for a period of 4 weeks. Post training values RPP, RPE and 6MWD Test were recorded at the end of fourth week of training.
Results: After performing a related t test with the observed values of RPP, RPE and 6MWD Test, the ‘t’ value was found significant.
Conclusion: There is a significant improvement in exercise tolerance of normal individuals after giving respiratory muscle training with cycle ergometer peak flow meter and Incentive Spirometer.

Keywords: Respiratory muscle training, Exercise tolerance, Incentive Spirometer, Cycle ergometer, Peak flow meter, Rate Pressure Product, Rate of Perceived Exertion, Six Minute Walk Distance Test.

INTRODUCTION

The lungs with their combined surface area of greater than 500m^2 are directly open to the external environment. Thus structural, functional or microbiological changes within the lungs can be closely related to epidemiology with environmental, occupational, personal and social factors. Primary respiratory diseases are responsible for a major burden of morbidity and ultimately deaths and the lungs are often affected in multisystem diseases. A number of important research advances have occurred in recent years. The discovery of genetic mechanism of cystic fibrosis provides a novel opportunity to develop gene. The lung especially favoured for gene therapy since its airway, epithelial cells are accessible to nebulized particles and the extensive microvascular pulmonary capillary endothelium is available to intravenously delivered agents.

The upper respiratory tract includes the nose, nasopharynx and larynx. It is lined by vascular mucous membranes with ciliated epithelium on their surfaces. The lower respiratory tract includes trachea and bronchi. These form an interconnecting tree of conducting airways eventually joining via around 640 terminals, bronchioles, with the alveoli to form the acini. The lower respiratory tract is lined with ciliated epithelium as far as the terminal bronchioles. The larynx & large bronchi are supplied with sensory nerve receptors involved in the cough reflex. The acinus is the gas exchange unit of lung and comprises branching of respiratory bronchioles with flattered epithelial cells type I pneumocytes, but there are some more unbodial type-II pneumocytes, later produce surfactant, a mixture of phospholipids, which acts to reduce surface tension and counter act the tendency of alveoli to collapse type-II pneumocyctes also display a remarkable capacity to divide and reconstitute the type-I pneumocyte after lung injury.

The right ventricle pumps blood against the relatively low pulmonary vascular resistance. Blood flows through a rich capillary network, intimately adjacent to alveoli facilitating gas exchange & increased pulmonary vascular resistance. The destructive changes caused by chronic obstructive pulmonary disease results in right ventricular hypertrophy & eventually right heart failure (cor pulmonale).

The elastic of a material is a measure of the stiffness of the material with respect to the gas transport system, the amount of stretch on the elastic walls is measured by change in volume, the force exerted by the walls as they try to return to their original volume is measured by change in pressure. Thus the elastance of the walls of gas transport system may be defined as the change in pressure divided by the change in volume. Clinically however, it is the compliance of the heart, the blood vessels or the lungs that is of concern. Compliance in the increase of elastance and it is a measure of the distensibility.

Compliance = Change of Volume/Change of pressure

$= \Delta V / \Delta P$

The respiratory system includes the bony thorax, the muscles of respiration, upper & lower airways and pulmonary circulation. Intimate and exquisite the interaction of these components is necessary for the accomplishment of the many respiratory and non-respiratory functions of respiratory system. These include gas exchange, fluid exchange, and maintenance of a relatively low volume, blood reservoirs, filtration and metabolism. Respiration results from the coordinated interaction of muscles of the neck thorax and abdomen. The timings of specific muscular action remain datable, the type and extent of activity probably changes with the magnitude of the respiratory effort.

Primary muscles of respiration include diaphragm a musculatory dinous dome shape forming the floor of the thorax, which arise from a tripartite (sternal, costal and lumbar) origin to converge into a central tendon at the apex of the dome. During normal respiratory effort (with lower ribs fixed) the diaphragm contract from its rural and rib attachment to pull the central tendon down and forward.

Accessory inspiration muscles are eleven pairs of intercostals muscles occupy the intercostals spaces, connecting adjoining ribs. The actions of intercostals muscles remain somewhat under dispute. It has been reported that as a group of intercostals acts as elevator of the ribs during inspiratory effort, that external intercostals elevate and the internal intercostals depress the ribs that they act in concert to prevent bulging or sucking in of the intercostals spaces during respiration that they may be primarily postural muscles. External intercostals each muscle passes obliquely upward and backward from the upper border of one rib to the lower border of the rib above. Internal intercostals each muscle passes obliquely upward and forward from the upper border of one rib to the floor of costal groove of rib.

Sternocleidomastoid (SCM) arises by two heads (sternal and clavicular from the medical part of clavicle), which unite to extend obliquely upward and laterally across the neck to the mastoid process. Scalene lie deep to the SCM but may be palpated in the posterior triangle of neck.

Trapezius (upper fibers) arises from the medical part of the superior nuchal line on the occiput and the ligamentum nuchae (from the vertebral spinal processes between the skull and the seventh cervical vertebrae) to insert on to the distal third of the clavicles. Pectoralis major arises from medical third of the clavicle and inserts in to lateral lip of the crest of the greater tubercle. Pectoralis minor arises from the second to fifth or third to sixth ribs, which insert into the medical side of coracoid process.

Serratus anterior arises from the outer surfaces of the upper eight or nine ribs to attach along the costal aspect of the medial border of the scapula. Latissimus dorsi arises from the spinous processes of lower six thoracic, lumbar & upper sacral vertebrae and from the posterior aspect of iliac crest. The quadratus lumborum arises from the iliac crest upward to the twelfth rib. The major controversy regarding rib motion centers on the types of motion at the costovertebral articulations and whether or not the rib cage can be deformed during inspiration, expiration. Using the theory of a common axis for cost vertebral and costo-transverse joints motion in ribs 2 to 10 generally occur around axis lying nearly in the frontal plane for the upper ribs and around an axis approaching the sagittal plane for the lowermost ribs given the closed kinematic chain formed by the ribs, some motion at the costosternal joints of these ribs, motion at the cost sternal joints is limited to slight vertical motion with no rotation. Motion at the interchondral joints of ribs 8 to 10^{th} is a superior inferior sliding. The resultant movement of the especially shaped ribs is a forward and upward motion of the upper ribs called "pump handle motion". The lower ribs move upward and laterally in what are known as 'bucket handle motion'. The intermediate ribs move minimally both forward and laterally. The sternum is also pushed upward and forward by the action of the ribs, increasing the anterior-posterior diameter of the chest wall during inspiration.

The muscles that attach to the ribcage, shoulder girdle or vertebral column assist with inspiration in situations of stress but not during quiet breathing in normal humans. Respiratory muscle training includes both inspiratory and expiratory by using different methods of training. Respiratory muscle training has been used to successfully increase muscle strength and endurance in healthy volunteer and in patients with COPD and chronic airflow limitation.

Belman & Mittman (1980) has proved the effects of inspiratory muscle training on muscle strength and endurance in healthy volunteers. Expiratory muscle will also be beneficial with these techniques by using inspiratory resistive or resistive breathing exercises[16]. SheelAW(2002) has proved the effects of respiratory muscle training in healthy individual's physiological rationale and also said that implications for exercise performance can improve endurance and strength of the muscle.[12]

Respiratory muscle training is currently used to increase the strength and endurance of respiratory muscles. Theoretically respiratory muscle training should reduce dyspnea by improving respiratory muscle function and exercise tolerance. To train a muscle to improve its functional ability, the muscle must be directed at developing specific functional abilities (e.g.: strength or endurance) of the muscle (specificity) & the training must be maintained or function will revert back to pertaining levels (reversibility).

Respiratory muscle training has been used successfully to increase muscle strength and endurance in healthy volunteers and in patients with chronic airflow limitation, COPD. Exercise training will be given by using following methods like cycle ergometer, incentive Spirometer, peak expiratory flow meter.

Incentive Spirometer is designed to mimic natural sighing or yawning by encouraging the patient to take long, slow & deep breaths. This is accomplished by using a device that patient with visual or other positive feedback when they inhale at a predetermined flow rate or volume and sustain the inflation for a minimum of 3secs.

The objectives of this procedure are to increase trans pulmonary pressure and inspiratory volumes, improve inspiratory muscle performance and re-establish or stimulate the normal pattern of pulmonary hyperinflation.
Peak flow meter measures peak expiratory flow rate, which is the highest speed that one can blow air out of his lungs after taking in as big breath as possible. The meter has a scale with numbers on it which indicates the airflow speed of the person who is blowing in litres per minute.
Cycle ergometer is also a method used for exercise training for tolerance in normal individuals by training both inspiratory and expiratory muscles. It may be intermittent or continuous but usually involves a progressively, increasing workload. Cycle ergometer may be mechanically or electrically braked and the work load is easily calibrated in watts or kilogram meter and tends to be as dependent on the patient weight and physical efficiency.
Though there are many research studies done to find out the efficacy of various procedures to improve the strength of the respiratory muscles, this study intends to find out the effect of respiratory muscle training on exercise tolerance in normal individuals so that it could be applied in future for respiratory disorder cases in their rehabilitation

REVIEW OF LITERATURE

Jaeock Kim MS et al (2005) extensively studied in the Department of Communication Sciences and Disorders, University of Florida, Gainesville, Florida on elderly individuals with regard to limb function but less with regard to respiratory function. Elderly individuals experience reduces muscle mass and strength in respiratory musculature. Increasing respiratory muscle strength may enhance an elderly individual ability to generate and maintain the respiratory driving force critical to cough, speak and swallow. [17]

McConnell AK & Romer LM (2004) reported that the effects of respiratory muscle training in healthy humans: resolving controversy in the Department of Sport Sciences, Brunel University, Uxbridge, Middlesex, UK. They proved the mechanism improves exercise performance are unclear. The putative mechanism includes a delay on respiratory muscle fatigue. Redistribution of blood flows from respiratory to locomotor muscles and decrease in the perception of respiratory and limb discomfort. [10]

M Beckerman et al (2004) investigated the short term and long term benefits of IMT on inspiratory muscle performance (strength and endurance), exercise capacity and the perception of dyspnea in Department of Medicine, Hadera, Israel concludes that, in patients with significant COPD, inspiratory muscle training results improvement in performance, exercise capacity and in the sensation of dyspnea. The benefits of 12 weeks of inspiratory muscle training decline gradually over one year of follow up if maintenance training is not performed. [24]

Rasmi Magadle et al (2003) did a study to evaluate whether the respiratory muscle weakness contributes to dyspnea and exercise limitation in patients with significant COPD. They made an attempt to reduce the severity of breathlessness and to improve exercise tolerance by comparing both inspiratory and expiratory muscle training. Patients were randomized into 4 groups, trained daily six times a week with each session consisting of one half hour of training for 3 months. Spirometry respiratory muscle strength and endurance, six minute walk distance test, the perception of dyspnea and Mahler Baseline Dyspnea Index (BDI) were measured before and following training. They found that inspiratory and expiratory muscles can be specifically trained with the improvement of both muscle strength and endurance. The improvement in the inspiratory muscle performance is associated with an increase in 6 MWD test and sensation of dyspnea. There is no additional benefit gained by combining SIMT and SEMT compared to using SIMT alone.

Paltiel Weiner MD et al (2003) discussed that expiratory muscle training can be specifically trained with improvement of both strength and endurance in patients with COPD in the Department of Medicine, Hadera, Israel. Patients were assigned to receive specific expiratory muscle training daily, 6 times a week, each session of half an hour of training for 3 months. Spirometry, respiratory muscle strength and endurance, six minute walk test distance and Mahler baseline dyspnea index (before) and transitional dyspnea index (after) were measured before and after training. Improvement was associated with increase in exercise performance and no significant change in sensation of dyspnea in daily activities.

Sheel AW (2002) conducted the study in School of Human Kinetics, University of British Columbia, Canada to find out the effects of respiratory muscle training in healthy individuals: physiological rationale and implications for exercise performance. They said that respiratory muscle training influences relevant measures of physical performance to a limited extent at most. The study evaluated the possible implications for exercise performance using sub maximal fixed work rate test.[12]

Gibbsons WJ et al (2001) suggested a multiple repetition six minute walk test in healthy adults older than 20 years and the study was conducted in Respiratory Division, Department of Medicine, Montreal Chest Institute, Victoria Hospital, Canada. They examined on 41 male and 38 female healthy volunteers ranging in 20 – 80 years. They performed 6 MWD with multiple repetitions. It was concluded that selection of appropriate predicted 6 MWD values for interpretation performance should be guided by subject, age and degree of test familiarization provided.[13]

Inbar O et al (2000) reported that Specific Inspiration Muscle Training (SIMT) will result improvement in respiratory muscle function and there upon in aerobic capacity in well-trained endurance athletes. 20 well-trained endurance athletes volunteered into two groups, namely the training group who received SIMT and a control group received sham training. Inspiratory muscle training was performed using a threshold inspiratory muscle trainer and sham training with the same device but with no resistance. They concluded that 10 week of SIMT can increase the inspiratory muscle performance in well-trained athletes using threshold inspiratory trainer. However, this increase was not associated with improvement in aerobic capacity, as determined by O_2 max or in O_2 desaturation during maximal graded exercise challenge.[23]

Gosselink R et al (2000) from University Hospitals Respiratory Rehabilitation Respiratory Division, Katholicke Universitieit Leuven, Belgium evaluated the contribution of respiratory muscle weakness and respiratory muscle training to pulmonary function, cough efficacy and functional status in patients with advanced Multiple Sclerosis (MS). Training group performed 3 series of 15 contractions against an expiratory resistance (60% maximum expiratory pressure [PEMAX]), 2 times a day. Control group performed breathing exercise to enhance maximal inspirations. The results showed that expiratory muscle training tended to enhance inspiratory and expiratory muscle strength.[26]

Troosters T et al (1999) recommended six minute walking distance test to estimate functional exercise capacity in Respiratory Rehabilitation and Respiratory Division, University Hospitals, Belgium. They proved its effects on 50 – 80 years aged healthy volunteers. Six minute walk distance was conducted in 80mt long corridor, its variability explained largely by age, sex, height and weight. They finally concluded that six minute walk distance test interpreted more adequately if expressed as a percentage of predicted value.[14]

Weiner P et al (1997) discussed the effect of incentive spirometry and inspiratory muscle training on pulmonary function after lung resection using 32 patients with COPD who were candidates for lung resection randomized into two groups. 17 patients received SIMT and incentive spirometry, 1 hour per day, six times per week, for two weeks and 15 patients who were assigned to control group received no training. In patients undergoing lung resection simple calculation of predicted postoperative FEV1 underestimated the actual postoperative FEV1 by a small fraction. The results showed lung functions can be increased significantly when incentive spirometry and SIMT are used before and after operation.

Suzuki S et al (1995) said that the sensation of respiratory effort may increase as expiratory muscle become fatigue during expiratory loading. They performed a study to determine whether Expiratory Muscle Training (EMT) effects the sensation of respiratory effort during exercise in healthy individuals. In this six subjects were performed EMT for 15 minutes twice daily, for 4 weeks. Using a pressure threshold device another 6 subjects served as a control group. Findings suggested that EMT increases expiratory muscle strength and reduces the sensation of respiratory effort during exercise, presumably by reducing minute ventilation.[22]

Mancini DM et al (1995) from Cardiovascular and Pulmonary Sections, Phi;adelphia found that selective respiratory muscle training improved respiratory endurance and strength with enhancement of submaximal exercise capacity in patients with heart failure and dyspnea during activities of daily living. The training program consisted of three weekly sessions of hyperpnea at maximal sustainable ventilatory capacity, resistive breathing and strength training. Peak VO2, and the six minute walk test were measured before (pre) and after (post) 3 months of training.[25]

Yoshiike Y et al(1993) studied whether Inspiratory Muscle Training (IMT) changed respiratory sensation during exercise in 12 healthy women. Training was given twice daily for 15 minutes using a pressure threshold device and continued for 4 weeks. Breathing effort was evaluated during the progressive exercise test using Borg Scale. Prior to the IMT, the Borg scale increased in proportion to exercise grade. The training group was not significant so they concluded that IMT may not affect respiratory sensation during exercises in normal subjects, although IMT increases diaphragmatic strength with treadmill exercise.[20]

Smith K et al (1992) investigated that endurance and function may be improved if resistance training with control of breathing pattern is undertaken overall, there is little evidence of clinically important benefit of respiratory muscle training in patients with chronic airflow limitation. Patients with COPD experience functional weakness of respiratory muscles which can contribute to dyspnea and functional impairment. Inspiratory muscle training reduces dyspnea by improving respiratory muscle function and exercise tolerance.[28]

Harver A et al (1989) compared the effects of targeted inspiratory muscle training on respiratory muscle function, clinical rating of dyspnea and perception of resistive loads in symptomatic patients with COPD. One group trained at 6 increasing levels of inspiratory resistance and control group trained at a constant, nominal level of resistance. They concluded stating that targeted inspiratory muscle training may enhance respiratory muscle function and reduce dyspnea in symptomatic patient with moderate to severe chronic COPD.[27]

Shadmehr et al (1988-1989) suggested that strength training results in increased number of fibers and inspiratory pressure in patients with COPD by improving strength or endurance of the diaphragm. Greater inspiratory loads may be tolerated there by prolonging exercise tolerance.

Chen H et al (1985) proved that 4 week inspiratory muscle training in pulmonary rehabilitation programme setting improves inspiratory muscle endurance using resistive loads trained on 13 patients with COPD without pulmonary function on exercise tolerance.[11]

Pardy RL et al (1981) did a study on inspiratory muscle training on exercise performance in chronic air flow limitation using a simple inexpensive method. At home program, 12 patients with moderate to severe chronic airflow limitation trained their inspiratory muscles. All showed increased inspiratory muscle endurance with no change in respiratory muscle strength.

Belman Mittman C (1980) examined the effect of six week of ventilatory muscle endurance training on Maximal Sustained Ventilatory Capacity (MSVC) and on exercise tolerance in 10 patients with COPD. No significant changes occurred in lung volumes or spirometric indices. Maximal exercise ventilation measured by an incremental ergometer test increased in leg exercise than arm exercise. Endurance time at a constant submaximal load was increased. The maximal distance covered in a 12 minute walk is increased.[16]

AIMS &OBJECTIVES OF THE STUDY

The main objectives of the study were:

- To find the effect of respiratory muscle training in improving the rate pressure product of normal individuals.
- To find the effect of respiratory muscle training in improving the rate of perceived exertion in normal individuals.
- To find the effect of respiratory muscle training in improving the exercise tolerance by 6 minute walk distance in normal individuals.

MATERIAL AND METHODS

STUDY DESIGN:

This study is an Experimental type of single subject design without any control group. It includes the normal individuals, tested with dependant variables such as six minute distance walk test, rate pressure product and rate of perceived exertion. The study was conducted in Goutham Physiotherapy and Rehabilitation Center during the year of 2005.

SAMPLE SELECTION:

Fifty (50) normal individuals aged between 30 – 40 years were selected using convenience (purposive) sampling based on the selection criteria from the nearby residents of Goutham Physiotherapy Rehabilitation Centre. All the participants took part in the study on a voluntary basis after signing a consent form and demographic data was collected from each subject. The purpose of the study was explained to all the subjects.

The subjects were selected based on the following criteria are: Healthy normal individuals, Age group 30 to 40 years, both females and males, onSmokers, and without any pre-existing cardiopulmonary disease. History of any Subjects with cardiovascular insufficiency and neuromuscular disease, History of any upper respiratory tract infections, History of any recent cardio thoracic and abdominal surgeries, Age group not less than 30 and not more than 40 were excluded

MATERIALSUSED: Assessment chart, Inch tape, Stethoscope, Sphygmomano-meter, Incentive spirometer, Peak expiratory flow meter, Cycle ergometer, Timer.

Measurement tools: Rate pressure product (RPP) Borg scale (Rate of perceived exertion), Six minute walk distance test (6 MWD)

Rate pressure product:

Development of tension within the myocardium and its contractility and heart rate determine the myocardial oxygen consumption which increases in each of these factors during exercises. Myocardial blood flow adjusts to balance oxygen supply with demand. One common estimate of myocardial workload resulting oxygen consumption uses the product of peak Systolic Blood Pressure (SBP) measured at the brachial artery and Heart Rate (HR). This index of relative cardiac work, termed the double product or rate pressure product, which relates closely to directly measure myocardial oxygen consumption and coronary blood flow in healthy subjects over a white range of exercise intensities.

RPP = Systolic blood pressure x heart rate

Changes in heart rate and blood pressure contribute equal changes in RPP. Typical values for RPP range from 6,000 at rest (HR = 50b min^{-1}, SBP = 120mmHg) to 40,000 (HR= 200b min^{-1}, SBP = 200mmHg) or higher depending on intensity and mode of exercise. Since it correlates with VO_2max, it is considered as one of the parameters to assess exercise tolerance.

Rate of perceived exertion (Borg)

Method of determining physical activity intensity is the Borg rating of perceived exertion (RPE). Perceived exertion is how hard one feels like the body is working. It is based on the physical sensation, a person experiences during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating and muscle fatigue.

This is a subjective measure; a person's exertion rating will provide a fairly good estimate of the actual heart rate during physical activity.

- Original Borg scale ranged from 6 to 20
- 6 to 11 (very, very light) essentially the range for warm up and cool down
- 12 to 13 (somewhat hot) approximately 60% maximum heart rate.
- 16 (between hard and very hard) approximately 90%.

Six minute walk distance test:

The 6 MWT is safer, easier to administer, better tolerated and better reflected activities of daily living than other walk test such as the shuttle walk test. It is commonly used to estimate functional exercise capacity. All participants were free of disease that could interfere with performance in a walking test. Test was performed in a quite 50mts long clinic corridor. Subjects were encouraged every 30 seconds to continue walking as quickly as possible. Its variability is explained largely by age, sex, height and weight. Results of six minute distance were interpreted more adequately if expressed as a percentage of predicted value.

INTERVENTION:

Fifty (50) individuals aged between 30 to 40 years were selected based on the inclusion and exclusion criteria. All these subjects underwent pre-evaluation to exclude any cardiopulmonary diseases. The subjects were given a training and demonstration how to use the incentive spirometer, peak expiratory flow meter, and cycle ergometer in the practice session for the duration of 50 minutes per session, in a day two sessions were given, five days a week for the duration of four weeks

INCENTIVE SPIROMETER:

Procedure:

a. Place the participants in a comfortable position (supine or semi-upright).
b. The participants were asked to take 5 to 10 breaths slow and easy breaths.
c. The participants were asked to maximally exhale with tenth breath.
d. Then ask the participants place the spirometer and hold the inspiration for several seconds.
e. The sequence is repeated 5 to 10 times, twice daily.

PEAK EXPIRATORY FLOW METER:

Procedure:

a. Place the participant in a comfortable position. Flow meter was held with thumb and forefinger of one hand and should not place the other hand over the meter.
b. Ask the participants to breathe in as deep as possible. Blow should be as hard

as fast as possible, a quick, short blast of 1 to 2 seconds was sufficient.

c. Participants were asked to take 5 to 10 breaths for 20 mins per session and twice daily.

CYCLE ERGOMETER:
PROCEDURE:

a. Participants performed cycle ergometer training at clinic on a calibrated cycle ergometer
b. Participants were trained 5 days per week, 20 mins per day. And interval training protocol were used with participant perform four work sets, 5 min in duration, separated by rest intervals (2 to 4 mins) of unloaded cycling.
c. Participants were instructed to pedal at a rate of 60 revolutions per min (rmp) and they were encouraged to work without exceeding a heart rate equal to 85% of the predicted maximal heart rate.
d. Training was initiated at 50% of peak work rate, was taken from the best baseline graded exercise test and evaluated at the end of the second and fourth week with progressive increases as tolerated.

The pre and post training values of RPP, RPE, 6 minute walk test were recorded at pre-training and the end of fourth week of training respectively.

DATA ANALYSIS:

In this study with a single group, the three different parameters were tested for significance to infer the effectiveness of respiratory muscle training on exercise tolerance in normal individuals. The statistical tool used in this analysis was dependent's' test. The difference of values between pretest and post test were found. It was done with the values taken at pre & the end of fourth week of training. The mean difference of all the three parameters of the test group was also calculated.

With the acquired 't' value from the pretest and post test, the accurate level of significance was analysed and interpretated. An alpha level of $p<0.001$ was the level of significance for the test.

RESULTS & INTERPRETATION

Fifty normal individuals aged between 30 to 40 years were selected based on the selection criteria with a mean age of 34.4years (Variance=8.78, SD=2.96) were selected for the study. All these values of age according to sex distribution are shown in Table-1.1

TABLE-1.1 MEAN, VARIANCE & STANDARD DEVIATION VALUES OF AGE ACCORDING TO SEX

SEX	N	MEAN	VARIANCE	SD
Male Subjects	38	34.6	8.94	2.99
Female Subjects	12	33.75	8.38	2.89
Total Subjects	50	34.4	8.77	2.96

FIG– 9

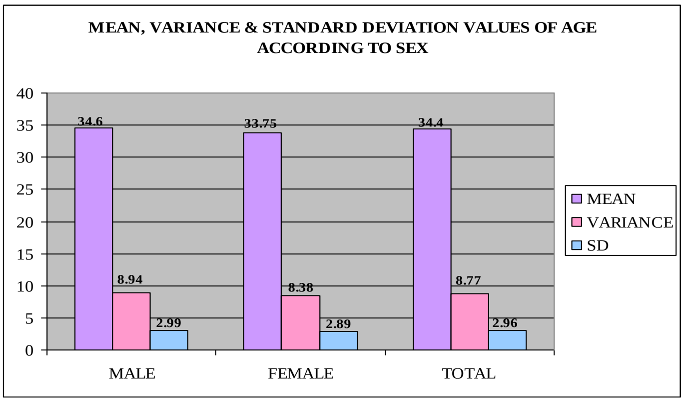


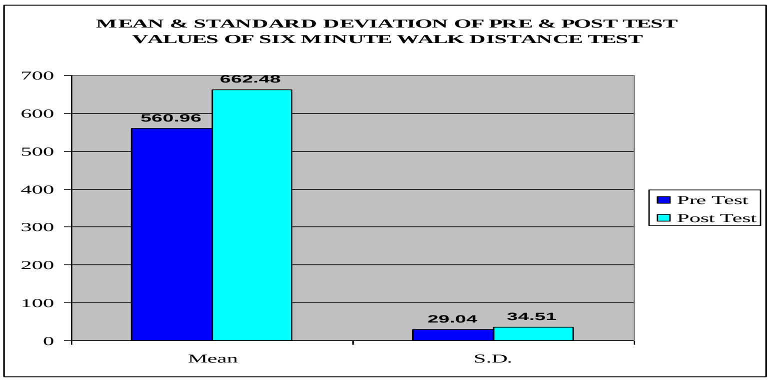
TABLE – 2.1 MEAN, VARIANCE & STANDARD DEVIATION FOR PRE & POST TEST VALUES OF SIX MINUTE WALK DISTANCE TEST

Subjects	Mean	Variance	Standard Deviation
Pre Test	560.96	843.67	29.04

TABLE – 2.2 MEAN, VARIANCE & STANDARD DEVIATION FOR PRE & POST TEST VALUES OF RATE PRESSURE PRODUCT

Subjects	Mean	Variance	Standard Deviation
Pre Test	9392.3	469921	685.51
Post Test	8516.7	502658	708.98

FIG – 10



FIG–11

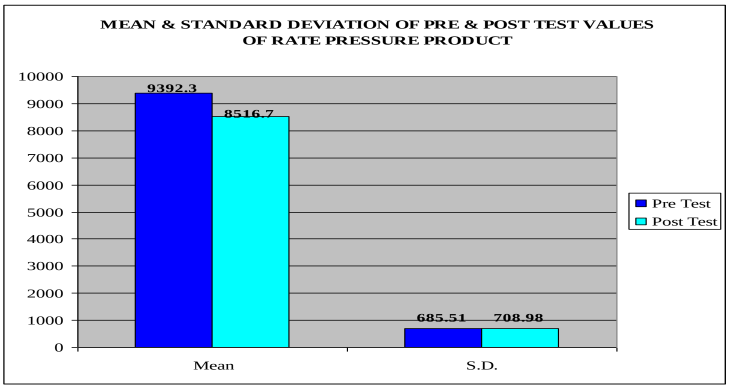


TABLE – 2.3 MEAN, VARIANCE & STANDARD DEVIATION FOR PRE & POST TEST VALUES OF RATE PERCIEVED EXERTION

Test	Mean	Variance	Standard Deviation
Pre Test	0.45	0.11	0.338
Post Test	0.28	0.12	0.352

FIG–12

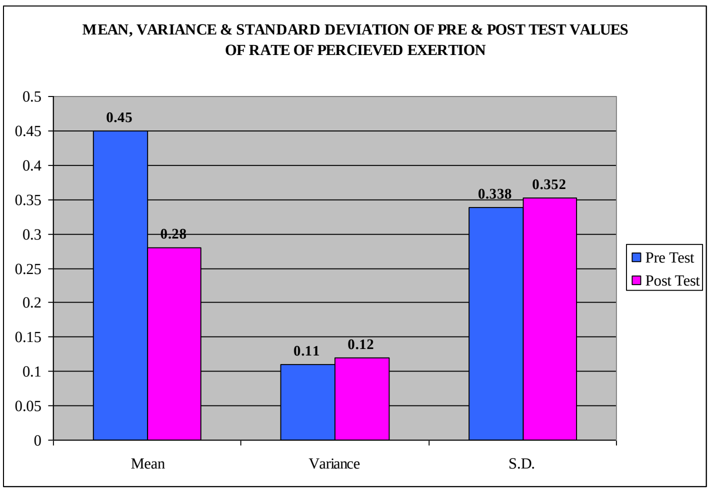


TABLE – 3.1 DEPENDENT 't' TEST PERFORMED WITH PRE & POST TEST VALUES OF SIX MINUTE WALK DISTANCE TEST

Subject No.	Pre test	Post test	Diff (d)	D*d	Subject No.	Pre test	Post test	Diff (d)	d*d
1	570	650	-80	6400	26	580	680	-100	10000
2	586	640	-54	2916	27	540	640	-100	10000
3	575	620	-45	2025	28	560	600	-40	1600
4	600	690	-90	8100	29	600	680	-80	6400
5	550	650	-100	10000	30	572	615	-43	1849
6	525	630	-105	11025	31	500	540	-40	1600
7	580	630	-50	2500	32	520	560	-40	1600
8	590	670	-80	6400	33	545	590	-45	2025
9	560	610	-50	2500	34	524	580	-56	3136
10	600	640	-40	1600	35	582	630	-48	2304
11	545	585	-40	1600	36	594	650	-56	3136
12	555	600	-45	2025	37	580	640	-60	3600
13	510	550	-40	1600	38	592	640	-48	2304
14	520	560	-40	1600	39	598	640	-42	1764
15	530	580	-50	2500	40	552	680	-128	16384
16	525	570	-45	2025	41	568	608	-40	1600
17	545	595	-50	2500	42	512	545	-33	1089
18	570	630	-60	3600	43	600	640	-40	1600
19	565	620	-55	3025	44	522	620	-98	9604
20	585	650	-65	4225	45	578	630	-52	2704
21	595	655	-60	3600	46	600	680	-80	6400
22	600	660	-60	3600	47	566	655	-89	7921
23	542	615	-73	5329	48	558	600	-42	1764
24	532	575	-43	1849	49	542	640	-98	9604
25	526	580	-54	2916	50	582	680	-98	9604
					SUM	28048	30518	-3070	215052
					MEAN	560.96	622.8163	-61.4	4301.04
					VAR	843.67	1534.486	541.91	11723959
					S.D.	29.046	39.17252	23.279	3424.026
					N	50			
					Factor	7			
					S	1152.2			
					T	-18.6503			

INTERPRETATION:

The above Table-3.1 shows the value of't' as 18.6503 at p<0.001 with the parameter of Six minute walk Test. Since the't' value is significant at p<0.001, which is lesser than p=0.05, the Respiratory muscle training on exercise tolerance was very effective in normal individuals.

TABLE – 3.2 DEPENDENT 't' TEST PERFORMED WITH PRE & POST TEST VALUES OF RATE PRESSURE PRODUCT

Subject No.	Pre test	Post test	Diff (d)	d*d	Subject No.	Pre test	Post test	Diff (d)	d*d
1	9120	8160	960	921600	26	10660	9500	1160	1345600
2	8160	7840	320	102400	27	10140	9850	290	84100
3	7920	6870	1050	1102500	28	9840	7920	1920	3686400
4	10320	9600	720	518400	29	9500	8640	860	739600
5	10620	9460	1160	1345600	30	8580	7480	1100	1210000
6	8580	7920	660	435600	31	8400	7260	1140	1299600
7	9500	8400	1100	1210000	32	10140	9460	680	462400
8	10120	9900	220	48400	33	9750	8610	1140	1299600
9	10140	8640	1500	2250000	34	9360	8510	850	722500
10	7920	7700	220	48400	35	10120	9850	270	72900
11	8910	8410	500	250000	36	9880	9240	640	409600
12	9360	8510	850	722500	37	8510	7820	690	476100
13	9880	9000	880	774400	38	9120	8610	510	260100
14	9020	8250	770	592900	39	9600	8050	1550	2402500
15	10000	8900	1100	1210000	40	9625	8640	985	970225
16	8250	7200	1050	1102500	41	9750	8280	1470	2160900
17	9360	8500	860	739600	42	10250	9300	950	902500
18	9120	8400	720	518400	43	8580	7520	1060	1123600
19	8800	9050	-250	62500	44	9360	8880	480	230400
20	9500	8640	860	739600	45	10120	9250	870	756900
21	8970	8160	810	656100	46	9360	8160	1200	1440000
22	9620	8640	980	960400	47	8800	7870	930	864900
23	9375	8400	975	950625	48	8750	7935	815	664225

Table 3.2 To Be Continued…									
24	9375	9250	125	15625	49	9500	8160	1340	1795600
25	10140	8480	1660	2755600	50	9840	8760	1080	1166400
					SUM	469615	425835	43780	46580300
					MEAN	9392.3	8516.7	875.6	931606
					VAR	469920	502658	168296	5.48E+11
					S.D.	685.507	708.98	410.23	740190.1
					N	50			
					Factor	7			
					S	20305.827			
					T	15.09222			

INTERPRETATION:

The above Table-3.1 shows the value of 't' as 15.0922 at p<0.001 with the parameter of Rate pressure product. Since the 't' value is significant at p<0.001, which is lesser than p=0.05, the Respiratory muscle training on exercise tolerance was very effective in normal individuals.

TABLE – 3.3 DEPENDENT't' TEST PERFORMED WITH PRE & POST TEST VALUES OF RATE OF PERCEIVED EXERTION

Subject No.	Pre test	Post test	Diff (d)	D*d	Subject No.	Pre test	Post test	Diff (d)	d*d
1	0.5	0	0.5	0.25	26	1	0.5	0.5	0.25
2	0.5	0	0.5	0.25	27	0.5	0.5	0	0
3	0.5	0.5	0	0	28	0	0	0	0
4	0	0	0	0	29	0.5	0	0.5	0.25
5	0.5	0.5	0	0	30	1	1	0	0
6	1	1	0	0	31	1	0.5	0.5	0.25
7	0	0	0	0	32	0	0	0	0
8	1	1	0	0	33	0	0	0	0
9	0.5	0	0.5	0.25	34	0.5	0	0.5	0.25
10	1	0.5	0.5	0.25	35	1	1	0	0
11	1	0	1	1	36	0.5	0	0.5	0.25
12	0.5	0	0.5	0.25	37	0.5	0.5	0	0
13	0.5	1	-0.5	0.25	38	1	0.5	0.5	0.25
14	0.5	1	-0.5	0.25	39	0	0	0	0
15	0.5	0.5	0	0	40	0.5	0	0.5	0.25
16	0	0	0	0	41	0.5	0.5	0	0
17	0	0	0	0	42	0.5	0.5	0	0
18	0.5	0	0.5	0.25	43	0.5	0	0.5	0.25
19	0.5	0.5	0	0	44	0	0	0	0
20	0.5	0	0.5	0.25	45	0	0	0	0
21	0	0	0	0	46	0	0	0	0
22	0.5	0.5	0	0	47	0.5	0	0.5	0.25
23	0	0	0	0	48	0.5	0.5	0	0
24	0.5	0.5	0	0	49	0.5	0.5	0	0
25	0	0	0	0	50	0.5	0	0.5	0.25
					SUM	22.5	14	8.5	5.75
					MEAN	0.45	0.28	0.17	0.115
					VAR	0.11	0.12	0.0843	0.03115
					S.D.	0.33	0.35	0.2964	0.17649
					N	50			
					Factor	7			
					S	14.6714			
					T	4.055509			

INTERPRETATION:

The above Table-3.1 shows the value of 't' as 4.0555 at p<0.001 with the parameter of Rate of perceived exertion. Since the 't' value is significant at p<0.001, which is lesser than p=0.05, the Respiratory muscle training on exercise tolerance was very effective in normal individuals.

INTERPRETATION OF STATISTICAL RESULTS:

This study was done with 50 subjects to assess the effects of Respiratory muscle training on exercise tolerance in normal individuals. Respiratory muscle training was given with cycle ergometer, Incentive spirometer and Peak flow meter.

The parameters used to assess the exercise tolerance of the normal individuals were Six minute walk distance test (6MWD), Rate pressure product (RPP) and Rate of perceived exertion (RPE) measured using Borg's Scale. The Pre and post test values were taken for all the three parameters before training and at the end of fourth week of training. The data were analyzed using related 't' test.

The results were found to be significant at p<0.001 with the calculated 't' values as 18.6503, 15.0922 and 4.0555 being more than the table values for the above mentioned parameters respectively stating that there is a significant effect with Respiratory muscle training on exercise tolerance in normal individuals.

DISCUSSION

It is proven fact that the age and physical functions decline, which influences respiratory performance associated with decrease in exercise tolerance and strength of respiratory muscle. This study was done on fifty individuals (both male and female) with mean age of 34.4(Variance-8.78, S.D.-2.96) to find out the effects of respiratory muscle training on exercise tolerance by RPP, RPE AND 6MWD Test. Same measurement tools were used for both inspiratory and expiratory muscle training. This finding supports a previous study, which demonstrated the training with incentive spirometer, cycle ergometer and peak flow meter. Hence it is working effectively when the training was performed with various methods.

The dependent t test values showed significant results for respiratory muscle training on exercise tolerance. The 't' values obtained by performing three related 't' test with the parameters 6MWD, RPP & RPE were t=18.6503 , t=15.0922 & t=4.0555 respectively. Since they were significant at p<0.001 for all the parameters, the alternate hypothesis was accepted rejecting the null hypothesis.

These results strongly support the earlier finding s of Sheel AW (2002) that respiratory muscle training in healthy individuals, physiological rationale and implications for exercise performance can improve endurance and strength of the muscle.[12]

Also studies done by Suzuki S et al (1995) supports our results that the sensation of respiratory effort may increase as the expiratory loading increases the expiratory muscle strength and reduces the sensation of respiratory effort during exercise by reducing minute ventilation. Yoshiike Y et al (1993) in their study showed that IMT may not affect respiratory sensation during exercises in normal subjects, although IMT increases diaphragmatic strength.

This study could have been done with either only one gender or both by comparing the inspiratory and expiratory muscle training or it could have been done with two groups so that there would have been a chance of other parameters and training methods in various lung pathology e.g.; COPD.

The results of the present study indicated that respiratory muscle training serves to improve exercise tolerance when measured with the variables of RPP, RPE and 6MWD.

This study implies that respiratory muscle training will be more effective when given in adjunct with the usual chest physiotherapy interventions to improve the exercise tolerance of both normal individuals and the patients with cardio respiratory problems.

CONCLUSION

Based on the outcome of statistical analysis, this study can be concluded that there is significant improvement in exercise tolerance in normal individuals after giving respiratory muscle training with cycle ergometer, incentive spirometer and peak flow meter.

Acknowledgement: None

Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

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How to cite this article: Roopa Lokesh, Ramesh Kumar Jeyaraman. Effect of respiratory muscle training in improving the exercise tolerance in normal individuals. *Int J Health Sci Res.* 2022; 12(10):63-77.
DOI: *https://doi.org/10.52403/ijhsr.20221009*

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