Effectiveness of Intercostal Stretch on Chest Expansion and Peak Expiratory Flow Rate

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Abstract

Introduction: The intercostal muscles play a role in moving the ribs upward and outward. This action leads to an increase in the antero-posterior diameter of the thoracic cavity. In respiratory physiotherapy, manual stretching techniques are widely used to improve lung function

Objective: To determine the effect of Intercostal stretch on chest expansion and peak expiratory flow rate.

Methods: A total of 100 subjects were recruited according to inclusion criteria i.e.age group 60-70 years, both genders and written informed consent was taken. Assessment and evaluation of participants was done. Chest expansion was measured and then after 2 minutes rest peak expiratory flow rate was taken using peak flow meter before the intervention. The stretch was applied in sync with the patient's exhalation and held while they continued breathing normally. As the stretch was sustained, there was a gradual increase in inspiratory movements in the area being stretched. Each subject received intercostal stretching for 20 days, with 5 repetitions per session and a 20-second hold on both the right and left sides. After the 20-day period, chest expansion and peak expiratory flow measurements were recorded.

Results: By applying Paired t-test for Pre-test and Post-test values of chest expansion and peal expiratory flow rate p-value obtained was < 0.01, which was statistically significant. This suggests that Intercostal stretch is effective in improving chest expansion and peak expiratory flow rate.

Conclusion: The study concludes that there was significant improvement in chest expansion and peak expiratory flow rate among the healthy older adults who underwent intercostal stretch.

Keywords: Intercostal Stretch, Chest Expansion, Peak Expiratory Flow Rate.

Introduction

The thorax serves as an osteocartilaginous cavity or cage that supports and protects various internal organs. This structure is dynamic, moving at its joints to alter the cavity's diameters, which is crucial for respiration—essential for life.[1]

On each side, there are 12 ribs that constitute the majority of the thoracic skeleton. These ribs form bony arches, arranged vertically, with gaps in between known as intercostal spaces. The ribs are oriented obliquely, with the upper ribs being less so than the lower ones. Their length increases from the first to the seventh rib and then gradually decreases from the eighth to the twelfth. The width of the ribs narrows from the top down. In the upper ten ribs, the anterior ends are wider than the posterior ends. The first seven ribs, which connect to the sternum via cartilage, are referred to as true ribs or vertebrosternal ribs. The remaining five are classified as false ribs. Among these, the cartilages of the eighth, ninth, and tenth ribs attach to the cartilage of the rib above, known as vertebrochondral ribs. The anterior ends of the eleventh and twelfth ribs are free, earning them the designation of floating ribs or vertebral ribs.[1]

The manubriosternal joint is a secondary cartilaginous joint that permits slight movement between the body of the sternum and the manubrium during breathing. In the costovertebral joints, the head of a typical rib connects with its corresponding vertebra and the body of the vertebra above, forming two plane synovial joints that are separated by an intra-articular ligament. Additionally, the tubercle of a typical rib forms a synovial joint with the transverse process of the corresponding vertebra in the costotransverse joints. Costochondral joints are created where each rib is anteriorly continuous with its cartilage, resulting in a primary cartilaginous joint that allows no movement. The first chondrosternal joint is also a primary cartilaginous joint that permits no movement, which helps stabilize the shoulder girdle and upper limb. The interchondral joints connect the fifth through ninth costal cartilages through synovial joints, while the tenth cartilage attaches to the ninth via fibrous tissue. The thoracic cage provides the skeletal framework of the thoracic wall, with the areas between the ribs referred to as intercostal spaces, which are deeper in the front than in the back and more pronounced between the upper ribs compared to the lower ones. These intercostal spaces are filled with intercostal muscles and contain intercostal nerves, vessels, and lymphatics, comprising nine spaces in the front and eleven in the back.[1]

Neurophysiological farcilitation of respiration involves using specific external proprioceptive and tactile stimuli to generate reflexive movements in the ventilatory apparatus. These stimuli help enhance breathing by altering both the rate and depth of respiration. The selected proprioceptive and tactile stimuli consistently elicit reflexive responses in the ventilatory muscles. Observed responses include inspiratory expansion of the ribs, increased epigastric excursion, heightened abdominal muscle tone, and changes in respiratory rate, often resulting in slower breathing. In clinical settings, these responses may accompany involuntary coughing, altered breath sounds on auscultation, quick stabilization of the chest wall, reduced need for suctioning, normalization of breathing patterns, and retention of improved breathing after treatment. These effects are most pronounced in patients who are deeply unconscious.[2]

Facilitatory stimuli encompass a range of techniques that enhance muscle engagement and movement. These include intercostal stretch, which promotes flexibility in the rib area, and vertebral pressure applied to both the upper and lower thoracic spine, helping to stabilize and mobilize the thoracic region. Additionally, an anterior-stretch lift of the posterior basal area targets specific muscle groups, while moderate manual pressure can further facilitate muscle activation. Perioral pressure is also employed to engage surrounding muscles, and abdominal co-contraction plays a crucial role in providing core stability throughout these processes. Together, these stimuli create an effective approach to enhancing physical function and coordination.[2]

Intercostal stretch is achieved by applying pressure to the upper border of a rib to widen the intercostal space above it, ensuring the pressure is directed downward rather than inward. Maintaining this stretch can gradually increase inspiratory movements in the area. This technique helps restore normal breathing patterns. When intercostal stretch is applied to the lower ribs, just above the floating ribs, epigastric excursions may be observed, indicating reflexive diaphragm activation through intercostal afferents.[2]

Vertebral pressure involves firm contact over the upper and lower thoracic vertebrae, activating the dorsal intercostal muscles. The pressure should be applied comfortably with an open hand, ensuring it is firm enough to induce some intrafusal stretch.[2]

The anterior-stretch basal lift involves placing hands under the ribs of a supine patient and gently lifting upwards. This action maintains both posterior pressure and anterior stretch, potentially performed bilaterally for smaller patients. Increased epigastric movements suggest diaphragm activation by intercostal afferents.[2]

Maintained manual pressure entails keeping firm contact over an area needing expansion, allowing gradual rib movement beneath the hands. This method is particularly useful when pain is present and can be effective for patients with COPD, as the inspiratory response likely originates from cutaneous tactile receptors.[2]

Perioral pressure is administered by applying firm pressure to the patient's upper lip without occluding the nasal passage. This stimulus typically induces a brief period of apnea, followed by increased epigastric excursion. The diaphragm's muscle spindles are sparse, meaning phrenic motor neurons receive limited excitatory input from spindle afferents, and few γ motor neurons are found in the phrenic motor nucleus.[2]

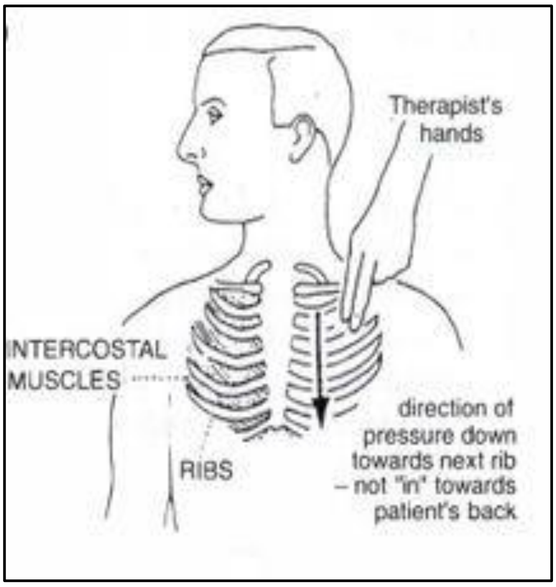
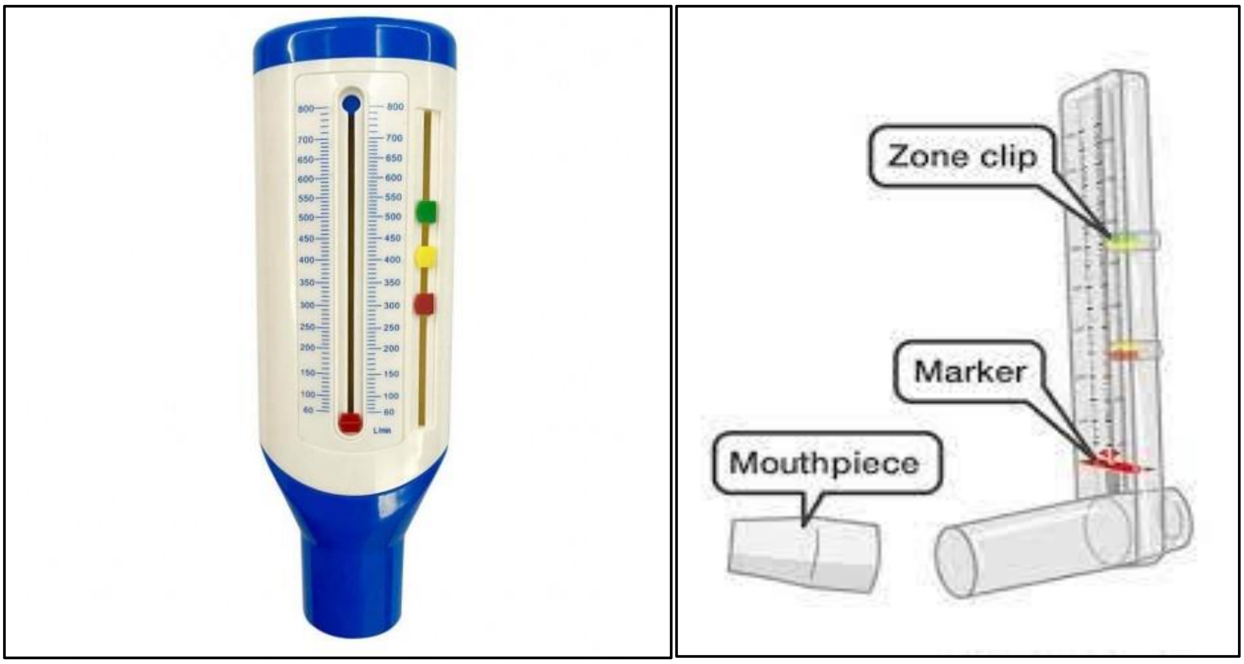


Figure 1 Intercostal Stretch

The peak flow meter is a device used to measure the amount of airflow in the human airway or often referred to as peak flow rate. Peak flow rate measurement is a simple and reliable way to detect airway obstruction.[2] Peak expiratory flow rate is the maximum airflow rate achieved during forced expiration after maximum inspiration.[3] Measurement of peak expiratory flow is a simple, non-invasive, and economical method to determine the speed and strength of expiration, in liters per minute, with forced expiration of total lung capacity. Peak expiratory flow, also called peak expiratory flow rate is a person's maximum expiratory speed, as measured by a peak flow meter, a small handheld device used to monitor one's ability to breathe air.[4] It measures the flow of air through the bronchi and thus the level of obstruction in the airways. Peak expiratory flow rate is defined as the maximum flow achieved during expiration given with maximum strength starting from maximal lung inflation.[5] Peak expiratory flow rate is the maximum flow rate produced during strong breathing, starting with full lung inflation. The peak flow rate mainly reflects large airway flow and depends on the voluntary effort and muscle strength of the subject.[6] Peak flow meter is a simple inexpensive handheld device; hence, it is relatively easy to measure peak expiratory flow rate by peak flow meter. Many factors are known to affect its value such as age, sex, height, and body surface area. The normal range for males and females is 450–550 L/min and 320–470 L/min, respectively.[7]

Figure 2 Peak Expiratory Flow Meter



Chest expansion measurements are used to evaluate the patient's baseline status, treatment effectiveness, and progression of respiratory diseases with regards to chest wall mobility and respiratory muscle function.[8] It is important to know the reference values of chest expansion of healthy adult Indian population for precise interpretation. A difference of more than 5cm between full expiration and full inspiration is regarded as normal.[9] The levels at which chest expansion is measured are, at the 2nd intercostal space, 4th intercostal space, the xyphoid process level.

Need of Study

As individuals advance in age, there is noticeable decrease in the strength of their intercostal muscles and maximum expiratory flow. Investigating the decline in intercostal muscle strength and maximum expiratory flow among aging individuals is crucial. The study aims to assess the efficacy of intercostal stretch as a potential intervention to enhance the strength of these muscles and improve the expiratory flow in elderly population.

Materials and Methodology

Materials

1. Measuring Tape
2. Surgical Marker
3. Peak Expiratory Flow Meter

Methodology

1. **Study design-** Pre and post experimental study
2. **Study population-** Geriatric population
3. **Source of study-** SJS hospital, Kopargaon
4. **Sampling method-** Random Sampling
5. **Sample size-** 100
6. **Study duration-** 6 month with intervention of 20 days

Inclusion criteria

1. Age 60 to 70 years
2. Both genders (male and female)
3. Non smokers
4. Willing to participate

Exclusion criteria

1. Having any cardiopulmonary condition
2. Recent rib surgery last 12 months
3. Substance misuse
4. Any co-morbidities

Outcome Measures

Chest expansion- Measurement of thoracic expansion with an inch tape is a reliable objective outcome measure in patients having respiratory diseases.

Peak flow meter- The peak flow meter is a simple portable instrument for measuring the maximum forced expiratory flow.

Procedure

The participants were selected based on the inclusion and exclusion criteria, and written consent was taken. After explaining the whole procedure to the participants, a pre-test measurement of chest expansion by tape method and lung function by peak flow meter were noted. Participants who fulfilled the inclusion criteria were selected and the participants were given intercostal stretch for 20 days. At the end of 20 days all the participants were reassessed to measure the chest expansion and peak expiratory flow.

Participants were in sitting position, elbows slightly flexed so that the hands rested on the arm rest chair. Chest was exposed and with the help of non-stretchable inch tape the chest expansion was measured at three levels that is 2nd Intercostal Space, 4th Intercostal Space and xyphoid process. Participant was asked to exhale the air as much as possible and then take a maximal deep inspiration. The difference between the full expiration and full inspiration were noted. Three trails were given at each level and average of three readings were noted. Then after giving 10 minutes rest, the peak expiratory flow value was recorded with the help of peak flow meter.

Intercostal stretch was provided by applying pressure to the upper border of a second rib in a direction that will widen the intercostal space above it. The pressure was applied in a downward direction, not pushing inward into the patient. The application of the stretch was timed with an exhalation and the stretched position was then maintained as the patient continues to breathe in his usual manner. As the stretch is maintained, a gradual increase in inspiratory movements in and around the area being stretched occurs. Intercostal stretch was given to each subject for 20 days, with 5 repetitions and 20 seconds hold on each side (right and left). After 20 days the measurement of chest expansion and peak flow meter were noted.

Figure 3 Chest Expansion at axillary level

Figure 4 Chest Expansion at nipple level

Figure 5 Chest Expansion at Xiphisternum Level

Figure 6 Intercostal Stretch

Figure 7 Peak Expiratory Flow Rate

Stastistical Analysis

The objective of this study was to find out the effectiveness of intercostal stretch on chest expansion and peak expiratory flow rate. Data was analysed using STATISTI version2.0 Descriptive statistics for all outcome measures were expressed as mean, standard deviation Paired 't' test was used for all intergroup comparisons [Pre-test and Post-test]. Unpaired 't' test was utilized to compare the intra group scores [Pre-test scores comparison between group A and B].

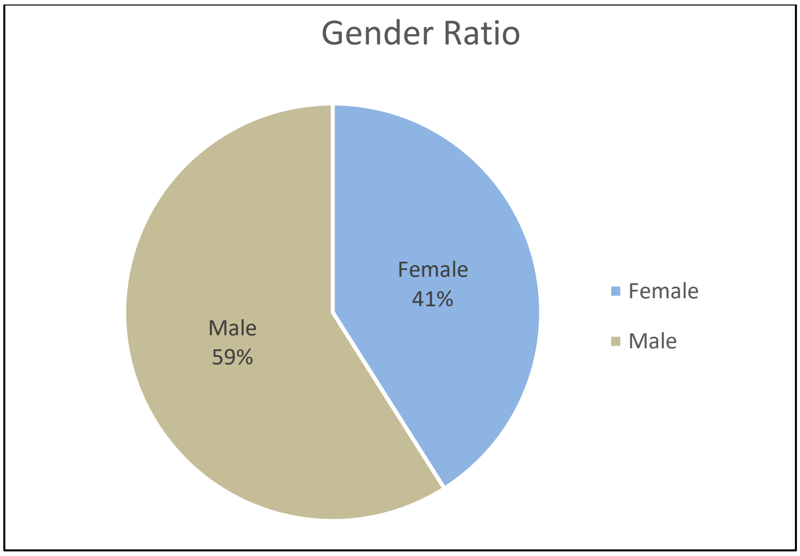
Result

Table 1 Gender Distribution Table

Gender distribution of participants		
Gender	**Gender count**	**Percentage**
Males	59	59%

Females	41	41%
Grand total	100	100%

Figure 8 Gender Distribution Graph

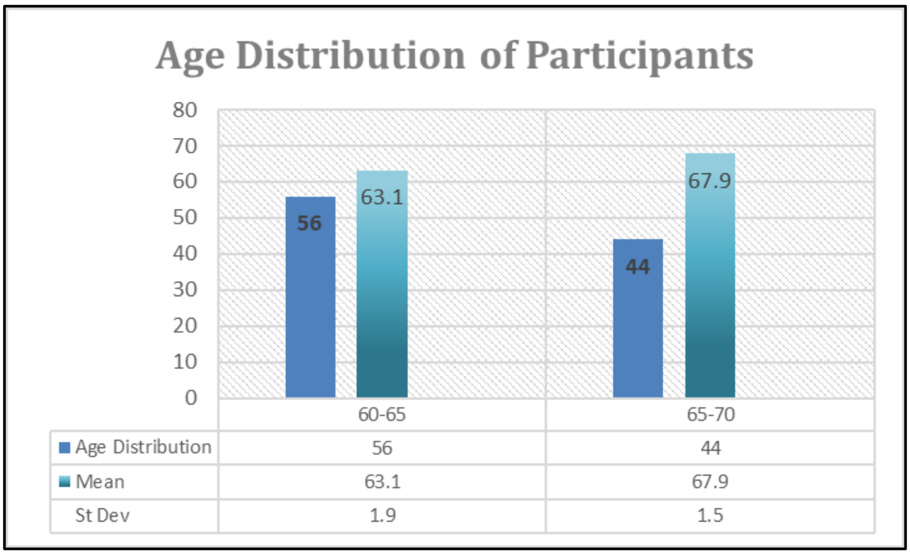


There were a total 100 participants included in the study, out of which 59% were males and 41% were females.

Table 2 Age Distribution Table

Age wise distribution of participants		
Age range	**Frequency (percentage)**	**Mean &SD**
60-65	56 (56%)	63.1 ± 1.9
65-70	44 (44%)	67.9 ± 1.5

Figure 9 Age Distribution Graph



All the 100 participants included in the study were bifurcated in two age groups such as one age group is from 60-65 in which a total of 56 participants are included, and other age group is from 65- 70 in which a total of 44 participants are included.

Table 3 Chest Expansion Pre-intervention and Post-intervention Score.

	Pre-intervention (mean and SD)	Post-intervention (mean and SD)	Paired "t" test value	"p" value and significance
Chest expansion score	3.01 ± 0.36 ±	3.72 ± 0.36 ±	21.045	'p' < 0.01 Significant

The mean value of chest expansion score before intervention (pre-test) was 3.01 and after intervention (post-test) was 3.72. Using paired t-test, statistically significant difference was seen in Chest expansion score at pre-intervention and post-intervention having p = <0.01, t = 21.045.

Table 4 Chest Expansion Pre and Post Score Comparison

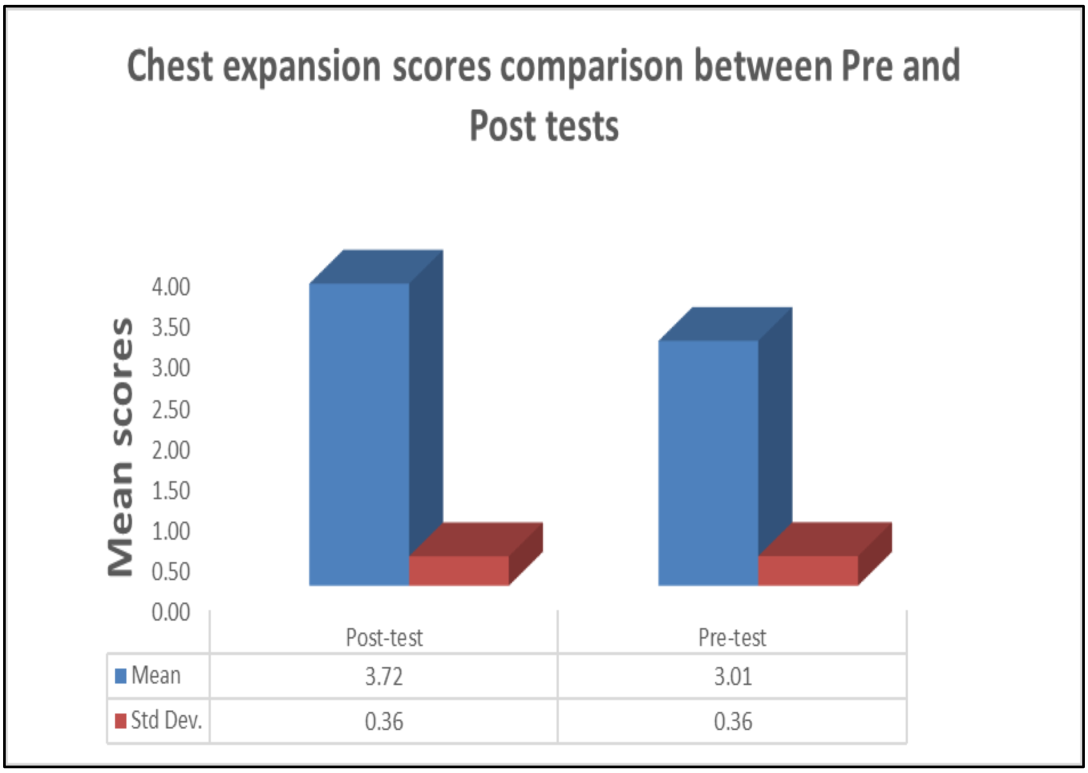
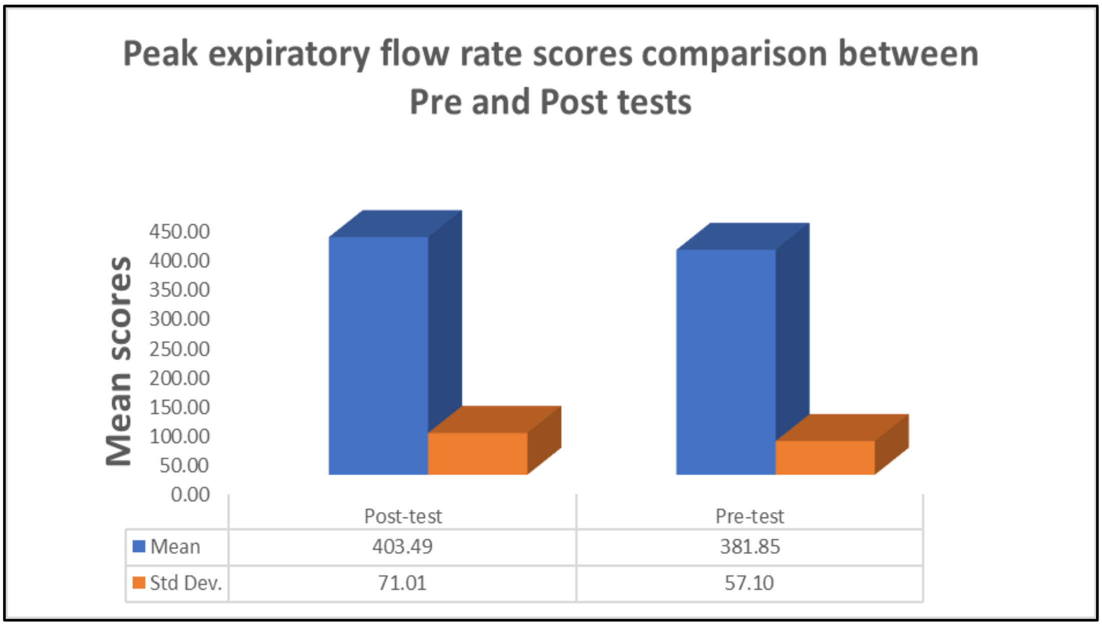


Table 5 Peak Expiratory Flow Rate Pre-Intervention and Post-Intervention Score

	Pre-intervention (mean and SD)	Post-intervention (mean and SD)	Paired "t" test value	"p" value and significance
Peak expiratory flow rate score	381.85 ± 57.10 ±	403.49 ± 57.10 ±	6.042	'p' < 0.01

Figure 10 Peak Expiratory Flow Rate Pre- Intervention and Post- Intervention scores Comparison Graph



The mean value of Peak expiratory flow rate score before intervention (pre-test) was 381.85 and after intervention (post-test) was 403.49. Using paired t-test, statistically significant difference was seen in Chest expansion score at pre-intervention and post-intervention having p = <0.01, t = 6.042.

Discussion

This study was done to determine the effect of Intercostal stretch on chest expansion and peak expiratory flow rate. 100 participants were taken age group 60 to 70 years. Graph 1 shows gender wise distribution of participants. Out of 100 participants 59% are males and 41% are females.

Graph 2 shows age wise distribution participants in two age groups. The two age groups are 6o-65 and 65-70 out of which 56% participants belongs to age group 60-65 and 44% participants belongs to 65-70 age group.

Graph 3 shows comparison of chest expansion score pre-intervention and post-intervention. A significant increase in chest expansion values in pre-intervention and post-intervention is seen. Whose mean value pre-intervention is 3.01 and post-intervention was 3.72

Graph 4 shows a comparison of peak expiratory flow rate score pre-intervention and post-intervention. A significant increase in peak flow rate values I pre-intervention and post-intervention. Whose mean values pre-intervention is 381.85 and post-intervention is 403.39.

The results of the present study shows that there is significant improvement in chest expansion and peak expiratory flow rate among healthy conscious older adults post intervention proprioceptive neuromuscular facilitation respiration intercostal stretch.

The increase in chest expansion and peak expiratory flow rate is due to firing discharged from the muscle spindle during a passive stretch phase.[15] IC stretching activates the stretch receptors in the chest wall, thereby distending thorax which could be neurologically linked to medulla with efferent nerve cells. The afferents, that innervate the margins of diaphragm activates the reflex which alters the pulmonary parameters.[16] The IC enhances the chest wall elevation and thereby increases the expansion by improving intra-thoracic lung volume which contributes to improve the flow rate percentage. This may contribute in increasing the ventilatory capacity (tidal volume), minute ventilation and oxygen status.[17] The IC may enhance the chest wall elevation and thus increase expansion to improve intra-thoracic lung volume which contributes to improvement in flow rate percentage.[18] This neurophysiological facilitatory stimuli may account for more normal respiratory patterns among unconscious subjects (Jennifer and Pryor, 2008), but the present study was carried out to discover the effect on IC stretch among healthy older adults.

A study conducted on effect of intercostal stretch on pulmonary function parameters among healthy males shows that there is significant improvement in lung function parameters.[19] This study suggested the IC stretching with breathing control may be more effective in improving dynamic lung parameters especially FEV1/FVC % than breathing control alone.

Another study conducted on effect of intercostal stretch and breathing control exercise on lung function among healthy females, showed that there was a significant improvement in the lung function (FVC, FEV1, FEV1 /FVC) and respiratory rate among the healthy young females who underwent IC stretch followed by breathing control exercise.[20]

A study done by T Puckree , F Cerny , B Bishop titled "Does Intercostal Stretch Alter Breathing Pattern and Respiratory Muscle Activity in Conscious Adults? Primary findings of this study are that localised stretch of the third or the eighth IC space applied during inspiration evoked a slower, deeper breathing pattern and enhanced the mean peak amplitudes and the burst durations of the diaphragm and parasternal IC EMGs in people who were awake. This is the first scientific evidence in conscious humans that IC stretch may impact on respiratory variables affecting gas exchange.[21]

Another study was conducted on Immediate effect of intercostal stretch on chest expansion in healthy smokers. The study shows that there is increase in the chest expansion post intervention with a mean value of 4.3 from 3.6 cms at 5th thoracic spine level. There is increase in the 6MWD immediately after the intervention from a mean value of 693.10 to 695.84.[22]

Conclusion

The findings of this study demonstrate that intercostal stretch is an effective intervention for improving both chest expansion and peak expiratory flow rate. The significant improvement observed in these parameters suggests that intercostal stretch is beneficial in promoting respiratory function, especially in individuals who require enhanced pulmonary performance or those whose chest mobility is restricted. These results showcase the potential of intercostal stretch as a simple, non-invasive technique for improving respiratory mechanics.

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