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Effect of Elastic Band Chest Training on Chest Expansion and Respiratory Muscle Strength in Young Male Smokers

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Abstract: ***Background**: Smoking is associated with impaired thoracic mobility and reduced respiratory muscle strength. Elastic band chest training provides a simple and economical approach for improving chest expansion and respiratory muscle performance; however, limited evidence is available regarding its effects among young smokers. **Objective**: The present study aimed to compare the effects of elastic band chest training and diaphragmatic breathing exercises on chest expansion and respiratory muscle strength among male smokers. **Methods**: A randomized controlled trial was conducted among 64 male smokers aged 20–25 years. Participants were randomly allocated into two groups of 32 participants each. Group A received elastic band chest training, whereas Group B performed diaphragmatic breathing exercises. Both interventions were performed 4 days per week for 4 weeks. Upper- and lower-level chest expansion, maximum inspiratory pressure (MIP), and maximum expiratory pressure (MEP) were assessed before and after the intervention. Paired and unpaired t-tests were used for within- and between-group comparisons, respectively. **Results**: Both groups demonstrated statistically significant improvements in upper- and lower-level chest expansion, MIP, and MEP following the intervention ($p < 0.05$). Between-group analysis demonstrated statistically significant differences in all four outcome measures, with the elastic band chest training group demonstrating greater post-intervention improvements compared with the diaphragmatic breathing group ($p < 0.05$) **Conclusion**: Both elastic band chest training and diaphragmatic breathing exercises improved chest expansion and respiratory muscle strength among male smokers. However, elastic band chest training demonstrated significantly greater improvements across the assessed outcomes, suggesting its potential as an effective physiotherapeutic intervention for enhancing thoracic mobility and respiratory muscle strength.***

Keywords: Elastic band chest training; chest expansion; respiratory muscle strength; maximum inspiratory pressure; maximum expiratory pressure; smokers

1. Introduction

Inhalation of tobacco smoke produced from burning cigarettes, cigars or pipes is called smoking.[1] Globally, around 2 million people die each year due to smoking, with nearly half dying before the age of 70. By the 1990s, tobacco was responsible for 24% of male deaths and 7% of female deaths in developed countries. If current trends continue, annual deaths from tobacco are expected to rise from 3 million to about 10 million by 2020–2030, making it one of the greatest public health threats worldwide.[2] Most smokers initiate the habit during adolescence or early adulthood. At the beginning, smoking produces a pleasurable sensation, which is often linked to positive reinforcement and leads to a progressive increase in the daily number of cigarettes consumed.[1]Nicotine, one of the principal constituents of cigarettes, is associated with coronary artery disease, chronic obstructive pulmonary disease (COPD), decreased quality of life and reduced exercise tolerance in smokers compared with non-smokers.[3]During combustion of cigarettes, numerous toxic substances including carbon monoxide, nicotine, dioxins and irritant gases are released in tobacco smoke. These substances accumulate on the pulmonary villi; impairing lung function, increasing phlegm production, and leading to chronic bronchial conditions.[4] Smoking stimulates hypertrophy and hyperplasia of mucus-producing cells, resulting in excessive and viscous mucus production along with thickening of the respiratory membranes, which impairs the lungs' defense mechanisms against inflammation. It also decreases the efficiency of gas exchange between the alveoli and pulmonary blood vessels, thereby reducing diffusion capacity. Furthermore, smoking impairs mucociliary clearance, increasing susceptibility to respiratory tract infections.[5]

Smoking is a significant risk factor for cardiovascular diseases, especially atherosclerosis and coronary heart disease, which remains a leading cause of mortality in developed countries. The two primary pathological processes underlying coronary heart disease are atherosclerosis and thrombosis. Smoking causes endothelial injury, which initiates atherosclerosis by promoting smooth muscle cell proliferation, lipid accumulation, foam cell formation and plaque development. Nicotine contributes to endothelial damage by increasing heart rate, blood pressure, cardiac output, blood viscosity and vasoconstriction through sympathetic nervous system activation. Smoking is responsible for approximately 85% of COPD-related morbidity and mortality.[2] Studies have shown that smoking reduces pulmonary function parameters such as FVC and FEV1, which may eventually contribute to airway obstruction and small-airway disease. The decline in pulmonary function among smokers has also been associated with weakened respiratory muscle strength.[6] Studies also reported that young smokers exhibit reduced chest circumference; especially at the axillary level, which correlates with diminished anteroposterior and transverse diameters of upper chest expansion. Such limitations impair breathing mechanics and subsequently decrease respiratory muscle strength as the strength of these muscles depends on maximal effort during chest expansion.[7] Strengthening the muscles involved in respiration enhances ventilatory efficiency and supports greater exercise performance.[8]Targeted exercise Enhances inspiratory and expiratory muscle strength, thereby generating greater pleural pressure gradients, facilitating airflow into the lungs and improving lung functions. Several studies demonstrated significant positive correlations between MIP and MEP, indicating increases in MIP and MEP were associated with enhanced chest wall mobility, suggesting that improvements in respiratory muscle strength contribute directly to enhanced thoracic expansion.[9] Various therapeutic interventions have been employed to improve chest function. Conventional exercise training often requires equipment such as treadmills, cycle ergometers, and weight-training machines, which may increase the burden on patients and healthcare resources. Elastic bands offer a simple and practical alternative as they are economical, safe, portable, and can be used in different setting.[10] Elastic chest band training has been found as a significant therapeutic adjunct to enhance diaphragmatic function and optimize respiratory mechanics. The external compressive resistance imposed by the band during thoracic expansion increases the mechanical load on the inspiratory muscles, thereby promoting greater diaphragmatic activation. Repeated exposure to this resistive load may facilitate adaptations in respiratory muscle strength and endurance, ultimately contributing to more efficient breathing patterns.[11] Therefore, this study aimed to evaluate the effect of elastic band chest training on respiratory muscle strength and chest expansion in young adult smokers.

2. Materials and Methods

Study design

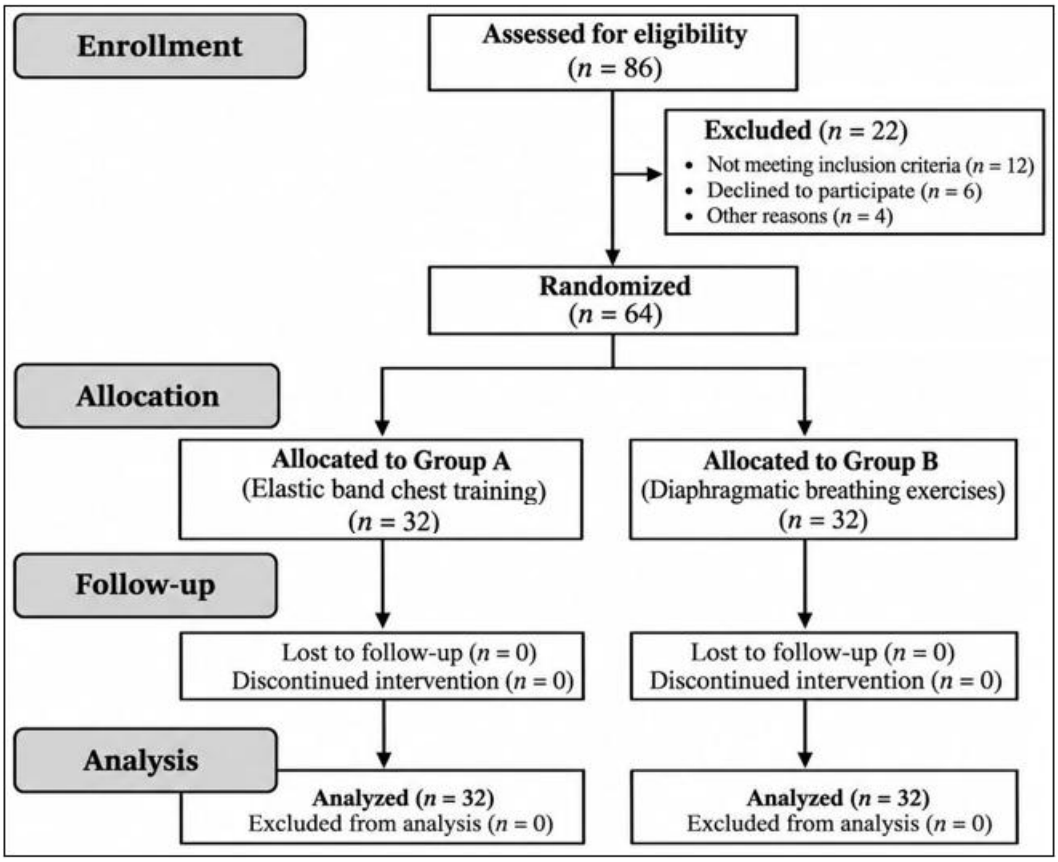
The study was a randomized controlled trial in nature.

Study Setting

The study was conducted at physiotherapy OPD, Khalsa College, Amritsar

Ethical Consideration

The current study was approved by Institutional Ethics Committee (IEC), Khalsa College, Amritsar (No.IEC/KCA/PT/2025/20). A consent form and an information form was given to the target smokers. This was given to inform them about the purpose of the study and to decide if they are willing to participate. They were allowed to ask questions regarding the same. The privacy and confidentiality of the subjects was maintained throughout the study. The relative design, conduct and data analysis of this research followed the recommendations of the CONSORT guidelines (Fig. 1)



Inclusion criteria

The included participants were Male smokers aged 20–25 years, current smokers with a smoking history of ≥2 pack-years, and clinically healthy individuals without diagnosed chronic respiratory, cardiac, or neurological diseases were included.

Exclusion criteria

Participants with COPD, asthma, restrictive lung disease, recent respiratory infection, chest wall or spinal deformities, congenital heart defects, neurological disorders limiting exercise, previous respiratory muscle training, or musculoskeletal conditions affecting upper-limb movements were excluded.

Sample Size

The required sample size was determined using G*Power software (version 3.1.9.7). An a priori power analysis was conducted using a one-tailed independent-samples t-test to assess the difference between two independent means. The analysis was based on an expected effect size (Cohen's d) of 0.63, a significance level (α) of 0.05, and a statistical power of 80%, with an equal allocation ratio of 1:1 between the two groups. The analysis yielded a total required sample of 64 participants, with 32 participants assigned to each group. The achieved power for the calculated sample size was 0.8016395 (approximately 80.16%). Accordingly, 64 young adult smokers aged 20–25 years were recruited for the study.

Procedure

A total of 64 participants fulfilling the selection criteria were included in the study. Written informed consent was obtained from all participants after explaining the study procedure and its benefits. Baseline assessment was performed before commencement of the intervention.

Participants were then randomly divided into two groups: Group A (n=32) received elastic band chest training, while Group B (n=32) performed diaphragmatic breathing exercises. Chest expansion was assessed at the upper and lower chest levels using a measuring tape. Respiratory muscle strength was assessed by measuring maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP). Each measurement was performed three times, and the highest value was recorded for analysis.Both groups underwent their respective intervention 4 days per week for 4 weeks. Following completion of the 4-week intervention period, the participants underwent post-intervention assessment using the same outcome measures, and the obtained data were recorded for statistical analysis.

Intervention

Study Group (A): Participants receiving elastic band chest training.
Study Group (B): Participants receiving diaphragmatic breathing exercises.

Instructions for Elastic Band Chest Training

Step 1: The therapist demonstrates the exercise technique once to familiarize the participant with the procedure.
Step 2: The participant sits upright on a chair without armrests or a backrest, keeping both feet flat on the floor and the knees in a comfortable, non-widened position.
Step 3: Warm-up: The participant performs 3–4 normal breathing cycles by inhaling and exhaling comfortably.
Step 4: The participant performs upper-limb flexion, abduction and external rotation during inspiration, followed by extension, adduction and internal rotation during expiration, initially without resistance.
Step 5: The same movement pattern is then performed using an elastic band while maintaining proper coordination between the limb movements and breathing.[12]
Step 6: During the four-week protocol, the elastic band is used to perform the resisted exercises as described above. Progression in the resistance level or color of the elastic band can be made according to the participant's requirement.

<u>Repetitions and Sets</u>: 10 repetitions were performed per set, with 3 sets completed during each session.
<u>Rest Interval</u>: A rest period of 1–2 minutes was provided between sets.
<u>Frequency and Duration</u>: The intervention was performed 4 days per week for a period of 4 weeks.

Instructions for Diaphragmatic Breathing

Step 1: The participant sits comfortably in an upright position with the back supported and both feet placed flat on the floor.
Step 2: One hand is placed over the chest and the other hand just below the ribcage to monitor chest and abdominal movement.
Step 3: The participant inhales slowly through the nose, allowing the abdomen to expand outward against the hand while keeping the chest as still as possible.
Step 4: The abdominal muscles are gently tightened, followed by slow expiration through pursed lips.
Step 5: The participant continues to focus on abdominal movement throughout each breathing cycle.[13]

<u>Repetitions and Sets</u>: 10 breaths were performed per set, with 3 sets completed during each session.
<u>Rest Interval</u>: A rest period of 1–2 minutes was provided between sets.
<u>Frequency and Duration</u>: The intervention was performed 4 days per week for a period of 4 weeks.

Following completion of the 4-week intervention period, post-intervention assessments were conducted using the specified outcome measures, and the collected data were recorded for statistical analysis.

3. Outcome Measures

Chest Expansion:

The subject stands erect. A measuring tape is used to assess chest expansion. The subject exhales out fully and chest circumference is noted. Then subject inhales maximally and chest circumference is noted at 2 levels. The differences between full inhalation and exhalation is recorded as chest expansion. For upper chest expansion anatomical landmark is third intercostal space or spinous process of fifth Thoracic vertebrae. For lower chest expansion, anatomical landmarks is xiphoid process or tenth Thoracic vertebrae.[14]

Respiratory Muscle Strength:

It is measured while subject will be in standing position. In order to measure maximum inspiratory pressure (MIP), subject is instructed to exhale as slowly as possible and then inhale as strongly as possible through a mouthpiece attached to pressure meter. For measuring maximum expiratory pressure (MEP), subject is instructed to inhale as much as they can, nearly to their maximum lung capacity and then exhale as forcefully as they can through mouthpiece attached to pressure meter. At every measurement, the highest pressure that lasted for a minimum of one second is noted. Three measurements will be taken and best one is recorded.[6]

Statistical Analysis

The collected data were analysed using the Statistical Package for the Social Sciences (SPSS), version 24. Paired and unpaired t-tests were employed for statistical analysis, with the paired t-test used to assess within-group changes and the unpaired t-test used to compare outcomes between the two groups.

4. Results

The results showed a statistically significant improvement in upper-level chest expansion, lower-level chest expansion, maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) in both groups following the intervention ($p < 0.05$).

In Group A, upper-level chest expansion increased from 8.219 ± 1.408 cm to 9.256 ± 1.591 cm, while lower-level chest expansion increased from 7.469 ± 1.391 cm to 8.40 ± 1.247 cm. MIP improved from −101.063 ± 18.189 cmH_2O to −121.16 ± 16.187 cmH_2O and MEP increased from 126.875 ± 25.219 cmH_2O to 153.781 ± 20.817 cmH_2O.
In Group B, upper-level chest expansion increased from 8.188 ± 1.575 cm to 8.463 ± 1.553 cm, while lower-level chest expansion increased from 7.219 ± 1.211 cm to 7.619 ± 1.128 cm. MIP improved from −102.656 ± 12.898 cmH_2O to −108.469 ± 12.949 cmH_2O and MEP increased from 130.344 ± 19.363 cmH_2O to 136.188 ± 18.993 cmH_2O.

Between-group analysis demonstrated significantly greater improvement in all four outcome measures in Group A, which received elastic band chest training (upper-level chest expansion: $p = 0.048$; lower-level chest expansion: $p = 0.011$; MIP: $p = 0.001$; MEP: $p = 0.001$) compared with Group B, which performed diaphragmatic breathing exercises. These findings indicate that elastic band chest training was more effective than diaphragmatic breathing in improving chest expansion and respiratory muscle strength.

Table 1: Unpaired t-test for comparison at Pre and Post score measurements of Upper chest level (cm) between Group A and Group B

Unpaired t- test	Comparison			
	Upper Chest Level (cm)			
	Pre Score		Post Score	
	Group A	Group B	Group A	Group B
Mean	8.219	8.188	9.256	8.463
SD	1.408	1.575	1.591	1.553
N	32	32	32	32
MD	0.031		0.794	
df	62			
Unpaired t test	0.084		2.02	
Tab Value at 0.05	1.999			
P value	0.934		.048*	
Result	Non- Significant		Significant	

Table 2: Unpaired t-test for comparison at Pre and Post score measurements of Lower chest level (cm) between Group A and Group B

Unpaired t- test	Comparison			
	Lower Chest Level (cm)			
	Pre Score		Post Score	
	Group A	Group B	Group A	Group B
Mean	7.469	7.219	8.4	7.619
SD	1.391	1.211	1.247	1.128
N	32	32	32	32
MD	0.25		0.781	
df	62			
Unpaired t test	0.767		2.628	
Tab Value at 0.05	1.999			
P value	0.446		.011*	
Result	Non- Significant		Significant	

Table 3: Unpaired t-test for comparison at Pre and Post score measurements of MIP (cmH2O) between Group A and Group B

Unpaired t- test	Comparison			
	MIP (cmH2O)			
	Pre Score		Post Score	
	Group A	Group B	Group A	Group B
Mean	-101.063	-102.656	-121.156	-108.469
SD	18.189	12.898	16.187	12.949
N	32	32	32	32
MD	1.594		12.688	
df	62			
Unpaired t test	0.404		3.462	
Tab Value at 0.05	1.999			
P value	0.687		.001**	
Result	Non- Significant		Significant	

Table 4: Unpaired t-test for comparison at Pre and Post score measurements of MEP (cmH2O) between Group A and Group B

Unpaired t- test	Comparison			
	MEP (cmH2O)			
	Pre Score		Post Score	
	Group A	Group B	Group A	Group B
Mean	126.875	130.344	153.781	136.188
SD	25.219	19.363	20.817	18.993
N	32	32	32	32
MD	3.469		17.594	
df	62			
Unpaired t test	0.617		3.532	
Tab Value at 0.05	1.999			
P value	0.539		.001**	
Result	Non- Significant		Significant	

5. Discussion

The current investigation was undertaken to determine the effects of elastic band chest training and diaphragmatic breathing exercises on chest expansion and respiratory muscle strength among young adult male smokers, considering the limited evidence available in the existing literature. In the present study, both groups demonstrated statistically significant improvements in upper- and lower-level chest expansion, maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) following the intervention ($p < 0.05$, within-group). However, the elastic band chest training group demonstrated significantly greater post-intervention improvements across all four outcome

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measures compared with the diaphragmatic breathing group ($p < 0.05$, between-group).

The improvement in respiratory muscle strength in the Thera-band group can be explained by the principle of progressive overload, where resistance applied during breathing increases the demand on inspiratory and expiratory muscles. This may contribute to improvements in respiratory muscle strength and functional performance. The findings of the present study are consistent with previous literature demonstrating beneficial effects of respiratory muscle training and resisted chest expansion exercises on chest mobility and respiratory muscle strength. Bostanci et al. demonstrated that inspiratory muscle training significantly improves respiratory muscle strength in smokers.[15] Similarly, Kim et al. reported significant improvements in maximal respiratory pressures following resistance-based chest expansion exercises.[14] Studies involving resistance band exercises and combined breathing techniques have also demonstrated increased activation of accessory respiratory muscles, contributing to improved respiratory muscle performance.[11,16] Additionally, research by Padkao et al. highlighted a strong relationship between respiratory muscle strength and chest wall expansion, further supporting the findings of the present study.[9]

The improvement in chest expansion observed following elastic band chest training may be attributed to enhanced thoracic mobility produced by resisted upper-limb movements combined with controlled deep breathing. These movements may facilitate stretching of the intercostal musculature, improve rib cage mobility and enhance chest wall compliance. Tantisuwat and Thaveeratitham reported reduced chest expansion among smokers and demonstrated that targeted exercise interventions can improve thoracic mobility.[6]Similarly, Kim et al. reported significant improvements in chest expansion following elastic band exercises combined with breathing techniques.[17]

Further support is provided by studies investigating elastic resistance and chest expansion training, which have demonstrated improvements in rib cage mobility and respiratory mechanics.[10,11,17]Shin and Kim also reported increased activation of accessory respiratory muscles during chest expansion exercises using elastic bands, which may contribute to enhanced thoracic expansion.[16] Padkao et al. identified a strong positive relationship between respiratory muscle strength and chest wall expansion, suggesting that improvements in respiratory muscle performance may contribute to enhanced thoracic mobility.[9]This may explain the greater improvement in chest expansion observed in the elastic band chest training group, which also demonstrated greater gains in respiratory muscle strength compared with the diaphragmatic breathing group.

The findings of the present study are also consistent with Bhatnagar and Sharma, who reported significant improvements in chest expansion following chest PNF and breathing exercises in smokers, further supporting the role of targeted interventions in improving thoracic mobility.[18]

The diaphragmatic breathing group demonstrated improvement, which may be attributed to enhanced diaphragmatic activation, increased diaphragmatic excursion, and improved neuromuscular coordination. However, the absence of external resistance limits accessory muscle engagement and strength gains, resulting in comparatively smaller improvements in chest expansion and respiratory muscle strength than those observed with elastic band chest training.

While diaphragmatic breathing demonstrated beneficial effects on chest expansion and respiratory muscle strength, the present study found that elastic band chest training produced significantly greater improvements in these outcomes. These findings support the potential of elastic band chest training as an effective physiotherapeutic intervention for enhancing thoracic mobility and respiratory muscle strength among male smokers.

6. Limitations of the Study

The present study had certain limitations, including the inclusion of only male smokers, which may limit the generalizability of the findings to females and other age groups. The intervention period was restricted to four weeks, limiting the evaluation of long-term effects. Smoking exposure was assessed using pack-years without separately accounting for variations in daily smoking intensity, while other lifestyle factors, including physical activity, dietary patterns, and smoking-related habits, were not controlled. Furthermore, the study was conducted at a single centre.

Future research should include larger and more diverse samples involving both sexes and different age groups, incorporate longer intervention and follow-up periods, assess smoking exposure more comprehensively, and monitor relevant lifestyle factors. Multicentre studies are also recommended to enhance the generalizability of the findings and strengthen the evidence regarding the effects of elastic band chest training on chest expansion and respiratory muscle strength.

7. Conclusion

The findings of the present study indicate that both elastic band chest training and diaphragmatic breathing exercises were effective in improving chest expansion and respiratory muscle strength among male smokers. However, elastic band chest training produced significantly greater improvements in upper- and lower-level chest expansion, maximum inspiratory pressure, and maximum expiratory pressure compared with diaphragmatic breathing. These findings suggest that elastic band chest training may be a more effective physiotherapeutic approach for enhancing thoracic mobility and respiratory muscle performance in male smokers.

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