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The Effect of Respiratory Muscle Training on Pulmonary Function among Workers of Cotton Industry: An Observational Study

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Introduction: Cotton industry workers face respiratory risks from inhaling cotton dust, leading to byssinosis with symptoms like coughing and wheezing. Prolonged exposure can cause lasting lung damage and reduced function. To reduce these risks, effective ventilation, protective gear, and regular health checks are crucial. Aim: To analyze effect of respiratory muscle training on pulmonary function among workers of cotton industry.

Objectives: To assess the impact of respiratory muscle training on forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio among workers in the cotton industry..

Methods: 70 subjects were enrolled after getting permission from ethical clearance of institutional ethical committee written consent was taken after that they were divided in two group according to pulmonary function test. Group A with 50-80% FEV1, Group B with >80% FEV1. Group A Received Respiratory muscle stretch gymnastic exercise 15 repetition 30 minutes 3days/week for 6 weeks with home-based balloon blowing exercise & Group B only received home based balloon blowing exercise. Pulmonary function test was on every 2 weeks' interval after intervention.

Results: After checking normality of data repeated ANOVA test was applied by using SPSS 23 version software. Both groups demonstrated a significant enhancement in Pulmonary Function Test results ($p<0.05$). That shows that severity-based protocol is needed for batter outcomes.

Conclusions: The study indicates that category-specific exercise programs show statistical and clinical importance in enhancing pulmonary function among cotton industry workers and severity-based protocol should be implicated.

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Keywords: respiratory stretch gymnastic exercise, pulmonary function test, cotton workers, forced expiratory volume in 1st Second

INTRODUCTIONA

The cotton industry is a major global sector, providing jobs to millions of individuals involved in different phases of textile manufacturing.(Suryadi et al., 2022) Chronic exposure to cotton dust increases cotton workers' risk of respiratory diseases, impairing lung function and leading to conditions like byssinosis. Prolonged exposure to cotton dust can lead to significant respiratory impairments in cotton workers, including reduced lung function and chest expansion. Studies indicate that such exposure, often lasting over several years, is linked to symptoms like cough, phlegm production, and a decline in measures such as forced expiratory volume (FEV1) and peak expiratory flow rate (PEFR)(Tank and Vyas, 2023)

Cotton dust, a common form of organic dust, poses significant risks to the respiratory system of workers. Prolonged inhalation of cotton dust can trigger byssinosis, a respiratory disease characterized by chest tightness and reduced lung function, particularly at the start of the workweek. Chronic exposure to cotton dust often leads to inflammation in the airways, causing conditions like bronchitis and chronic obstructive pulmonary disease (COPD). The dust may also carry microbial contaminants, which can exacerbate respiratory infections and cause immune-mediated diseases like hypersensitivity pneumonitis.(Poole et al., 2024)

Prolonged exposure to cotton dust leads to inflammation and irritation of the airways, causing conditions like chronic bronchitis and byssinosis, a respiratory disorder specific to cotton workers. Workers often report symptoms such as coughing, chest tightness, and difficulty breathing, which worsen over time with increased exposure duration. The small size of cotton dust particles allows deep penetration into the lungs, contributing to long-term respiratory dysfunction. Medical evaluations show that cumulative exposure, particularly in older workers with extensive work experience, exacerbates the decline in lung function. Age and years of service are significant factors in the progression of these diseases, with older workers displaying more severe symptoms. Preventative measures, such as regular health monitoring, improved workplace ventilation, and protective equipment, are critical to reducing respiratory risks. The study underscores the need for tailored interventions to protect workers and prevent severe respiratory health issues.(Lim and Ibrohimov, 2022)

Due to impact of occupational there is a significant declines in pulmonary health among workers in dust-heavy industries. Prolonged exposure increases the risk of respiratory diseases like pneumoconiosis. The study emphasizes the need for regular lung function monitoring and enhanced protective measures. Improving occupational health standards is crucial to safeguarding workers' respiratory health.(He et al., 2022)

Long-term exposure to cotton dust in textile workers is linked to an increased risk of respiratory symptoms and obstructive airway disease, which worsens with prolonged exposure. High-resolution CT (HRCT) .effectively detects pathologic changes, correlating well with pulmonary function test (PFT) findings.(Mansouri et al., 2016)

"The Respiratory Muscle Stretch Gymnastics (RMSG) technique involves four steps designed to enhance lung function and flexibility: 1) Inhalation Stretch: Stand upright and inhale deeply through the nose while raising your arms overhead. Stretch your chest and upper back, expanding the ribcage to maximize lung capacity. 2) Exhalation Flexion: Slowly exhale through the mouth while bending forward, allowing your spine to flex and stretch the lower back muscles. This movement helps relax the respiratory muscles and improves diaphragm mobility. 3) Lateral Stretch: While inhaling, lean to one side, extending the side muscles and intercostal muscles between the ribs. This enhances flexibility in the chest wall, aiding deeper breaths. 4)Rotation Stretch: Exhale as you twist your torso to each side, engaging the oblique muscles and further stretching the intercostal. This step promotes better oxygen distribution by loosening the thoracic muscles. Respiratory muscle stretch gymnastics exercises are beneficial for COPD patients as they help strengthen respiratory muscles, improve lung function, and enhance overall breathing efficiency. These exercises can also contribute to a better quality of life by reducing symptoms like breathlessness, thus making daily activities easier to manage (Rohmah, Amin and Makhfudli, 2023).

Occupational health is crucial as it helps mitigate risks and prevent work-related illnesses and injuries, ensuring a safer work environment. By prioritizing health and safety measures, organizations can enhance worker productivity and overall workplace health so there is a need to take a look for this.(Alayyannur and Arini, 2024) Aim: To analyze effect of respiratory muscle training on pulmonary function among workers of cotton industry.

OBJECTIVES

To assess the impact of respiratory muscle training on forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio among workers in the cotton industry.

METHODS

An observational study was done among workers of cotton industry of Rajkot Gujarat India

Sample size calculation criteria:

1. 95% confidence level
2. Z1-n/2 represents the inverse normal value for a given significance level (z = 1.96 at a 5% significance level)
3. The confidence interval or margin of error corresponds to a desired precision of 2%
4. P = Proportion rate in the cotton industry, which is 11.25% as reported in the reference arti

Statistical analyses were performed using SPSS software, version 23. After assessing data normality with the Shapiro-Wilk test, repeated measures ANOVA was employed for evaluation.

Inclusion criteria:

5. Male workers employed in cotton spinning industries
6. Individuals aged between 20 and 40 years
7. At least 2 years of work experience in the cotton industry
8. FEV1 greater than 80% and FEV1 ranging from 50% to 80%
9. Exclusion criteria: Any Co Morbid Conditions like Diabetes, Hypertension, Asthma

The present study was conducted on February 2024 at Shemla Cotton Industry Following approval from the Institutional Ethics Committee (IEC) No: IEC/P-487/2023

Total 70 participants were enrolled based on sample size calculations and selection criteria. Informed written consent was obtained from each participant, and demographic information, including gender, age, height, weight, and BMI, was recorded.

Participants were divided into groups based on their pre-intervention pulmonary function test (PFT) results. Group A consisted of workers with an FEV1 (Forced Expiratory Volume in 1 second) greater than 80%, while Group B included those with an FEV1 between 50% and 80%. Outcome measures were assessed every two weeks over a six-week period.

Group A participated in supervised respiratory muscle stretching exercises, performing 15 repetitions for 30 minutes, three times per week for six weeks, along with home-based balloon-blowing exercises for 30 minutes, five days per week. Group B only engaged in the home-based balloon-blowing exercises for 30 minutes, five days per week.

Outcome measures: Pulmonary function test [FEV1, FVC, FEV1/FVC].

RESULTS

Statistical significance was set at a p-value of 0.05, and a 95% confidence interval (CI) was applied.

Table.1 Mean Comparison of FEV1 between Group A & B

	Group - A		**Group – B**	
	Mean	**Std. Deviation (SD)**	**Mean**	**Std. Deviation (SD)**
Day 1	2.32	± 0.138	1.75	± 0.232
2nd Week	2.46	± 0.134	1.92	± 0.239
4th Week	2.72	± 0.022	2.19	± 0.285
6th Week	2.83	± 0.022	2.37	± 0.283

Table 1 data Group A consistently demonstrated higher mean scores than Group B across all time points, with significant improvements noted from Day 1 to the 6th week. This indicates a more effective intervention or treatment for Group A compared to Group B throughout the study period.

Table 2. Mean Comparison of FVC (Group – A & B)

	Group- A		Group-B	
	Mean	**Std. Deviation (SD)**	**Mean**	**Std. Deviation (SD)**
Day 1	2.55	± 0.116	2.36	± 0.158
2nd Week	2.63	± 0.109	2.49	± 0.150
4th Week	2.73	± 0.100	2.60	± 0.137
6th Week	2.75	± 0.353	2.70	± 0.133

Table 2 Group A exhibited higher mean scores than Group B at all-time points, with both groups showing gradual improvement over the study period. The consistent differences suggest that Group A may benefit from a more effective intervention compared to Group B.

Table 3. Intragroup Pairwise Comparison of FEV1 of Group - A

Factor(I)	Factor (J)	Mean Differen ce (I-J)	Std. Error	Sig. (p-value)
Day 1	6nd Week	- 0.509	0.022	0.000
Day 1	2th Week	- 0.143	0.011	0.000
2nd Week	4th Week	- 0.256	0.018	0.000
4th Week	6th Week	- 0.110	0.008	0.000

Table 3 indicates the repeated measures ANOVA results indicate significant mean differences across the time points, with all p-values below 0.001, confirming that improvements occurred over time.

Table 4. Intragroup Pairwise Comparison of FVC of Group - A

Factor (I)	Factor (J)	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Day 1	6th Week	- 0.201	0.055	0.000
Day 1	2nd Week	- 0.081	0.005	0.000
2nd Week	4th Week	- 0.094	0.006	0.000
4th Week	6th Week	- 0.027	0.055	0.000

Table 4 data show The ANOVA results show significant differences between time points (p = 0.000). The largest change is between Day 1 and the 6th week (-0.201), and the smallest is between the 4th and 6th weeks (-0.027).

Table 5. Intragroup Pairwise Comparison of FEV1/FVC of Group - A

Factor (I)	Factor (J)	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Day 1	6th Week	- 12.532	0.377	0.000
Day 1	2nd Week	- 3.612	0.184	0.000
2nd Week	4th Week	- 4.856	0.297	0.000
4th Week	6th Week	- 4.064	0.187	0.000

Table 5 results indicate significant differences between all-time points (p = 0.000). The largest change is between Day 1 and the 6th week (-12.532), while the smallest is between the 4th and 6th weeks (-4.064).

Table 6. Intragroup Pairwise Comparison of FEV1 of Group – B

Factor (I)	Factor (J)	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Day 1	6th Week	- 0.616	0.039	0.000
Day 1	2nd Week	- 0.170	0.012	0.000
2nd Week	4th Week	- 0.268	0.035	0.000
4th Week	6th Week	- 0.179	0.010	0.000

Herein table 6 The ANOVA test indicates significant variations across all time points (p = 0.000). The most substantial difference occurs between Day 1 and the 6th week (-0.616), while the least difference is seen between the 4th and 6th weeks (-0.179).

Table 7. Intragroup Pairwise Comparison of FVC of Group – B

Factor (I)	Factor (J)	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Day 1	6th Week	- 0.342	0.008	0.000
Day 1	2nd	- 0.132	0.005	0.000

	Week			
2nd Week	4th Week	- 0.104	0.006	0.000
4th Week	6th Week	- 0.107	0.005	0.000

In Table: 7 The ANOVA results show significant differences at all time points (p = 0.000), with the largest change from Day 1 to the 6th week (-0.342) and the smallest from the 2nd to 4th weeks (-0.104).

Table 8. Intragroup Pairwise Comparison of FEV1/FVC of Group – B

Factor (I)	Factor (J)	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Day 1	6th Week	- 11.825	0.304	0.000
Day 1	2nd Week	- 3.543	0.178	0.000
2nd Week	4th Week	- 4.194	0.206	0.000
4th Week	6th Week	- 4.088	0.141	0.000

In above table: 8 data the ANOVA results show significant differences (p = 0.000) with the largest change between Day 1 and the 6th week (-11.825) and the smallest between the 4th and 6th weeks (-4.088).

DISCUSSION

Respiratory muscle stretch gymnastics (RMSG) exercises are essential for enhancing lung function, particularly in individuals exposed to sedentary lifestyles or specific occupational hazards. These exercises improve the elasticity and strength of respiratory muscles, leading to better ventilation and an increase in peak expiratory flow rate. By promoting the full expansion of the lungs, RMSG helps reduce stiffness in the thoracic cage, improves oxygen exchange, and alleviates respiratory discomfort. For individuals, such as computer workers who often adopt poor postures, RMSG aids in correcting posture, reducing muscle strain, and preventing secondary respiratory complications. Incorporating these exercises regularly can significantly enhance exercise capacity, lower the perceived rate of exertion during physical activities, and support overall pulmonary health RMSG exercises are shown to positively influence peak expiratory flow rate, exercise capacity, and the rate of perceived exertion, all of which contribute to enhanced physical endurance and respiratory efficiency. Additionally, the intervention was found to reduce pain and improve posture, addressing common musculoskeletal and respiratory issues associated with prolonged computer use. The study highlights RMSG as a practical and effective approach for mitigating the negative health impacts of sedentary, screen-based work, promoting overall well-being in this population..(Chokshi et al., 2024).

Research has consistently demonstrated the efficacy of RMSG in improving exercise capacity and overall quality of lifethe study by Rohmah, Amin, and Makhfudli (2020) emphasizes the effectiveness of combining upper limb exercises with respiratory muscle stretch gymnastics (RMSG) in reducing dyspnea among patients with chronic obstructive pulmonary disease (COPD). The intervention demonstrated significant improvements in respiratory function and overall physical capacity, enhancing the patients' quality of life. The integration of upper limb exercises with RMSG not only helps alleviate respiratory distress but also supports musculoskeletal strength, providing a comprehensive approach to managing COPD symptoms. This combination offers a promising, low-cost, and accessible strategy for improving the health outcomes of COPD patients, particularly in settings with limited resources. (Rohmah, Amin and Makhfudli, 2020)

The research by Hidayat and Multazam (2020) highlights the positive impact of combining Gymnastic Respiratory Muscle Stretch (RMSG) exercises and Buteyko Breathing exercises on improving peak expiratory flow rates in the older population. Both interventions, individually and in combination, were found to enhance respiratory function and contribute to better overall health, which is particularly important for older adults at risk of respiratory decline. These findings support the use of non-pharmacological approaches such as RMSG and Buteyko Breathing to improve lung capacity and ease of breathing in older individuals, suggesting a viable strategy for managing age-related respiratory challenges and promoting better quality of life in this demographic. (Mahfud Hidayat and Ali Multazam, 2020)

Rohmah, Amin, and Makhfudli (2023) demonstrates the effectiveness of combining upper limb exercises with respiratory muscle stretch gymnastics (RMSG) in improving lung function and enhancing the quality of life for patients with chronic obstructive pulmonary disease (COPD). The intervention led to significant improvements in both pulmonary function and overall well-being, highlighting its potential as a beneficial rehabilitation approach. The findings suggest that incorporating these exercises into COPD management can help reduce symptoms, improve physical capacity, and provide patients with a better sense of control over their health, ultimately contributing to better long-term outcomes. This combination offers a promising, cost-effective solution for improving the lives of individuals with COPD. (Rohmah, Amin and Makhfudli, 2023)

Hetal and Ashok also demonstrate that respiratory muscle stretch gymnastics can be highly advantageous for the elderly, significantly enhancing maximum breathing capacity, peak expiratory flow rate, and exercise tolerance. These improvements in respiratory function are vital for maintaining physical activity and overall quality of life. This evidence supports the integration of such exercises in elderly care routines to promote better lung health and endurance, aligning with findings from similar studies.(Hetal and Ashok, 2020)

Moreover, studies by Noman Sadiq and his friends shows that the balloon-blowing exercise effectively reduces perceived stress and enhances pulmonary function, showing positive impacts on cardiac measures such as ventricular depolarization and repolarization. This suggests that simple respiratory exercises can have a broader physiological benefit, potentially supporting cardiovascular and respiratory health.(Sadiq, Shaukat and Riaz, 2018)

Another study by Hetal and Ashok (2020) highlights the positive effects of respiratory muscle stretch gymnastics (RMSG) on respiratory function and physical capacity in the elderly. The findings demonstrate that RMSG significantly improves maximum breathing capacity, peak expiratory flow rate, and exercise tolerance, all of which are crucial for maintaining respiratory health and overall mobility in older adults. This intervention, being simple and non-invasive, offers a valuable approach for enhancing pulmonary function and supporting physical independence in the aging population. By improving both respiratory efficiency and exercise capacity, RMSG presents a promising tool for promoting healthy aging and mitigating age-related decline in respiratory health.(Hetal and Ashok, 2020)

The study by Shikha, Thapa, and Zafar (2022) examines the effect of balloon-blowing exercises on lung capacity in patients suffering from text neck syndrome due to improper posture. The findings indicate that balloon-blowing exercises can significantly improve lung function by enhancing respiratory muscle strength and promoting better lung expansion. This exercise encourages diaphragmatic breathing, which helps in improving both the depth and efficiency of breathing. When incorporated into a therapeutic regimen alongside other exercises like modified cervical exercises and Swiss ball exercises, balloon-blowing contributes to improving lung capacity and alleviating the respiratory limitations associated with text neck syndrome, demonstrating its potential as an effective intervention for postural and respiratory issues.(Shikha, Thapa and Zafar, 2022)

There is an evidence which also supports the other breathing exercise are also helps in employee's performance like the study by Tavoian and Craighead highlights the significant role of deep breathing exercises in enhancing workplace well-being and productivity. Implementing structured breathing techniques can lead to measurable reductions in stress levels among employees, fostering a healthier work environment. The authors suggest that regular practice of these exercises may not only improve individual performance but also contribute to a more positive organizational culture.(Tavoian and Craighead, 2023)

Liang also illustrate that breathing exercises can serve as a practical intervention for reducing muscle tension and improving cognitive abilities during stressful situations. Their findings suggest that such techniques may enhance overall mental resilience in high-pressure environments. (Liang et al., 2023)

Khant and Dave also demonstrate that inspiratory muscle training significantly enhances pulmonary function and improves the quality of life for workers in the cotton industry. This intervention highlights the potential benefits of targeted breathing exercises like inspiratory muscle training (IMT) and aerobic exercise in occupational health settings.(Khant et al., 2023)

CONCLUSION

The research highlights the effectiveness of FEV1-based, customized exercise programs in enhancing lung function and physical performance among cotton industry workers, who are often exposed to respiratory irritants. Tailoring these programs to individual FEV1 measurements allows for specific adjustments in exercise intensity, frequency, and duration, optimizing respiratory benefits and reducing risks associated with respiratory strain. Additionally, incorporating community-based group exercises fosters a supportive environment, which can further improve worker health and productivity. This approach demonstrates the importance of personalized physiotherapy within industrial settings to protect and enhance respiratory health.

The body of evidence surrounding RMSG and its associated exercises strongly supports their role in improving pulmonary function, exercise capacity, and quality of life for various populations, particularly those affected by respiratory conditions. Future research should continue to explore the mechanisms behind these benefits and assess the long-term impact of such interventions. Additionally, further studies are warranted to establish standardized protocols for RMSG, ensuring its effective integration into clinical practice for optimal patient outcomes.

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