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Assessment of respiratory impairment in brick factory workers using pulmonary function test: A cross- sectional study

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Abstract
Background: Occupational exposure to dust, smoke, and particulate matter in brick factories poses a significant risk for respiratory impairment among workers. Pulmonary function tests (PFTs) are essential for evaluating lung function and distinguishing between obstructive and restrictive respiratory patterns. Obstructive lung disease is characterized by reduced airflow and a low FEV1/FVC ratio, while restrictive lung disease presents with decreased lung volumes and a preserved or elevated FEV1/FVC ratio. Early detection of these impairments is crucial for preventive and therapeutic interventions in high-risk occupational populations.
Aim: To assess respiratory impairment in brick factory workers.
Methods: A cross-sectional study was conducted on 100 brick factory workers. PFT parameters measured included FVC, FEV1, FEV1/FVC ratio, and PEFR. Participants were categorized into Normal (n=13), Restrictive (n=52) and Obstructive (n=35) groups. Mean ± SD values were calculated and Restrictive & Obstructive is compared using independent t-tests.
Results: FVC was significantly lower in the restrictive group (61 ± 10.91) compared to the obstructive group (67 ± 10.52), p = 0.013. FEV1 did not differ significantly between groups (Restrictive: 58 ± 10.49, Obstructive: 59 ± 12.22; p = 0.684). FEV1/FVC ratio was significantly lower in the obstructive group (68 ± 6.14) compared to the restrictive group (83 ± 1.53), p < 0. 001.PEFR showed no significant difference (Restrictive: 57 ± 12.46, Obstructive: 61 ± 12.68; p = 0.149).
Conclusion: The study demonstrates that FEV1/FVC ratio and FVC are the most reliable parameters to differentiate obstructive and restrictive respiratory impairments in brick factory workers. Regular pulmonary function assessment is recommended for early detection and management of occupational respiratory disorders in this high-risk population.

Keywords: Pulmonary function test (PFT), obstructive lung disease, restrictive lung disease, brick factory workers, respiratory impairment, occupational health

Introduction

The brick manufacturing industry is one of the oldest forms of construction-related production across the world and continues to play a vital role in the infrastructure development of many developing nations, including India. Bricks remain an essential building material due to their durability, accessibility, and low cost. Despite the economic contribution of this sector, brick factories are characterized by harsh working conditions, limited mechanization, and inadequate safety regulations. Workers employed in brick kilns often belong to low socioeconomic backgrounds, receive minimal occupational training, and are exposed to a wide range of environmental health hazards every day. Brick kiln workers in India are regularly exposed to fine dust that contains silica while doing manual work such as brick molding and firing. Breathing this dust for a long time can harm the lungs.

According to studies their lung function values like FVC and FEV1 were lower compared to people who were not exposed to brick kiln dust. This study explains that long-term work in brick kilns affects normal lung function and shows the importance of pulmonary function tests for early identification of respiratory problems [1].

Brick manufacturing is a labor-intensive process that involves activities such as clay excavation, molding, drying, and firing in kilns. Workers in brick factories and kilns are continuously exposed to a range of occupational hazards, particularly airborne dust, particulate matter, and combustion gases. Fine dust particles, including respirable crystalline silica (SiO) along with pollutants like sulfur dioxide (SiO)nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs) are released during brick production. These substances can enter the respiratory tract, reaching the small airways and alveoli, and trigger inflammatory reactions and oxidative stress in lung tissue. Repeated exposure to these irritants over months and years can cause airway inflammation, mucus hypersecretion, and structural changes in the lungs, including fibrosis and reduced elastic recoil. These changes impair normal lung mechanics and compromise gas exchange, leading to respiratory symptoms such as chronic cough, wheezing, shortness of breath, and decreased exercise tolerance. Chronic exposure may result in long-term respiratory diseases such as chronic bronchitis, obstructive airway disease, and even occupational pneumoconiosis [2].

Many brick kilns workers had breathing problems and abnormal lung function test results. Most workers showed obstructive lung patterns, which means the airways were affected by dust and smoke exposure. The study highlighted

that pulmonary function tests are useful for detecting early lung problems in these workers [4]. Pulmonary Function Tests (PFTs) provide an objective method to assess lung function by measuring the volume and flow of air during inhalation and exhalation. Parameters such as Parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Peak Expiratory Flow Rate (PEFR), and mid-expiratory flows (FEF25–75%) help identify obstructive, restrictive, or mixed patterns of respiratory impairment. PFTs are especially useful in detecting early functional changes before clinical symptoms appear, making them an essential tool for occupational health screening. Assessing the respiratory health of brick factory workers through PFTs is important not only for early diagnosis and management of lung impairment, but also for implementing preventive measures such as protective equipment, workplace ventilation, and exposure control. Such assessments provide valuable information about the impact.

Materials & Methodology

Study Design: Cross-sectional observational study.

Sample size & Sampling: A total 100 brick factory workers were selected using Simple random sampling (depending on accessibility and consent).

Selection Criteria

Inclusion Criteria

- Brick factory workers aged between 18 and 60 years.
- Workers with a minimum of 1 year of occupational exposure in brick kilns.
- Individuals who provide informed written consent to participate in the study.

Exclusion Criteria

- Individuals with a history of known chronic respiratory illnesses not related to occupational exposure (e.g., tuberculosis, asthma diagnosed prior to employment).
- Workers with acute respiratory infections at the time of testing.
- Individuals who are physically or mentally unable to perform the Pulmonary Function Test.

Outcome Measures

The study was conducted following approval from the Institutional Ethics Committee. Prior to data collection, permission was obtained from the Head of the Physiotherapy Department. The study procedure was explained to all eligible participants, and written informed consent was obtained in accordance with ethical guidelines.

a. Participant Selection

- Participants will be selected on the basis of the inclusion and exclusion criteria.
- The participants will be explained about the procedure and consent will be taken.

b. Preparation and Positioning

- **Preparation of the Worker:** Explain the procedure clearly to the worker to reduce anxiety and ensure cooperation. Ask them to avoid heavy meals, smoking, or vigorous exercise at least 1–2 hours before the test. Remove any tight clothing or accessories that may restrict chest movement. Check for any acute respiratory illness or symptoms that may affect the test results.

- **Positioning for the Test:** The worker should sit comfortably on a chair with back support, keeping feet flat on the floor. Ensure the head is upright and the neck is not bent, to allow free movement of the chest and diaphragm. Hands should rest on the lap or armrests, and the worker should be relaxed to prevent false readings. Proper sealing of the mouth around the PFT mouthpiece is necessary to prevent air leaks.

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Procedure

Once the worker is prepared and properly positioned, the Pulmonary Function Test (PFT) is carried out using the following steps:

Initial Instructions: Explain to the worker how to breathe into the mouthpiece correctly. Emphasize taking a deep breath in and blowing out as forcefully and completely as possible.

Performing the Test: The worker places the mouth tightly around the PFT device's mouthpiece and wears a nose clip to prevent air escape. Ask the worker to inhale deeply to fill the lungs completely. Then, instruct them to exhale as quickly and forcefully as they can until no more air can be expelled. Some PFTs may also require slow, steady breathing in and out to measure lung volumes.

Repetition for Accuracy: The test is usually repeated 2–3 times to ensure reliability of the results. Between attempts, allow the worker to rest and breathe normally. Record the best reading that shows maximal effort.

Monitoring and Safety: Observe the worker for any signs of dizziness, discomfort, or coughing. Stop the test immediately if any adverse symptoms occur.

Recording Results: Note all readings including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), and other parameters.

Compare the results with standard predicted values for age, sex, and height to assess any respiratory impairment.

Statistical Analysis

Data collected from 100 brick factory workers (Normal: n=13, Obstructive: n=35, Restrictive: n=52) among that 87 wokers which showing obstructive and restrictive changes were entered into Microsoft Excel for initial calculation of descriptive statistics. Descriptive statistics: Continuous variables (FVC, FEV1, FEV1/FVC, PEFR) were expressed

as Mean ± Standard Deviation (SD). Categorical variables, if any, were expressed as percentages.

Comparative analysis: Independent Student's t-test was used to compare mean PFT values between the Obstructive and Restrictive groups. Significance level: $p < 0.05$ was considered statistically significant.

Parameters analyzed: FVC (L), FEV1 (L), FEV1/FVC (%), PEFR (L/min)

Rationale for test selection: The independent t-test is appropriate because the two groups (Obstructive and Restrictive) are independent, and the data are continuous and approximately normally distributed. The test evaluates whether the mean difference between the two groups is statistically significant.

Software used: Microsoft Excel for calculation of mean, SD, and t-values.

Results interpretation: $p < 0.05$: Significant difference between groups. $p \geq 0.05$: No significant difference.

Result

The results of the study are presented in terms of pulmonary function test (PFT) parameters among brick factory workers. The participants were categorized into obstructive (n=35) and restrictive (n=52) groups based on spirometric findings. The mean values of FVC, FEV1, FEV1/FVC ratio, and PEFR were calculated and expressed as mean ± standard deviation (SD). Independent t-test was used to compare the mean PFT values between the two groups, and the results are summarized in the table below.

Table 1: Comparision of Obstructive & Restrictive

Parameter	Obstructive (n=35) Mean ±SD	Restrictive (n=52) Mean ±SD	T Value	P Value	Result
FVC	67 ± 10.52	61 ± 10.91	2.55	0.013	Significant
FEV1	59 ± 12.22	58 ± 10.49	0.41	0.684	Not Significant
FEV1/FVC	68 ± 6.14	83 ± 1.53	-16.90	<0.001	Highly Significant
PEFR	61 ± 12.68	57 ± 12.46	1.46	0.149	Not Significant

Independent t-test was applied to compare mean PFT values between obstructive and restrictive groups. FVC ($p=0.013$) and FEV1/FVC ratio ($p<0.001$) showed statistically significant differences. However, FEV1 ($p=0.684$) and PEFR ($p=0.149$) did not show significant differences.

Discussion

1. Forced Vital Capacity (FVC)

Results: Obstructive: 67 ± 10.52

Restrictive: 61 ± 10.91, t = 2.55, p = 0.013 (Significant)

Interpretation: The restrictive group showed significantly lower FVC, consistent with classical restrictive lung disease, where lung expansion is limited and total lung capacity is reduced.

The obstructive group had relatively higher FVC, as airway obstruction typically affects flow rather than total volume.

Clinical relevance: Reduced FVC in restrictive patterns highlights decreased lung compliance, which may result from chronic exposure to occupational dust or environmental factors in brick factories.

2. Forced Expiratory Volume in 1 Second (FEV1)

Results: Obstructive: 59 ± 12.22

Restrictive: 58 ± 10.49, t = 0.41, p = 0.684 (Not Significant)

Interpretation: No significant difference in FEV1 between the groups. FEV1 measures the volume of air expelled in the first second of forced expiration, which may be moderately affected in both obstructive and restrictive patterns. In restrictive impairment, both FEV1 and FVC decrease proportionally, keeping the FEV1/FVC ratio normal or high. In obstructive impairment, FEV1 is reduced due to airflow limitation, but the degree of reduction may vary depending on disease severity and exposure duration.

Clinical implication: FEV1 alone is insufficient to distinguish between restrictive and obstructive patterns; it should always be interpreted along with FEV1/FVC ratio.

3. FEV1/FVC Ratio

Results: Obstructive: 68 ± 6.14

Restrictive: 83 ± 1.53, t = -16.90, p < 0.001 (Highly Significant)

Interpretation: The obstructive group showed a markedly lower FEV1/FVC ratio, consistent with airflow limitation characteristic of obstructive lung disease. The restrictive group had a higher FEV1/FVC ratio, reflecting proportionally preserved expiratory volume relative to FVC. This confirms that FEV1/FVC ratio is the most sensitive and reliable parameter for differentiating obstructive versus restrictive respiratory impairment.

Clinical relevance: In brick factory workers, a low FEV1/FVC ratio may indicate chronic obstructive airway disease due to prolonged exposure to dust and particulate matter.

4. Peak Expiratory Flow Rate (PEFR)

Results: Obstructive: 61 ± 12.68

Restrictive: 57 ± 12.46, t = 1.46, p = 0.149 (Not Significant)

Interpretation: No significant difference was observed between the groups. PEFR is effort-dependent and measures maximal airflow during expiration. While it can reflect airway obstruction, it is less sensitive than FEV1/FVC in distinguishing obstructive vs restrictive patterns.

Clinical implication: PEFR alone may not be reliable but can support interpretation when combined with FEV1/FVC and FVC.

5. Overall Interpretation

FEV1/FVC ratio and FVC are the most informative parameters for identifying restrictive and obstructive respiratory patterns. FEV1 and PEFR alone are less reliable for differentiation. These findings align with classical pulmonary physiology:

Obstructive: Reduced FEV1/FVC ratio, variable FEV1, relatively preserved FVC.
Restrictive: Reduced FVC, normal/high FEV1/FVC ratio, reduced lung volumes.

6. Occupational Significance

Brick factory workers are exposed to airborne particulate matter, which can lead to chronic respiratory impairment. Obstructive patterns may indicate airway inflammation and narrowing due to long-term dust exposure. Restrictive patterns may reflect decreased lung compliance, potentially from fibrosis or restrictive lung pathology secondary to environmental exposure. Early detection via PFTs allows preventive interventions, such as respiratory protective equipment, work environment modifications, and periodic health monitoring.

7. Comparison with Literature

Studies on occupational respiratory exposure consistently show: Obstructive impairments in workers exposed to smoke and dust. Restrictive impairments in workers with chronic exposure leading to reduced lung volumes. Your study's findings are consistent with these observations, confirming the utility of PFTs in occupational health assessment.

8. Limitations

Cross-sectional design limits ability to establish causality. PFTs are effort-dependent and may vary based on participant cooperation. No control group of unexposed individuals was included. Environmental and smoking history could further refine interpretation.

Summary

FEV1/FVC ratio and FVC are key parameters for differentiating obstructive and restrictive impairment. Regular pulmonary function monitoring in brick factory workers is recommended for early detection and prevention of occupational respiratory diseases.

Conclusion

Pulmonary function assessment in brick factory workers demonstrated that FEV1/FVC ratio and FVC are the most reliable parameters to differentiate between obstructive and restrictive respiratory impairments. The obstructive group showed significantly lower FEV1/FVC ratio, confirming airflow limitation consistent with obstructive lung disease. The restrictive group exhibited significantly lower FVC, reflecting reduced lung volumes typical of restrictive lung disease. FEV1 and PEFR did not show statistically significant differences between the groups, indicating that these parameters alone are less useful for differentiating respiratory patterns. These findings emphasize the importance of regular pulmonary function testing for early detection of respiratory impairment in high-risk occupational populations, enabling timely preventive and therapeutic interventions. Occupational health measures, including proper dust control, respiratory protective equipment, and periodic health monitoring, are recommended to minimize the risk of long-term respiratory morbidity among brick factory workers.

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