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# Pulmonary Function in Marble Industry Workers and Non-Exposed Individuals: A Comparative Cross-Sectional Study

[1]Dr Amit Jatolia, Post Graduate Student, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

[2]Dr Yamini Singh, Associate Professor, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

[3]Dr Poonam Gogania, Professor, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

[4]Dr Garima Bafna, Senior Professor and Head, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

[5]Dr Teena Sogan, Assistant Professor, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

[6]Dr Navni Jain, Post Graduate Student, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

**Corresponding Author:** Dr Garima Bafna, Senior Professor and Head, Department of Physiology, Jawaharlal Nehru Medical College, Ajmer

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**Type of Publication:** Original Research Article

**Conflicts of Interest:** Nil

## Abstract

**Background**: Occupational exposure to dust generated during marble processing may adversely affect respiratory function. Pulmonary function testing provides an objective method for identifying functional abnormalities among exposed workers.

**Objective**: To compare pulmonary function parameters between marble industry workers and non-exposed individuals and to assess the respiratory effects associated with occupational marble-dust exposure.

**Methods**: A comparative cross-sectional observational study was conducted in the Department of Physiology, J.L.N. Medical College and Associated Group of Hospitals, Ajmer, from March 2024 to February 2025. A total of 170 participants were studied, comprising 85 marble factory workers of Kishangarh residing in Ajmer and 85 individuals from the same community residing in Ajmer who were not employed in the marble industry. Pulmonary function was assessed using an RMS Helios 702 spirometer (version 3.2.38). FVC, $FEV_1$, $FEV_1$/FVC ratio, PEFR, and $FEF_{25–75\%}$ were recorded. Three forced expiratory manoeuvres were performed and the highest values were selected. Data were analyzed using SPSS version 24. Student's t-test, ANOVA, and chi-square test were used as appropriate; $p<0.05$ was considered statistically significant.

**Results**: Mean age was comparable between marble workers and controls (35.36 ± 3.92 vs 35.37 ± 3.95

years; p=0.98). Mean BMI was also comparable (25.68 ± 3.64 vs 24.83 ± 4.10 kg/m²; p=0.15). Measured FVC was significantly lower among workers than controls (2.86 ± 0.44 vs 3.41 ± 0.42 L; p<0.0001), as was FVC% predicted (75.31 ± 6.22 vs 91.62 ± 4.72%; p<0.0001). Measured $FEV_1$ (2.86 ± 0.41 vs 3.02 ± 0.40 L; p=0.01), $FEV_1$% predicted (75.31 ± 6.22 vs 91.63 ± 4.74%; p<0.001), PEFR (6.26 ± 0.88 vs 7.61 ± 1.00 L/s; p<0.001), PEFR% predicted (75.28 ± 6.25 vs 91.52 ± 4.73%; p<0.001), measured $FEF_{25–75\%}$ (2.69 ± 0.46 vs 3.19 ± 0.53 L/s; p<0.0001), and $FEF_{25–75\%}$ predicted (75.38 ± 6.25 vs 91.62 ± 4.74%; p<0.0001) were significantly lower in workers. $FEV_1$/FVC did not differ significantly between groups.

**Conclusion**: Marble industry workers demonstrated significantly lower pulmonary function indices than non-exposed individuals. The pattern was characterized by reduced FVC and airflow-related indices without a significant reduction in $FEV_1$/FVC. These findings support the need for occupational dust-control measures, appropriate respiratory protection, health education, and periodic pulmonary function surveillance.

**Keywords**: marble dust; occupational exposure; pulmonary function; spirometry; FVC; $FEV_1$; PEFR; $FEF_{25–75\%}$.

## Introduction

Marble is widely used in construction, monuments, flooring, and other industrial applications, and marble powder has been characterized for use in construction materials[1]. Processing activities such as cutting, grinding, drilling, and polishing generate airborne particulate matter; workers may therefore experience prolonged exposure to marble and stone dust[2-4]. The respiratory effects depend on dust composition and concentration, work process, exposure duration, ventilation, and use of personal protective equipment. Where respirable crystalline silica is present, long-term occupational exposure is associated with serious respiratory hazards and an increased risk of lung cancer[5].

Previous studies have reported reductions in pulmonary function among workers exposed to marble, stone, mineral, and other occupational dusts. Butt et al. found significantly lower pulmonary function parameters among marble workers in Lahore[6], and a study of marble-industry workers in India reported similar concerns[7]. Studies of stone-crusher, stone-cutting, quarry, and other mineral-dust workers have also documented reduced spirometric indices and deterioration with increasing exposure duration[8-11].

The present study was undertaken to compare pulmonary function tests between marble industry workers and individuals not employed in the marble industry in the Ajmer region and to assess the potential respiratory effects associated with occupational marble-dust exposure.

### Aim And Objectives

**Aim**: To conduct a comparative analysis of pulmonary function test parameters between individuals working in the marble industry and individuals from the general population who were not exposed to marble dust.

**Primary objectives**:

1. To evaluate pulmonary function parameters including FVC, $FEV_1$, $FEV_1$/FVC ratio, PEFR, and $FEF_{25–75\%}$ among marble industry workers.
2. To compare pulmonary function parameters between marble industry workers and non-exposed individuals.

**Secondary objective**:

To assess respiratory symptoms among marble industry workers and relate them to pulmonary function findings.



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## Materials and Methods

### Study design and setting

This comparative cross-sectional observational study was conducted in the Department of Physiology, J.L.N. Medical College and Associated Group of Hospitals, Ajmer, Rajasthan, from March 2024 to February 2025.

### Ethical considerations

Institutional Ethics Committee approval was obtained before commencement of the study. Written informed consent was obtained from participants. The dissertation contains the study consent form and institutional ethical approval documentation.

### Sample size and participants

The sample size was calculated using a previously reported prevalence of 12.5% [6], resulting in a total sample size of 170 participants. Participants were divided equally into two groups: Group I, 85 marble factory workers from Kishangarh residing in Ajmer; and Group II, 85 individuals from the same community who were not employed in the marble industry.

### Inclusion Criteria:

The study included:

1. Male and female marble workers.
2. Individuals aged between 18 and 40 years.
3. Participants who had been exposed to marble dust for more than one year.
4. Individuals who provided informed consent for participation in the study.

### Exclusion Criteria:

Participants were excluded based on the following criteria:

1. Workers diagnosed with respiratory diseases, including asthma, tuberculosis, or bronchiectasis.
2. Individuals with thoracic deformities.
3. Individuals with a history of pneumothorax, hemoptysis, or recent abdominal or eye surgery.
4. Participants deemed unfit for spirometry.
5. Individuals who did not provide consent for participation.

### Pulmonary function testing

Pulmonary function was assessed using the RMS Helios 702 spirometer, version 3.2.38. Participants were instructed regarding the procedure and were seated comfortably for testing. Each participant performed three forced expiratory manoeuvres after a deep inspiration, and the highest values were selected for analysis. The study recorded FVC, $FEV_1$, $FEV_1$/FVC, PEFR, and $FEF_{25–75\%}$ together with demographic and anthropometric variables. Ambient temperature and humidity were also recorded. The testing approach was aligned with accepted general principles for standardized lung-function measurement [12].

### Spirometric interpretation

The present study defined impairment using FVC or $FEV_1$ below 80% of predicted and an $FEV_1$/FVC ratio below 0.70. For this publication, these thresholds are reported as the study's prespecified interpretation rather than as universally applicable diagnostic criteria, because current interpretive standards emphasize appropriate reference equations and lower limits of normal[13,14]. A reduced FVC with a preserved $FEV_1$/FVC ratio is therefore described cautiously as a possible restrictive pattern; confirmation of true restriction requires measurement of total lung capacity, which was not performed in this study [15].

### Statistical analysis

Data were analyzed using SPSS version 24. Continuous variables were summarized using mean and standard deviation, while categorical variables were summarized



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as frequencies and percentages. Student's t-test was used for comparisons of continuous variables between groups, ANOVA was used for comparisons across exposure-duration categories, and chi-square testing was used for categorical comparisons. A two-sided p-value <0.05 was considered statistically significant.

**Results**

A total of 170 participants were included, with 85 participants in each group. The demographic and clinical characteristics are summarized in Table 1.

Table 1:

| Variable | Marble workers (n=85) | Controls (n=85) | p-value |
|---|---|---|---|
| Age, years | 35.36 ± 3.92 | 35.37 ± 3.95 | 0.98 |
| BMI, kg/m² | 25.68 ± 3.64 | 24.83 ± 4.10 | 0.15 |
| Pulse, bpm | 75.23 ± 9.51 | 74.70 ± 8.86 | 0.70 |
| SBP, mmHg | 120.58 ± 5.84 | 118.65 ± 7.51 | 0.06 |
| DBP, mmHg | 77.20 ± 4.67 | 77.36 ± 8.18 | 0.87 |

Age, BMI, pulse rate, systolic blood pressure, and diastolic blood pressure did not differ significantly between the groups. The sex distribution differed between groups: 48 (56.47%) workers were male and 37 (43.53%) were female, whereas the control group comprised 35 (41.18%) males and 50 (58.82%) females (p=0.05). All exposed participants were marble factory workers; the control group comprised individuals from several occupations.

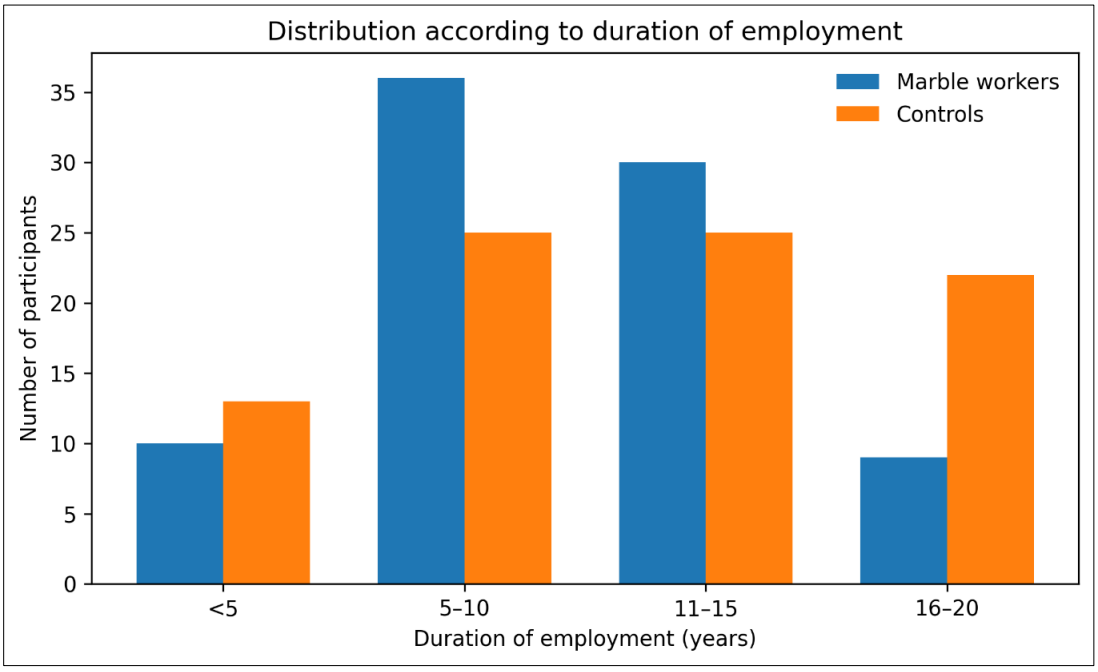



Figure 1: Distribution of participants according to duration of employment.

The mean duration of employment was 10.02 ± 4.27 years among marble workers and 11.61 ± 5.02 years among controls (p = 0.02). Among workers, 36 (42.35%) had 5–10 years of employment and 30 (35.29%) had 11–15 years of employment.



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Table 2: Pulmonary function parameters

| Parameter | Marble workers Mean ± SD | Controls Mean ± SD | p-value |
|---|---|---|---|
| FVC predicted (L) | 3.79 ± 0.44 | 3.73 ± 0.42 | 0.36 |
| FVC measured (L) | 2.86 ± 0.44 | 3.41 ± 0.42 | <0.0001 |
| FVC (% predicted) | 75.31 ± 6.22 | 91.62 ± 4.72 | <0.0001 |
| $FEV_1$ predicted (L) | 3.79 ± 0.44 | 3.30 ± 0.42 | <0.001 |
| $FEV_1$ measured (L) | 2.86 ± 0.41 | 3.02 ± 0.40 | 0.01 |
| $FEV_1$ (% predicted) | 75.31 ± 6.22 | 91.63 ± 4.74 | <0.001 |
| PEFR predicted (L/s) | 8.32 ± 0.95 | 8.31 ± 1.02 | 0.94 |
| PEFR measured (L/s) | 6.26 ± 0.88 | 7.61 ± 1.00 | <0.001 |
| PEFR (% predicted) | 75.28 ± 6.25 | 91.52 ± 4.73 | <0.001 |
| $FEF_{25–75\%}$ predicted (L/s) | 3.57 ± 0.57 | 3.49 ± 0.56 | 0.35 |
| $FEF_{25–75\%}$ measured (L/s) | 2.69 ± 0.46 | 3.19 ± 0.53 | <0.0001 |
| $FEF_{25–75\%}$ (% predicted) | 75.38 ± 6.25 | 91.62 ± 4.74 | <0.0001 |

Predicted FVC and predicted PEFR were comparable between groups. In contrast, measured FVC and FVC% predicted were significantly lower among marble workers. Measured $FEV_1$ and $FEV_1$% predicted were also lower in workers. PEFR and PEFR% predicted showed similarly significant reductions. Measured $FEF_{25–75\%}$ and $FEF_{25–75\%}$ predicted were significantly lower among workers, whereas predicted $FEF_{25–75\%}$ did not differ significantly.

Table 3: $FEV_1$/FVC ratio

| Parameter | Marble workers Mean ± SD | Controls Mean ± SD | p-value |
|---|---|---|---|
| $FEV_1$/FVC predicted (%) | 80.27 ± 3.00 | 79.67 ± 3.20 | 0.20 |
| $FEV_1$/FVC measured (%) | 80.13 ± 3.90 | 79.47 ± 4.26 | 0.29 |
| $FEV_1$/FVC (% predicted) | 99.82 ± 2.91 | 99.72 ± 3.05 | 0.82 |

There was no statistically significant difference in predicted, measured, or percentage-predicted $FEV_1$/FVC between groups. Thus, the study did not demonstrate a significant obstructive pattern based on the reported ratio values.

**Discussion**

The present comparative cross-sectional study demonstrated significantly lower measured FVC, $FEV_1$, PEFR, and $FEF_{25–75\%}$ among marble industry workers than among non-exposed participants. The corresponding percentage-predicted values were also lower in workers, whereas the $FEV_1$/FVC ratio did not differ significantly between groups. Taken together, the findings indicate impaired pulmonary function without evidence of a significant obstructive pattern based on the reported ratio values. The reduced FVC with a preserved $FEV_1$/FVC ratio is compatible with a possible restrictive or non-specific spirometric pattern, but restriction cannot

be confirmed because total lung capacity was not measured.

The mean duration of employment among marble workers was 10.02 ± 4.27 years, and 42.35% had worked for 5–10 years. Butt et al. reported a comparable mean work duration of 11.2 ± 5.67 years among marble workers and found abnormal pulmonary function tests in 71% of workers, including a restrictive pattern in 34% [6]. This comparison supports the possibility that sustained occupational exposure contributes to respiratory functional impairment; however, the present cross-sectional data do not establish an individual dose-response relationship, and workplace dust concentration was not measured.

Measured FVC and FVC% predicted were markedly lower among workers than controls in the present study. Butt et al. likewise reported lower FVC% among marble workers than controls[6]. Ahmed et al. documented substantial spirometric and respiratory abnormalities among stone-cutting workers[10]. Although the populations and exposure conditions differ, the direction of these findings is consistent with an adverse association between prolonged stone-dust exposure and lung volume.

Measured $FEV_1$, $FEV_1$% predicted, PEFR, and PEFR% predicted were also significantly reduced among marble workers, suggesting impairment of airflow-related indices. Similar reductions in $FEV_1$ and PEFR have been reported among workers in dusty industries. Al-Neaimi et al. observed lower $FEV_1$ and PEFR among cement-factory workers than comparison participants[16], while Ahmed et al. reported impaired spirometric indices among stone-cutting workers[10]. Differences in industrial processes, dust composition, exposure intensity, and participant characteristics should be considered when comparing the magnitude of effects across studies.

The significantly lower measured $FEF_{25–75\%}$ and $FEF_{25–75\%}$ predicted values may suggest involvement of smaller airways. Studies by Tosca et al. and Rao et al. found lower $FEF_{25–75\%}$ values in asthma groups with poorer control or greater morbidity[18,19]. Those studies involved asthma populations rather than occupationally exposed workers, so they provide physiological context only and do not directly establish occupational small-airway disease in the present sample. $FEF_{25–75\%}$ is variable and should not be interpreted as a stand-alone diagnostic measure.

The findings have practical occupational-health implications. Engineering controls, effective local ventilation, wet processing where feasible, appropriate respiratory protective equipment, worker education, and periodic spirometric surveillance should be encouraged. At the same time, the association must be interpreted cautiously because respirable dust and crystalline silica concentrations were not quantified, smoking and protective-equipment data were not adequately incorporated into the comparative analysis, and pulmonary function was assessed at a single time point. Future longitudinal studies should combine standardized spirometry with quantitative exposure monitoring and detailed assessment of smoking, ventilation, and protective practices.

**Conclusion**

Marble industry workers in the present study demonstrated significantly lower pulmonary function parameters than non-exposed individuals. Measured FVC, $FEV_1$, PEFR, and $FEF_{25–75\%}$ and their percentage-predicted values were significantly reduced among workers, whereas the $FEV_1$/FVC ratio remained



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comparable between groups. The findings indicate impaired pulmonary function associated with occupational exposure and are compatible with a possible restrictive or non-specific spirometric pattern, although true restriction cannot be confirmed without total lung capacity measurement. Strengthening dust-control measures, use of appropriate respiratory protection, occupational-health education, and periodic spirometric surveillance should be encouraged among marble workers.

**Strengths**

The study included a balanced comparison of 85 marble workers and 85 non-exposed participants from the same community, reducing variation related to geographic setting. The groups were comparable in age, BMI, and measured hemodynamic characteristics. Clearly defined eligibility criteria and a consistent spirometry protocol, including three forced expiratory manoeuvres, supported standardized data collection. Evaluation of FVC, $FEV_1$, $FEV_1$/FVC, PEFR, and $FEF_{25–75\%}$ provided complementary information on lung volume and airflow. The contemporaneous control group, reporting of both measured and percentage-predicted values, and cautious interpretation of the preserved $FEV_1$/FVC ratio strengthen the transparency and clinical relevance of the findings.

**Limitations**

The study was conducted in a specific geographic region and included participants from selected marble workplaces, which may limit generalizability. Quantitative assessment of workplace dust concentration and respirable crystalline silica exposure was not performed. Detailed information regarding personal protective equipment, workplace ventilation, and smoking status was collected or considered in the study protocol but was not adequately incorporated into the presented comparative results. Potential environmental and occupational confounding therefore cannot be excluded. Pulmonary function was assessed at a single time point, precluding assessment of longitudinal decline or reversibility. Finally, total lung capacity was not measured, so a restrictive ventilatory defect could not be confirmed.

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