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Original Research Article

Pulmonary function tests in granite quarry workers in Kuppam, Andhra Pradesh

Jayalakshmi M. K.[1]*, Margaret Mary M.[2], Caroline Priyadarshini[1], S. S. Vinay Kumar[1]

[1]Department of Physiology, PES Institute of Medical Sciences and Research, Kuppam, Chittoor District, Andhra Pradesh, India
[2]Department of Physiology, Jubilee Mission Medical College and Research Institution, Thrissur, Kerala, India

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***Correspondence:**
Dr. Jayalakshmi M. K.,
E-mail: jayalakshmimalavar@gmail.com

ABSTRACT

Background: Quarrying is the process by which rock, sand, gravel, or other minerals from the earth are removed to produce materials for construction work and other uses. During the process of quarrying, large amounts of dust particles of heavy metals, silica, and organic solvents are emitted from the earth's surface. Kuppam region of Andhra Pradesh is famous for the green coloured granite stone which has global demand, which is specifically found in the Kuppam and surrounding villages, hence number of quarries are more and causing respiratory diseases of local quarry workers.
Methods: The study was conducted in the department of physiology with total of 50 quarry workers for more than or equal to 5 years duration of working, both gender is randomly selected between 25-55 years of age. 50 Apparently normal healthy individuals of both genders were chosen from 5 km away from the quarry area as the control group. Ethical approval for the study protocol was obtained from institutional ethical clearance committee (IECC). After inclusion and exclusion criteria, lung function tests were done in quarry and the normal healthy subjects.
Results: There was a statistically significant change in FEV1, FVC and PEFR among quarry workers.
Conclusions: Not only quarry workers but also nearby residing population were also at the risk of deterioration of lung function tests.

Keywords: Granite quarrying, Lung function tests, Silicosis

INTRODUCTION

Diseases which are caused due to the adverse environment at the workplace are called occupational diseases.[1] Silicosis is one of the occupational lung diseases which is caused by silica exposure via inhalation, causing mild to moderate changes in pulmonary function tests, mortality and many years of exposure result in inflammation and fibrosis in the lung parenchyma. Exposure to silica dust due to stone quarrying can cause severe respiratory problems of obstructive/restrictive airway diseases depending on the number of years of exposure. Other than respiratory problems, exposure to quarry dust may also increase the risk of health problems affecting the heart, liver, kidney, and central nervous system. Deaths due to epidemics of silicosis still continued to be reported both in developing and developed countries and silica exposure is an important occupational health hazard at present.[2]

Quarrying is the process by which rock, sand, gravel from the earth are removed to produce materials for construction works. Though it can cause serious medical problem in many workers but quarrying plays an important role in the lives of rural people in developing countries because it provides their livelihood needs. In quarry workers, pulmonary function tests (PFTs) may reveal significant lung damage due to chronic dust exposure, leading to an increased prevalence of restrictive or obstructive lung

disorders. These tests are vital for early detection of respiratory problems, monitoring work-related lung conditions and assessing the effectiveness of preventive measures like dust control and ventilation in quarrying environments. During the process of quarrying, large amounts of dust particles of heavy metals, silica, and organic solvents are emitted from the earth's surface.[3]

Silica is one of the key constituents of granite stones. Crystalline silica exposure is ubiquitous in the environment, occurring in stone processing. The adverse health effects due to silica exposure have become a public health issue in recent years.[4] Deposited crystalline silica particles cause respiratory mucosal irritation, mucosal hyper secretion in the large airways, mucosal gland hypertrophy of trachea and bronchi, which results in the formation of a mucous plug in the lumen, and fibrosis of small airways. Obstruction in the air flow in airways results in decreased FVC (forced vital capacity), FEV1 (forced expiratory volume in first second) and FEV1/FVC ratio airways. A previous cross-sectional study among Indian stone crush workers reported a noteworthy decrease in FEV1, FVC and FEV1/FVC parameters. Several previous studies demonstrated that longer duration of exposure to occupational dust (silica) leads to a gradual decrease in pulmonary function tests (PFTs).[5]

In one study it was found among granite workers, lung cancer mortality which was related to silica exposure, while subsequent study found it was not related to exposure of silica.[6] Exposure to crystalline silica in Vermont granite workers was associated with increased mortality from silicosis and other non-malignant respiratory disease, but there was no evidence that increased lung cancer mortality in the cohort study was due to exposure to silica. Mortality from malignant and non-malignant kidney disease was not significantly increased or associated with exposure to silica dust.[7] Respiratory symptoms and ventilator functions among quarry workers in end state, Nigeria showed that respiratory symptoms were more in workers with chronic exposure to quarry dust.[8]

Studies have shown that the presence of high levels of silica in stone-crushing workplaces may cause silicosis within six months only.[9] Diseases like silicosis are not curable, it is important to have awareness and preventive measures for its effective control.[10] Kuppam region of Andhra Pradesh is famous for the green coloured granite stone which has global demand, which is specifically found in the Kuppam and surrounding villages, hence number of quarries are more and causing respiratory diseases of local quarry workers.

This study focuses not only quarry workers of both the gender but also to study the residing population of 5km away from the quarry sites and to know the effect of silica dust produced by the quarries. In this study a sample of 100 people contain 50 quarry workers and 50 residents of nearby villages of 5 kilometers away from the quarry sites were taken, so that we can assess the effect of silicon dust by studying and comparing the FEV1, FVC, FEV1/FVC and PEFR between the two groups.

METHODS

Study design and population

It was a comparative cross sectional study. Granite quarry workers between the ages of 25 to 50 year of both the gender formed the study population.

Sample size

A total of 100 people were included 50 granite quarry workers and 50 apparently normal healthy individuals residing 5 km away from the quarry.

Study period

The study took place for one year from July 2024 to June 2025.

Study place

This study was carried out at the department of physiology, PESIMSR, Kuppam.

Inclusion criteria

Workers between the age group of 25 and 55 working in the quarry for more than or equal to 5 years duration of working, both the gender who were willing to participate are included in the study. Apparently healthy individuals of both the genders between the ages of 25 to 50 years old residing 5 km away from the quarry site.

Exclusion criteria

Smokers, diabetic patients, patients with respiratory illnesses (pulmonary tuberculosis, COPD), flour mill workers, patients with cardiac illnesses (coronary artery disease, congestive cardiac failure, hypertensive heart disease, valvular heart disease), pregnant women, patients with sleep apnoea, physical disabilities that may affect the lung function, obese individuals, patients with history of thoracic/abdominal surgery in the last 3 months.

Data collection procedure

The study was conducted in the department of physiology a total of 50 quarry workers for more than or equal to 5 years duration of both genders was randomly selected. 50 apparently normal healthy individuals of both genders chosen from 5 km away from the quarry area as the control group. Ethical approval for the study protocol was obtained from institutional ethical clearance committee (IECC). Written informed consent form was obtained from all the participants after explaining study procedure in their preferred language (Telugu).

Healthy individuals were undergone thorough clinical examination to ensure that they meet the inclusion criteria. Basic parameters such as age, gender, weight (in kg), height (in cm), pulse rate, respiratory rate, temperature, SPO_2, blood pressure, waist circumference and hip circumference were measured. Pulmonary function tests (PFTs) including FVC, FEV1, FEV1: FVC, PEFR were performed. Using the PC Spirometer between 9:00 am to 3:00 pm. So the test was conducted according to American thoracic society (ATS).[8] Tests was conducted in a quiet room, participants in sitting position. Spirometry was conducted 3 times at an interval of 15 minutes and the best of 3 was considered. Percentage of predicted values for the respective age height, weight was calculated for all parameters.

Instruments used

The instruments used in the study were portable digital spirometer (simple model), digital thermometer, pulse oximeter, stethoscope, sphygmomanometer, non-stretchable-measuring-tape.

Questionnaire development and data collection

A face-to-face interview was conducted by trained personnel using a structured, standardized questionnaire. Details on socio-demographic, anthropometric parameters (standing height and weight), smoking history, occupational history, and health-related information were recorded.

Lung function assessment (using spirometer)

Pulmonary functions were measured using an electronic spirometer (model: easy one) as per the guidelines of the American Thoracic Society/European Respiratory Society.[11] Details on the age, gender, standing height, weight and smoking status of the participant were collected before spirometry test. Standard spirometric measures such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the ratio of FEV1/FVC were recorded. Pulmonary function variables were recorded as the percentage of the normal values predicted on reported height and age. Based on the spirometric reading, the lung conditions were classified as normal, obstructive, and restrictive as per the global initiative for chronic obstructive lung disease classifications.[12]

Statistical analysis

The data was entered into the latest version of Excel, and further analysis was conducted using SPSS (version 23.0; SPSS Inc., Chicago, IL, USA).

Descriptive analysis

For categorical variable, frequencies and percentages will be calculated, and appropriate graphs such as bar charts or pie charts were generated to visualize the distribution. For continuous variables, the mean standard deviation was computed, and histograms or box plots were created to illustrate the distribution and central tendency.

Inferential analysis

Numerical data was analyzed using the ANOVA-test. Categorical data was analyzed using the Chi-square test.

A significance level of "p" <0.05 was considered statistically significant.

RESULTS

Table 1 shows the demographic characteristics of the Quarry workers includes mean age 45.6 years and in Residents was 36.92 years. The mean value of male gender was 45(90%) of quarry workers and 35 (70) in residents respectively, female subjects were 5 (10%) among quarry workers and 15 (30%) residents. Mean body mass index (BMI) range was 24.92 (17.31-36.76) in quarry workers and in residents was 25.50 (15.79-30.33).

Table 1: Demographic characteristics of the quarry workers and residents.

Variables	Categories	Groups	
		Quarry workers (n=50) (%)	Residents (n=50) (%)
Age (years)	<40	14 (28)	33 (66)
	41-50	24 (48)	17 (34)
	>50	12 (24)	0
	Mean age	45.6	36.92
Gender	Male	45 (90)	35 (70)
	Female	5 (10)	15 (30)
Body mass index (BMI) kg/cm^2	<18.5	3 (6)	2 (4)
	18.5-22.9	11 (22)	12 (24)
	23-24.9	13 (26)	5 (10)
	>25	23 (46)	31 (64)
	Mean BMI (range)	24.92 (17.31-36.76)	25.50 (15.79-30.33)

Table 2: Proforma for data collection.

Age (in completed years)	
Gender	Male/Female
Duration of work (in years)	
Height (cm)	
Weight (kg)	
BMI (kg/m^2)	
Waist circumference (cm)	
Hip circumference (cm)	
Waist to Hip Ratio (WHR)	
Pulse rate (beats/minute)	
Respiratory rate (cycles/minute)	
Systolic blood pressure (mmHg)	
Diastolic blood pressure (mmHg)	
Pulmonary function tests	
FVC (L)	
FEV1 and FEV1%	
FEV1:FVC (ratio)	
PEFR (L/minute)	
Systemic examination- **R.S, CVS, P/A, CNS**	

BMI: body mass index, FVC: forced vital capacity, FEV1: forced expiratory volume in one second, FEV1%: percentage of forced expiratory volume, PEFR: peak expiratory flow rate, respiratory system (RS), cardiovascular system (CVS), per abdomen (P/A), central nervous system (CNS).

Table 2 shows proforma of data collection in quarry workers and in residents.

From Table 3 paired t test results, one can observe that ΔFVC showing average value of 0.60, with the standard deviation of 0.71 in quarry workers and also show in average value of 0.02, with the standard deviation of 0.20 in residents. With p value of 0.0001* which was highly significant. ΔFEV1 showing average value of 0.30, with the standard deviation of 0.75 in quarry workers and also showing average value of 0.04, with the standard deviation of 0.26 in residents. With p value of 0.0002* which was significant. ΔFEV1:FVC showing average value of 4.99, with the standard deviation of 18.4 in quarry workers and also showing average value of 2.32, with the standard deviation of 7.4 in residents. With p value of 0.8276 which was not significant. ΔPEFR showing average value of 4.23, with the standard deviation of 1.65 in quarry workers and also showing average value of 0.92, with the standard deviation of 0.86 in residents. With p value of 0.0001* which was not significant (Table 3).

From the Table 4 pair wise correlation test between distances of residence from quarry site and PFT Parameters among residents, showing ΔFVC with 'r' value of 0.1146 which was weak and positively correlated, with p value of 0.4283 which was statistically significant. ΔFEV1 with 'r' value of 0.0433 which was weak and positively correlated, with value of 0.7652 which was statistically not significant. ΔFEV1: FVC with 'r' value of -0.0354 which was weak and negatively correlated, with p value of 0.8073 which was statistically not significant. ΔPEFR with 'r' value of -0.4282 which was weak and negatively correlated, with p value of 0.0019 which was statistically significant (Table 4).

Table 3: Paired 't' test between quarry workers and residents.

Variables	Groups		t-value	P value	Results
	Quarry workers Mean±SD	Residents Mean±SD			
Δ FVC	0.60±0.71	0.02±0.20	5.5404	0.0001*	Highly significant
Δ FEV1	0.3±0.75	0.04±0.26	3.7417	0.0002	significant
Δ FEV1:FVC	4.99±18.4	2.32±7.4	0.9494	0.8276	Not Significant
Δ PEFR	4.23±1.65	0.92±0.86	12.5371	0.0001*	Highly significant

*P value <0.05considered as significant correlation

Table 4: Pair wise correlation test between distance of residence from quarry site and PFT parameters among residents.

Variable	Residents	
	R value	P value
Δ FVC	0.1146	0.4283
Δ FEV1	0.0433	0.7652
Δ FEV1:FVC	-0.0354	0.8073
Δ PEFR	-0.4282	0.0019*

R value is between -1 to +1, "-" indicates negative correlation, "+" indicates positive correlation, 0 to 0.4weak correlation, 0.4 to 0.7 moderate correlation, >0.7 strong correlation.
*'P' value <0.05 considered as significant correlation.

DISCUSSION

Our study was aimed to find the effect of silica dust on pulmonary function tests in stone crusher workers of Kuppam. Working in granite quarries can increase the risk of silicosis, because silica dust produced by heavy stone cutting and grinding works, but also resident population of nearby villages are also at higher risk of getting silicosis, as their distance increasing from the quarry their risk of silicosis is reduced, but the duration on exposure at the quarries among quarry workers doesn't show much significance, most of the studies shown that the longer exposed workers developed more advanced stages of lung diseases, may be the safety protocols, environmental

factors and the lifestyle of the people could have helped them from worsening the lung diseases.

According to the findings of other authors who have also studied these workers' pulmonary functions. Silica dust deteriorates pulmonary health which is similar to our study.[13] Similar to our present study, Nwibo et al also found that the mean±SD FEV1 and FVC values were significantly decreased among quarry workers of stone crushing industrial site at Umuoghara, Ebonyi state, Nigeria.[14] Kumar et al also found significant reduction in mean values of FVC, FEV1, FVC/FEV1%, PEF, and FEF25-75% between quarry workers and their matched controls.[15] Based on observations and results of statistical analysis we can conclude that:

There is a significant change in FEV1 among quarry workers but slight change is seen in residents. There are significant changes in FVC among quarry workers but slight change is seen in residents. There is a significant change in PEFR among quarry workers and mild changes in residents. But the changes in FEV1:FVC shown mild negative correlation but not significant, which suggests that some people as their distance from the quarry sites decreasing their FEV1:FVC is deviating predicted value. Changes in PEFR have shown moderate negative correlation and also which is statistically significant. Which suggests that as the people's distance from the quarry sites increases, deviation of PEFR is decreases and comes equal to predicted value. Adequate ventilation, and suitable masks and eyewear supply for each employee. Awareness of quarry workers is necessary for improved health.[16,17]

There are limitations of the study. Sample size was less and the individuals from the residents were selected randomly. Whereas the quarry workers were selected by purposive sampling. Wind direction and seasonal variations were not accounted for. Information related to social economic status, hygiene, and housing-related factors of the workers and the residents were not included in the study and hence the effects of these factors on the presence of the pulmonary complications have not been reported. The study was conducted in particular geographic areas and cannot be generalized to the entire population. Multicenter studies are needed.

CONCLUSION

Based on observations and results of statistical analysis we can conclude that: there was a significant change in FEV1, FVC and PEFR among quarry workers but slight change was seen in residents. When we correlated the parameters with the years of quarry working experience among quarry workers all the parameters shown mild positive correlation but not significant. When we correlated the distance of residence from the quarry site showed some interesting results among local resident population showed FVC and FEV1 shown mild positive correlation but not significant, deviations of FVC and FEV1 are increasing which was totally unexpected. There may be unknown underlying causes for this phenomenon, further detailed studied studies needed in this area. With these results it was showed that not only quarry workers but also nearby residing population are also at the risk of deterioration of lung health.

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