Original Article

A Comparative Study and Correlation of Pulmonary Function Tests between Granite Quarry Workers and Healthy Residents in Proximity to Quarries

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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 .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 & exclusion criteria, lung function tests were done in quarry and the normal healthy subjects.

Results: There is a statistically significant change in FEV1, FVC & PEFR among quarry workers. Positive correlation of parameters with number of years of exposure to quarry work and with distance from the quarry site. PEFR has shown negative correlation with the distance from the quarry sites.

Conclusions: Not only quarry workers but also nearby residing population are also at the risk of deterioration of lung function tests.

Keywords: Lung function tests, Granite quarrying, Silicosis.

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Introduction

Diseases which are caused due to the adverse environment at the workplace are called occupational diseases.[1] Silicosis is an occupational lung disease due to crystalline silica exposure via inhalation, which leads to a range of clinical outcomes including mild pulmonary function loss, mortality, and years of life lost as a result of inflammation and fibrosis in the lung parenchyma. Exposure to silica dust due to stone quarrying can cause severe respiratory ailments. Besides lung problems, research show that exposure to quarry dust may also increase the risk of health problems affecting the heart, liver, kidney, central nervous system, and other organs. Deaths due to epidemics of silicosis still continue to be reported both in developing and developed countries and silica exposure from different sectors remains an important occupational health concern.[2]

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. Although it can cause serious medical conditions, quarrying plays an important role in the lives of rural people in developing countries because it provides their livelihood needs. Stone quarrying involves a collective process by which rock is extracted from the earth's crust and crushed to produce aggregate sizes. It is a process by which heavy metals, organic solvents, and silica are excavated from the earth by blasting, drilling, and crushing. Workers exposed to such an environment include miners, quarry workers, ceramic workers, glass manufacturers, and masons. 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]

Crystalline silica, one of the most abundant minerals in the Earth's crust, is a key constituent of granite. Crystalline silica exposure is ubiquitous in the environment, occurring in stone processing. It is estimated that the figures of workers exposed to industrial crystalline silica in India, China, Europe, and the U.S. are 11.5 million, 23 million, 2 million, and 1.7 million, respectively. The adverse health effects due to silica exposure have become a growing public health concern in recent years.[4]

Continuous inhalation of respirable silica causes many diseases including silicosis characterized by inflammation and pulmonary fibrosis. Silica dust particles enter the alveoli, increase the production of inflammatory mediators in the peripheral airway, and cause emphysema. The particles are mainly deposited on airway surfaces where air flow changes direction. Silica particles having a size 0.2 to 2 micrometers get deposited on the walls of the airway and particles less than 0.2 micrometers enter the terminal respiratory epithelial surfaces and finally diffuse into alveolar gas.

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 exposure to occupational dust (silica) leads to a gradual decrease in Pulmonary Function Tests (PFTs).[5]

One study of Vermont granite workers found a modest increase in overall 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 was due to exposure. Mortality from malignant and non-malignant kidney disease was not significantly increased or associated with exposure.[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 Andhrapradesh 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 but also 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 6, 7, 8 km away from the quarry sites were taken. We can assess the effect of silicon dust by studying and comparing the FEV1, FVC, FEV1/FVC and PEFR between the two groups.

Aims and Objectives of The Study

The main objective of this comparative cross-sectional study is

1. To assess spirometric parameters in 50 granite quarry workers between the ages of 25 to 55 year of both the gender.
2. Compare spirometric parameters of those 50 Quarry workers with the 50 Normal healthy individuals who are residing at least 5km away from the quarry sites
3. Expecting significant changes in pulmonary function test parameters of quarry workers based on their compliance to protective gear usage and years of silica dust exposure.
4. Also expecting mild changes in pulmonary function test parameters among resident population of about 5 km away from the quarry sites.

Patients and Methods

Sample size: 100

- 50 granite quarry workers
- 50 apparently normal healthy individuals residing 5km away from the quarry.

Type of Study: Comparative Cross Sectional Study

Study Population: Granite Quarry Workers between the age of 25 to 50 year of both the gender.

Study Period: One year from July2024 to June 2025.

Study Place: Department of Physiology, PES IMSR, Kuppam.

Inclusion Criteria

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

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 or 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 gender will be 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) NO:PESIMSR/HEC/C-55/2024.

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, SPO2, Blood pressure, waist circumference and hip circumference were measured.

Pulmonary function tests (PFTs) including FVC, FEV1, FEV1: FVC, PEFR was performed. Using the PC Spirometer between 9:00 AM to 3:00 PM, so the test was conducted according to American thoracic society (ATS)[11]. Test 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 will be calculated for all parameters.

Instruments used

- Portable Digital spirometer (simple model)
- Digital thermometer
- Pulse Oxymeter
- Stethoscope
- Sphygmomanometer
- Non stretchable measuring tape.
- Standard Weighing machine.

(I) 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.

(II) 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[8]. Details of 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].

Plan of Analysis/ Statistical Tools

Statistical Analysis: Data was being entered into the latest version of Excel, and further analysis will be conducted using SPSS (version 23.0; SPSS Inc., Chicago, IL, USA).

Descriptive Analysis

For categorical variable, frequencies and per centages were calculated. For continuous variables, the mean standard deviation was computed.

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.

Correlation analysis was conducted to explore relationships between continuous variables.

Obeservations & Results

From table 1.1 paired t test results, one can observe the change of FVC showing average value of 0.60, with the standard deviation of 0.71 in quarry workers and also showing average value of 0.02, with the standard deviation of 0.20 in residents. With p value of 0.0001* which is highly significant. Change in FEV1 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 is significant. Change in FEV1: 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 is not significant. Changes in PEFR 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 value of 0.0001* which is highly significant.

Table 1.1. Paired t test between quarry workers and residents

Variable (Measured with standard reference values)	Groups		't' value	'p' value	RESULTS
	QUARRY WORKERS Mean ± SD	RESIDENTS Mean ± SD			
(changes in) FVC	0.60 ± 0.71	0.02 ± 0.20	5.5404	0.0001*	**Highly significant**
(changes in) FEV1	0 .3± 0.75	0 .04± 0.26	3.7417	0.0002	**significant**
(changes in) FEV1:FVC	4.99 ± 18.4	2.32 ± 7.4	0.9494	0.8276	**Not Significant**
(changes in) PEFR	4.23 ± 1.65	0 .92 ± 0 .86	12.5371	0.0001*	**Highly significant**

*'P' value < 0.05 considered as significant correlation

*'P' value > 0.05 considered as insignificant correlation

From the Table 1.2 pair wise correlation test between quarries working experience and PFT Parameters among quarry workers showing change in FVC with r value of 0.1746 which is weak and positively correlated, with p value of 0.2251 which is statistically not significant. Change in FEV1 with r value of 0.2541 which is weak and positively correlated, with p value of 0.0751 which is statistically not significant. Changing FEV1: FVC with r value of 0.2150 which is weak and positively correlated, with p value of 0.1337 which is statistically not significant. Changing PEFR with r value of 0.1738 which is weak and positively correlated, with p value of 0.2274 which is statistically not significant.

Table 1.2. Pair wise correlation test between quarry working experience and PFT Parameters Among quarry workers

Variable (Measured with standard reference values)	Quarry workers	
	R value	P value
(changes in) FVC	0.1746	0.2251
(changes in) FEV1	0.2540	0.0751
(changes in) FEV1:FVC	0.2150	0.1337
(changes in) PEFR	0.1738	0.2274

R value is between -1 to +1, "-" indicates negative correlation, "+" indicates positive correlation, 0 to 0.4 weak correlation, 0.4 to 0.7 moderate correlation, > 0.7 strong correlation

*'P' value < 0.05 considered as significant correlation

*'P' value > 0.05 considered as insignificant correlation

From the Table 1.3 pair wise correlation test between distance of residence from quarry site and PFT Parameters among residents, showing difference of FVC with r value of 0.1146 which is weak and positively correlated, with p value of 0.4283 which is statistically not significant. Change in FEV1 with

r value of 0.0433 which is weak and positively correlated, with p value of 0.7652 which is statistically not significant. Changes in FEV1: FVC with r value of - 0.0354 which is weak and negatively correlated, with p value of 0.8073 which is statistically not significant. Changes in PEFR with r value of - 0.4282 which is weak and negatively correlated, with p value of 0.0019 which is statistically significant.

Table 1.3. Pair wise correlation test between distance of residence from quarry site and PFT Parameters among residents

Variable (Measured with standard reference values)		Residents	
		R value	P value
(changes in)	FVC	0.1146	0.4283
(changes in)	FEV1	0.0433	0.7652
(changes in)	FEV1:FVC	-0.0354	0.8073
(changes in)	**PEFR**	**-0.4282**	**0.0019 ***

R value is between -1 to +1, "-" indicates negative correlation, "+" indicates positive correlation, 0 to 0.4 weak correlation, 0.4 to 0.7 moderate correlation, > 0.7 strong correlation

*'P' value < 0.05 considered as significant correlation

*'P' value > 0.05 considered as insignificant correlation

Discussion

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. Further more studies are needed to be conducted to know the exact situation of the scenario.

Conclusions and Summary

Based on observations and results of statistical analysis we can conclude that:

1. There was a significant change in FEV1 among quarry workers but slight change is seen in residents.
2. There were significant changes in FVC among quarry workers but slight change is seen in residents.
3. There were a significant changes in PEFR among quarry workers and mild changes seen in residents.
4. 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, which suggests that some people as their years of working experience in quarry worsening their lung health, most of the people were not much affected. We need to assess associated other factors to know the proper underlying cause for it.
5. When we correlated the distance of residence from the quarry site showed some interesting results among local resident population as follows

   - Changes in FVC and FEV1shown mild positive correlation but not significant, which suggests that, as the people's distance from the quarry sites increases, deviations of FVC and FEV1

are increasing which is totally unexpected. There may be unknown underlying causes for this phenomenon or even residing near the quarry sites can also affect the lung function tests, further detailed studied studies needed in this area.

6. 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.
7. 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.

Above evidences 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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Conflict of Interest: None

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