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Spirometric evaluation of lung function in labourers using handheld granite polishing tools

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Abstract

Exposure to free silica by the labourers who work with handheld granite polishing machines is expected to have a decrement in their pulmonary function. Objective of the study is to find out the extent of decreased lung function in labourers working in granite polishing. Randomly selected granite polishing labourers at our college construction site were included as study subjects for this study. Fifteen granite polishing labourers were screened for their Anthropometric parameters like Age, Height, and Weight. Spirometric evaluation was done with Schillers Spirovit SP-1 digital machine. Blood pressure was estimated using semiautomatic digital sphygmo-manometer (OMRON Hem-401). Slow vital capacity (SVC), Forced Vital capacity (FVC), Minute ventilation (MV) and Maximum Voluntary Ventilation (MVV) are the Spirometric tests done. Data collected were analysed by Students 't' test using SPSS 17.0 Significant Spirometric changes are observed in Forced expiratory Volume (FEV_1),Forced Vital Capacity (FVC),Peak expiratory flow rate (PEFR),and Forced expiratory flow. The extent of lung function decrement in comparison with the age matched individuals as controls showed that there is an urgent need to increase the safety measures that these labourers has to follow as there is large number of labourers in this industry posed with a severe occupational hazard leading to fatal conditions.

Keywords: Granite polishers, free silica exposure, spirometric tests.

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Introduction

Daily exposure to dust in our living environment and their effects on our respiratory health is well studied and understood. Large scale increase in the construction of housing apartments and commercial skyscrapers is seen in almost all the cities in India. Large numbers of labourers are involved in this construction industry with a dusty occupational environment. Less a number of studies on respiratory problems associated with these labourers in the construction industry have been done, although a lacuna is found with no available reports on granite polishers who do granite polishing/cutting using handheld machines in

these construction sites. This study is to understand the impact of the granite dust exposure in these kinds of labourers on their lung function and also to generate a report on this topic, to create awareness and to implement whatever we could do, for these poor labourers plunging their life day by day into the depth of death. Objectives of the study are,

1. To screen the granite polishers for any alteration in their pulmonary function.
2. To document our findings, which we believe that it is not reported in this group of labourers who use handheld machines to polish the granite slabs.

Silicosis is an occupational disease, which is an incurable lung disease caused by inhalation of dust containing free crystalline silica. Exposure to free silica contributes to respiratory diseases like pulmonary fibrosis, scar lung, silico-tuberculosis, silicosis and lung cancer. Lung cancer due to silicosis was already proved among granite workers by researchers in china.[1] Greater the duration of exposure to granite dust, greater is the probability to get ventilatory disorders. Suggestions to change the job of a worker who does granite polishing for his livelihood for more than 5 years with severe silica exposure is a practical difficulty.[2] With these building construction jobs on the rise, also the multiple occupational hazards specific to these jobs.In a country like India with poor employment opportunities it is very important to save these poor labourers from occupational hazards rather than suggesting them to quit the job. Every home or building needs these granite polishers who shape up these stones to the expectations of the architect. With the advent of the electrical polishers/cutters they execute this job with much precision. But the safety measures which they have to follow they abandon, unknowingly exposing themselves to a serious hazard, the Silicosis. Free silica particles from the stones that are grilled, chiselled, or polished get into the air directly and it is inspired by the labourer. Although mechanisation of these work are of advantage with less manpower they also have a devastating impact on the humans if not handled properly. At times the safety gears or arrangements that come with these machines are not properly followed by the innocent labourers not knowing the importance of these safety measures. For example, the handheld machine that cuts granite has a provision for attaching a hose tube connected to a water tank that makes it to be a wet stone cutting process. This is not followed and so the job becomes a dry cutting process with exposure directly to free silica by the labourer.

we conducted a spirometric evaluation in these granite polishing labourers to understand the impact of crystalline silica exposure on their lung function.

Materials and methods

After taking the Institutional Ethical Committee clearance, this study was carried out in the Research lab, Department of Physiology. Written informed consent from all the participants was obtained. Randomly selected male granite polishers based on the inclusion criteria from construction sites within the campus was selected for the study.

The subjects were grouped into two,

Control group (n=15): Age related males with no exposure to granite dust.

Study group (n=15): Labourers who use handheld machines for polishing granites

The subjects were recruited from the college construction site based on the following inclusion and exclusion criteria. A primary clinical examination in the outpatient department of Pulmonary Medicine was done to exclude gross pulmonary diseases, anatomical deformity of the chest or spine that may affect the respiratory parameters. The subjects were then called to the Research lab between 9 to 11am in the forenoon. Height and Bodyweight was measured to calculate the Body mass index (BMI). To accommodate themselves to the Lab, they were allowed to sit and relax for 10 minutes. After this time period of relaxation, Blood pressure was measured using a digital semi-automatic sphygmomanometer (Omron HEM 401). Average of the three readings with one minute interval inbetween was taken into account .With an introduction to the Digital Spirometry, the entire procedures and the four tests were explained and their doubts cleared. The four tests include Forced Vital Capacity (FVC), slow vital capacity (SVC), Minute

ventilation (MV) and Maximum Voluntary ventilation (MVV). Digital display of the flow time curve was showed and explained the significance for obtaining a 6 sec long expiratory effort. Disposable cardboard mouthpieces were given to them and were asked to practice breathing through that.

Inclusion criteria	Exclusion criteria
Age between 19 to 30 years	Age <19 or >30 years
>1year to <3 year experience	Month old experience
No acute respiratory illness	Acute respiratory problems
Non-smokers	Smokers
Non-alcoholics	Alcoholics
Pure vegetarian's (food that don't include animal products like egg and meat)	Non vegetarians
Non tobacco users (any form)	Tobacco users
Non –Gutkha users	Gutkha users
No other acute illnesses	Any other acute illness

Table – 1: Shows inclusion and exclusion criteria of the study

The technique to tighten the lips around the mouthpieces to prevent air leak was taught and the nose clips were used during the recording. After they had a feel of comfort with the test procedures, in a sitting posture the PFT was done using Schiller Spirovit SP-1machine with settings set for International black –Indian standards. For every test, three consecutive recordings were done with two minutes interval and the machine gives the best out of the three readings. The sequence of the tests performed was FVC, SVC, MV and lastly MVV. Accessibility and repeatability of the flow time and flow volume graph was checked well before getting the results. Print copies of the results were obtained on thermal paper and this was immediately photocopied for data storage. The values are accounted at BTPS standards only. The following parameters were recorded by the digital spirometer, Slow vital capacity(SVC),Forced expiratory volume in 1 second (FEV_1),Forced vital capacity (FVC),FEV_1 as a percentage of the FVC(FEV_1/FVC),Forced expiratory flow at 25% of volume as a percentage of VC ($FEF_{25\%}$), Forced expiratory flow at 50% of volume as a percentage of VC ($FEF_{50\%}$),Forced expiratory flow at 75% of volume as a percentage of VC ($FEF_{75\%}$),Forced expiratory flow at 25 -75% of volume as a percentage of VC ($FEF_{25-75\%}$), Peak expiratory flow (PEF), Maximum voluntary ventilation (MVV),Peak inspiratory flow (PIF),Forced inspiratory flow at 50% of inhaled volume ($FIF_{50\%}$) and Tidal volume. (TV).

Lung age was calculated using FEV1 recorded and the height of the subject.[3]

{ Lung Age = 2.870(H)-31.250(observed FEV1) -39.375}

The recorded data were later entered into an Excel sheet and stored in a computer for later analysis. After the observations are complete in all respects, the data was analysed for statistical significance using Statistical

software package SPSS.17. All data were expressed as mean ± SE.

During the entire study, the machine was calibrated after recording in every 3 subjects with a 3 litre syringe. The transducer in this machine is of Pneumotach type.

Results

The collected data was analysed using students't' test and the values were expressed in Mean ± SE. Age, bodyweight, and BMI were compared between the control and study groups. It was found that there was a significant difference in the bodyweight and BMI, (control group 21.9 ± 0.8and study group 19.0±0.4) (Table I).

Parameter	Age related Normal Control group (n = 15)	Granite polisher Study group (n = 15)
Age (year)	23.0 ± 0.8	21.9 ± 0.8
Weight (Kg)	61.1 ± 2.9	52.5 ± 0.9 *
Height (cms)	166.5 ± 1.7	165.2 ± 1.5
BMI (Kg/m^2)	21.9 ± 0.8	19.0 ±0.4*

Table 2: Demographic features of control and study groups Values are Mean ± SE.
* p value <0.001

It was also observed that there was a significant decrease in FVC control group 3.26±0.12 greater than the study group 2.90±0.10 ($p<0.001$), FEV_1 ($p<0.001$), $FEF_{25\%}$ ($p<0.001$), $FEF_{25-75\%}$ ($p<0.001$), PEF ($p<0.001$), MVV ($p<0.001$) and TV ($p<0.001$) in the study group compared to the control group (Table II). FEV_1/FVC ratio showed no significant decrease than the control group. PIF and $FIF_{50\%}$ showed significant decrease in the study group compared to the control group. In granite polishers there was a significant increase in Systolic blood pressure 129.80± 4.37 mm Hg than the control group with 126.46±2.72mmHg($p<0.001$) and Diastolic blood pressure 74.60+3.18mmHg($p<0.001$) than the age related normals.70.20+3.21 mmHg. (Table III)The predicted lung age and the Deficit lung age in granite polishers were also increased in comparison to the control group (Table IV).

Discussion

Multiple storey residential and commercial buildings are seen growing in and around each corner of this ever expanding metropolitan city, Chennai. Inside every building that is being constructed, these granite polishing labourers are working with handheld machines to grind, polish, chisel out or even stick granites. Dry mechanical drilling / polishing/cutting is an important source of fine silica dust.[4]Crystalline silica has been classified as a human carcinogen (group I) by the International Agency for research on Cancer. (IARC)[5]. Fifty four lakhs of construction workers are at the risk of silica exposure[6].
Continuous exposure to free silica that comes from these handheld machines has direct access to the granite polisher's lungs. With no masks they just inhale the silica continuously. Though we found none of these granite polishers working at our college campus construction site reporting to our hospital for any respiratory problems and so we did this assessment on their pulmonary status.

Evaluating the decrement of lung functions in these workers is our objective. To our surprise none of these labourers complained of dyspnoea, chest pain etc. But during this study we were able to identify one subject with appendicitis and another with cardiomegaly, both of them were excluded from this study and referred to the department concerned for further medical care.

Silicosis is debilitating and a fatal lung disease resulting from breathing microscopic particles of crystalline silica.[7]The Limit quantity of respirable quartz is only $0.1mg/m^3$.[8] Descriptive studies invariably suggest an excess lung cancer risk in silica – exposed workers compared with the general population, but exposure response studies have consistently failed to confirm that the cause is exposure to quartz.[9]Although Quarry workers are studied in detail for silicosis, these days the granite polishers/cutters at construction sites who work with these granites also exhibit an equal probability of getting this disease.

Parameters		Age related Normals (Control group) (n = 15)	Granite polishers (Study group) (n =15)
FVC	L	3.26 ± 0.12	2.90 ± 0.10 **
FEV_1	L	3.02 ± 0.10	2.67 ± 0.12 **
FEV_1/FVC	%	92.63 ± 0.9	92 .06 ± 2.8
PEF	L/s	6.41 ± 0.32	5.11 ± 0.42 **
$FEF_{25\%}$		6.08 ± 0.35	4.98 ± 0.39 **
$FEF_{50\%}$		4.52 ± 0.21	4.50 ± 0.28 *
$FEF_{75\%}$		2.21 ± 0.12	2.48 ± 0.14 *
$FEF_{25-75\%}$		4.02 ± 0.16	3.83 ± 0.22 **
PIF	L/s	6.02 ± 0.39	5.02 ± 0.49 **
$FIF_{50\%}$		5.90 ± 0.40	4.42 ± 0.54 **
MVV	L/min	106.41 ± 4.94	81.75 ± 5.35 **
TV	L	0.72 ± 0.04	0.54 ± 0.02 **

Table 2: Comparison of PFT parameters between general labourers (Control group) and granite polishers (Study group) values are Mean ± SE;*p value < 0.05 **p value <0.001

Decrease in pulmonary functions in all of these labourers involved in granite polishing/cutting job is noted. There is a definite impairment in the expiratory flow rates especially the $FEF_{25-75\%}$ which is the flow rate over the middle half of the forced vital capacity (FVC).Mild airflow limitation is seen. Peak expiratory flow rate is also significantly reduced which reflects the response of the larger and smaller airway as a result of reflex bronchoconstriction.FEV_1 and FVC values are decreased significantly (p <0.001).FVC between the study and the control group differed by 360ml whereas FEV_1 was 350ml.Similar decrease in FEV_1 & FVC was reported earlier in these kind of subjects.[8] Significant difference in the PEFR (130) p =<0.001and TV (180) p=<0.001 is also seen.

Parameters		Age related Normals (Control group) (n=15)	Granite polishers (Study group) (n = 15)
Age	years	23.0 ± 0.8	21.9 ± 0.8
Systolic BP	mm Hg	126.46 ± 2.72	129.80 ± 4.37 *
Diastolic BP	mm Hg	70.20 ± 3.21	74.60 ± 3.18 *
MABP	mm Hg	88.95 ± 3.2	93.00 ± 3.19
Pulse pressure	mm Hg	56.26 ± 2.2	55.20 ± 4.9
Pulse rate	bpm	84.26 ± 3.43	84.40 ± 2.75

Table 4: Comparison of Cardiovascular parameter between general labourers (control group and granite polishers (study group). Values are Mean ± SE; * p value <0.001

Intergroup comparison between the marble polishers and the age related normals showed the results of significant decrease in the pulmonary function parameters like FVC, FEV_1, PEFR, $FEF_{25\%}$, $FEF_{25-75\%}$, $FIF_{50\%}$. Significant decrease in the body weight and BMI also indicates that they are losing weight due to silicosis or tuberculosis. Also a little rise in the blood

pressure suggests their chances towards cardiovascular diseases. All these decreased lung function parameters without any reported respiratory disease or chest wall deformity showed that they have developed restrictive kind of pulmonary disease and it would be as a result of pulmonary fibrosis. Earlier the hard and sharp edges of the silica particles was thought for its injurious effects.[9]But later researchers like Gardner proved that particles of silicon carbide which is similar to silica do not produce fibrosis[10]. Fibrogenic theory of Heppleston and Styes [11] is the most popular theory till date, which explains as follows, Macrophages after ingestion of the inhaled quartz particles release a factor called Macrophage fibrogenic factor (MFF) which stimulates fibroblasts to increase the production of collagen. MFF is a peptide, released from the lysosomes of the macrophages that have engulfed silica particles. It causes the translation of collagen from rough endoplasmic reticulum through the secretory vesicles to the extracellular fibrillary state in the fibroblasts of the pulmonary interstitium.[12] However this theory does not take into account, the immunologic factor in causation of silicosis and does not explain the high levels of antinuclear factors and various antibodies observed in silicotics[13,14,15,16].In summary, the exact mechanism of action of the silica dust on the lungs is still not known but available evidence indicates that the silica particles in some manner cause increased permeability of the digestive vacuole of alveolar macrophages leading to their autodigestion. The dying macrophages liberate a fibroblast stimulating factor which causes increased formation of collagen tissue. Autoimmunity is probably responsible in the evolution of the later stages of silicosis.

Parameters		Age related Normals (Control group) (n=15)	Granite polishers (Study group) (n = 15)
Chronological Age	years	23.0 ± 0.8	21.9 ± 0.8
Lung Age	years	54.2 ± 2.6	60.8 ± 3.0 **
Lung age deficit	years	-31.2 ± 2.2	-36.1 ± 3.4 **

Table 5: Comparison of chronological age & Lung age between general labourers (control group) and granite polishers (study group). Values are Mean ± SE; * p value <0.001

It is responsible for high morbidity and mortality in industrial workers. Since there is no specific therapy for this progressive and irreversible disease all steps should be taken for its prevention. The benefits of prevention includes the economic effects such as increased production by healthy workers ,reduction of sickness absenteeism and less expenditure on health care and above all the alleviation of human suffering.

Lung age and deficit lung age showed that there is as decline in the lung age of these labourers with a mean lung age of 60.8 ± 3.0 and a deficit of -36.1± 3.4 years.($p<0.001$) in comparison with the age related normals.

Conclusion

This study showed the extent to which the exposure to silica is decrementing the functions of the lung and thereby debilitating these labourers involved in granite polishing/cutting work. Although Silicosis is to be studied with radiographic images we were in a preliminary stage and so we restricted ourselves with the Spirometry. We have also planned for a detailed study in terms of radio graphical, microbiological, biochemical and cardiovascular parameters in near future. All lung parameters were found to be significantly reduced along with the bodyweight indicating the urgent need to take preventive measures for this occupational hazard as it could bring economic.

A large scale study in these populations with multifactorial approach may throw more light on this occupational health hazard. Few of the suggested ideas to reduce the morbidity are,

1. Change the working direction with respect to the wind direction.
2. Durable and wet masks.

3. Goggles for eyes
4. Regular nutritious meals
5. Regular respiratory check-ups/health check ups
6. Periodic intervals of leave from the routine work
7. Flushing water in the blades of the machines that is cutting /polishing marbles.
8. Flushing oil films all over the granite to get the dust settled well before it gets into the air.
9. Very good natural ventilation at the work place.
10. Stringent Labour laws for the use of safety devices by the these labourers
11. Health Insurance coverage for long term illness.

Limitations

The small sample size in our study became unavoidable as ours is a single center study. A multicentric study in this subject with chest radiography and tubercle bacilli detection, if conducted all across the country would definitely give a greater and detailed picture of this occupational hazard. This will also help the policy makers to design some final and binding laws safeguarding the health of these poor labourers.

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