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Lung Function Indices among Marble Workers with Age Matched Healthy Individuals in Lahore

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ABSTRACT

Background: Marble dust predominantly comprises of free silica which is a principal constituent of Earth's crust. Production of toxic substances, chemicals, and respirable dust in marble industry offers an occupational threat to the workers. Free silica dust is generated during quarrying, grinding cutting and polishing of marble and is responsible for occupational pulmonary diseases. **Objective:** This study was conducted to compare pulmonary function test results among the workers of marble industry and healthy persons of same age in district, Lahore. **Study Design:** Cross-sectional study. **Settings:** Study was conducted in marble workshops workers, located in Township area College Road, Institute of Public Health, Lahore Pakistan. **Duration:** Six months from 05 May 2021 to 04 August 2021. **Methods:** A cross-sectional study was conducted among 225 individuals. Forty-five male persons, each were selected from cutting, grinding and polishing sections along with office workers from the marble workshop. Forty-five age matched healthy individuals selected from the same community. After getting approval from the Institutional Review board, the data was collected in a pretested standardized questionnaire after taking informed written consent by the respondents. Lung function tests were conducted by a Spiro Lab Spirometer which included forced vital capacity, forced expiratory volume in one second and ratio of forced expiratory volume to forced vital capacity**.** **Results:** The mean years of work experience of respondents was 11.58 ±5.92 and that of non-exposed healthy individuals was 11.23±5.32 years. A significant relationship of marble dust and deranged pulmonary function tests (p-value≤0.001) was noted which was normal in case of non-exposed individuals. Duration of work in marble industry and age in years had significant relationship with reduction in pulmonary function tests (p- value<0.001 in each). About 83 (46%) marble workers working in different sections had reported abnormal spirometry as compared to non-exposed individuals (p-value<0.001). **Conclusion:** According to the current study, individuals who had worked in the marble industry for more than 15 years had a steady reduction in their lung function indices, which ultimately had a detrimental effect on their health and when compared to healthy individuals of the same community, marble workers' pulmonary function tests showed significant impairments.

Keywords: *Marble workers, Marble dust, Respiratory symptoms.*

INTRODUCTION

Dust exposure at work, primarily from silica dust is a common public health problem which is usually neglected in underdeveloped countries.[1] Over 4.2 million preventable deaths occur globally as a result of the approximately ninety-nine percent of people on the planet living in cities and towns where the air quality does not satisfy the basic standards set by the World Health Organization (WHO).[2] Chronic Obstructive Pulmonary Disorders ((43%), lung cancer (29%), ischemic heart disease (25%), heart stroke (24%) and acute lower

respiratory infection (17%) are the main reason of deaths linked to poor air quality.[2,3] According to the European Community Respiratory Health Study, employees who are exposed to biological dust, gases, fumes, and pesticides are more likely to develop COPD than the general population as a whole (21%), which is another concerning finding.[2]

Solid particles in dust range in size from less than one micron to around one hundred microns.[4] Silica is a key component of marble rocks.[5] Silica can be found in concrete, bricks, tiles, man-made stones, cement and in other building materials[6]. Inhalation of dust containing free silica, often known as SiO2, is the cause of many diseases.[5,6]

The disease known as "Silicosis" is characterized by a variety of respiratory symptoms and radiological abnormalities because of exposure to dust containing crystalline silica.[7] In addition to silicosis, silica exposure is linked to autoimmune disorders,[7] benign renal diseases,[8] benign respiratory diseases,[9] lung cancer,[9,10] Chronic Obstructive Pulmonary Disaeses[10] and other respiratory conditions such as pneumoconiosis, asthma, and tuberculosis.[9,10]

A systematic analysis by Leso *et., al.*[11] revealed that accelerated silicosis associated with synthetic stones was evident in young workers, had a short latency time, and caused severe lung damage. The study author blamed the lack of effective control methods for this aggression. According to this review, a number of chemical characteristics of resin-based artificial stones may play a significant role in the origin of silicosis. Dry cutting and polishing may raise the temperature locally that could lead to the thermal breakdown of the organic resin and the release of volatile organic compounds. Pulmonary problems are common in workers who have been inhaling respirable silica dust for more than ten years. The severity of the lung problems is directly influenced by additional contributing factors like dust density, advancing age, tobacco use, and duration of exposure to silica-containing dust.[12] Majority of people affected by dust pollution worldwide come from low and middle income nations, including the poor and marginalized who live close to factories and busy roadways in developed nations. As a result, people with lower socioeconomic level usually have a higher burden of disease caused by dust.[2] In Pakistan, there aren't enough resources or individuals who know how to employ personal protective equipment to avoid silica dust inhalation from stone-crushing areas. Since they are exposed to silica dust over an extended period of time, these employees may experience serious, irreversible pulmonary function damage.[12,13] The current study aimed to compare the lung function tests of age-matched healthy persons with employees of marble workshops located in Lahore.

METHODS

A descriptive cross-sectional study was conducted in the Township area, the busiest and densely populated commercial district, where the majority of small to medium-sized marble workshops are located. The study lasted for six months. Using the WHO sample size calculator, the sample size was determined using the following assumptions: 90% power of study, 5% significance level, $Z_{1-\beta}$ = 90% power of study, population variance (σ^2) = 0.5329, and expected means for study groups μ_1 (2.77) and μ_2 (3.14) respectively.[14] Forty-five workers from each predetermined sections of marble workshop were selected by simple random sampling along with 45 controls from the community by convenience sampling technique. The inclusion criteria for marble workers were male workers who were involved in grinding, wet cutting, polishing and office workers of marble workshops, aged 18-40 years, working for more than one year and at least worked for 30 hours a week. The control group inclusion criteria were males with aged 18-40 years from the same community without any respiratory problems. Those marble workers with history of any respiratory problems such as bronchiectasis, tuberculosis, thoracic deformity etc, recent abdominal surgery, unstable cardiovascular conditions (recent heart attack, aneurysm) and those who were ineligible for spirometry were excluded. After approval from ethical review board of University of Health Sciences Lahore and written consent by the respondents, data was collected on a validated American Thoracic Society (ATS)[15,16] proforma, and lung function tests were done as mentioned in Medical Research Council[17] questionnaire by same Spirolab Spirometer. The proforma comprised of two sections. The first section included sociodemographic information such as residential address, date of birth, marital status and level of education whereas second section comprised of questions related to work history, job type, working hours, and overall years of employment. All study participants had their weight and height measured in kilograms and centimeters, respectively. Spirometry indicates the existence of pulmonary impairment, if FVC< 80%, FEV1<80% and FEV1/FVC ratio < 0.7 predicted normal. According to the NICE (National Institute of Health & Care Excellence) COPD recommendations, mild, moderate, severe, and very severe airflow obstruction is termed if FEV1 more than 80%, if FEV1 between 50-80%, if FEV1 between 30-49% and if FEV1 is less than 30% predicted airflow limitation.[18]

Data was entered and analyzed in SPSS version 24. For categorical variables frequency tables were generated and

for continuous variables mean and standard deviations were calculated. The mean lung function parameters (FVC, FEV1, and FEV1/FVC ratio) among marble workers and healthy individuals were compared by applying the student t-test. The ANOVA test was applied for comparing the lung function tests by years of exposure; post-hoc pairwise comparisons were made using the Tukey's technique. To control and test for smoking-related confounding on pulmonary function markers, ANCOVA was applied. All analyses were considered statistically significant if the p-value was ≤0.05.

RESULTS

There was statistically significant association of educational status among the four groups of workers of marble workshop and non-exposed group (p-value≤0.001). Workers of cutting section and grinding section had reported statistically significant (p-value≤0.001) association with smoking as compared to nonsmoker (workers of polishing, office workers and non-exposed groups); (Table -1). Out of 45 workers belonging to the grinding section, 39 (86.67%) had reported abnormal spirometry followed by workers of cutting group where 25 (55.56%) had abnormal spirometry. However, all 45 (100%) non exposed group had normal spirometry (Table-2). Out of 180 marble workers, 50 (27.77%) had restrictive type of pulmonary impairment whereas 28 (15.55%) had obstructive type of pulmonary impairment. Nineteen workers (42.22%) of grinding section had mild restrictive pulmonary impairment as compared to workers of cutting section, where only11(24.44%) reported mild restriction (Table-3). The mean ± SD values of FVC%, FEV1% and FEV1/FVC ratio had significant association between exposed and non-exposed group (p-value≤ 0.0001 of each pulmonary function parameters); (Table 4).

Table 1: Demographic characteristics of marble workshop workers (Exposed Group) and healthy individuals from the community (Non-Exposed Group)

Study variables	Marble workshop workers (Cutting Group)	Marble workshop workers (Grinding Group)	Marble workshop workers (Polishing Group)	Marble workshop workers (office workers group)	Healthy individuals from the community (Non-Exposed Group)	P-Value
	n (%)	n (%)	n (%)	n (%)	n (%)	
Age (years)						
21–25	8 (17.78)	8 (17.78)	8 (17.78)	8 (17.78)	8 (17.78)	
26–30	12 (26.66)	12 (26.66)	12 (26.66)	12 (26.66)	12 (26.66)	0.986
31–35	8 (17.78)	8 (17.78)	8 (17.78)	8 (17.78)	8 (17.78)	
36–40	17 (37.78)	17 (37.78)	17 (37.78)	17 (37.78)	17 (37.78)	
Mean ± SD	31.60 ± 6.58	31.51 ± 5.78	32.09 ± 5.96	32.04 ±5.91	31.98 ± 6.08	
Marital status						
Single	21 (46.67)	23 (51.11)	27 (60.00)	23 (51.11)	20 (44.44)	0.691
Married	24 (53.33)	22 (48.89)	18 (40.00)	22 (48.89)	25 (55.56)	
Educational status						
Middle	35 (77.78)	36 (80.00)	25 (55.55)	8 (17.78)	3 (6.67)	
Matric	5 (11.11)	5 (11.12)	12 (26.67)	8 (17.78)	5 (11.12)	<0.001
Intermediate	5 (11.11)	2 (4.44)	8 (17.78)	15 (33.33)	13 (28.88)	
Graduation	----	2 (4.44)	----	14 (31.11)	24 (53.33)	
Smoking status						
Smoker	13 (28.89)	3 (6.67)	00 (00.00)	00 (00.00)	00 (00.00)	<0.001
Non-smoker	32 (71.11)	42 (93.33)	45 (100.00)	45 (100.00)	45 (100.00)	
Height (cm) Mean ± SD	171.84±10.71	172.84 ± 9.50	170.80 ± 7.13	171.44 ±7.66	170.69 ± 7.75	0.765
Weight (kg) Mean ± SD	74.69 ± 15.25	71.69 ± 12.58	74.33 ± 15.76	74.51 ±12.19	73.51 ± 11.66	0.829
Experience (years) Mean ± SD	11.36 ± 6.15	12.08 ± 5.34	11.70 ± 6.08	11.18 ± 6.11	11.23 ± 5.32	0.943

Statistically significant at a ≤ 0.05

Table 2: Spirometry Result among marble workers by Study Group (n=225)

Study variables	N	Normal Spirometry (%)	Abnormal Spirometry (%)
Marble workshop workers **(Cutting Group)**	45	20 (44.44%)	25 (55.56%)
Marble workshop workers **(Grinding Group)**	45	06 ((13.33%)	39 (86.67%)
Marble workshop workers **(Polishing Group)**	45	33 (73.33%)	12 (26.67%)
Marble workshop workers **(office workers group)**	45	38 (84.44%)	07 (15.16%)
Healthy individuals from the community **(Non-Exposed Group)**	45	45 (100%)	00 (00%)

Table 3: Comparison of pulmonary function parameters (PFTs) by study group (n=225)

Study Variables	Marble Workshop workers (Cutting Group) n (45)	Marble Workshop workers (Grinding Group) n (45)	Marble Workshop workers (Polishing Group) n (45)	Marble Workshop workers (Office Workers Group) n (45)	Healthy Individuals from the Community (Non -Exposed Group) n (45)	P-Value
FVC% Mean ± SD	86.96 ± 17.43	80.58 ± 14.66	87.66 ± 20.50	90.37 ± 8.51	102.29 ± 14.32	<0.0001
FEV1% Mean ± SD	81.79 ± 17.05	67.33 ± 13.38	85.19 ± 19.63	85.94 ± 11.70	98.77 ± 14.54	<0.0001
FEV1 / FVC ratio Mean ± SD	78.15 ± 8.82	70.56 ± 14.85	79.78 ± 8.60	78.45 ± 10.79	79.80 ± 5.03	<0.0001

Statistically significant at a ≤ 0.05

Table 4: Pulmonary Impairment among marble workers

Type of Pulmonary Impairment	Marble Cutting Group (%age)
Obstruction Type Impairment in marble workers	**28 (15.55 %)**
Mild Obstruction	11 (6.11%)
Moderate Obstruction	10 (5.56%)
Moderate Severe Obstruction	5 (2.78%)
Severe Obstruction	1 (0.55%)
Very Severe Obstruction	1 (0.55%)
Restriction Type of Impairment in marble workers	**50 (27.77%)**
Mild Restriction	36 (20.00%)
Moderate Restriction	8 (4.44%)
Severe Restriction	5 (2.78%)
Moderate Severe Restriction	1 (0.55%)
Combined Type of Impairment in marble workers	**5 (2.78%)**
Obstruction with Possible Restriction	5 (2.78%)
Normal Spirometry in marble workers	**97 (53.90 %)**

In comparison to the healthy individuals the marble workers (cutting, grinding, office and polish group) having 16-20 years of work exposure the values of FVC% and FEV1 was deteriorated significantly (P<0.001). However, FVC values were also impaired for 6–10 years, 11–15 years of work exposure in grinding (P<0.001) and polish workers (P<0.05) respectively, while the value of FVC significantly (P<0.001) reduced in grinding workers only, who had 1–5 years of work exposure. The value of FEV1% was decreased significantly in grinding (P<0.001) and cutting (P<0.05) marble workers having work exposure of 11–15 years, while the values of FEV1/FVC ratio was decreased significantly only in grinding (P<0.001) and office marble workers (P<0.05) respectively, who had 16-20 years of work experience. (Figure 1)

When compared all groups of marble workers by age of work experience with healthy individuals, all three pulmonary function indicators (FVC%, FEV1%, and FEV1 / FVC ratio) revealed a statistically significant reduction with increasing age (P< 0.001). The study result showed that the workers who were 36 - 40 years of age and worked in the marble workshops for an extended period of time demonstrated the greatest reduction in pulmonary function indices. (Figure 2)

In comparison to the healthy individuals the marble workers (cutting, grinding, office and polish group) having work exposure with ages 31-35 years, 36-40 years the FVC% value was reduced significantly (P<0.001), the FVC value also reduced for exposure with ages 26-30 years in grinding (P<0.001) and cutting workers (P<0.05) respectively, while the value of FVC significantly (P<0.001) decreased in grinding workers only, who had exposure with ages 21–55 years. Similarly, when compared to the healthy individuals the marble workers (cutting, grinding, office and polish group) having exposure with ages 36-40 years, the value of FEV1% decreased significantly (P<0.001). The FEV1% values reduced significantly (P<0.001) in marble (cutting, grinding and polish) workers having exposure with ages 31-35 years, and for 26-30 year of ages in cutting and grinding (P<0.001) workers, while FEV1 value was reduced only in grinding group for ages 21-25 years (P<0.001). The values of FEV1/FVC ratio were decreased significantly in grinding and office marble workers (P<0.001) having work exposure with ages 36-40 years, while in ages of 21-25 years the ratio was decreased significantly (P<0.001) in grinding workers only. No other significant differences between groups were observed. (Figure 2)

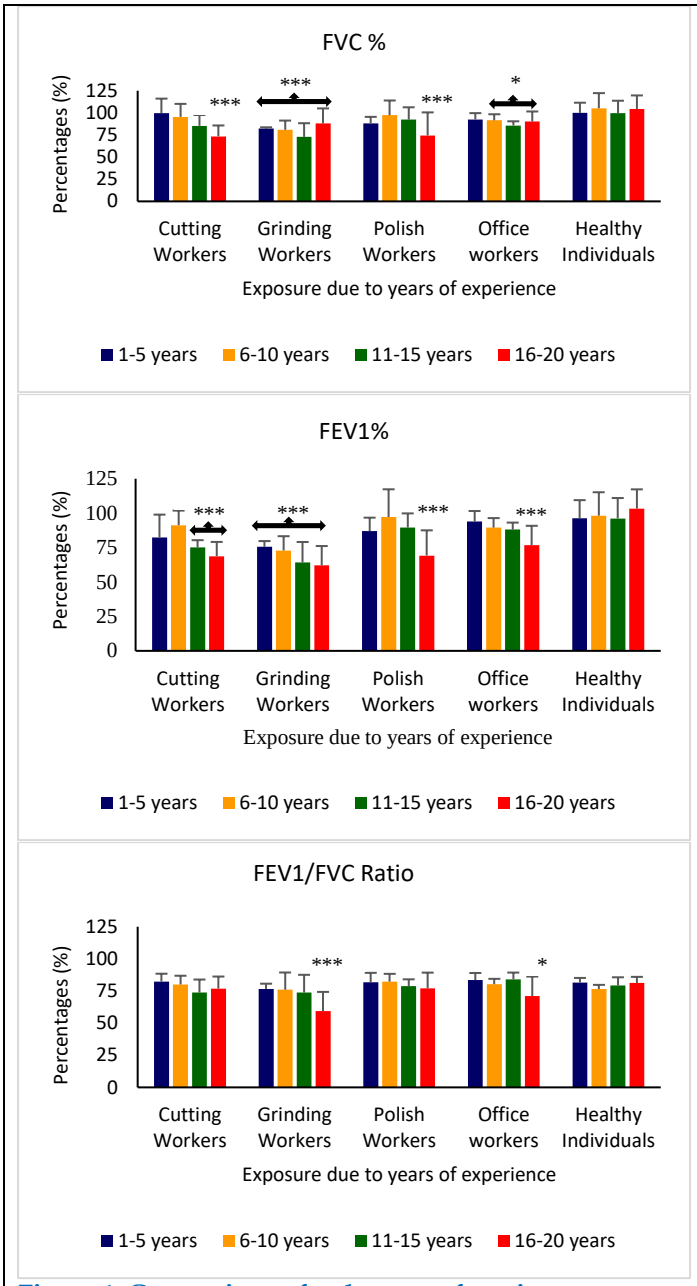

Figure 1: Comparison of pulmonary function parameters among marble workers by years of exposure

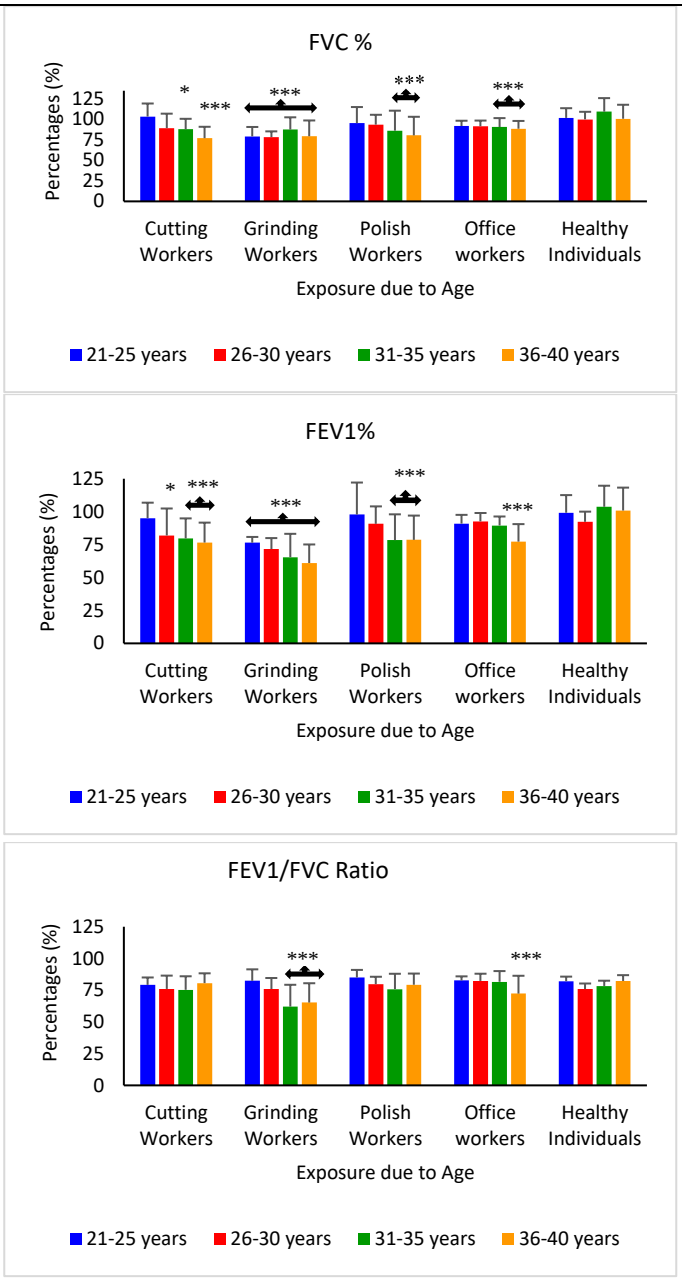

Figure 2: Comparison of pulmonary function parameters among marble workers and healthy individuals by age exposure

Statistically significant at α≤0.05 (*p-value≤0.05, **p-value≤0.01, ****p-value ≤0.001≤ Vs Healthy Individuals)

DISCUSSION

Pulmonary function tests can be applied to determine the pathophysiology of airways. Pulmonary function testing is an essential method for determining respiratory health and establishing and confirming a clinical diagnosis of COPD and asthma.[19] Impaired pulmonary function levels are an indicator of higher mortality and morbidity.[20] Forced vital capacity (FVC), the forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio are commonly used pulmonary function indicators.[21] The FEV1/FVC is a ratio that can be used to determine whether a lung function limitation is restricted or obstructive type.[19,22]

According to the current study, all study groups of marble workers had significantly (P < 0.001) lower mean values of PFT's, although these PFT values (FVC%, FEV1%, and FEV1/FVC ratio) are significantly (P < 0.001) more declined in the grinding workers than the workers working in the other areas of marble workshops. These differences were still significant, even after adjusting for age, job experience, and smoking.

The findings of the current study were comparable with the study in China on silica exposed dust workers, which stated that the impaired pulmonary function was significantly associated with higher levels of silica dust exposure.[23] Similarly, another study of Ullah[13], documented that stone cutters who were exposed to high levels of silica had severe pulmonary impairment.[13] In a recent study, Alia Siti also observed same results, noting that all PFT indices were compromised and that the FEV1 (41.8%) had the lowest value of all the pulmonary parameters.[24] Moreover, research work done in Nigeria,[14] Indonesia,[24] Iran,[25,26] and Bangladesh[27] revealed marked pulmonary dysfunction among marble, quarry and stone cutting workers.

Dust particles that are inhaled settle in the lungs, irritating the tissue and causing an inflammatory response that results in fibrosis, poor diffusion of oxygen, and impaired lung function.[28] The cause of airflow obstruction and reduced PFTs is a luminal mucosal constriction and fibrosis of the small airways.[24,28] The restrictive and obstructive forms of lung problems are indicated by reduced FVC and FEV1 capabilities, and one of the key signs of restrictive lung impairment is a change in the pulmonary function indices (FVC, FEV1, FEV1 / FVC ratio).[19,22,23]

About 74.6% of the marble workers in our study had abnormal PFTs; however, the workers in the grinding section had the greatest prevalence of abnormal spirometry, followed by the cutting workers. Majority of the workers had restrictive type of pulmonary impairment.

The results of recent study about lung abnormalities were comparable with studies conducted in India[29] and Myanmar[30] stating 64% and 55.8% abnormal PFTs. However, in contrast to our findings, a lower percentage of abnormal spirometry 30.4% and 25% was reported in studies of Ullah[13] and Widajati[31] respectively. The diet and the lifestyle pattern of the study participants were one of the reasons of low incidence. Regarding obstructive type of pulmonary impairment our results are comparable (28%) with another study which stated 22% lung impairment.[25] Whereas obstructive type of lung impairment in other studies was 3.95%[13] and 5%[29]. Our study's findings are strikingly similar to those of an earlier study, which found restricted categories of impairment to be 41.8%, 53%, 66.67%, and 59% respectively.[24,25.27,29] Contrary to our findings, stone crushing workers in another study revealed 26.5% restrictive impairment which was 50% in the current study. In a recent study on stone crusher workers in Bangladesh, a relatively high percentage of obstructive (75%) type of lung damage was also identified.[27] Lung parenchymal fibrosis, chest wall limitations, neuromuscular diseases, and pleural abnormalities are the primary causes of restrictive type of pulmonary impairment, while chronic bronchitis, asthma and emphysema are the most frequent causes of the obstructive variety of lung illness.[27]

The age of the study subjects, which accounts for substantially a higher prevalence rate could be considered an essential factor for variation in lung functions parameters.[31] Earlier research reported that the anthropometric measurements have a significant correlation with PFTs.[23,32] The results of the current study showed that the age distribution of workers exposed to marble dust and healthy non-exposed workers was similar; nevertheless, neither group was statistically significant ($P = 0.986$). Comparable studies on marble stone workers did not find any age differences between the marble exposed workers and control groups that were statistically significant ($P > 0.05$).[29]

The results of sociodemographic characteristics in our study showed no statistical difference in age, weight, and height. Our results for mean age, weight, and height are consistent with those earlier published data[14,29,33] for case control studies involving stone quarry employees.

The marble group workers in our study had an average work experience of 11.58±5.92 years, with a statistically insignificant difference ($P=0.943$). Majority of marble workers (31.66%) had been in their occupation for more than 16 years, and as a result of the extended exposure, their PFT values dramatically decreased ($P< 0.001$). The marble employees working for 16–20 years revealed the greatest reduction in pulmonary function indicators and due to this increase work exposure statistically a significant ($P<0.001$) reduction in all three pulmonary (FVC%, FEV1%, and FEV1/FVC ratio) parameters was observed. Our study's results are similar to those of a previous investigation where the author observed a statistically significant ($P < 0.001$) decrease in PFT's indices.[34] In his research, he found that the length of dust exposure is the most important and reliable indicator of reduced lung functioning in silica dust-exposed workers.

The results of our investigation align with those of another study, where the author discovered that longer exposure periods in marble companies led to a statistically significant ($P < 0.05$) decline in lung function indices, and that the decline in PFT is closely linked to longer exposure times to silica.[27] Similar kinds of outcomes were also observed in Nigerian quarry workers, where the author reported that the mean PFT values were decreased significantly ($P< 0.05$).[34] In accordance with our findings, previous studies in China,[23] Iran,[25] and India[33] also noted a substantial reduction in FVC, FEV1 and FEV1 / FVC ratio among quarry and granite employees, who had more than 10 years of silica dust exposure ($P< 0.001$).

Age and smoking both have the potential to cause confounding. Since individuals in the community (the control group) were chosen who were of similar ages, it is unlikely that age-related confounding will occur. Additionally, ANCOVA analysis showed that smoking was not statistically significant, therefore confounding brought on by smoking is also improbable.

CONCLUSION

The lung function tests of marble workers were considerably impaired than those of healthy persons living in the same community. The current study concluded that over the duration of more than 15 years of working exposure in the marble industry, workers' lung function indices continued to decline, which eventually had a detrimental effect on their health.

LIMITATIONS

Beyond exposure to marble dust, several other factors contribute to the loss in lung function. Other potential causes could include the presence of harmful substances in the workplace and undetectable amounts of other dust particles along with silica. In both study groups, no comparison to silica dust was performed and not even dust exposed particle testing was employed to determine the composition and concentration of the dust. In addition, other respiratory tests, such as chest radiography, should be performed for comparison with earlier research in order to verify results.

SUGGESTIONS / RECOMMENDATIONS

There is a need to educate the marble workers about their health and use of personal protective measures, as none of them used any kind of protective gear to prevent silica dust inhalation. People are also exposed to noise pollution from drilling, cutting, and grinding, which might impair their hearing and cause skin issues that require further scientific research in the region to detect and address. Employers should be educated about the workers' preplacement and routine medical examinations including pulmonary function tests. Government should take necessary steps and control health hazards associated with marble industry. To learn more about respiratory issues among marble workers, more research can be conducted to determine the concentration and size of the marble dust particles in the area of marble workshops.

CONFLICT OF INTEREST / DISCLOSURE

None.

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