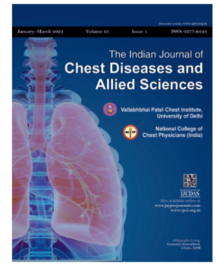
ORIGINAL ARTICLE

Relationship between Body Surface Area and Pulmonary Functions in Patients of Silicosis



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Received on: 28 March 2022; *Accepted on:* 16 February 2023; *Published on:* 29 June 2023

Abstract

Background and objective: Silicosis is one of the oldest occupational lung diseases. However, there are very few studies identifying the anthropometric variables associated with silicosis. The present study aimed at studying the association between body surface area (BSA), pulmonary function indices, and 6-minute walk distance (6MWD) in patients with silicosis.

Materials and methods: The study was conducted on 102 male patients of silicosis. Height and weight were measured to calculate BSA. Spirometry and 6 minute-walk tests were performed. Data were analyzed using EPI info V 7 software. Student's *t*-test of significance (ANOVA) was applied to test the difference between means.

Results: There are no significant changes found in the 6-minute walk distance with years of exposure and BSA. Statistically significant lower values of pulmonary function indices were observed in patients with BSA <1.6 sq m. Statistically significant higher values of forced expiratory volume in the first second and forced vital capacity were observed in patients with BSA >1.9 sq m in all categories of exposure.

Conclusion: In conclusion, patients of silicosis with >1.9 sq m BSA had higher values of pulmonary function indices. Large body size may be of value in protection from developing occupational lung disease.

Keywords: Occupational lung disease, Pneumoconiosis, Pulmonary function test, 6-minute walk test.

The Indian Journal of Chest Diseases and Allied Sciences (2023): 10.5005/jp-journals-11007-0059

Abbreviations Used in this Article

BSA = Body surface area; FEV1 = Forced expiratory volume in first second; FVC = Forced vital capacity; PEFR = Peak expiratory flow rate; 6MWD = 6-minute walk distance; 6MWT = 6-minute walk test.

Introduction

Silicosis is an occupational lung disease that occurs gradually over a period of 12–15 years on chronic exposure to Silica dust. Silicosis is prevalent in several states of India, Haryana being one of them. Its prevalence in India ranges widely from 5.2% in mica mines and mica processing to 35.2% in stone cutters.[1] Silica dust (particles <5 µm in size), penetrates the walls of alveoli where gas exchange occurs. Macrophages try to remove the inhaled crystalline silica particles but are themselves ruptured in the process. This results in the development of fibrotic nodules and scarring around the trapped silica particles in the lung, thereby leading to significant obstructive and restrictive impairment of pulmonary function.[2] Pulmonary function impairment is often defined in relation to forced expiratory volume in the first second, forced vital capacity, and dyspnoea.[3] Pulmonary ventilation, i.e., the exchange of gases between the environment and lungs is affected by a large number of factors, body surface area (BSA) being one of the most important. People with larger BSA have larger lung volumes and capacities. Therefore, low pulmonary ventilatory capacity can be a risk factor for developing silicosis. A strong correlation has been documented between the 6-minute walk distance (6MWD) and clinical outcomes in patients with pulmonary disease, including occupational lung disease. The data provided by 6-minute walk test (6MWT) acts as a strong adjunct to standard pulmonary function tests, serving as a useful assessment tool for overall functional ability as well as a measure of the influence of various factors on exercise capacity.[4] To eliminate occupational lung diseases prevention is the primary strategy. Several potential risk factors have been implicated in the pathogenesis of silicosis. Even on an extensive search of literature no study on individual risk factors for developing occupational lung disease could be documented. It would be of value to consider the physical characteristics of individuals as risk factors for developing occupational lung disease.

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How to cite this article: Agarwal A, Singh M, Sinha P, *et al*. Relationship between Body Surface Area and Pulmonary Functions in Patients of Silicosis. Indian J Chest Dis Allied Sci 2023;65(1):14–17.

Source of support: Nil

Conflict of interest: None

The present study aimed to calculate BSA among diagnosed cases of silicosis and study its association with pulmonary function indices and also study the association between BSA and 6MWD in diagnosed cases of silicosis.

Materials and Methods

This descriptive cross-sectional study was conducted in the Department of Physiology at ESIC Medical College, Faridabad, India, over a period of 10 months (July 2020 to April 2021). The study was conducted following approval by the Institutional Ethics Committee of ESIC Medical College & Hospital, Faridabad, India (No. 134/A/11/16/Academics/MC/2016/180 dated 04/07/2020). Written informed consent was obtained. The study sample comprised diagnosed male patients of silicosis visiting the Respiratory Medicine Department for follow-up and referred to the Department of Physiology for Pulmonary function tests. It is a well-established fact that males have greater vital capacities than females. Therefore, females were excluded from the study to eliminate gender bias. Additional exclusion criteria were smokers, subjects with musculoskeletal abnormalities and heart disease.

Study Tools

Anthropometric Measurements

Height was measured using a stadiometer to the nearest 0.5 cm without shoes. A digital weight recorder was used to measure weight to the nearest 0.1 kg. DuBois and DuBois's formula was used to calculate BSA and subjects were divided into three groups.[5] Group I: BSA <1.6 m^2, group II: BSA 1.6–1.9 m^2, and group III: BSA >1.9 m^2. Within each group, subjects were further divided into subgroups a, b, and c. Subgroup 'a' has 10–15 years of silica dust exposure, subgroup 'b' 15–20 years, and subgroup 'c' >20 years of exposure.

Lung Function

Forced spirometry was performed in the sitting posture on each subject according to American Thoracic Society (ATS) guidelines, using digital portable spirometer (Cosmed Pony FX model no. C09062-01-99).[6] The parameters obtained were: forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), FEV_1%/FVC, and peak expiratory flow rate (PEFR). The mean percentage predicted value was based on various parameters like subject age, weight, standing height, gender, and ethnic group as calculated and adjusted by the spirometer device. At least three acceptable maneuvers were performed. The largest volumes (as percentage predicted lung function) were selected for analysis.

6-minute Walk Test

Pre-test instructions for participants: consumption of a light meal on the day of the test, comfortable clothing, and appropriate shoes. The 6MWT was performed indoors as per ATS guidelines along a long, flat, straight, enclosed corridor with a hard surface.[7] During the walk, research staff walked behind the participants carrying an oxygen delivery system to provide supplemental oxygen therapy in case of emergency. 6-minute walk distance was noted as an absolute value in meters.

Data and Statistical Analysis

The outcome variables were FEV_1, FVC, FEV_1/FVC and PEFR (continuous variables). The BSA and 6MWD were independent, continuous variables. Data collected was entered in Microsoft Excel sheet and analyzed statistically in Epi info v 7. The continuous variables were presented as mean and were further grouped to arrive at a categorical variable. They are presented in the form of mean and standard deviation. Student's *t*-test of significance (ANOVA) was applied to test the difference between means. Level of significance was set at 5%.

Table 1: Frequency distribution of subjects with respect to BSA and years of exposure to silica dust

BSA (m^2)	*Years of exposure (in years)*			*Total*
	10–15 (a)	16–20 (b)	>20 (c)	
<1.6 m^2 (I)	7 (30.4%)	6 (21.6%)	10 (45.3%)	23
1.6–1.9 m^2 (II)	3 (4.8%)	26 (41.9%)	33 (53.2%)	62
>1.9 sq m^2 (III)	4 (25.3%)	5 (29.4%)	8 (47.1%)	17

BSA, body surface area

Results

A total of 102 subjects participated in the study. The average age of the subjects was 43.80 ± 8.8 years (range 26–65 years). The average duration of exposure to silica dust was 21.25 ± 6.35 years (range 11–37 years). Table 1 presents the frequency distribution of subjects with respect to BSA and years of exposure to silica dust. Table 2 shows the relationship between BSA and duration of exposure to silica dust (in years) with pulmonary function indices. The test of significance (ANOVA) was applied to three groups of exposure (a, b, and c) and results in the form of *p* values are shown in Table 3.

The total mean of 6MWD increased with the increase in years of exposure from 10–15 to 16–20 years. However, the increase was not statistically significant. No trend for 6MWD was observed within the BSA groups. Except for FVC the total mean of all other pulmonary function indices showed a statistically significant decrease as we move from groups Ia to Ic. In groups II and III only FEV_1 and FVC showed a statistically significant decrease as we move from groups IIa to IIc and IIIa to IIIc. The spirometric indices were higher in group III in all categories of exposure. The difference was statistically significant for FEV_1 ($p = 0.03$) and FVC ($p = 0.01$).

Discussion

Silicosis is among the most commonly encountered occupational lung disease which is widely prevalent among workers in the mining, quarrying, cutting, and polishing industries of low-income countries. According to the data from the Global Burden of Disease Study 2017, the incidence of silicosis in 2017 was 23,700, which is only the tip of the iceberg.[8] Since no treatment of silicosis can reverse the damage already done, the primary strategy for prevention is the identification of risk factors.

Previous studies have implicated that lung function may theoretically be affected by several directly measured or derived anthropometric variables including standing height, trunk-leg ratio, weight, body surface area, and body mass index.[9] Das and Jahan found that an increase in BSA is associated with an increase in lung volumes and PEFR both in males and females.[10] However, the effect of BSA on the pulmonary functions in patients of silicosis is an arena hardly explored.

In the present study, we attempted to explore this rarely researched area by comparing the spirometric indices and 6MWD

Table 2: Relationship between years of exposure to silica dust and body surface area with pulmonary function indices

	No.	*FEV1*	*FVC*	*FEV_1/FVC (%)*	*PEFR (L/s)*	*6MWD (m)*
BSA 10–15 years of exposure						
<1.6 m^2 (Ia)	7	1.87 ± 0.66	2.30 ± 0.64	79.57 ± 6.77	4.55 ± 1.01	256.71 ± 11.02
1.6–1.9 m^2 (IIa)	3	2.16 ± 0.22	2.80 ± 0.31	76.66 ± 0.57	4.57 ± 0.66	281.33 ± 25.40
>1.9 m^2 (IIIa)	4	3.05 ± 0.09	3.66 ± 0.31	83.75 ± 5.05	6.72 ± 0.51	278.50 ± 10.97
Total	14	2.27 ± 0.69	2.80 ± 0.76	80.14 ± 5.84	5.18 ± 1.27	268.21 ± 18.07
		0.01	**<0.01**	**0.04**	**0.29**	**<0.01**
BSA 15–20 years of exposure						
<1.6 m^2 (Ib)	6	2.07 ± 0.54	2.69 ± 0.54	76.33 ± 7.28	6.19 ± 1.68	291.67 ± 10.59
1.6–1.9 m^2 (IIb)	26	2.44 ± 0.28	3.14 ± 0.36	77.53 ± 4.57	6.16 ± 1.35	275.69 ± 25.84
>1.9 m^2 (IIIb)	5	2.93 ± 0.66	3.5 ± 0.81	83.40 ± 0.54	6.03 ± 0.10	266.40 ± 26.83
Total	37	2.44 ± 0.44	3.12 ± 0.51	78.13 ± 5.15	6.15 ±1.29	277.03 ± 24.74
		<0.01	**0.02**	**0.22**	**0.04**	**0.98**
BSA > 20 years of exposure						
<1.6 m^2 (Ic)	10	1.09 ± 0.43	1.83 ± 0.73	59.40 ± 4.64	2.94 ± 1.40	279.60 ± 16.17
1.6–1.9 m^2 (IIc)	33	2.09 ± 0.44	2.80 ± 0.58	75.0 ± 9.30	5.40 ± 1.71	264.30 ± 37.88
>1.9 m^2 (IIIc)	8	2.23 ± 0.37	2.90 ± 0.20	76.50 ± 8.08	6.31 ± 0.79	281.50 ± 49.10
Total	51	1.91 ± 0.59	2.62 ± 0.69	72.17 ± 10.45	5.06 ± 1.88	270 ± 36.93
		<0.001	**<0.001**	0.334	**<0.001**	**<0.001**

BSA, body surface area; FEV_1, forced expiratory volume in first second; FVC, forced vital capacity; PEFR, peak expiratory flow rate; 6MWD, 6-minutes walk distance. Figures in bold indicate statistically significant *p*-value < 0.05

Table 3: ANOVA results of changes in pulmonary function indices and 6MWD with respect to BSA across the three durations of silica dust exposure

	<1.6 m^2 (I)	*1.6–1.9 m^2 (II)*	*>1.9 m^2 (III)*
FEV1	**<0.01**	**<0.01**	**0.03**
FVC	0.06	**0.03**	**0.01**
FEV1/FVC (%)	**<0.001**	0.43	0.09
PEFR (L/s)	**<0.01**	0.08	0.27
6MWD (m)	**<0.001**	0.35	0.78

FEV_1, forced expiratory volume in first second; FVC, forced vital capacity; PEFR, peak expiratory flow rate; 6MWD, 6-minute walk distance. Figures in bold indicate statistically significant *p*-value < 0.05

in three groups of established cases of silicosis with different BSA and duration of exposure to silica dust. In the group exposed to silica dust for >20 years, the mean spirometric indices were found to be lower compared to those with lesser exposure to silica dust in all categories of BSA. However, within the group (>20 years of exposure) the spirometric indices and 6MWD were highest in those with BSA >1.9 m^2. 6-minute walk distance did not show any significant change with years of exposure and BSA.

Aminian et al. analyzed spirometric indices including FEV_1/FVC, FVC, PEF, FEV_1, and FEF 25–75% in workers exposed to cement dust and observed a significant reduction in the mean percentage of these indices.[11] The respiratory symptoms and functional status of workers exposed to silica were studied by Hertzberg et al. who found a decreased percentage of predicted FVC and FEV_1.[12] Cumulative exposure to respirable crystalline silica dust showed a significant negative correlation with the respiratory parameter, FVC among mine workers from Iran in a work published by Tavakol et al.[13] The results of our work are consistent with most findings of the above-mentioned studies.

The major limitation of this study was that spirometry and 6MWT could be performed one time only. The major reason for a lack of regular follow-up and repeat testing among the silicosis patients was the restrictions imposed as well as the reluctance of patients on account of the COVID pandemic. Repeated testing over time would have been helpful to monitor the progression of the disease and change in functional status.

Conclusion

To conclude, the current study found that the mean spirometric indices of the group exposed to silica dust for >20 years were lower than those exposed to 10–15 and 15–20 years in all categories of BSA. However, within the group (>20 years of exposure) the spirometric indices and 6MWD were highest in those with BSA >1.9 m^2. This corroborates our hypothesis that workers with larger BSA may have less risk of developing silicosis. However, to draw definite conclusions and provide standardized guidelines large multi-center follow-up study is required.

Identification of physical characteristics as risk factors of silicosis will benefit not only the academic research community but also the workers, employers, and policymakers. If significant correlations between BSA, pulmonary impairment, and functional exercise capacity are found, regulations could be enacted worldwide to recruit people of appropriate body size only. This might help in reducing the burden of silicosis.

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