

Comparative Study on Changes in Spirometric Lung Function Indices of Cobblestone Workers

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Abstract: Cobblestone workers exposed to dust inhalation and physical injuries during cobblestone work activities exposed to respiratory problems due to proliferation and fibrotic alteration changing in their spirometric lung function indices. This study was designed to determine changes in spirometric lung function indices of cobblestone workers. Comparative cross-sectional study was applied. Cobblestone workers exposed for one and above years and proportional non exposed non-smoking normal study participants with similar age range and anthropometric values were participated. The study showed higher change in Spirometric lung function indices. Mean values and percent predicted mean values of lung functions (FVC, FEV1, FEV1/FVC, PEFr, PIFr and FEF25-75) were significantly reduced ($p < 0.05$). Reduction in spirometric values was more marked in chiseling workers. Thus, dust emission during cobblestone preparation adversely affects pulmonary function of workers. Further studies should be conducted on many workers to make standing decisions and regulations. Workers should be trained and appropriate PPEs should be provided. Guideline has to be developed to provide guidance on how to assess and reduce health impacts of dust emissions.

Keywords: Cobblestone Workers, Lung Function Indices, Spirometry

1. Introduction

In Ethiopia, Cobblestone work has become good job opportunity. However, workers are exposed to dust inhalation and physical injuries during excavating, cutting, drilling, handling, loading, transporting, chiseling and paving activities. Many studies show occupations involving stone materials increase chance of stone dusts exposure leading to proliferation and fibrotic alteration that change in spirometric lung function indices and cause respiratory problems [1, 2]. Fine dust in underground and from stone could have metals and other substances that are risky for human health [2, 3]. Such problems could result in changes in spirometric lung function indices (FVC, FEV1, FEV1/FVC, PEFr, PIFr and FEF25-75) that estimate lung volumes and lung capacities [4, 5].

Recording test trace is taken as a forced spirogram (volume over time) or as a flow-volume loop (flow against volume). Evaluation of forced expiration after a complete inhalation determine forced vital capacity (FVC) and forced expired volume during first second (FEV1). Ratio of FEV1/FVC, mean forced expiratory flow during middle half

of FVC (FEF25-75%), peak expiration flow rate (PEFr) and peak inhalation flow rate PIFr imply airways and lung problems [20]. Dozens of other indices (IRV, ERV, VT, FRC, VC, TLC, RV, FET etc) can be derived. Environmental and occupational risks closely associated with changes in these lung function indices resulting normal, obstructive, hyperinflation or restrictive lung function patterns [5, 6]. Thus, dust particles affect transport and removal of air and deposited within respiratory system associated with change in lung volumes and lung capacities [7-9]. Previously, effect of stone dust and related dusts on pulmonary function of cobblestone workers was not studied. Therefore, the study was designed to determine changes in spirometric lung function indices of cobblestone workers.

2. Materials and Methods

The present study was conducted on cobblestone workers. Sampling population was chiseling and quarry workers.

Comparative cross-sectional study was applied. Participants were within 18-35 years age range had working for one and above years and proportional non exposed groups were taken. Clearance from medical ethical committee and consent was obtained from participants. Exclusive and inclusive criteria were checked. Spiro metric lung function indices values and percent predicted mean values of lung functions (FVC, FEV1, FEV1/FVC, PEFR, PIFR and FEF25-75) were taken early morning and after a day stone dust exposure. A pocket sized digital spiro meter called Spiro pro made by

JEAGER was used to measure pulmonary function indices. Digital balance and measuring tape were used to measure weight and height so that BMI was calculated.

3. Results

In the course of the study, factors that affect lung function indices like mean \pm SD duration of years stayed at the cobblestone work, anthropometric measurements workers and control participants were considered.

Table 1. Anthropometric measurements in both exposed and controls groups.

No.	Group	Age range (years)	Age years (Mean \pm SD)	BMI(kg/m ²)
1	Controls	N=151	26.44 \pm 3.55	21.38 \pm 2.62
		18-26(n=88)	23.90 \pm 1. 73	21.31 \pm 2.62
		27-35(n=63)	29.78 \pm 2.36	21.47 \pm 2.64
	Exposed (Total)	N=151	26.52 \pm 4.12	20.99 \pm 3.13
		18-26(n=88)	23.55 \pm 1.99	21.13 \pm 3.31
		27-35(n=67)	30.52 \pm 2.55	20.80 \pm 2.89
2	Quarry	(n=73)	27.59 \pm 3.98	22.12 \pm 2.56
		18-26(n=41)	24.21 \pm 1.83	22.19 \pm 2.65
		27-35(n=32)	30.79 \pm 2.20	22.04 \pm 2.48
	Chiseling	(n=82)	25.56 \pm 4.02	19.98 \pm 3.26
		18-26(n=47)	23.20 \pm 2.01	20.20 \pm 3.57
		27-35(n=35)	29.93 \pm 2.89	19.67 \pm 2.81

The study showed higher changes in spiro metric lung function indices. The mean values and percent predicted mean values of lung functions (FVC, FEV1, FEV1/FVC, PEFR, PIFR and FEF25-75) were significantly reduced ($p < 0.05$).

Table 2. Paired t-test on lung function, predicted and actual value of workers and controls (Mean \pm SD).

Lungs Function Indices	Control (n=151)				Exposed (n=155)			
	Predicted	Actual	t-value	p-value	Predicted	Actual	t-value	p-value
FVC(L)	4.985 \pm 0.425	4.322 \pm 0.703	12.228	0.000	4.869 \pm 0.755	3.599 \pm 0.982	15.390	0.000
FEV1(L/s)	4.136 \pm 0.328	4.267 \pm 0.701	-2.535	0.012	4.027 \pm 0.594	3.524 \pm 0.850	7.441	0.000
FEV1%	82.709 \pm 0.942	98.940 \pm 3.412	-55.251	0.000	82.574 \pm 1.701	98.652 \pm 5.45	-34.549	0.000
FEF25-75(L/s)	4.343 \pm 0.303	6.578 \pm 1.495	-19.373	0.000	4.222 \pm 0.537	6.161 \pm 1.857	-13.589	0.000
PEFR(L/s)	9.417 \pm 0.732	8.748 \pm 2.204	3.954	0.000	9.215 \pm 1.261	8.632 \pm 2.470	3.185	0.002

Table 3. Lung function indices in cobblestone workers compared with controls.

Lungs Function indices	Actual		Significance		Percent predicted		%predicted difference	Significance	
	Control	Exposed	t-value	p-value	Control	Exposed		t-value	p-value
FVC(L)	4.32 \pm 0.70	3.53 \pm 0.99	-7.98	0.000**	86.98 \pm 13.29	74.65 \pm 19.39	12.32	-6.47	0.000**
FEV1(L/s)	4.26 \pm 0.70	3.45 \pm 0.85	-9.03	0.000**	103.596 \pm 15.88	87.95 \pm 20.01	15.64	-7.56	0.000**
FEV1%	98.9 \pm 3.41	98.61 \pm 5.62	-0.61	0.540	119.636 \pm 4.410	119.155 \pm 7.364	0.48	-0.69	0.490
FEF25-75(L/s)	6.58 \pm 1.49	6.00 \pm 1.71	-3.13	0.002*	150.464 \pm 32.60	143.72 \pm 41.39	6.74	-1.58	0.11
PEFR(L/s)	8.75 \pm 2.20	8.42 \pm 2.36	-1.24	0.22	92.92 \pm 22.17	93.55 \pm 23.87	-0.63	0.24	0.81

Values are mean \pm SD * significant ($p < 0.05$) ** highly significant ($p < 0.001$)

**Significant difference existed in FVC, FEV1 and FEV1% between controls and exposed groups ($p < 0.001$).

Table 4. Mean and standard deviation of lung functions measurement for both control and exposed group.

Lung Function Indices	Age range	Control (n=151)		Exposed (155)		t-value	p-value
		N	(Mean \pm SD)	N	(Mean \pm SD)		
VC(L)	18-26	86	3.469 \pm 0.698	89	3.280 \pm 0.921	1.525	0.129
	27-35	65	3.509 \pm 0.601	66	3.286 \pm 0.892	1.681	0.095
FVC(L)	18-26	86	4.3001 \pm 0.763	89	3.686 \pm 1.034	4.460	0.000*
	27-35	65	4.350 \pm 0.619	66	3.487 \pm 0.897	6.414	0.000*
FEV1(L)	18-26	86	4.239 \pm 0.770	89	3.574 \pm 0.828	5.495	0.000*
	27-35	65	4.303 \pm 0.601	66	3.462 \pm 0.875	6.415	0.000*
FEV1%	18-26	86	103.157 \pm 14.674	89	87.975 \pm 19.139	5.833	0.000
	27-35	65	81.232 \pm 1.501	66	103.508 \pm 18.27	-9.091	0.000
FEF25-75(L/s)	18-26	86	6.499 \pm 1.633	89	6.196 \pm 1.806	1.164	0.246
	27-35	65	6.638 \pm 1.311	66	6.108 \pm 1.923	1.842	0.068
PEFR(L)	18-26	86	8.610 \pm 2.305	89	8.718 \pm 2.382	-0.305	0.760
	27-35	65	8.868 \pm 2.094	66	8.490 \pm 2.587	0.920	0.359
PIFR(L/s)	18-26	86	5.180 \pm 2.368	89	6.434 \pm 2.608	-3.323	0.001*
	27-35	65	5.401 \pm 2.198	66	6.351 \pm 2.474	-2.330	0.021*

Table 5. Exposure effect (%) on spirometric parameters across gender and age groups.

Age (yr)	Group	Gender	VC	FVC	FEV1	FEV1%	PEFR	FEF25-75	PIFR
18-26	Control	Male (n=74)	3.50 \pm 0.65	4.42 \pm 0.60	4.37 \pm 0.61	105.43 \pm 13.80	8.95 \pm 2.17	6.65 \pm 1.45	11.39 \pm 52.45
		Female (n=13)	3.32 \pm 0.65	3.91 \pm 0.60	3.84 \pm 0.68	93.77 \pm 12.01	8.91 \pm 2.61	6.11 \pm 1.68	4.55 \pm 1.59
	Exposed	Male (n=73)	3.42 \pm 0.89	3.80 \pm 1.03	3.68 \pm 0.79	87.08 \pm 18.73	8.83 \pm 2.36	6.21 \pm 1.86	6.88 \pm 2.50
		Female (n=10)	2.29 \pm 0.64	2.75 \pm 0.52	2.73 \pm 0.49	92.90 \pm 22.59	6.94 \pm 1.14	5.59 \pm 1.07	3.94 \pm 1.73
27-35	Control	Male (n=54)	3.48 \pm 0.62	4.34 \pm 0.76	4.28 \pm 0.73	104.47 \pm 18.46	8.89 \pm 1.99	6.81 \pm 1.47	5.49 \pm 2.09
		Female (n=10)	53.30 \pm 0.77	13.99 \pm 1.02	0.443.96 \pm 1.01	98.40 \pm 17.24	6.53 \pm 1.94	5.49 \pm 1.26	5.03 \pm 1.77
	Exposed	Male (n=51)	3.46 \pm 0.86	3.66 \pm 0.89	3.64 \pm 0.86	89.29 \pm 21.53	8.92 \pm 2.66	6.38 \pm 1.96	6.64 \pm 2.54
		Female (n=11)	2.50 \pm 0.6	2.75 \pm 0.5	2.71 \pm	94.73 \pm 15.93	6.24 \pm 1.09	4.52 \pm 0.76	4.29 \pm 1.83

Values are mean \pm SD

Comparison of Similar Exposure Groups (SEGs): Mean \pm SD values of VC, FVC, FEV1 and FEF25-75 were lower in chiseling workers significantly ($p<0.05$). PEFR reduction was very significant ($p=0.000$). FEV1% and PIFR were

lower but not significant. When we compare relative reduction between PEFR and PIFR, former one was significantly reduced ($p=0.00$) and reduction in PIFR was not significant (0.73).

Table 6. Comparison between subgroups (quarry and chiseling) of Cobblestone Workers.

Lungs Function Indices	Quarry (n=73*) (Mean \pm SD)	Chiseling(n=61*) (Mean \pm SD)	t-value	p-value
VC(L)	3.604 \pm 0.791	3.209 \pm 0.909	2.700	0.008
FVC(L)	3.912 \pm 1.008	3.505 \pm 0.895	2.425	0.017
FEV1(L)	3.812 \pm 0.804	3.443 \pm 0.824	2.591	0.011
FEV1%	90.459 \pm 20.425	84.262 \pm 19.333	1.797	0.075
PEFR(L)	9.618 \pm 2.435	7.983 \pm 2.184	4.013	0.000
FEF25-75(L)	6.630 \pm 1.943	5.908 \pm 1.701	2.244	0.027
PIFR(L/s)	6.820 \pm 2.493	6.670 \pm 2.546	0.340	0.734

All are males

4. Discussion

Normal lung function indices depend on gender, age and BMI. Race and geographical location may contribute to lung function indices variability. According to a study [10], Ethiopian men and women normal spirometric lung function test indices measured in Addis Ababa varied from results observed in other parts of the world. For example, mean FVC in men was 4.35 liters and 3.11 liters in women. The mean FEV1 was 3.52 liters for men and 2.45 liters in women.

The present study in cobblestone workers showed reduction in pulmonary function indices. Inhalation of dust over periods of time leads to proliferation of alveolar epithelium and fibrotic changes in lungs [11-13, 15]. Severity

depends on several factors including chemical nature, physical state of inhaled substance, size, concentration of dust particles, duration of exposure and individual susceptibility. Proximity to sensitive receptors, prevailing wind direction, speed and nature of works topography influence level of impact [1].

The probable reason could be: chiseling workers were very proximate to dust and perform the chiseling without machinery support. Another could be body size. Quarry workers were a bit bigger in height and weight than chiseling workers although it was tried to match BMI (22.12 \pm 2.56 and 20.21 \pm 2.54), respectively. This might be reflecting on lung function and justify discrepancy.

Pulmonary impairment in cobblestone workers and controls were interpreted to assess the severity of occurrence

of obstructive and restrictive or mixed conditions. Pulmonary impairment conditions of the present study participants were analyzed combining the two ATS and ITS recommendations. Accordingly, About 4.6% and 18.1% of controls and exposed participants respectively have had obstructive condition respectively. About 2% of controls have had mixed pattern of lung function while 17.4% of exposed groups have had mixed condition. Neither control nor exposed group has had restrictive pattern alone. There was great lung function pattern difference between the groups. From the result, it could be stated that, the dust effect on lung function is on both airways and lungs.

Interpretation of PFTs is usually based on comparisons of data measured in an individual patient or subject with reference (predicted) values based on matched healthy subjects.

To say obstructive, restrictive, or normal pattern, the first step could be to evaluating FEV1/FVC ratio. If this ratio is less than the lower limit of normal ($\leq 70\%$), it shows FEV1 has fallen to a greater degree than FVC indicating presence of an obstructive defect. If this ratio is greater than lower limit of normal, then either the spirometry test is normal or a restrictive defect is present. The next step is to look at the FVC. If the FVC is less than predicted lower limit of normal ($\leq 70\%$), it verifies presence of restriction. If FEV1% become beyond 90% it is indicative for restrictive condition. If both FEV1/FVC ratio and percent predicted FVC values are within 70-90%, this indicates normal condition [6, 20, 22].

A mixed ventilatory defect is characterized by coexistence of obstruction and restriction and is defined physiologically when both FEV1/FVC and FVC are below the 5th percentiles of their relevant predicted values. Since FVC may be equally reduced in both obstruction and restriction, the presence of a restrictive component in an obstructed patient cannot be inferred from simple measurements of FEV1 and FVC. One can state that the FVC was also reduced, probably due to hyperinflation, but that a superimposed restriction of lung volumes cannot be ruled out. Conversely, when FEV1/FVC is low and FVC is normal, a superimposed restriction of lung volumes can be ruled out [23].

5. Conclusion

From present study it could be concluded that dust emission during cobblestone work adversely affect pulmonary function. The mean values and percent predicted mean values of lung functions (FVC, FEV1, FEV1/FVC, PEFR and FEF25-75%) were significantly reduced ($p < 0.05$). Reduction in pulmonary functions indices in chiseling workers was more significant compared to quarry workers.

Recommendations

Medical surveillance of early detection contributes to reduce burden of lung function impairments. Further studies should be conducted on many workers to make standing

decisions and regulations. Concentration, composition, nature and specific effects of dust in the work site should be studied. Workers should be trained and appropriate PPEs should be provided. Guideline has to be developed to provide guidance on how to assess and reduce health impacts of dust emissions.

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