QUANTIFICATION OF INCREASE IN BLOOD PRESSURE WITH THE REDUCTION IN FORCED VITAL CAPACITY OF LUNGS OF SAND STONE MINE WORKERS

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ABSTRACT

When any human being is constantly exposed to respirable suspended particulate matter for longer duration his respiratory tract is damaged and forced vital capacity is reduced. Sand stone mine workers are continuously working in the environment having high concentration of RSPM. Study has been carried out on 370 male sand stone mine workers engaged in various activities. Reduction in FVC and increase in BP was measured . Analysis indicates that the IFVC (Decrease in vital capacity) account for the increase in ISBP upto 56 % and remaining rest 44 % increase is due to other reasons and IFVC account for the increase in IDBP upto 74.1 % and remaining 25.9 % variation is due to other reasons. Increase in DBP is varying from 16.3 % to 23.2 % and increase in SBP is varying from 30.5% to 41.9 % depending upon reduction in FVC. Result indicates that increase in DBP is closely associated with the decrease of FVC. Hence it can be revealed from the study that reduction in FVC is responsible for increase of DBP and SBP.

Key Words:

Systolic Blood Pressure , Diastolic Blood Pressure, Respiratory tract, Respirable Suspended Particulate matter, Forced Vital Capacity

Introduction:

Occupational exposure to dust is a well-known phenomenon, especially in developing countries. Although sources of air pollutants include power plants, cement factories, refineries and petrochemical industries, the emission of particulates is quite high from sand stone quarries. Workers working in sand stone mines are exposed to high concentration of respirable suspended particulate matter (RSPM) and this RSPM is deposited in the respiratory tract. The toxicology of the RSPM depends upon the size of the particles and chemical composition of particles. The deposition of RSPM in the lungs decrease Forced Vital Capacity (FVC) of lungs. The decrease in FVC depends upon the exposure duration and concentration of RSPM. Several observational studies have demonstrated that short-term exposure to fine particulate matter (PM) <2.5 μm in diameter (PM2.5) can acutely raise blood pressure (BP) [3,4]. Ibald-Mulli et al., (2001); Linn et al., (1999), analysed effects of air pollution on blood pressure in a population based sample as well as in a panel of asthmatic subjects found an increase in systolic blood pressure with elevated concentrations of particulates[6,7]. Brook et al., (2008) messaged the clinicians that the cardiovascular health consequences of air pollution are generally equal or exceed those due to pulmonary diseases [5]. Dvonch et al., (2009), suggested a link between exposure to ambient particulate matter <2.5 μm in diameter (PM2.5) and adverse cardiovascular outcomes. PM2.5 was significantly associated with systolic blood pressure; a 10-μg/m^3 increase in daily PM2.5 was associated with a 3.2-mm Hg increase in systolic blood pressure (P= 0.05). However, in models that added a location interaction, larger effects were observed for systolic blood pressure within the community with highest PM2.5 levels; a 10 μg/m^3 increase in daily PM2.5 was associated with a 8.6 mm Hg increase in systolic blood pressure (P=0.01) [2]. According to Bellavia et al., (2013), Short-term exposures to fine (<2.5 lm aerodynamic diameter) ambient particulate-matter (PM) have been related with increased blood pressure (BP) in controlled-human exposure and community-based studies. However, whether coarse (2.5 to 10 μm) PM exposure increases BP is uncertain. Recent observational studies have linked PM exposures with blood DNA hypomethylation, an epigenetic alteration that activates inflammatory and vascular responses [1]. Most of the researchers have carried out the study on a particular concentration of a particular pollutant and its effect on blood pressure. All most in all the study researchers have considered either pollutant concentration as variable or exposure duration as a variable and extent of damage were reported as increase of blood pressure.

Quantification of increase of blood pressure with the decrease of forced vital capacity is not established. In this study attempt is made to establish relationship between increase in BP and decrease in FVC.

Methodology:

The sandstone quarrying/ mining process is done manually and mechanically but the involvement of workers in both the cases is significant. There are three types of workers, in the quarrying process:

a. Driller : These sets of workers are employed for blasting, and drilling operations
b. Dresser: These are the workers employed for doing finer work, by chiseling , cutting or dressing the stone pieces for decorative works.
c. Labours: These sets of workers are employed for loading & unloading operations and are exposed to normal quarry environment.

(1) The workers were selected for the study from various stone quarries. The selection of workers was based upon the exposure duration, type of work, socioeconomic factor, and previous diseases. The workers having hereditary respiratory & cardiovascular problems were not taken for study. Only male workers have been considered in this study . The workers were divided into three categories:

(a) Driller
(b) Dresser
(c) Labours

The control workers were selected from the same category of life style, socioeconomic standard but are not exposed to pollution.

(2) RSPM concentration was measured during various activities in the mines and average concentration of RSPM for various activities are given in table-1.

(3) The systolic blood pressure (SBP) and diastolic blood pressure (DBP) and FVC (Forced vital Capacity of lungs) of mine workers exposed to different concentration of RSPM was measured with the help of Multiparameter Monitor and Spirometer respectively. SBP & DBP and FVC of control population was also measured. Total number of workers of various categories, involved in this study are given in table-2

(4) The lung capacity of a person depends upon its age, height and weight, and the reduction of lung volume due to damage depends upon the concentration of particulate matter and duration of exposure. Therefore, it is not possible to find out the generalised amount of volume reduction due to pollution. Hence index is developed to find out the extent of damage in terms of percentage of volume reduction in fraction. The index is designated as IFVC for "forced vital capacity". Similarly, indices were also calculated for Systolic blood pressure and Diastolic blood pressure and are represented as ISBP (percentage increase in systolic blood pressure in fraction) and IDBP (percentage increase in diastolic blood pressure in fraction) respectively. These indices were calculated from equations given below and are given in table -3.

IFVC = (FVCp – FVC) / FVCp

ISBP = (SBP-120) / 120

IDBP = (DBP-80) / 80

Where : FVC_P = Predicted value of Forced vital capacity of lungs

FVC = Measured value of Forced vital capacity of lungs

SBP = Measured value of Systolic blood pressure

DBP = Measured value of Diastolic blood pressure

Table-1

Particulate concentration for different activities

S.N.	Activity	Respirable suspendered Particulate matter (RSPM) Concentration	Concentration category
1	Normal Quarry Environment	460.00 µg/m³	1
2	Dressing	970.00µg/m³	2
3	Drilling	1890.00µg/m³	3

Table-2

Category of workers and exposure duration

Category of Workers	Exposure Duration in Years	Number Of Workers	Exposure Category
Labour (120)	0-5	30	1
	5-10	27	2
	10-15	36	3
	>15	27	4
Dresser (125)	0-5	32	1
	5-10	27	2
	10-15	36	3
	>15	30	4
Driller (125)	0-5	33	1
	5-10	30	2
	10-15	28	3
	>15	34	4
Control workers	----------	36	------

Table- 3

Mean values of indices

(Decrease in PF Values & Increase in Blood Pressure)

S.N	No .Of Obs.	Worker Category	Exposure Duration (Yrs)	Exposure Concentration	Mean IFVC	Mean IDBP	Mean ISBP
1	30	Labour	0-5	460.00 μg/m³	0.479	0.163	0.305
2	27	Labour	5-10	460.00 μg/m³	0.519	0.177	0.327
3	36	Labour	10-15	460.00 μg/m³	0.523	0.179	0.326
4	27	Labour	>15	460.00 μg/m³	0.626	0.185	0.326
5	32	Dresser	0-5	970.00 μg/m³	0.546	0.18	0.361
6	27	Dresser	5-10	970.00 μg/m³	0.609	0.184	0.326
7	36	Dresser	10-15	970.00 μg/m³	0.638	0.205	0.364

8	30	Dresser	>15	970.00 μg/m³	0.638	0.213	0.377
9	33	Driller	0-5	1890.00 μg/m³	0.592	0.195	0.338
10	30	Driller	5-10	1890.00 μg/m³	0.624	0.215	0.382
11	28	Driller	10-15	1890.00 μg/m³	0.609	0.221	0.397
12	24	Driller	>15	1890.00 μg/m³	0.708	0.232	0.419
13	36	Control Population			0.256	0.146	0.309

Analysis of Observations:

Table - 4

Statistical Parameters for IFVC-IDBP (ANOVA)

Model	R	R Square	Std. Error of the Estimate	F-Value		df		Coeff.	t
1	0.861	0.741	.011289	28.545	Regression Residual Total	1 10 11	Constant IFVC	.028 .283	.888 5.343

a. Dependent variable : IDBP
b .Independent variable: IFVC

F test

$H_o : \beta_1 = 0$ against H_1 : not all $\beta_k = 0$:(k= 1)

Table-4 gives the value of calculated 'F' i.e. F = 28.545 and

$F_{k, n-k-l, \alpha} = 4.96$ (critical value from standard tables).

Here, $F_{calculated} > F_{k, n-k-l, \alpha}$

Hence, reject H_0 at α (value = 0.05)

level of significance individual of significance β's be tested by 't - Test'.

t- Test

$H_0 : \beta_j = 0$ against $H_1 : \beta_j \neq 0$: (j = 1)

The calculated values for 't - statistics' for β_1 is given in ANOVA table-4.

t (for β_1) = 5.343

The value of $t_{n-k-1, \alpha/2} = 2.26$

Here $t > t_{n-k-1; \alpha/2}$; therefore reject H_0.

Hence, $\beta 1 \neq 0$

As the estimated b_0 and b_1 are

b_0 = 0.028

b_1 = 0.283

Thus, estimated multiple regression equation for IDBP can be expressed as :

IDBP = 0.283 IFVC + 0.028

Table - 5

Statistical Parameters for IFVC-IDBP (ANOVA)

Model	R	R Square	Std. Error of the Estimate	F-value		df		Coeff.	t
2	0.748	0.560	.024166	12.730	Regression Residual Total	1 10 11	Constant IFVC	.114 .405	1.691 3.568
a. Dependent variable : ISBP b. Independent variable: IFVC									

F test:

$H_o : \beta_1 = 0$ against H_1 : not all $\beta_k = 0$:(k= 1)

ANOVA table-5 gives the value of calculated 'F' i.e. F = 12.730 and

$F_{k, n-k-l, \alpha} = 4.96$ (critical value from standard tables).

Here, $F_{calculated} > F_{k, n-k-l, \alpha}$

Hence, reject H_0 at α (value = 0.05)

level of significance individual of significance β's be tested by 't - Test'.

t- Test:

$H_0 : \beta_j = 0$ against $H_1 : \beta_j \neq 0$: (j = 1)

The calculated values for 't - statistics' for β_1 is given in ANOVA table-5.

t (for β_1) = 3.568

The value of $t_{n-k-1, \alpha/2} = 2.23$

Here $t > t_{n-k-1; \alpha/2}$; therefore reject H_0.

Hence, $\beta 1 \neq 0$

As the estimated b_0 and b_1

b_0 = 0.114

b_1 = 0.405

Thus, estimated multiple regression equation for IFVC can be expressed as :

ISBP = 0.405 IFVC + 0.114

Analysis indicates that the independent variable IFVC (Decrease in vital capacity) account for the increase in ISBP upto 56 % and remaining rest 44 % increase is due to other reasons and independent variable IFVC account for the variation in IDBP upto 74.1 % and remaining 25.9 % variation is due to other reasons. Increase in DBP is varying from 16.3 % to 23.2 % and increase in SBP is varying from 30.5% to 41.9 % depending upon reduction in FVC. As per the medical science increase in DBP is more dangerous and as per statistical analysis indicates that increase in DBP is closely associated with the decrease of FVC. Hence it can be revealed from the study that reduction in FVC is responsible for increase of DBP and SBP.

Conclusion:

Sand stone mine workers inhale air which contains high amount of RSPM and these small particles are deposited in the respiratory system at different places. The deposition of RSPM in the respiratory tract can damage the system thereby reducing the FVC of the lungs and adversely affect the working of respiratory system.

Based on the study done the important conclusions drawn are :

1. Increase in DBP or SBP is associated with reduction in FVC.
2. It is concluded that the increase in DBP significantly depends on the reduction in FVC .
3. The multiple regression equation developed to relate the increase in DBP/ SBP with the decrease of FVC are

ISBP = 0.405 IFVC + 0.114

IDBP = 0.283 IFVC + 0.028

Exposure to high concentration of RSPM (workers are exposed to high concentration of RSPM) in stone quarries and deposition of RSPM in respiratory system is not causing various respiratory diseases but indirectly it is damaging cardiovascular system . Hence it is urgent need to develop some techniques to reduce the RSPM in the working place and provide good working environment .

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