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Effectiveness of Pulmonary Rehabilitation on Physiological and Biochemical Parameters among Workers Occupationally Exposed to Silica

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Abstract

Occupational workers are at heath risk due to exposure to silica dust which is presence in construction and manufacturing sectors, masonry works, as well in mining sector. A comparative study was done to determine the Effectiveness of pulmonary rehabilitation on physiological and biochemical parameters among workers occupationally exposed to silica.

Design: A true experimental research design was used for this study.

Materials and methods: Occupational workers who are exposure to silica and working in cement factories.Who fulfills the inclusion criteria, sample size was ((n=160) divided in control group (n=80) , experimental group (n=80). Pre test was conducted to control and experimental group. Pulmonary parameters, base line clinical variables, spirometry to check the pulmonary function,6MWT stress tolerance test, HB,ESR,RBS blood investigtions, pranayama (yoga) and nutritional education was done for Experimental group.Supervised pulmonary rehabilitation was carried out and post test was done after 12 weeks, 18weeks and 24 weeks. The results were analyzed by descriptive and inferential statistical methods using SPSS statistical package (Systat software inc. San Jose, USA).

Conclusion: Pranayama and nutritional education showed significant improvement in lung capacity and pulmonary functions, SGRQ shows experimental pre and post statistically significance (p=<0.001).

Keywords: pulmonary parameters, pulmonary rehabilitation, SGRQ and pranayama(yoga).

Introduction

Silicosis is an irreversible disease and is caused by exposure to free silica. Silicosis can lead to a reduction in the lung function of the exposed workers and interferes with their activities of daily living and work. Consequently, it leads to a decline in their quality of life; however, there are few studies that evaluate the effect of the silica exposure and lung function on the quality of life of the workers. In 1917, the **US Public Health Services** identified sandblasters and foundry workers are to be at high risk of silicosis. Although recognized as a preventable occupational disease almost a century ago, there is no Occupational safety and Health Administration (OSHA) standard for silica other than a 1971 exposure limit. In 1997, the International Agency for Research on Cancer (IARC) classified crystalline silica as a group 1(known) human carcinogen. **IARC(1997).[1]**

The epidemiological studies carried out in India have shown marked variation in the prevalence of silicosis. The prevalence rate was varied from 3.5% in ordnance factories to 54.6% in the slate pencil industry. The variation is due to the fact of variability of concentration of silica in work environment of different occupations, duration of exposure and the physical properties of the silica.[2] India has a large mining industry, concentrated in the states of Chattisgarh, Jharkhand, Orissa and West Bengal.[3] In 1999, the Indian Council of Medical Research reported that around 3.0 million workers are at high risk of exposure to silica; of these,1.7 million work in mining or quarrying activities, 6.0 million in the manufacture of no – metallic products (such as refractory products, structural clay, glass and mica) and 0.7 million in the metals industry.[4-5] It is suggested that free seminars, symposiums, and medical camps are required at different levels at medical centers to increase the awareness about the cause and complications for silicosis among stone mine workers.

The national program on elimination of silicosis; The ILO /WHO program target is to promote the advancement of National Programs for the elimination of silicosis to reduce its incidence drastically by 2015, and have silicosis as a public health problem eliminated by 2030.(**Gupta A 1999)[6]**

The Indian National Institute of Occupational Health (NIOH) has undertaken environmental and medical surveys in several industries and found that prevalence of silicosis to be very high concentration of total and respirable dust and great percentage of silica, the free silica levels of between 55%-60% of total dust were

reported at some of the industrial sites[7].In Cement factories workers are exposure to dust in manufacturing section and production sectors. Polish cutting, stone cutting and sculptures are also high prevalence of respiratory illnesses.(**Meo SA, Al-Drees AM 2013)[8].**

The large deposit of silica, clay and sand is found in Bethamcherla, Panyam, Cement Nagar, Malkapuram, Nandavaram villages. Quartzes near Orvakal and Kamarolu villages is high, it contains 99.62% of silica with less iron which is suitable in glass industry. **Napa slabs :-** there are about 650 polishing units at Bethamcherla , Dhone and Kurnool district. The polished slabs of black, white, pink, light green types are being supplied to every nook and corner within the state and also outside. It is a good building stone used for flooring and roofing. Few more polishing units are start at Bethamcherla **,** based on the napaslabs available in and around **Bethamcherla.(according to 2011 census)[9].**

Mosaic chip stone:- at present there are about 40 mosaic chip stone factories situated at **Bethamcherla.** The mining are contributes around 44.89sq.km, quarry area contributes around 92.25sq.km. Total of 286.49sq.km.**(department of mines and geology)[9]**

Pulmonary rehabilitation is a program of exercise, education and support, developed especially for people with occupational workers and shortness of breath. Nutritional counseling to improve their health related quality of life. Prevention and control measures are Exposure monitoring, engineering controls, Medical surveillance, Work practices, Personal protective equipment, and Worker education.(**CDC, Silicosis-1968-2002).[4]**

The radiological patterns of pneumoconiosis have been categorized by the International Labour Organization [ILO] based on size, shape and profusion category. In silicosis, rounded opacities of the 'q' and 'r' type dominate. Radiographic progression is accomplished by increasing ventilator impairment and gas exchange abnormalities, which leads to respiratory failure and eventually to death from intractable hypoxemia.[10-11] The diagnosis of silicosis may require several medical procedures and examinations, including review of medical and occupational history. Review of duration of exposure and occurrence of symptoms, a chest X-ray, a lung function test, and a sputum test **(E.Lombardi, F. Gonçalves, I. Firigato etal 2019[12])** To reduce workers' exposure, it is recommended to establish an industrial hygiene control hierarchy, including engineering control measures (e.g., replacing old machines with new ones, work rotation, and installation of local exhaust ventilation systems), safe work practices, administrative control, and the use of appropriate respirators and personal protective equipment. **(David L Johnson , Margaret Phillips 2017[13]).** Additionally, silica-exposed workers should be instructed to cessation of smoking.

Pranayama mode of action towards the improvement of respiratory system: boosts elasticity and strength of collagen fibers thereby facilitates contraction and power of respiration. Stimulates secretion of pulmonary surfactant which increases exchange volume of lungs. Maintain level of prostaglandins which decreases bronchiolar smooth muscle tonicity leading to the enhanced flow of air into lungs. It is stated that, stimulates stretch receptors which affects smooth muscles and improves lung capacities. Relaxes skeletal muscles and thoracic cage, it also relaxes smooth muscles of bronchi thus boost pulmonary functions.[14-15] Extended expiratory period and voluntary breath holding period improves lungs capacity when these techniques of Pranayama performed regularly. During the process of the study the investigator observed and identified that people were economically poor, an educational level was primary and secondary level, and even they were habituated for doing stone works as well as in cement factories. The source of income was mainly with cement factories,polish cutting stones and cultivation. The workers did not know much about preventive aspects of pulmonary symptoms they were not concentrating of their healthy food habits.

Aim of the Study

To determine the effectiveness of pulmonary rehabilitation by means of spirometry, 6MWT, nutritional counseling and yoga- pranayama on physiological and biochemical parameters among workers occupationally exposed to silica.

Ethical Consideration

The Institute of Ethical Committee of Health Sciences under the Saveetha Institute of Medical and Technical Sciences approved a study (002/09/2022/IEC/SMCH) dated on 14/09/2022.

Methods and Materials

A quantitative approach was used in this study. True experimental pretest and post test research design was chosen for the study to asses the Effectiveness of pulmonary rehabilitation on pulmonary parameters among workers occupationally exposed to silica. Duration of the study: One year (2022-May-2023-April). Inclusion

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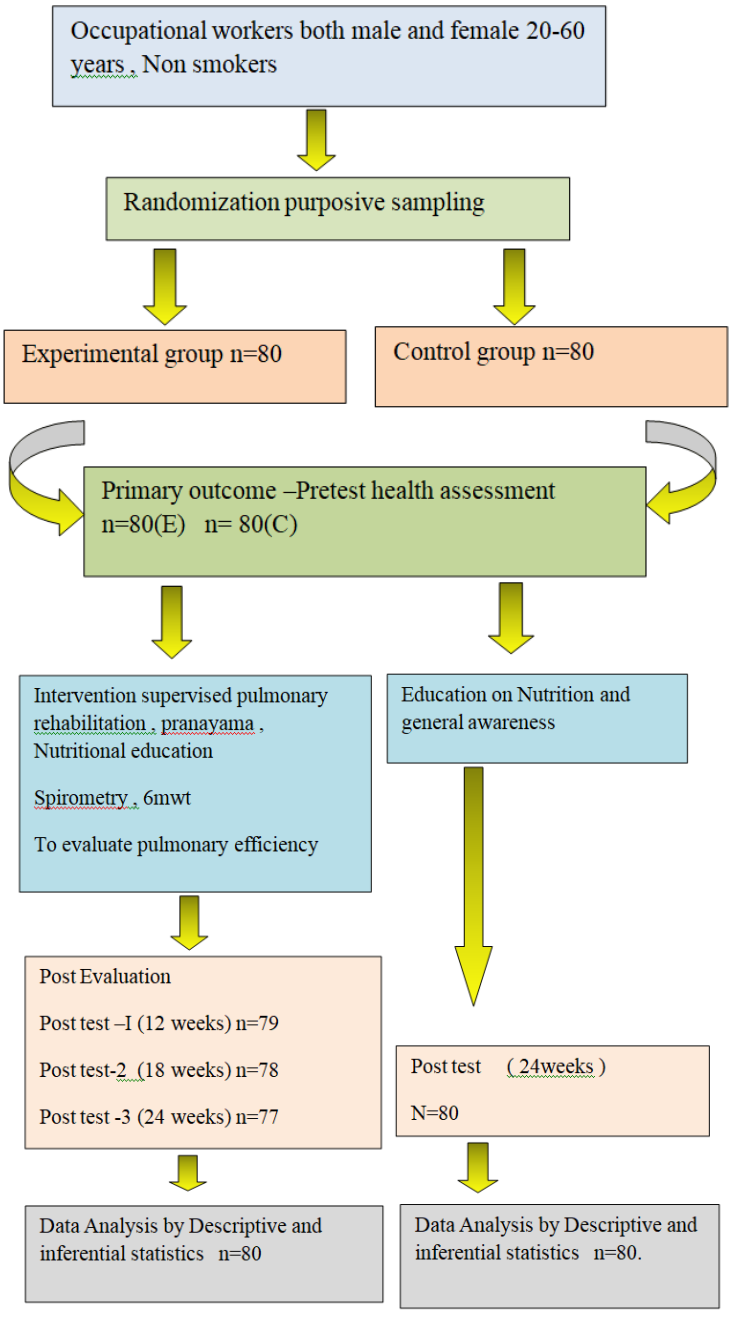
and exclusion criteria:- Occupational workers both male and female, The age group of 20-60 years, Nonsmokers, After exposure to silica asthma, COPD and pulmonary TB were included, Weight loss due occupational exposure more than one year, Working under pressure/stressful conditions, h/o post Covid -19 persons. The study excluded the below < 18 year of age group were excluded, Workers who were undergone past surgical procedures, All systemic diseases and extra pulmonary TB cases excluded, Eg: Unstable cardio vascular disease severe orthopedic or neurologic impairments patients, Known psychiatric illness workers eg: schizophrenia, mood disorders. The sample size was 160 (experimental group 80 and control group80), Convenience sampling technique was done.

Schematic presentation of research plan



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Data Collection Procedure

Investigator was administering spirometry, checking of SPO2, 6MWT, breathing exercises training and nutritional counseling for experimental group. Explain the procedure to the workers who are exposure to silica by a detailed description about the spirometer, 6MWT, Breathing exercises and nutritional counseling, including a reference pamphlet after assessing St. George's Respiratory Questionnaire. (SF-36, SGRQ). Then investigator make sample to do spirometry followed by the investigator will administer 6MWT (exercise tolerance test), breathing exercises (pranayama) which help the sample to increase lung function. Spirometry for 5minuts and 6 minutes for walk test and breathing exercises for 15-20 minutes at the interval of 30 minutes. All these interventions were carried out for 4 days a week for continuation of three months. For the control group, routine care was given followed with same tools.For an experimental group initial checking of vitals temperature, pulse, respiration and systolic and diastolic blood pressure was recorded. After that weight with weighing scale and height with chart used to calculate BMI and recorded. After explanation about collection of blood sample, the investigator has collected and transported to laboratory tests HB%, ESR and RBS. Later results were collected and recorded. Chest X-Ray was done both control and experimental group. Post test was conducted after three months and six months and later one year. The questionnaires were, demographic, clinical parameters,SGRQ and modified mini nutritional scale were used to collect the data with both experimental and control group.

Data analysis

The data was analyzed by descriptive and inferential statistical methods using SPSS statistical package (Systat software inc. San Jose, USA). The demographic and clinical variables were described as frequency and percentage. The effectiveness of intervention within the group was calculated by paired t test, and the effect of intervention between the experimental and control group was compared by unpaired t test. Inferential statistics like t test, Chi square test, ANOVA and repeated measures ANOVA and other relevant statistical techniques.

Results and Discussion

The results revealed that the frequency and percentage distribution of control and experimental groups demographic variable males were 35.0 and 71.2, respectively. The percentage of female in control and experimental groups were 65.0 and 28.8, respectively. It was found to be statistically significant (P < 0.001). Percentage distribution of control an experimental groups demographic variable occupation, polish cutting males and females were 62.50 and 57.50 respectively. Stone cutting workers males and females were 17.50 and 21.25 respectively. Others like filling section, sculptures were 17.50 and 21.25. It was found to be statistically not significant (P < 0.784). Percentage distribution of control and experimental groups demographic variable was education among workers male and female workers primary education was 81.25and 73.75 respectively. The most of the workers were completed secondary education 15.00 and 21.25. graduate/ diploma were very less 3.75 and 5.00 respectively. It was found to be statistically not significant (P =0.523). Consumption of alcohol liquids answered No 95.00 and 73.75 respectively. Yes answered was 5.00 and 26.25 respectively. It was found to be statistically significant (P < 0.001). Table: 1

Table 1: Comparative analysis of baseline demographic and clinical parameters of control (con) and experimental (exp) groups.

S.No.	Variable	Category	Con	Exp	Statistics
1	Gender	Male	28	57	P = <0.001
		Female	52	23	
2.	Occupation	Polish cutting	50	46	P = 0.784
		Stone cutting	14	17	
		Others	16	17	
3.	Education	Primary	65	59	P = 0.523
		Secondary	12	17	
4.	Alcoholic liquids	Yes	4	21	P <0.001
		No	76	59	

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The Mean and SEM of control and experimental groups clinical variables are given in Table 2. The mean age of control and experimental groups were 42.7 and 41.9 (years) respectively. Which was not found to be significant (P = 0.662).Weight (kg) was 55.2 and 56.8.It was not found to be significant (P = 0.0645) body mass index (kg/m2) was 22.42 and 22.86.Which was not found to be significant (P = 0.219). Pulse rate (beats/min) was 85.1 and 89.2.Which was found to be significant (P = 0.0340). Respiratory rate was 19.7 and 19.7. Which was not found to be significant (P = 1.0). SPO2 (%) was 97.1 and 97.8. Which was found to be significant (P = 0.0170). Systolic blood pressure (mm/hg) was 123.0 and 124.5.Which was not found to be significant (P = 0.473). Diastolic blood pressure (mm/hg) was 78.0 and 77.6. It was not found to be significant (P = 0.699). Hemoglobin(g/dl) was 10.1 and 10.8. It was found to be significant (P = 0.002). Erythrocyte sedimentation rate (mm/hr) was 15.4 and 15.9.Which was not found to be significant (P = 0.197). Random blood sugar (mg/dl) was 141.1 and 148.8. It was not found to be significant (P = 0.461) Table 2:

Table 2: Comparative analysis of baseline clinical parameters of control (con) and experimental (exp) groups.

S.No.	Variable	Analysis	Con	Exp	Statistics
1	Age (years)	Mean	42.7	1.3	t = 0.438
		SEM	41.9	1.3	P = 0.662
2	Weight (kg)	Mean	55.2	0.6	t = 1.862
		SEM	56.8	0.6	P = 0.0645
3	Body mass index (kg/m^2)	Mean	22.42	0.24	t = 1.233
		SEM	22.86	0.27	P = 0.219
4	Pulse rate (beats/min)	Mean	85.1	1.2	t = 2.139
		SEM	89.2	1.5	P = 0.0340
5	Respiratory rate(breath/min)	Mean	19.7	0.1	t = 0
		SEM	19.7	0.1	P = 1.0
6	SpO_2 (%)	Mean	97.1	0.2	t = 2.412
		SEM	97.8	0.2	P = 0.0170
7	Systolic blood pressure (mmHg)	Mean	123.0	1.4	t = 0.720
		SEM	124.5	1.6	P = 0.473
8	Diastolic blood pressure (mmHg)	Mean	78.0	0.7	t = 0.387
		SEM	77.6	0.7	P = 0.699
9	Haemoglobin (g/dL)	Mean	10.1	0.2	t = 3.220
		SEM	10.8	0.1	P = 0.0016
10	Erythrocyte sedimentation rate (mm/hr)	Mean	15.4	0.3	t = 1.295
		SEM	15.9	0.2	P = 0.197
11	Random blood sugar (mg/dL)	Mean	141.1	6.5	t = 0.739
		SEM	148.8	8.2	P = 0.461

n – Control = 80; Experimental = 80. SEM = Standard error of mean.
The 't' and 'P' values are by Student's 't' test.

The median and percentiles of SGRQ activity score. The median score of control pre-test and post-test 3 were 35.68 and 41.39, respectively. The median score of experimental pre-test, post-test 1, post-test 2 and post-test 3 were 35.79, 35.56, 35.47 and 29.49, respectively. Kruskal Wallis one-way ANOVA on ranks showed statistical significance (P < 0.001). Within the group comparison of control pre-test and post-test 3, did not showed significance (P = 1.0). Where as the experimental group showed progressive decrease in the median score. Within group comparison of experimental pre-test and post-test 3, showed significance (P = 0.030). However between the group comparison of control and experimental pre-test, did not showed significance (P = 1.0). Between group comparison of control and experimental post-test 3, showed significance (P < 0.001). figure:1

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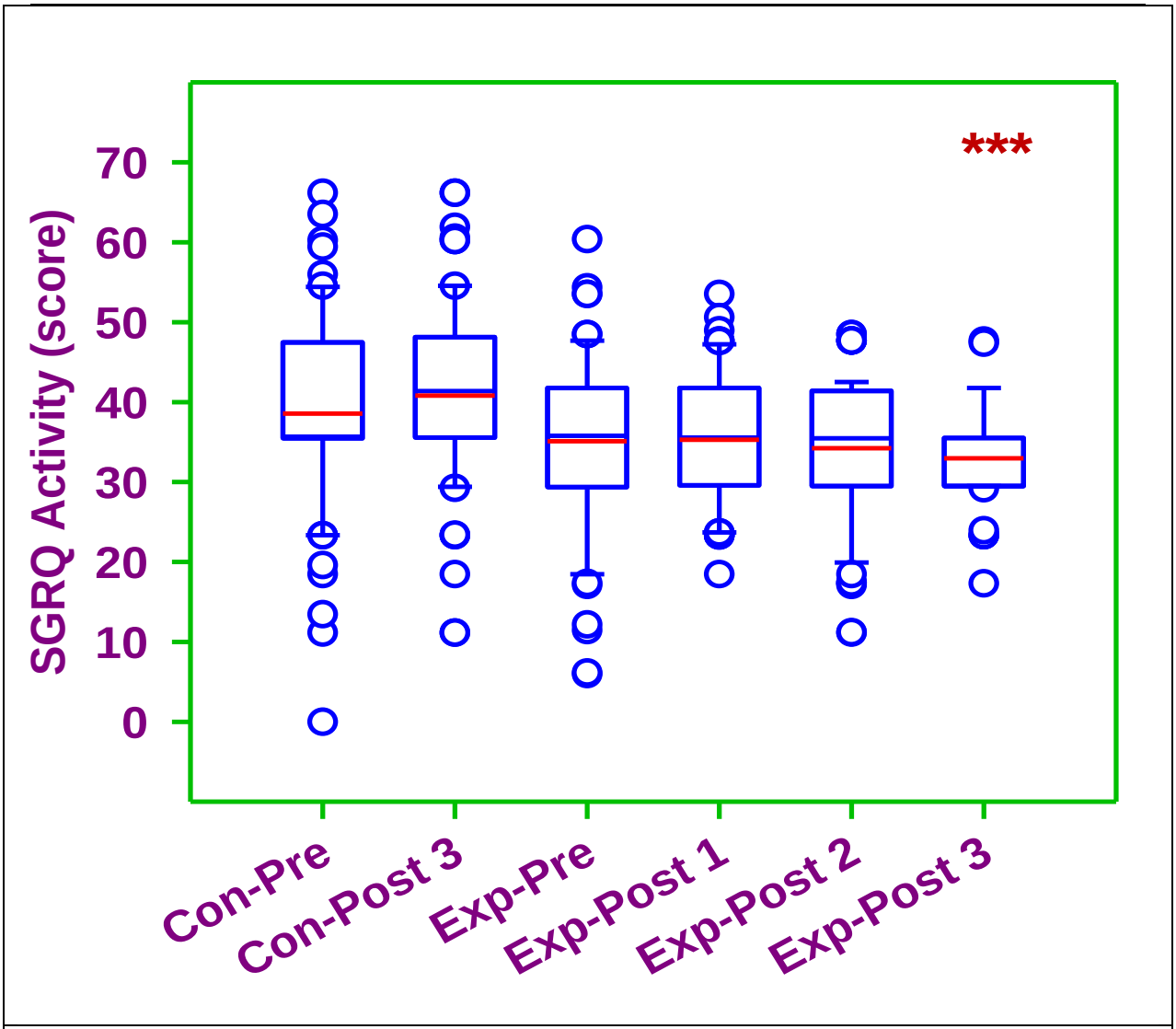

Figure 1: Comparison of expand (SGRQ) activity in control and experimental groups.
n – Control and Experimental, 70 to 80, due to missing values and dropouts.
The middle red line is the mean. The data was analysed by Kruskal Wallis one-way ANOVA on ranks with Dunn's multiple comparisons test.
Statistically significant from the respective pre-test of control or experimental group - *P < 0.05; **P < 0.01; ***P < 0.001).

Discussion

Silicosis is an old occupational disease; it is common major and the most serious of all the pneumoconiosis. Silicosis is a lung disease caused by breathing dust that contains extremely fine particles of crystalline silica. Crystalline Silica is a common mineral found in materials such as sand, quartz, concrete, masonry and rock. **(American Lung Association. Silicosis 2014)[15].** Silicosis is a progressive lung disorder. Pulmonary rehabilitation is method of treatment option to treat the lung infections related to silica dust exposed workers. An experimental pre and post test were done to check the effectiveness of pulmonary rehabilitation and compared with control group with out any intervention. Percentage distribution of control and experimental groups demographic variable males were 35.0 and 71.2, respectively. The highest percentage of males were working and they were exposed to silica particles. **(Prahlad K Sishodiya 2023)[16].** The percentage of female in control and experimental groups were 65.0 and 28.8, respectively. It was found to be statistically significant (P < 0.001). Most of them were working in polish cutting 57.50, whereas comparatively less in others as well stone

cutting works 20.62 and 19.37 respectively. It was found that not to be statistically significant (P < 0.784). Most of the workers were educated up to primary level of education 81.25 and 73.75. Secondary and graduates are less than 15.00, 21.25. Nutritional education, maintenance of adequate caloric intake, iron rich content diet, avoidance of allergenic food items which aggravate the respiratory system.

A quantitative approach was used to compare between control and experimental baseline clinical parameters. The percentage of mean value of age of the workers was 42.66 and 41.86 **(Dutt, K,L.2015)[17].** control and experimental SEM was 1.31 and 1.28 respecively. This was not a statistically significant difference between the input groups (P=0.662). Most of them were young age,they can do hard work comparing with other age groups.[18] The weight of persons in control and experimental workers mean was 55.21 and 56.78. SEM was 0.60 and 0.59 respectively.This was not a statistically significant difference between the input groups (P=0.0 64). most of them were moderate body built fewer were thin and obese. Control and experimental mean of BMI was 22.42 and 22.86. the SEM was 0.24 and 0.27 respecively. This was not a statistically significant difference between the input groups (P=0.219).

Pulse rate comparison between control and experimental groups mean was 85.05 and 89.15. SEM of control and experimental 1.15 and 1.53 respectively. There was a statistically significant difference between the input groups (P=0.034). Percentage of saturation (SPO2) in control and experimental mean value was 97.11 and 98.81. SEM was 0.23 and 0.17 respectively. There was a statistically significant difference between the input groups (P=0.017)[19]. Equal variance test (Brown-Forsythe) indicates that the two samples were from population with equal variance, but does not guarantee the equality or inequality of the two variances. Systolic blood pressure of control and experimental mean was 123.00 and 124.50. SEM was 1.39 and 1.55. There was not a a statistically significant difference between the input groups (P=0.473).diastolic blood pressure mean was 78.00 and 77.62 where as SEM was 0.69 and 0.67. There was not a statistically significant difference between the input groups (P=0.699).Haemoglobin percentage mean of control and experimental group was 10.05 and 1.32, where as SEM was 0.18 and 0.14 respectively. There was a statistically significant difference between the input groups (P=0.002). level of ESR control and experimental mean was 15.43 and 15.92, SEM was 0.29 and 0.23 respectively**.(Hani chanbour, Ahmad Jiblawi-2021)[20].** There was not a statistically significant difference between the input groups (P=0.197).RBS levels was checked for workers unidentified higher sugar values was identified and referred them for treatment. The mean value of control and experimental was 141.10 and 148.80, SEM was 6.48 and 8.15 respectively. There was not a statistically significant difference between the input groups (P=0.461).

SGRQ questionnaire analysis activity score comparison in control pre test and post test median was 35.68 and 41.39. experimental group pre test and post test 1, 2 and 3 tests median 35.79, 35.56, 35.47 and 29.49 respectively. Kruskal Wallis one-way ANOVA on ranks showed statistical significance (P < 0.001). SGRQ impact scores control pre and post test median scores were 28.00 and 30.66. experimental pre and post test 1 2, and 3 median score were 27.49, 30.96, 30.02 and 25.76. There was statistical significance (P < 0.001) **(Jeffery, et. al, 2014)[21]** However, purpose is to assess perceptions of the occupational exposed workers recent respiratory difficulties. Symptoms frequency , severity of the respiratory illness and addresses current state of the worker in cement factory. Prior radio graphic evidence lung function abnormality may present in silica exposed workers. **(WangX et al 1995[22])** The activity score just measures difficulties to patient's daily physical activity. The impact scores covers wide range of difficulties encountered in psycho social aspects of the worker. SGRQ total score of control pre and post test median was 66.42 and 68.46. where as experimental pre test and post test 1,2 and 3 was 64.80,66.05 , 65.15 and 56.69. There was statistical significance (P < 0.001). Breathing exercises (pranayama) **(Rajashree Ranjita 2016[23])** nutritional education helps to improve the functional capacity of the lungs. The effectiveness of intervention showed in figure.**(David A. Kaminsky 2017[24])**.

Conclusion

The results of the study indicates that the cement dust, polish cutting, stone and sculpture workers are exposing to crystalline silica can cause respiratory problems. Chronic exposure can damage the permanent pulmonary function. Pulmonary rehabilitation and exercise tolerance, lung function test has showed significant difference between control and experimental group. SGRQ total score of control pre and post test median was 66.42 and 68.46, where as experimental pre test and post test 1,2 and 3 was 64.80,66.05 , 65.15 and 56.69. There was statistical significance (P < 0.001). Gradual progress of effectiveness was determined in experimental group.

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Conflict of Interest :-
The authors declare there are no conflicts of interest.

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