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TO ASSESS THE PULMONARY FUNCTIONS AMONG GOLDSMITH WORKERS IN CHENNAI: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: India is one of the largest markets for gold, and its growing affluence is driving the demand. Gold has a central role in the country's culture; it's considered a store of value and a symbol of wealth and status, constituting a fundamental part of many customs and rituals. Spirometry is a simple, non-invasive, and standardized procedure to assess respiratory functions in goldsmith workers and compare with the control group. The aim of our study was to evaluate the pulmonary function in goldsmith workers exposed to occupational dust and to compare it with that of non-exposed healthy controls working in jewellery shops, and to find a correlation between respiratory parameters and the duration of exposure. **Materials and Methods:** The sample size was 200. 100 Goldsmith workers and 100 Jewellery shop workers were included in the study, with the inclusion criteria being males in the age group of 20 to 50 years. The pulmonary function test was carried out using the Easy One™ Diagnostic Spirometer. Statistical analysis was done using the Welch two-sample t-test, Pearson's chi-squared test, and Fisher's exact test. **Result:** The basic parameters of age, height, weight, and BMI were matched with those of jewellery shop workers. The lung function parameters FVC, FEV1, and MVV values were significantly reduced in goldsmith workers, whereas the FEV1/FVC ratio was not affected, which indicates a restrictive type of lung impairment. **Conclusion:** Spirometry is a powerful tool that can be used to detect, follow up, and manage goldsmith workers with lung disorders.

INTRODUCTION

India is one of the largest markets for gold, and its growing affluence is driving the demand. Gold has a central role in the country's culture, it's considered a store of value, a symbol of wealth and status, constituting a fundamental part of many customs and rituals. In the Indian population, either urban or rural, a deep affinity for gold goes hand in hand with practical considerations of the portability and security of jewellery as an investment. On occasions, Tamil Nadu's Kanjivaram silk saree is complemented by its traditional gold jewellery. In the evolution of human beings, people, especially males, were occupied in making jewels in various elements depending on economic status. Mostly the jewels are worn by females, however, the jewels are made by goldsmith workers who are found to be only males.

The goldsmith workers making these beautiful ornaments are exposed to various acidic and metallic fumes at work continuously. The occupational hazards reported in goldsmith workers are due to the exposure to various chemicals during jewellery making like sulphuric acid, nitric acid, cadmium, palladium, iridium, cyanide, lead, zinc, and chalk moulds containing high percentages of silica, a little coal dust, rice bran dust, etc.[1] This occupational exposure may lead to multisystem diseases such as anaemia, digestive problems, nervous disorders, memory loss, poor concentration, malignancy [2] and so on. There are a few research works done in various countries [3] but not many studies have been reported on goldsmith workers in Tamil Nadu's jewellery industries evaluating the relation between occupational exposure and respiratory health.

The long years of workplace exposure happen to the goldsmith workers as they start to accompany their parents to learn the techniques and crafting, without the knowledge of using any preventive measures. Spirometry is a simple, non-invasive and

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standardized procedure to assess the respiratory functions in goldsmith workers. It is a portable device that can be carried to the goldsmith workers' place, making them feel more at ease and comfortable in participating our study.

Aim: The aim of our study was to evaluate the pulmonary function in goldsmith workers exposed to occupational dust and to compare with controls without exposure to the metallic with chemical fumes and dusts, as jewellery Shop workers, and to find a correlation between respiratory parameters and the duration of exposure.

MATERIALS AND METHODS

The Institutional Ethics Committee approval was obtained. The study centre was Gold-Silver Jewel making Goldsmith Workers Welfare Association near Chennai Central, and data was stored and analysed in the research laboratory, Institute of Physiology and Experimental Medicine, Madras Medical College, Chennai-3. The duration of the study was from July 2019 to December 2019. The Study design was a cross-sectional observational study with a sample size of 200. 100 Goldsmith workers and 100 Jewellery shop (indoor) workers were included with the inclusion criteria of males in the age group of 20 to 50 years. The goldsmith workers, by profession, working for 10 hours/ day for at least 5 years or more, were selected. Age, BMI-matched healthy controls who were not exposed to any kind of metallic and chemical fumes at their workplaces, as jewellery shop workers, mostly salesmen, supervisors and managers were selected as controls. Subjects with a history of acute or chronic respiratory infections, tuberculosis, cardiovascular diseases, diabetes, hypertension, abdominal or chest surgery, neuromuscular diseases, abnormalities of the spine and any other systemic illnesses, and those with a history of smoking were excluded from the study.

Informed written consent was obtained after explaining the complete procedure. A brief history was taken, and clinical examination of the respiratory system and other systems was done to exclude medical problems and to prevent confounding of results. The study subject's height and weight were taken, and BMI was calculated. Height and weight were measured uniformly on a standardized height scale and weighing machine. The pulmonary function test was carried out using the Easy OneTM Diagnostic Spirometer. To minimize the confounding results due to diurnal variation of tests, the study was carried out uniformly at the Goldsmith Association Office in the forenoon session before lunch and tests were done in accordance with the official statement of the American Thoracic Society on standardization of spirometry. Proper instructions to all the study subjects about the procedure were given clearly in their own language, and they were also well motivated. The tests were performed in the sitting position with a nose clip attached. The subject was asked to hold the mouthpiece between the subject's lips and was asked to breathe in order to familiarize himself with the equipment. On entering the necessary anthropometric data, the software from the recorder and the Medicare system, which was loaded to the computer which commutes the predicted value and also gave the actual value and the percentage predicted value for the individual. The tests were repeated three times after adequate rest, with intervals and the best one was taken for the study. The parameters studied were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Forced Expiratory ratio (FEV1/FVC%) and Maximum Voluntary Ventilation (MVV). All the techniques of measurement, duration, and instruments were maintained uniformly throughout the study.

Statistical Analysis: The data obtained were tabulated, and the results were analysed using SPSS software. It was done by the Welch two-sample t-test, Pearson's chi-squared test, and Fisher's exact test.

RESULTS

There was no significant difference observed in the values of age, height, weight and BMI between the goldsmith workers and jewellery shop workers, as shown in [Table 1]. When compared to jewellery shop workers, the pulmonary function parameters: FVC, FEV1 showed reduced values in a statistically significant way in goldsmith workers, as shown in [Table 2]. FEV1/FVC ratio was not affected, which indicates restrictive type of lung impairment. The MVV values of goldsmith workers were lower than those of jewellery shop workers, with a statistical significance. The goldsmith workers were separated into groups, those who were in their profession continuously for less than 15 years and those who were working for more than 15 years depicted in [Table 3]. The FVC and FEV1 values were reduced in those who were exposed for more than 15 years and the values were very significant. The FEV1 / FVC ratio values were in fact in those exposed for more than 15 years, were also not affected. The MVV values were also reduced in those exposed for more than 15 years, and the values were statistically significant.

Table 1: Demographic characteristics of Goldsmith workers with Jewellery shop workers.

Variables	Goldsmith. workers (n = 100) Mean ± S.D	Jewellery shop workers (n = 100) Mean ± S.D	p value
Age years	50 ±12	48± 10	0.5^{ns}
Height (Meters)	1.63 ± 7	1.64 ± 7	0.7^{ns}

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Weight (Kg)	69.08 ± 13	66 ± 11	0.6 ^{ns}
BMI(Kg/m2)	25.9 ± 4.4	23.9 ± 3.98	0.56^{ns}

ns – not statistically significant

Table 2: Comparison of Spiro metric parameters among Goldsmith workers with Jewellery shop workers.

Study parameters	Goldsmith Workers (n = 100) Mean ± S.D	Jewllery Shop Workers (n = 100) Mean ± S.D	p Value
FVC (L)	3.21 ± 1.16	4.71 ± 0.77	<0.001*
FEV1 (L)	2.66 ± 0.92	3.74 ± 0.53	<0.001*
FEV1/FVC ratio	0.85 ± 0.18	0.80 ± 0.07	0.025
MVV (L/min)	81.20 ± 25	113.10 ± 25.50	<0.001*

<0.001* - Very Significant, ns - not significant

Table 3: Comparison of Spiro metric Parameters between the groups of Goldsmith workers based on duration of exposure

Study parameters	Duration of Exposure <15years (n=39) Mean ± S.D	Duration of exposure >15years (n = 61) Mean ± S.D	pvalue
FVC (L)	4.26 ±1.1	3.3 ± 1.30	<0.001*
FEV1 (L)	3.44 ± 0.83	2.70 ± 0.91	<0.001*
FEV1/FVC ratio	0.82 ± 0.11	0.84±0.18	0.3^{ns}
MVV (L/min)	104 ± 29	83 ± 24	<0.001*

<0.001* - Very Significant

Table 4: Distribution of type of inference: Obstructive/restrictive generated from the spirometer machine among both study groups.

Inference generated in the spirometer on study subjects(n=200)		
TYPE	**Duration of Exposure <15years (n=136)**	**Duration of Exposure >15years (n = 64)**
Mild Obstruction	1 (0.7%)	3 (4.7%)
Moderate Obstruction	2 (1.5%)	2 (3.1%)
Normal	33 (24%)	37 (58%)
Restrictive	91 (67%)	13 (20%)
Severe Obstruction	8 (5.9%)	7 (11%)
Very Severe Obstruction	1 (0.7%)	2 (3.1%)

Table 5: Distribution of type of inference: Obstructive/restrictive generated from the spirometer machine among Goldsmith workers.

Inference generated in the spirometer on Goldsmith workers(n=100)		
TYPE	**Duration of Exposure <15years (n=39)**	**Duration of Exposure >15years (n = 61)**
Mild Obstruction	1(2.6%)	3(4.9%)
Moderate Obstruction	2(5.1%)	2(3.3%)
Normal	11(28%)	15(57%)
Restrictive	36(41%)	12(20%)
Severe Obstruction	8(21%)	7(11%)
Very Severe Obstruction	1(2.6%)	2(3.3%)

In [Table 4 and 5], the inference shown in the Easy OneTM Diagnostic Spirometer is tabulated for both the study groups, the goldsmith workers and jewellery shop workers followed by a table with the goldsmith workers only. The inference showed majority of restrictive pattern among the study groups.

DISCUSSION

In our pulmonary function study, we recorded the following parameters: FVC, FEV1, FEV1/FVC ratio, and MVV of 100 goldsmith workers and compared the values with the age, height, weight, and BMI-matched 100 jewellery shop workers. All the pulmonary function parameters were reduced and statistically significant in the goldsmith workers as compared to 100 jewellery shop workers, except FEV1/FVC Ratio. The study subjects with chronic restrictive lung diseases have normal FEV1/FVC ratio with proportionate reduction in FVC and FEV1. FVC, FEV1 and FEV1/FVC ratio are reliable indices of ventilatory capacity and help to distinguish between restrictive and obstructive ventilatory defects. A reduced FVC and FEV1 indicate a restrictive pattern of pulmonary impairment in goldsmith workers. The maximal voluntary ventilation (MVV) maneuver is another test that can be used to confirm obstructive and restrictive conditions. MVV is also reduced to support a type of respiratory impairment in goldsmith workers.

When very fine metallic or mineral dust particles are breathed in, they reach deep into the lungs, escaping the lung mucociliary defense escalator, and finally cannot be cleared. As time passes from years to decades, this accumulation leads to inflammatory reactions inside the lung parenchyma and leads to scarring or fibrosis. The nylon stockings arrangement specializes in the compliant lung working wonderfully, but stiff lung tissue makes it harder to fully expand the chest and recoil back smoothly, leading to restrictive lung diseases.

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The type of occupational lung disease varies according to the nature of inhaled dusts and fumes. Some dusts are inert, causing no reaction and damage at all, while others cause immunologic damage and predispose to various infections like tuberculosis or may even lead to neoplasia in lung tissues.[4] The factors that determine the extent of damage caused by inhaled dusts depends on size, shape, solubility, physiochemical composition and the quantity of dust, especially retained in the lungs indirectly linked to the long years of exposure. The additional factors acting as irritants to them might be smoking, tobacco and host factors such as the efficiency of individuals' clearance mechanisms and the immune status of the goldsmith worker also.

There are various kinds of jobs among goldsmith workers, such as wax model making/ casting, moulding, polishing, gemstone cutting and setting, gold or silver melting and jewel making. But all are invariably, continuously inhaling the finer metallic dust particles and fumes as their working places are small cubicles in a building with no sufficient ventilation.

The exposure to nitric acid vapours and nitrogen oxides can damage the mucosa of the respiratory tract, causing pneumonitis and chronic bronchitis.[5] Another study by Beltrami V et al,[6] has reported occupational asthma in goldsmith workers. A study by Sakurai H et al,[7] has reported that the percentage of the predicted function values of the highly exposed workers to cadmium was significantly deteriorated for FVC, FEV1, PEFR, and respiratory impedance, whereas those of the slightly exposed workers were reduced only for FVC and FEV1. Bodo M et al,[8] have reported in their study in relation to silicosis in gold jewellery workers that each silica sample promoted a profibrotic lung microenvironment in a different manner and also elicited different Fibroblast Growth Factor-2 signalling pathways. Their data confirmed that different micro-morphology of silica particles affects the fibrogenic potential and the molecular mechanisms of dust pathogenicity.[9]

There is a metal fume fever also termed as “Monday Morning Fever”, because of the recurrence of acute disease on return to exposure following a short period of absence. There is an association between metal fumes fever on the later development of occupational asthma. The pathobiology is due to increase in pro-inflammatory cytokine activity in the lung as evidenced by an increase in broncho alveolar lavage fluid concentration of Tumour Necrosis Factor, interleukin -6 and interleukin-8. Soluble transition metal particles generate reactive oxygen species and deplete glutathione stores that are responsible for fume cytotoxicity.[10]

The interstitial lung diseases with predominant fibrosis caused by inorganic metallic fumes and some metal dusts cause predominant granulomatous reactions of the lungs.[11] The occupational asthma may be sensitizer induced caused by an identified underlying immunologic mechanism, or irritant induced asthma caused by an exposure agent not considered to be sensitizing.[12,13]

Another pathophysiology might be the concept of ‘DYSANAPSIS’ which means disproportionate size or growth of the airways in comparison with the lung parenchyma. The people with dysanapsis are at increased risk of chronic obstructive pulmonary disease (COPD) regardless of their smoking habits. Disproportionate growth of the airway and lung parenchyma affects the proportion of FVC, FEV1 that is air expired per unit time, and an apparent reduction in this flow. Dysanapsis (as measured by the FEF25-75%/FVC ratio) has been found to be associated with airway hyper-responsiveness (AHR) and atopy. By this association, it was proposed that dysanapsis could have a role in the pathogenesis of restrictive disease, such as interstitial lung disease and also obstruction in someway as chronic obstructive pulmonary disease, in goldsmith workers affected on exposure to metallic fumes and minute particles.

The central area in Chennai is crowded without factories or machineries but has air pollution, which increases the risk of asthma.[14,15] The long-term exposure to NOx and SOx leads to bronchitis, asthma, pulmonary oedema and respiratory mucosal injury, sometimes fulminant poisoning. Goldsmith workers traditionally blended gold with 8% cadmium to create a low-melting-point solder paste used to join delicate and finer parts of gold jewellery. When this happens at higher temperature, during soldering or brazing, cadmium releases highly toxic, carcinogenic fumes. Hence goldsmith workers inhaling these fumes frequently suffered chronic respiratory diseases, acute lung injury, and kidney complications.[16]

Pulmonary function tests in goldsmith workers who had worked for more than 15 years were more affected than those who had worked for less than 15 years. The decrease in pulmonary function in goldsmith workers is most probably due to continuous occupational exposure to air pollutants, which harm respiratory functions. Long-term exposure leads to accumulation of metals in body tissues such as hair, bones and toxic effects on other organs as the kidneys.remove reference

This current study provides valuable information of understanding the adverse effects of inhaled pollutants from the working environment on lung function. Goldsmith workers are at high risk to the effects of exposure to metallic fumes and finer metallic dusts when compared to jewellery shop workers who are mostly salesmen, front desk workers, supervisors and managers.

Limitations of the study: This study can lay a platform for a cross-sectional study with a large sample in future. The quality of air can be checked in the future follow-up studies planned.

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CONCLUSION

The dust exposure is a modifiable risk factor that can be controlled to reduce the morbidity of respiratory problems among goldsmith workers. The following preventive measures can be suggested and implemented for the working goldsmith workers currently, such as having a local window exhaust, suitable masks and goggles designed for their profession economically and regular periodic health check-ups with awareness about their health measures. If possible, the air quality of their workplace may be measured at regular intervals.

Dysanapsis is believed to arise early in life. Understanding the biological basis of dysanapsis may one day lead to early life interventions to promote healthy and resilient lung development.[17-22]

Spirometry is a powerful tool that can be used to detect, follow, and manage workers with lung disorders. Technology advancements have made spirometry much more reliable and relatively simple to incorporate into a routine workplace visit.

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