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# CHRONIC EFFECT OF WELDING FUMES ON RESPIRATORY SYSTEM OF WELDERS, KOLKATA: A COMPARATIVE STUDY

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## ABSTRACT

**Background:** Welding is a precise, reliable, cost-effective, and high-tech method for joining materials in manufacturing industries. Occupationally welding is a kind of profession which requires extreme caution about safety and health management. **Objectives:** To detect the chronic effects of Arc-welding fumes on pulmonary function; to quantify specific damage profile of arc-welders in comparison to control counterpart and recommend some preventive measures to avoid the prevalence of the chronic lungs diseases and use of personal protective equipment to reduce the inhalation. **Material & Methods:** This comparative study was conducted amongst 96 subjects, where n=51 non-smoker welder subjects assigned as experimental group, whereas n=45 non-labour smoker subjects assigned as control group. All general physical parameters, physiological, metabolic and dynamic pulmonary parameters were performed between experimental & control groups by standardised procedure. **Result:** Experimental group showed high blood pressure and COHb% level. The values of all the lung function parameters individual non-smoker welder subjects were found to be lower as compared to those of the non-labour smoker subjects. **Conclusion:** Due to direct and repetitive exposure to chemical substances in daily welding, there was a deterioration of the lung function among the experimental group compare to smokers, who inhale 9-12 cigarette per week. Daily inhalation of tobacco is also hazardous for health. It required wearing musk during working time. Results further indicated that control group were less inhale chemical substances.

**KEYWORDS:** Welder, smoker, COHb%, lung disorder, personal protective equipment.

## INTRODUCTION

Welding is a precise, reliable, cost-effective, and high-tech method for joining materials in manufacturing industries. In fact, no other technique is so widely used by manufacturers, in India, to join metals and alloys efficiently to add value to their products. Most of the familiar objects in modern society, right from buildings and bridges, to vehicles and medical devices, could not be made without the use of welding. Occupationally welding is a kind of profession which requires extreme caution about safety and health management.[1]

The International Standard Classification of Occupations (ISCO) defines welders and flame cutters as welding and cutting metal parts using gas flame, electric arc and other sources of heat to melt and cut, or to melt and fuse metal. Welders are employed in average numbers of 3 to 5 in private owned small-scale workshops. As they come

under the unorganized sector, safety precautions are not strictly implemented. Some of the commonly seen injuries are eye injuries like arc eye or flash burns to cornea, photo keratosis, astigmatism, pingecula, cataract and retinal damage due to exposure to excessive light and ultra violet rays and foreign body injuries to cornea. Inhalation of metal fume causes metal fume fever and pneumonia due to exposure to noxious fumes of zinc, copper, cobalt, nickel, chromium, platinum and their oxides. Other injuries that include accidental cut injuries, amputations; occupational heat stress, thermal burns, electrocution are also common among welders. The fume given off by welding and hot cutting processes is a varied mix of airborne gases and very fine particles which, if inhaled, can cause severe health problems. Harmful gases that may be present in the fume include nitrous oxide ($N_2O$), carbon dioxide ($CO_2$), carbon monoxide (CO), argon (Ar), helium (He) and ozone ($O_3$). Four of the leading occupational health hazards in welding are respiratory problems, vibration issues, noise-related problems and musculoskeletal disorders (MSD).[2] One of the most common processes electric arc welding is performed with hand held electrodes coated with suitable slag forming flux to protect the arc. The high temperature of the process heats both the base metal pieces to be joined and the filler metal from a consumable electrode or wire, which is fed into the weld. Molten fluxes from the consumable electrodes carry away impurities in a liquid form; and when heated consumable electrodes generate a shielding gas to protect the weld from oxidation. Fluxes are commonly a major source of inhalation exposures.

The adverse health effects of welding come from chemical, physical, and radiation hazards. Common chemical hazards include particulates i.e. lead, nickel, zinc, iron oxide, copper, cadmium, fluorides, manganese, chromium and gases i.e. carbon monoxide, oxides of nitrogen, ozone. Each welding technique and application produces a characteristic range of particulate composition and morphology.[3] Some constituents of welding fume are potentially harmful and there has been increasing concern that even low concentrations could result in an increased frequency of chronic bronchitis and emphysema. Some studies suggest respiratory outcomes include metal fume fever, siderosis, lobar pneumonia and less definitively lung cancer and asthma; although some studies have shown an increased prevalence of chronic bronchitis in welders.[4]

In Kolkata most of the welding works are done by labourers of unorganized sectors. Accordingly they are not well equipped and not aware of their safety either. They are totally ignorant about the personal protective equipments. Seldom have they used gloves and accordingly they are prone to huge kinds of disorders. Under this circumstances this study has been taken up with pulmonary hazards assessment of welders of Kolkata which can be properly done and frontiers of damage profile would emerge accordingly.

## OBJECTIVES

Under these circumstances the study aims to fulfil the following purposes

- To detect the chronic effects of Arc-welding fumes on pulmonary function.
- To quantify specific damage profile of arc-welders in comparison to control counterpart.
- Recommend some preventive measures to avoid the prevalence of the chronic lungs diseases and use of personal protective equipment to reduce the inhalation.

## MATERIAL AND METHODS

### *Sample for the study*

The comparative study was carried out on the arc-welders of Kolkata with comparison to smokers. The study sample was selected randomly from the welding plants. The study sample consists of manual metal arc welding workers of respective area. The samples comprised of 51 non-smoker arc-welders and 45 non-welder smokers (n= 96). 96 subjects were divided into two groups, 51 subjects were randomly assigned for experimental group with at least five years of welding work experience but completely non-smoker whereas in Control group, 45 samples, who are not involved in labour work and not exposed to toxic fumes during work but do smoke maximum 9-12 cigarette per week were taken into account.

The subjects belonged to same socio-economic status. Ethical clearance was procured from Institutional Ethics Committee (IEC-H) from Hooghly Mohsin College, Govt of West Bengal.

### *Inclusion criteria*

- Healthy adults in age group of between 30 to 35 years
- Willing to actively participate in the study

### *Exclusion criteria*

- Subjects with prior history of lungs diseases
- Experimental subjects with history of smoking
- Subjects with chronic illness

All the following parameters were assessed.

**Table 1: Assessments of different Dynamic Anthropometric and Physiological parameters.**

| Serial no | Parameters assessed | Testing method |
|---|---|---|
| 1. | Age | Questionnaire method |
| 2. | Height | Anthropometric rod |
| 3. | Weight | Weighing machine |
| 4. | Body Mass Index (BMI) | Calculated by the formula(height/weight2) |
| 5. | Blood pressure | Sphygmomanometer |
| 6. | Pulse pressure | Systolic BP-Diastolic BP |
| 7. | Resting Heart Rate | Stop watch |

**Table 2: Assessments of Different Dynamic Performance Parameters.**

| Serial no | Parameters assessed | Testing method |
|---|---|---|
| 1. | Carboxy-Hb | Micro CO monitor |
| 2. | Force Vital Capacity | German make 28 channel computerized Chest graph Machine |
| 3. | Slow Vital Capacity | |
| 4. | Forced Expiratory Volume in first sec | |
| 5. | Maximum Voluntary Ventilation | |
| 6. | FEV1/FVC | |
| 7. | FEV1/SVC | |
| 8. | Peak Expiratory Flow Rate | |

***Statistical Analyses***

Statistical analyses were done by Minitab 16 software. Quantitative variables were expressed as mean±SD. Paired t tests were performed to evaluate the overall cumulative effects when treatment effects were significant. P-values<0.05 were considered to be significant.

**RESULTS**

There are approximately 20-30% of labors involved in different welding working area. The workers routinely and repeatedly exposes to different chemicals, gases, fumes etc and light glare. In this portion of this study, the observations were presented.

The mean age of both groups was 33years. Both groups had insignificant anthropometric value like height, weight; B.M.I. But the present study revealed that different lung functions parameters like FVC (Force Vital capacity), SVC (Slow Vital capacity), FEV1 (Forced Expiratory Volume in the first second), FEV1/FVC ratio, FEV1/SVC ratio, PEFR (peak expiratory flow rate) and MVV (maximum voluntary ventilation) along with blood pressure values have significant difference in experimental group (Non-smoker Welder) than control group (Non-Welder Smoker)($p<0.05$).

**Table 3: Representation of different Anthropometric and Physiological parameters of Experimental & control group.**

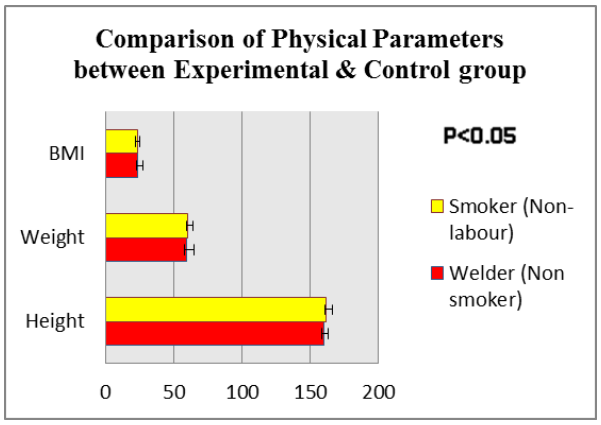
| Parameters | Experimental and Control group | | | | p- value (<0.05) |
|---|---|---|---|---|---|
| | *Mean values* | *SD* | *Mean values* | *SD* | |
| *Height (cm)* | 159.67 | 3.50 | 161.33 | 4.76 | 0.132 |
| *Weight (kg)* | 59.17 | 5.33 | 60.10 | 4.19 | 0.108 |
| *BMI(kg/m2)* | 23.47 | 3.74 | 23.19 | 1.85 | 0.10 |
| *Systolic Blood Pressure (mmHg)* | 134.00 | 5.4 | 128.00 | 3.8 | **0.002*** |
| *Diastolic Blood Pressure (mmHg)* | 94.00 | 2.5 | 86 | 4.2 | **0.039*** |
| *Pulse Pressure (mmHg)* | 40.00 | 3.37 | 42.00 | 3.1 | 0.37 |

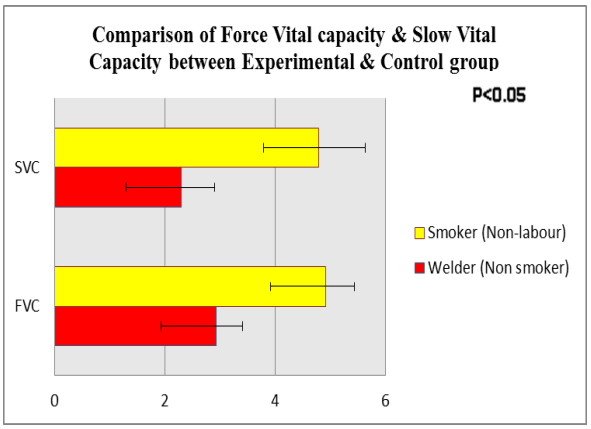
*= Significant

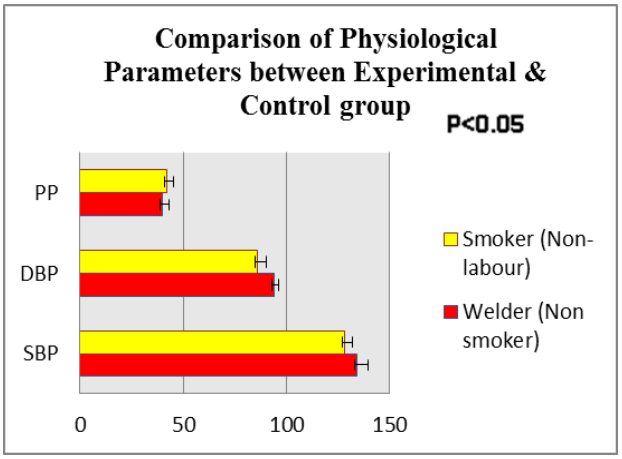
**Table 4: Representation of metabolic & different dynamic pulmonary parameters of Experimental & control group.**

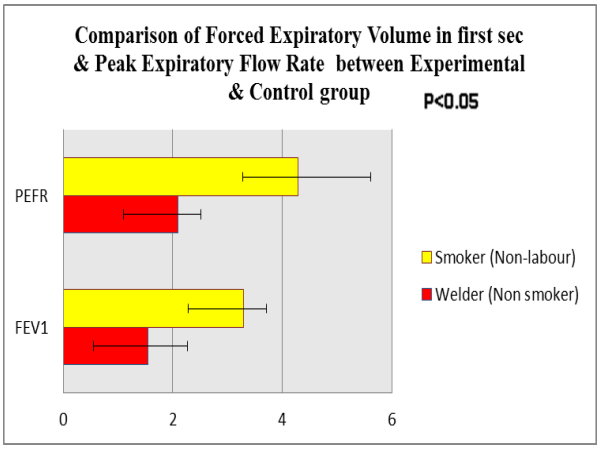
| Parameters | Experimental and Control group | | | | p- value(<0.05) |
|---|---|---|---|---|---|
| | *Mean* | $S_D$ | *Mean* | $S_D$ | |
| *Carboxy-Hb (%)* | 0.858 | 0.129 | 0.225 | 0.012 | **0.001*** |
| *Force Vital Capacity (Lit)* | 2.923 | 0.48 | 4.92 | 0.52 | **0.007*** |
| *Slow Vital capacity (Lit)* | 2.301 | 0.6 | 4.79 | 0.85 | **0.005*** |
| *Forced Expiratory Volume in first sec (Lit/sec)* | 1.552 | 0.72 | 3.29 | 0.416 | **0.002*** |
| *Maximum Voluntary Ventilation (Lit/min)* | 67.6 | 2.8 | 111.96 | 6.7 | **0.011*** |
| *FEV1/FVC* | 0.992 | 0.172 | 0.8433 | 0.52 | **0.001*** |
| *FEV1/SVC* | 0.913 | 2.92 | 0.762 | 2.96 | **0.005*** |
| *Peak Expiratory Flow Rate (L/s)* | 2.00 | 1.16 | 4.28 | 1.34 | **0.002*** |

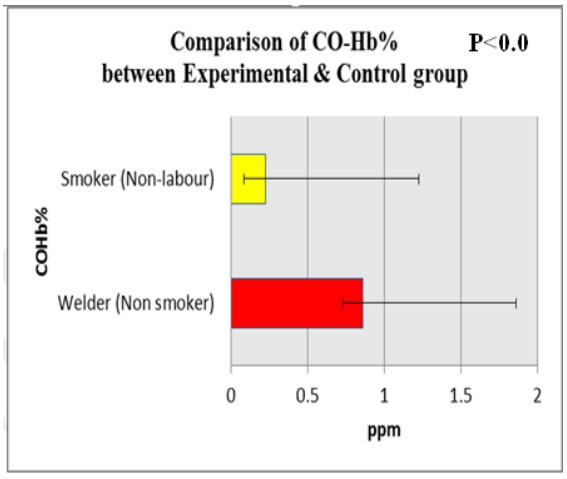
*= Significant

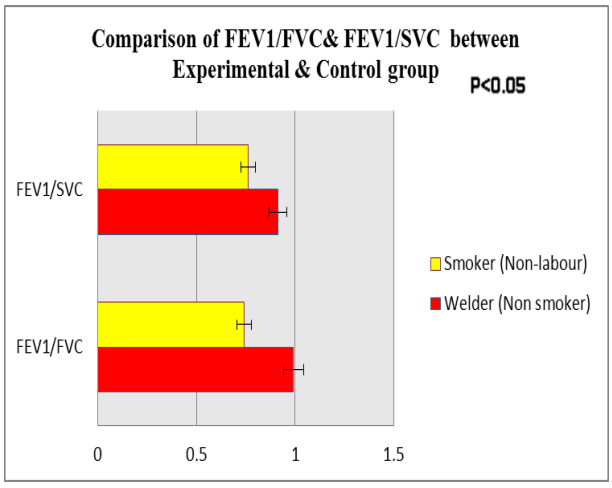


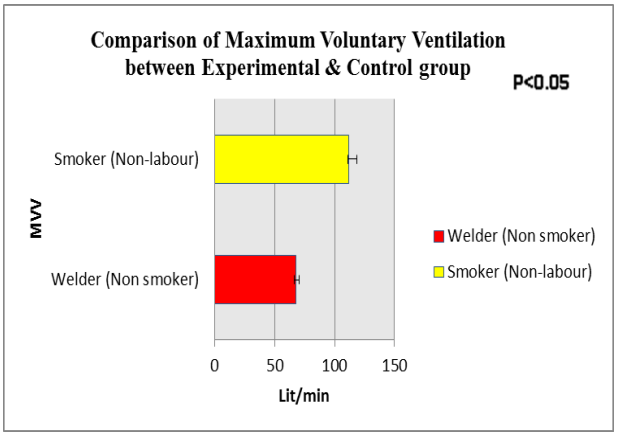






## DISCUSSION

Welding has been around for centuries and is a common industrial process. With these new methods and techniques, welding has left the confines of industrial settings and can now be done practically anywhere. Hazards that have both acute and long-term chronic effects are welding fume/ dusts, toxic gases and radiation. Fumes are solid particles that originate from welding consumables, the base metal and any coatings present on the base metal. In welding, the intense heat of the arc or flame vaporizes the base metal and/or electrode coating. This vaporized metal condenses into tiny particles called fumes that can be inhaled. Toxic gases also are produced from welding processes which include nitric oxide, nitrogen dioxide, carbon monoxide and ozone. Factor such as chemical (toxic gas, fumes), physical (radiation, flammability, reactivity), and biological (carcinogenetic, toxicity), are closely to characterize the welding exposure.[5] The present comparative study investigates that, is welding fumes more dangerous than often smoking habits?

It revealed that 80% of welders were unequipped, at least in this part of the world. From earlier studies it appears that due to unequipped condition, they are suffering from different physical hazards. As a result of highly stressful physical activities in untoward workplace conditions these workers are compelled to suffer additional burden of occupational hazards. Earlier studies confirmed that the welders suffering from different body part discomfort, probably as manifested occupational hazard. This study further confirms that welders are suffering from lung related discomfort than non-labour smoker who has been smoking 9-12 cigarette per week. This is probably one of the unique studies where classified groups are not performing same work culture but share same type of physical hazards have been taken into account in Kolkata.

A primary observation of our result showed that the experimental group and control group had comparable physique, as evident from their mean height, weight, BMI index. In this study, it was found that, systolic blood pressure and diastolic blood pressure showed significantly higher values in experimental group than control group. These differences are probably due to strenuous physical activity without proper rest cycle with unorganised workstation. In spite of all physical parameters amongst two classes of workers showed insignificant data, different lung function parameters were found to be significantly lower in welder group as compared to those of the smoker group. Occupational, environmental, social stress and lack of awareness cumulatively resulted in such deterioration in lung function status of subjects. Due to repetitive exposure to fumes, dust particle and SPM, respiratory health of workers showed gradual deterioration.

Repetitive exposure to silica, mica, iron, magnesium and other chemical substances causes poor lung functions. Continue exposure to these chemical substances for 5 to 10 years, it blocks movement of air in and out of lungs. Dust deposits in the lungs, damages lung tissue, and causes scarring. Lungs become inflamed and filled with fluid, causing severe shortness of breath and low blood oxygen. Ultimately this leads to development of Chronic Obstructive Pulmonary Disease (COPD), Bronchitis, emphysema, silicosis.[6]

Although these subjects are non-smokers, probably due to continuous exposure to dust, fumes etc; significantly elevated level of COHb% and increased value of expired CO content. Resulted Carboxy-haemoglobin (COHb) is a stable complex of carbon monoxide that forms within red blood cells when carbon monoxide is inhaled. COHb% is useful in examining the treatment of carbon monoxide poisoning in blood. The reference range of COHb for smokers is up to 10-15% and non-smoker up to 3%. But, here it found that non-smoker welder showed elevated level of COHb% than limited tobacco inhalers. From that point, it could be understood that welding fumes contains much dangerous partials that a cigarette have and continues exposure to that fumes may leads to high COHb% in blood. COHb levels generally increase as a result of hemolysis.[7]

Smoking habits seem to be a factor of importance to the occurrence of respiratory symptoms. Inhaled tobacco smoke moves from the mouth through the upper airway, ultimately reaching the alveoli. As the smoke moves more deeply into the respiratory tract, more soluble gases are adsorbed and particles are deposited in the airways and alveoli. The substantial doses of carcinogens and toxins delivered to these sites place smokers at risk for malignant and non-malignant diseases involving all components of the respiratory tract including the mouth. The dose of inhaled toxic particles and gases received from each of these cigarettes varies depending on the nature of the tobacco, the volume and number of puffs of smoke drawn from the cigarette, the amount of air drawn in through ventilation holes as the smoke is inhaled, and local characteristics within the lung that determine the diffusion of toxic gases and the deposition of particles. Because of this repetitive and sustained injurious stimulus, the repair and remodel process that heals the

damaged lung tissue takes place at the same time the lung's defences continue to deal with this unrelenting inhalation injury.[8]

In this study, it was found and indicates that welding fume inhale is more dangerous than limited tobacco smoking & it leads to lung cancer in near future. There is no provision of pre-employment and periodic medical examination for these workers and none of the workers had social security such as health insurance. Welding workers should use respiratory protective equipment during their work time.

In summary, in this study examined the continuous exposure to welding fumes is more dangerous than a cigarette smoking. The finding suggests that association of welding fumes causes increased risk of pulmonary severe diseases in near future, but a longitudinal study with a larger number of subjects is needed to confirm any causal association.

## CONCLUSION

The study concludes that due to continued welding toxic fumes exposure welders are highly affected in their lung functions. Dynamic lung function parametric changes among non-smoker welders showed a peculiar indication representing some of the vivid characteristics of both obstructive pulmonary disorders as well as restrictive pulmonary diseases, in comparison to their non-labour smoker counterpart. Thus, emerging multiple respiratory disorders amongst welders of Kolkata is found to be a unique characteristic of occupational hazard. Practice of recommended industrial hygiene ensures that proper engineering control may be used to reduce work stress to a permissible limit. Proper personal protective equipments (PPE) like masks may be used during their working time.

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