PULMONARY FUNCTIONS IN RELATION TO WELDING PROCESSES AND MATERIALS

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The relation between pulmonary function indices (VC, FEV%, MEF 50, MEF 25, RV/TLC%, Raw) and welding processes and materials has been investigated in 489 welders in a heavy engineering (fabrication) industry. The welding processes studied were Manual Metal Arc (MMA) welding, gas metal arc (CO2) welding and Tungsten inert Gas (TIG) welding. The materials studied were carbon steel, alloy steel and stainless steel. No statistically significant differences were observed in any of the pulmonary function indices either across processes or across mat erials. With a proper understanding of the charteristics of the welding processes and hygeinic monitoring of the work environment, welder protection against fume is assured.

INTRODUCTION

In welding processes, respirable particles and irritant gases are emitted which may affect the respiratory tract. Numerous cross sectional studies of the respiratory functions of welders have been conducted. Lyngenb et al (1) found that welders had significantly reduced values (of VC, FVC, TLC, PEF) than the control group but some of the lung function parameters were not significantly different. Hunnicutt et al (2) also showed that arc welders had reduced Peak Expiratory flow rates, reduced FEF(25- 75), together with reduction in FEV1. the differences were statistically significant for smokers.

The principal effects of respirable particles and absorbed gases or free gases in welding fume appear to be on the small airways or terminal bronchioles. The changes seem to be more pronounced in those who smoke (3). It has therefore been suggested by Kalliomaki et al (4) that the application of flow-volume curves and/or other measures of peripheral airway ventilation might be more justified in the case of welders then the use of conventional spirometric indices (VC, FEVI, FEV%).

Only few studies (5) have differentiated between different welding processes, while none have considered the effects of different welded materials.

A study of 412 welders in our industry (6) did not find any significant differences between spirometric indices (VC,FVC,FEVI) as percentages of the predicted values. No significant differences could be observed in these indices among welders in different welding processes between smoking and non-smoking welders, and also over a five-year follow-up period.

Objectives

The present study was carried out with the following objectives :

i) To investigate the relation between pulmonary function indices and (a) different welding processes and (b) different materials welded

ii) To evaluate the pulmonary function of the welders using tests of small-airway ventilation (flow-volume curves, RV/TLC%).

Material

The study was conducted on 489 welders of height 163.0 + 5.99 cm (mean + SD), weight 60.9 + 8.45 kg and age 37.4 + 35.5 years, who were free from respiratory diseases. There were 305 (62.4%) non-smokers and 184 (37.6%) smokers and ex-smokers in this group.

The welders were segregated into different groups, process-wise (those doing only MMA welding, TIG welding, CO_2 welding) and material-wise (carbon steel, alloy steel, stainless steel).

Methods

The following pulmonary function indices were measured, using a whole body plethysmograph (E.Jaeger) :

Vital Capacity (VC) as a percentage of the predicted VC, based on regression equations developed in our laboratory for an identical control populations developed in our laboratory for an indentical control population. (Normal = 80% and above)

Forced Expiratory Volume (FEV) in 1.0 sec as a percentage of the Forced Vital Capacity (FVC). (Normal = 80% and above)

Maximum Expiratory Flow Rate (MEF) at 50% of the FVC, expressed as a ratio of the predicted VC. Airflow at this point is relatively effort independent. The ratio MEF 50/VCpred is related to lung elasticity. (Normal = 0.8 - 1.4).

MEF at 25% of the FVC remaining in the lungs, expressed as a ratio of predicted VC, which is an indicator of peripheral airway ventilation. (Normal = 0.35 and above)

Residual Volume as a percentage of the Total Lung Capacity (RV/TLC%), which is an indicator of small airway obstruction. (Normal = 22-35%)

Airway Resistance (Raw) predominatly reflects the condition of the large airways, and is sensitive to irritant inhalation.

(Normal = 0.2 - 2.5 cm H_2O / 1/sec)

Table I : PULMONARY FUNCTION INDICES IN RELATION TO WELDING PROCESS

(Mean ± SD)

Process	n		VC %VCpred	FEV%	MEF50 /V Cpred	MEF25 /VCpred	RV/TLC %	Raw $cmH_2O/1/sec$
MMa	181		100.5	82.4	1.09	0.38	30.4	1.44
			11.07	6.15	0.343	0.135	6.34	0.587
TIG	26		100.3	81.8	1.13	0.38	29.6	1.45
			11.44	5.42	0.310	1.126	5.97	0.552
CO2	24		104.6	81.8	1.02	0.35	30.4	1.45
			14.63	5.77	0.260	0.080	4 55	0.467
	df							
F-ratio	2	1.917	0.184	0.745	1.216	0.208	0.004	(ns = not significant)
	229	ns	ns	ns	ns	ns	ns	

Table II : PULMONARY FUNCTION INDICES IN RELATION TO MATERIALS WELDED

(Mean ± SD)

Material	n	VC %VCpred	FEV% /VCpred	MEF50 /VCpred	MEF25 %	RV/TLC	Raw cm $H_2O/1/sec$
Carbon	86	101.1	82.1	1.07	0.37	30.5	1.42
steel		12.02	5.80	0.304	0.123	5.38	0.613
Alloy	89	100.9	81.9	1.07	0.37	30.6	1.51
Steel		11.79	6.47	0.358	0.131	6.97	0.568
Stainless	57	102.0	83.0	1.14	0.39	29.7	1.38
steel		10.67	5.62	0.327	0.139	5.80	0.499
	df						
F-ratio	2	0.188	0.571	0.918	0.753	0.361	0.972
	229	ns	ns	ns	ns	ns	ns

(ns = not significant)

Table III : Student's 't' - Val;ues of Pulmonary Function Indices in Relation to Welding Processes

Selection	df	VC %VCpred	FEV%	MEF50 /VCpred	MEF25 /VCpred	RV/TLC %	raw $cmH_2O/1/sec$
MMA x TIG	205	1.189	0.478	0.613	0.069	0.653	0.072
MMA x CO2	203	1.375	0.445	1.213	1.632	0.0006	0.090
TIG x CO2	49	0.365	0 0004	1.378	1.317	0.553	0.006

non significant at 10% level

Table IV : Student's 't' - Values Of Pulmonary Function Indices In Relation to Materials Welded

Selection	df %VCpred	VC /VCpred	FEV%	MEF50 /VCpred	MEF25 /VC pred	RV/TLC %	Raw cm $H_2O/1/sec$
CS x AS	173	0.118	0.147	0.121	0.341	0.058	0.969
CS x SS	141	0.502	0.942	1.198	0.887	0.797	0.426
AS x SS	144	0.622	1.039	1.236	1.155	0.771	1.414

none significant at 10% level

Variability of each of the above parameters was assessed across processes and across materials using ANOVA. Individual means were tested against each other using student's 't'-test. Significance was tested at the 10% level.

Results

The pulmonary function indices are presented in tables I and II along with the repective F-ratios, while the results of the 't'-tests are presented in

table III and IV. None the F-ratios and none of the 't'-values were significant at the 10% level.

Discussion

These results indicate that the hypothesis that the three welding processes or the three types of material welded affect the pulmonary function of the welders, stands rejected at the level of fume exposure in our industry.

Even the value of the indices per se indicate that the pulmonary function of the welders is within normal limits. These results also corroborate the findings of the earlier study (6) that there is no significant reduction in the spirometric indices of welders.

This may only reflect the levels of exposure to welding fume in our industry, which are low (below the respective TLVs). In this connection, kaliomaki et al (7) have shown using magnetopneugraphy, that hygienic improvements are directly related to reduced rates of deposition and retention in the lungs.

Thus, a proper understanding of the characteristics of different welding processes, material composition, etc., along with effective engineering control and hygienic monitoring of the work environment leads to protection of the welder from the effects of the welding fume.

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