SPIROMETRIC AND AUDIOMETRIC ABNORMALITIES AMONG WORKERS IN AN AGRICULTURAL EQUIPMENT FACTORY

By

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Abstract

Introduction: Workers in metal fabrication are exposed to the hazardous effects of welding fumes, gases, and noise that may lead to acute and chronic health effects. **Aim of Work:** To measure occupational auditory and respiratory disorders among workers in Tanta Motors Factory in Tanta City, Egypt. Also, to investigate the association between the workplace and occupational auditory and respiratory disorders among workers. **Materials and Methods:** It is a comparative cross-sectional study. The study included 120 male workers and an equal number of 120 administrative male workers as a comparative group. An interview questionnaire was filled to collect the required data. Clinical examination, spirometry and audiometry were done for all workers. Environmental monitoring of the work place was taken from the records which include noise measurement, heat indices, dust level. **Results:** There were significantly lower mean values of FVC%, FEV1% and FEV1/FVC% among the exposed group compared to the control one. Hearing threshold levels in "dB" were significantly higher among exposed workers than controls at frequencies of 250 and 8000 Hz in both right and left ears which was higher in frequency of 4000 HZ more than other frequencies. **Conclusion and Recommendations:** There were early changes in the spirometric and audiometric measurements among the exposed workers. Working in agricultural equipment metal industries was associated with a high prevalence of chest manifestations and hearing impairment. Periodic medical examination yearly for early detection and management of health problems. Encourage the use of PPE as earmuff or ear plug and masks.

Keywords: Metal industry, Risk assessment, Auditory disorder, Spirometry and Respiratory disorder.

Introduction

The metal equipment sector manufactures structural components and parts with extensive utility across numerous industries, such as the automotive, aerospace, agricultural, and appliance sectors (Shukur, 2020). Metal fabrication entails the use of bending, cutting, and joining to construct metal structures. Coating, polishing, or painting the metal components were also performed concurrently with the other procedures(Tadesse et al., 2016).

The metal industries require an enormous quantity of labor force (Benti et al., 2019) Welding noise and fumes constitute a hazardous composition that metal fabricators are exposed to, which can result in both acute and chronic health complications (Benti et al. (2019).

A large industrial process for joining metals is welding. The extent to which fume exposure endangers the health of the welder is contingent upon the fume's composition, concentration, and duration of exposure (Balkhyour and Goknil, 2010) concentration, and the length of exposure. The aim of this study was to investigate workers' welding fume exposure levels in some industries in Jeddah, Saudi Arabia. In each factory, the air in the breathing zone within 0.5 m from welders was sampled during 8-hour shifts. Total particulates, manganese, copper, and molybdenum concentrations of welding fumes were determined. Mean values of eight-hour average particulate concentrations measured during welding at the welders breathing zone were 6.3 mg/m3 (Factory 1. Metals such as manganese, iron, and chromium, in addition to ozone (O3), carbon monoxide (CO), carbon dioxide (CO2), and nitrous oxides (NOx) are the primary pollutants that enter the breathing zone of workers (Reinhold and Pallon , 2014).

Epidemiological research has demonstrated that a large number of welders are afflicted with respiratory ailments (Riccelli, et al., 2020). Welders have been associated with reversible and irreversible respiratory complications, acute diseases as infectious pneumonia, chronic diseases as fibrosis, asthma, chronic bronchitis, and chronic obstructive pulmonary disease also malignant diseases as lung cancer (Singh et al., (2013).

Occupational noise-induced hearing loss (ONIHL) is a prevalent occupational hazard, with an estimated 1.3 billion workers experiencing noise-induced hearing loss (Chen et al., 2020). ONIHL is an irreversible condition that has no viable treatment (Kirchnerbet al., 2012) . Prevention continues to be the most effective method for halting hearing loss.

Aim of Work

To measure the occupational auditory and respiratory disorders among workers in Tanta Motors Factory in Tanta City, Egypt. Also, to investigate the association between the workplace and occupational auditory and respiratory disorders among workers.

Materials and Methods

Study design: It was a comparative cross-sectional study.

Place and duration of the study: The study was carried out at Tanta Motors, a prominent Egyptian joint stock company operating in the trading and manufacturing of agricultural equipment and machinery, located in Tanta city, Gharbia governorate, Egypt. The study started from 1 October 2021 till 1 June 2023.

Study sample:

All 120 exposed factory employees were present throughout the research study.

A comparable quantity of unexposed subjects was selected from an area remote from the factory. In terms of socioeconomic status, age, education, and gender, they were matched. Exclusion criteria of exposed workers: Individuals who have worked in a factory for less than one year, as well as those who have a prior medical history of respiratory or auditory disorders, were excluded. Inclusion criteria of the exposed workers: All available workers during period of the study who have worked in the factory for more than one year and agreed to participate in the study.

Study methods:

I. An interview questionnaire that included personal information, and occupational background. The Arabic questionnaire was subjected to content and face validity assessments by three specialists in occupational health and industrial medicine. These experts examined both the individual items and the questionnaire as a whole to determine their relevance and suitability for measuring the intended constructs. The calculation of the questionnaire's face validity was predicated on the opinions of experts. In order to determine the questionnaire's reliability, a pilot study computed Cronbach's alpha, which was 0.721.

II. Spirometry measurements: Prior to performing spirometry, the workers' height was measured without shoes or boots. Also, weight was measured using a portable weighing scale.

Spirometry analyses were performed utilizing the Contac SP10BT device. The subject was seated during the examination and was instructed in straightforward language on its principles and proper execution. Following the application of a nasal clip, the subject was linked to the apparatus using a sterile mouthpiece that was individually replaced for each worker. Subsequently, the subject was provided with the following instructions: the worker was directed to maintain regular breathing until four cycles were completed, followed by a deep inspiration of their maximum capacity, followed by a forceful and continuous expiration for approximately six seconds, until they reached their maximum output, after which they were instructed to resume inspiration.

The printout of the test includes(Moore, 2012):

1) Forced Vital Capacity (FVC %): It is used to grade restriction: 80-60 mild, 59-40 moderate, <40 severe.

2) Forced Expiratory Volume at the first second (FEV1%): The obstruction is categorized as follows: >80% mild, (79-50) moderate, (49-30) severe, and <30 extremely severe.

3) Forced Expiratory Ratio (FEV1/FVC %): The FEV1 to FVC ratio is denoted by 75–80 % is what this should be in healthy adults. If this falls below 70%, it is regarded as obstruction.

III. Audiometer measurements

To exclude workers with organic ear damage or injury past medical history was taken. Also, the Weber test was often combined with the Rinne test to detect the location and nature of hearing loss.

Audiometer measurements were done using the r15C resonance, which is a computerized portable apparatus. The test was conducted in a quiet room. Earphones were placed on the head (red for right ear and blue for left ear) to cover the whole ears, and then conducted to the apparatus. Following a brief explanation of the test's principles and procedure in straightforward language, the subject was required to respond to a tone. The threshold was the sound level at which the subject perceived the least intensity at each frequency. The severity of hearing loss is denoted by degrees of hearing loss, which are typically classified as mild, moderate, severe, or profound. Table (A) represents the WHO grading of hearing impairment. (WHO, 2013).

Grade of impairment	Corresponding audiometric ISO value
0– None	25 dB or better
1– Slight	26–40 dB
2– Moderate	41–60 dB
3– Severe	61–80 dB
4– Profound, including deafness	81 dB or greater

Table (A): Grades of hearing impairment(WHO, 2013)

IV. Environmental monitoring of work area:

The data of environmental measurements were extracted from the records which include noise measurements and dust level.

Consent

An approval from the factory manager was obtained. A formal consent was taken from each worker before examination after explanation of the study's objectives to every participant. The collected data was kept strictly confidential and was not utilized for any objective other than scientific research.

Ethical Approval

The study received approval from the Ethical Committee of the Faculty of Medicine at Tanta University during a meeting held in September 2021 and the approval code was 34815/7/21. A letter of official authorization was acquired. The research ethical guidelines of Tanta Faculty of Medicine were duly considered during the entire course of this study's execution.

Data Management

Following data entry in an Excel spreadsheet, the information was exported to version 21 of the Statistical

Package for the Social Sciences (SPSS) which version software for data analysis, sorting, and tabulation. The range, mean, and standard deviation were computed for the quantitative data. Qualitative data pertains to a categorical set of information that is described by the frequency and percentage of each category. When necessary, significant tests were conducted. The researchers utilized the Chi-squared test, Monte Carlo exact test, and Fisher exact test to examine the relationship between categorical variables across at least two independent samples.For quantitative parametric variables comparing the means of two independent samples, the Student t test was utilized. For quantitative nonparametric variables comparing the median of two independent samples, the Mann Whitney test was applied for non-parametric data. The One Way of Variance (ANOVA) is a significance test utilized to compare quantitative variables that are normally distributed across more than two groups. The predetermined level of significance was 5%, and the corresponding p value was ≤ 0.05.

Results

Table (1): Socio-demographic characteristics, smoking habits and work duration of the studied groups.

Sociodemographic characteristics	Exposed group (No=120)		Control group (No=120)		Test of significance	p value
	No	%	No	%		
Age /years:					t=1.43	0.154
Mean ± SD	44.9± 8.9		8.9±46.5			
Range	27-69		22-60			
Residence:					χ^2=0.74	0.785
Rural	78	65	80	66.7		
Urban	42	35	40	33.3		
Education:					χ^2=7.03	0.071
Illiterate	16	13.3	9	7.5		
Read and write	27	22.5	20	16.7		
Intermediate education	71	59.2	76	63.3		
High education	6	5	15	12.5		
Smoking habit:						
Nonsmokers	69	57.5	72	60		
Ex-Smokers	5	4.2	2	1.7	χ^2=1.35	0.509
Smokers	46	38.3	46	38.3		
Type of smoking	No= 51		No=48			
Cigarettes	39	76.5	40	83.3		
Shisha	12	23.5	8	16.7	χ^2=0.722	0.395
Cigarettes Smoking index:	(No=39)		(No=40)			
Mean ± SD	434±223		215±405		U=693	0.391
Median	400		400			
Work duration/year						
Mean ± SD	15.57± 10.19		14.93 ± 8.97		t=0.715	0.605
Range	5 – 42		1 - 33			

χ^2: Chi squared test   U= Mann Whitney test.   t: Student t test

Table 1 showed that the entire workforce in both the exposed and control groups consisted of males, with respective mean ages of 44.9±8.9 and 46.5±8.9. With respect to their level of education, 63.3% held an intermediate level of education, while 59.2% held a bachelor's degree.

Approximately 66.7% and 65%, respectively, were derived from rural regions. More than one-third of both groups (38.3%) were smokers, with the majority being cigarette smokers (76.5%), followed by control group members (83.3%), with a median of 400 cigarettes in the smoking index for both groups. There was no statistically significant difference observed in terms of sociodemographic characteristics or smoking habits between the exposed and control groups.

Table (2): Spirometric measurements of the studied groups.

Spirometery	Exposed group (No =120)	Control Group (No =120)	t test	p value
	Mean ± SD	Mean ± SD		
FVC:	13.9±72.11	84.7±9.8	8.08	<0.001*
FEV1:	73.18±13.2	85.4±7.8	8.75	<0.001*
FEV1/FVC%	69.6±16.6	83.5±8.3	8.2	<0.001*

t: Student t test. *: Statistically significant at p ≤ 0.05. FVC: Forced Vital Capacity

FEV1: Forced Expiratory Volume at the first second. FEV1/FVC: Forced Expiratory Ratio

The exposed group had significantly lower mean values of FVC%, FEV1%, and FEV1/FVC% than the control group (P0.05), as shown in Table 2.

Table (3): Distribution of the studied groups according to the pattern of ventilatory dysfunction.

Spirometry results		Studied group				χ^2 Test	p Value
		Exposed group (No =120)		Control Group (No=120)			
		No	%	No	%		
Normal		66	55.0	113	94.2	49.3	**<0.001***
Abnormal	Restrictive	11	9.1	3	2.4		
	Obstructive	20	16.7	2	1.7		
	Combined	23	19.2	2	1.7		

χ^2 : Chi squared test. *: Statistically significant at $p \leq 0.05$.

As shown in Table 3, the majority of the workers in the exposed group (55%) exhibited normal ventilatory functions, while 19.2% of them displayed a combined pattern of ventilatory dysfunction, while in control group the majority of workers (94.2%) had normal respiratory functions followed by restrictive pattern in (2.4%) of them. There was a highly significant difference between both studied groups regarding patterns of ventilatory dysfunction.

Table (4): Distribution of audiograms findings among the studied groups.

Audiograms Findings	Exposed group (No =120)		Control group (No =120)		Test of significance	p value
	No	%	No	%		
Right ear:						
Normal hearing (0-25) dB	19	15.8	115	95.8	χ^2=156.5	**<0.001***
Mild hearing loss (26-40) dB	52	43.3	5	4.2		
Moderate hearing loss (41-60) dB	49	40.8	0	0.0		
Left ear:						
Normal hearing (0-25) dB	23	19.2	111	92.5	χ2=132.6	**<0.001***
Mild hearing loss (26-40) dB	58	48.3	9	7.5		
Moderate hearing loss (41-60) dB	39	32.5	0	0.0		

χ^2: Chi squared test *: Statistically significant at $p \leq 0.05$.

Table (4) showed that regarding right ear, the majority of exposed workers suffered from hearing loss with nearly equal percentage for mild and moderate hearing loss (43.3%)- (40.8%). Regarding left ear, the majority of study workers suffered from hearing loss with (48.3%) mild and (32.5%) moderate hearing loss. There was a highly significant difference between both studied groups regarding audiograms findings.

Table (5): Environmental measurements at the workplace.

Environmental measurement at the workplace	Work sites						Permissible Level of Egyptian Environmental Law (2011)
	Forming and cutting section	Turning Section	Welding Section	Sand washing section	Joining section	Painting section	
Noise level (dB)	86	76	75	85	96	89	85 dB
Total dust (µg/m³)	1.5	-	-	5.1	-	1.9	3
Welding fumes (µg/m³)	2.6	-	2.5	-	-	-	5
VOCs (µg/m³)	-	-	-	-	-	255	200

VOCs: volatile organic compounds

The workplace environmental conditions are detailed in Table 5. based on the environmental measurement records from different factory sectors within the agricultural equipment industry in 2022 and the Egyptian labor law.

Noise level exceeded the permissible level at four sectors in factory, with a mean of (84.33±7.94).

Also, total dust, welding fumes and VOCs in specific sections in the factory, it was found that heat stress exceed permissible level in welding section, while sand washing section is exposed to total dust with the highest level 5.1 μg/m. Also, welding fumes were within permissible level in both welding and cutting sections. As regarding VOCs was measured only in painting section and it was exceeding permissible level (255 μg/m).

Discussion

The agricultural equipment industry covers a lot of equipment used for different activities across the agriculture value chain (Tadesse et al., 2016). It is generally established that metal workers have a high frequency of occupational respiratory problems at work. Also, occupational noise-induced hearing loss (ONIHL) is a common occupational disease among metal industry workers (Girma, 2019).

The present study revealed that the exposed group exhibited significantly reduced mean values of FVC%, FEV1%, and FEV1/FVC% in comparison to the control group (Table 2). A majority of the exposed workers, specifically 55%, exhibited normal ventilatory functions. A combined pattern of ventilatory dysfunction was reported by 19.2% of the exposed workers (Table 3). A notable distinction was observed among the groups under investigation with respect to patterns of ventilatory dysfunction.

Ahmad and Balkhyour (2020) from Saudi Arabia, Hamzah et al. (2015) from Malaysia, Singh et al. (2013) from India, and Gomes et al. (2001) from Canada, all corroborated this finding, reporting that the exposed group exhibited reduced values for spirometric parameters including FVC, FEV1, and FEV1/FVC ratio, in comparison to the control group. The observed decrease in FVC, FEV1, and FEV1/FVC% indicates the coexistence of restrictive and obstructive patterns.

Mozaffari et al. (2023) from Tehran, Iran documented elevated percentages; specifically, the exposed group exhibited a general prevalence of lung function impairment of 100%, whereas the reference group maintained a rate of 10.5%. The majority of those with lung function impairment in the exposed group (54.9%) had both obstruction and restriction, whereas obstruction alone (45.1%) was the most prevalent condition. Significant impairments were observed in individuals who had been exposed to fumes and dust.

A high level of solvents, fumes, and vapors, which are known to induce systemic pulmonary inflammation, as well as an unsafe working environment, can be attributed to the diminished pulmonary functions observed in the exposed group in comparison to the control one.

As regards hearing impairment in the right ear, a significant proportion of workers who were exposed experienced hearing loss, with percentages nearly equal between mild and moderate (43.3%) and (40.8%). The findings of the study revealed that a significant proportion of the workers (48.3%) experienced mild hearing loss and 32.5% moderate hearing loss in their left ear (Table 4).

The findings of the present study align closely with those of Sam et al. (2017) from Selangor, Malaysia, who reported a prevalence of 73.3% for hearing loss and identified the highest number of hearing loss cases at 4 kHz and 6 kHz. The elevated prevalence of hearing impairment observed in both the current study and previous research may be accounted for by noise-generating machinery (compressors, pneumatic grinders) and operations involving grinding, rolling, crushing, and drilling. Additionally, this may be explained by the participants' similar work-related procedures (Singh, et al 2012)audiometric tests were conducted at low (250-1000 Hz. Additionally, Agarwal et al. (2016) from India found that 37.83% of employees had mild sensorineural hearing loss in the right ear, ranging from 26 to 40 dB. A mere 2.63% of the workforce exhibited moderate sensorineural hearing loss (41-60 dB) in their right ear. Conversely, 42.52% of the workforce reported mild sensorineural hearing loss (26-40 dB) in their left ear and 54.25% of the workforce reported having normal hearing. Only 3.23% of employees suffered from moderate (41-60 dB) hearing loss.

In contrast, Melese et al. (2022) from Gondar city, Northwest Ethiopia reported a lower percentage compared to the current results, specifically 30.7%, for the prevalence of hearing loss among metalworkers. Furthermore, a total of 7% of the participants exhibited unilateral hearing loss (3.3% in the left ear and 3.7% in the right ear), while 23.7% had bilateral hearing loss. In relation to the extent of auditory impairment, approximately 17%, 11%, and 2.7% of the respondents, correspondingly, exhibited mild, moderate, and severe hearing loss.

Potential factors contributing to this difference include variability in the work environment, including noise levels, machine types, and quantities utilized, as well as the extent to which occupational health and safety protocols safeguard against hearing impairment (Kirchner et al., 2012).

Based on environmental measurement records done in the factory sectors within the agricultural equipment industry in 2022 and the Egyptian labor law; noise level exceeded the permissible level at four sectors in factory, with a mean of (84.33±7.94) (Table 5). This was in agreement with the study done by Noweir et al. (2014) from Saudi Arabia who demonstrated that the beverage can manufacturing sector exhibited the most significant noise exposure among metalwork industries, with the majority of recorded measurements surpassing 90 dB. This was a result of the machines utilized and the high noise levels produced during the processing of thin steel and aluminum sheets. Also, in the trail of Agarwal et al., (2016) from India, noise level was found to be in the range from 65dB to 92dB.

According to a study done by Worede et al. (2022) from Northwest Ethiopia., the mean noise exposure level in the metalworking sector was 96.2 dB ± 4. The highest level of noise produced by cutters and welding machines was 108dB. Extensive research corroborates the findings of the present study concerning noise exposure, which may be accounted for by the elevated noise levels generated by cutting machines, as well as forming and welding procedures.

Also, total dust exceeded the permissible level in sand washing section, with the highest level of 5.1 μg/m (Table 5). This is in harmony by the work done by Mozaffari et al. (2023) from Iran who demonstrated that casting sand exhibited the highest mean dust concentration of 0.83 mg/m3. Also, Singh et al. (2013) from India detected that the respirable suspended particulate matter level was significantly elevated in the grinding and casting sections, while the machining section had a comparatively lower dust concentration. The concentration of respirable suspended matter exceeded the threshold of 5 mg/m3 as mandated by the Indian Factory Act. Elevated levels of dust were documented by Gomes et al. (2001) from Canada, with the exposed workers exhibiting mean metal dust concentrations of 16.53 μg/m3±7.25.

Conclusion

There are numerous health risks associated with working conditions in the metal industry, including respiratory and auditory disorders. Initial alterations were detected in the audiometric and spirometric assessments of exposed workers. Various spirometric measurements exhibited lower mean values among exposed workers in comparison to the control group. Additionally, exposed workers had a higher prevalence of noise-induced hearing loss than the control group. The utilization of personal protective equipment among workers was conspicuously inadequate.

Recommendations

- Occupational health program emphasis; yearly medical examinations for early detection and management of health issues.

- Properly documented and precise health records of employees, enabling the monitoring of those who are at risk.

- Hearing protection devices and maintaining a noise level in the workplace below the permissible threshold are adequate measures to prevent the majority of occupational noise-related injuries. Regrettably, the enforcement of hearing protective device usage is often lax in numerous workplaces, and employees often lack adequate training on how to attain sufficient attenuation.

Conflict of Interest

None

Funding

None

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