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Pulmonary Function Tests of Workers at the State Company of Petrochemicals Factory in Basrah City, South of Iraq

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Abstract

BACKGROUND: Workers who are exposed to chemical and physical elements at work on a regular or continuous basis are more likely to acquire various occupational diseases, particularly respiratory problems.

AIM: This observational study was carried out to determine the impact of exposure to specific industrial pollutants, such as petroleum products, on the pulmonary function tests of workers at a facility in Iraq's south.

METHODS: The study involved two groups of people: Exposed workers (G1) and non-exposed workers (G2) (G2). Asthmatics, healthy smokers, and healthy nonsmokers were split into three subgroups. All individuals had their pulmonary function tests (PFTs) performed using a medical spirometer.

RESULTS: There were substantial decreases (p0.05) in PFTs of exposed workers, as well as a significant rise in estimated lung age. The effects of exposure were most noticeable in asthmatics and healthy smokers, while healthy nonsmokers were unaffected. In addition, the exposed group had a considerably higher percentage of obstructive and mixed respiratory illnesses.

CONCLUSION: Workplace exposure to some industrial compounds, such as petrochemical products, may impair PFTs, with the impairment being more pronounced in the presence of other risk factors such as smoking or asthma. Asthmatics and smokers should be cautioned against working in industrial settings for more than five years. In general, all workers should be aware of the risks of working at such a location for more than 5 years, and all workers should adhere to occupational safety regulations.

Introduction

Employees who are exposed to chemical and physical elements on a regular basis at work are more prone to acquire a variety of occupational diseases [1], [2] Occupational diseases are disorders or abnormalities induced by exposure to certain substances in the workplace, and there are many of them [3]. Allergic diseases are a type of disease that develops as a result of an allergic reaction and immunological response, such as rhinitis and asthma. Allergies cause chronic or acute airway inflammation [4], and workers are exposed to chemical pollutants in the workplace mostly through inhalation [5]. Inhalation of particular materials causes a variety of respiratory difficulties and health impacts, ranging from nose and throat irritation to lung cancer and other cancers [6]. Occupational exposures, on the other hand, continue to be a major source of lung disease [7], [8], [9]. Several compounds, notably petrochemical products, which are a mixture of various hydrocarbons, pose an occupational hazard [10]. When excessive quantities of volatile organic compounds (VOCs) and other pollutants are present, they cause serious respiratory illnesses [11]. Pulmonary function tests (PFTs) can be used to diagnose obstructive or restrictive lung disease and detect respiratory illnesses. It is one of the tests used in clinical evaluations, management of probable occupational lung illnesses, fitness for duty examinations, and medical screening of employees exposed to various agents and pollutants. These tests can often detect issues early in the course of a disease, even before physical examinations or other testing are performed. The diagnosis of occupational lung illnesses has significant implications for those who are exposed [2], [12]. This study was designed to analyze the lung function of occupationally exposed workers in a specific industrial factory in Southern Iraq by physiological assessment, as measured by pulmonary function tests.

Methods

This was a cross-sectional observational research conducted in Basrah, Iraq's south. It has been conducted in agreement with the guidelines for reporting observational studies as recommended by the Strengthening the Reporting of Observational

Studies in Epidemiology (STROBE) statement. There were 370 participants in the study, who were separated into two groups based on their occupational exposure. The first group consisted of 220 exposed workers (G1) who were exposed to a variety of petrochemical compounds, dust from organic and inorganic materials, and chemical vapors during work. At work, the time of exposure ranged from 5 to 20 years. Data was sampled at random. Steven K. Thompson's equation was used to estimate the sample size:

$$n = \frac{N \times p(1-p)}{\left[\left[N - 1 \times (d^2 \div z^2)\right]\right] + p(1-p)}$$

Where

N: population (510); p: probability (0.5); d: Error proportion (0.05); Confidence level at 95% (1.96) [13].

The control group consists of 150 non-exposed people (G2). The participants were all males between the ages of 22 and 60. Asthmatics, healthy smokers, and healthy nonsmokers were separated into three subgroups in each group. All individuals appeared healthy (excluding asthmatic subgroups) and devoid of any diseases or anomalies that could impact the respiratory system, according to their medical histories and physical examinations. Workers from the State Company of Petrochemicals were chosen to be exposed. The asthmatic patients came from Basrah Teaching Hospital's outpatient department. The healthy control group consisted of university of Basrah students and employees. This work was approved by the local ethic committee, and signed informed consents were obtained from all participants. The characteristics of all patients including: Age, sex, height, weight, co-morbidities, drug intake, and smoking status were obtained by filling a detailed questionnaire.

Measurement of pulmonary function tests

The measurement of pulmonary function is a reasonably easy and accurate test that can be performed at work. Spirometry is a useful method for determining whether or not someone has a pulmonary disease, what type of disease they have, if they are improving or deteriorating, and how bad their health is.

Pulmonary function tests (PFTs) including: Forced expiratory volume at the first second of expiration (FEV1), forced vital capacity (FVC), FEV1/FVC ratio (FEV1%), peak expiratory flow (PEF), mid expiratory flow (MEF), maximum voluntary ventilation (MVV), and estimated lung age (ELA) for all participants were measured by using the medical spirometer (Micro medical Ltd.-England).

A micro medical lab spirometer with an integrated printer is a compact and fully portable data recording equipment. Instructing the patient to stand comfortably in front of the spirometer and breathe in until their lungs are totally full, then sealing their lips around the mouthpiece and blowing out as hard and fast as possible until they cannot push any more air out, is a simple technique to make the measurement. The spirometer measures how much air is exhaled as well as how quickly the lungs can be emptied.

The spirometer will not collect any readings until a key is hit, allowing the patient to breathe tidally through the transducer before forcing expiration readings if necessary. As the patient conducts forced expiration through the transducer, the expiratory flow/volume curve is shifted. The values of FEV1, FVC, and PEF, as well as the expiratory flow volume curve, are displayed at the end of each test, allowing the decision to be taken whether to accept or reject the blowing [14]. All collected values are automatically rectified and compared to the subject's projected value. Before 12:00 p.m., a well-trained technician performed pulmonary function testing. The best results were evaluated using the American thoracic society (ATS) criteria [15], which states that normal lung function is defined as FVC and FEV1 both being normal. One's health may deteriorate, resulting in pulmonary problems. When FEV1 is less than normal, FVC is normal, and FEV1/FVC is 70%, obstructive lung disease is diagnosed, while restrictive lung disease is diagnosed when FVC is 80%, and a combined disorder (restrictive and obstructive lung disease) is diagnosed when both FVC and the percentage of FEV1/FVC are reduced [12], [16].

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) Statistical Software for Windows, Version 25.0 IBM (SPSS Inc, IL, USA). The data were presented as a means value with a standard error (SE). To discover the differences between the groups, a one-way analysis of variance (ANOVA) with the least significant difference was utilized. The Pearson Chi-square test was used to test qualitative data, which was summarized as (percent). At p = 0.05, the result was considered significant.

Results

All participants were with no significant differences ($p < 0.05$) in most characteristic parameters such as the age, weight, height, and body mass index (BMI), as represented by mean ± SE, as shown in Table 1. Furthermore, data analysis showed that there were no significant differences between G1and G2 in the percentage of the smokers numbers (41.8% vs. 38%) and the percentage of asthmatics numbers (15.9% vs. 13.33%) as shown in Table 1.

When comparing PFTs between G1and G2, we found significant declines in each of FEV1, FEV1%,

Table 1: Characteristics of the exposed workers group and non-exposed group

Parameters	Exposed workers group (G1) n = 220	Non exposed group (G2) n = 150	*p value
Age	38.45 ± 2.42	37.86 ± 3.95	0.12
Weight (kg)	83.56 ± 3.11	85.43 ± 2.35	0.078
Height (cm)	172.59 ± 3.41	175.12 ± 2.16	0.125
BMI (kg/m)	27.65 ± 2.85	28.13 ± 2.23	0.14
No. of smokers	92 (41.8%)	57 (38%)	0.063
No. of asthmatics	35 (15.9%)	20 (13.33%)	0.091

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

PEF, and ELA (p > 0.05). While, there were no significant changes in each of FVC, MEF, and MVV, (p < 0.05) as shown in Table 2.

Table 2: Comparison of pulmonary function tests between exposed workers group and non-exposed group

Pulmonary function tests	(G1) n = 220	(G2) n = 150	P. value
FEV1	3.05 ± 0.06	3.26 ± 0.03	0.025*
FVC	3.61 ± 0.082	3.47 ± 0.041	0.75
FEV1%	86.24 ± 0.52	90.13 ± 0.40	0.003*
PEF	361.13 ± 1.01	399.6 ± 6.28	0.0014*
MEF	3.39 ± 0.23	3.82 ± 0.06	0.053
MVV	116.12 ± 2.26	118.28 ± 1.25	0.241
ELA	62.65 ± 0.58	58.51 ± 0.83	0.036*

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

Regarding the comparison between each two subgroups of the main groups, there were significant differences between the two asthmatic subgroups and between the two healthy smokers subgroups in the mean value of FEV1, (p > 0.05), but there was no significant difference between healthy nonsmokers subgroups (p < 0.05), as shown in Table 3.

Table 3: Comparison of FEV1 between each two subgroups (asthmatic, healthy smokers and healthy nonsmokers) of the two main groups (exposed workers and non-exposed)

subgroup	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N	FEV1	N	FEV1	
Asthmatic	35	2.13 ± 0.14	20	2.75 ± 0.18	0.045*
Healthy smokers	92	2.96 ± 0.08	57	3.32 ± 0.08	0.038*
Healthy non-smokers	93	3.34 ± 0.08	73	3.84 ± 0.17	0.051

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

The comparison in FVC between subgroups showed that the only significant difference was between healthy smokers subgroups of G1and G2 (3.24 ± 0.14 vs. 3.85 ± 0.07), (p > 0.05). Both asthmatic and healthy nonsmoker subgroups revealed non-significant changes, (p < 0.05), (Table 4). The parameter FEV1% showed the same findings to that of FEV1, these are: Significant differences between the two asthmatics subgroups of G1 and G2 and between the two healthy smokers subgroups but no significant difference was found between healthy nonsmokers subgroups (p < 0.05), (Table 5).

Table 4: Comparison of FVC between each two subgroups (asthmatic, healthy smokers and healthy non-smokers) of the two main groups (exposed workers and non-exposed)

Subgroup	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N	FVC	N	FVC	
Asthmatic	35	2.85 ± 0.12	20	2.93 ± 0.18	0.062
Healthy smokers	92	3.24 ± 0.14	57	3.85 ± 0.07	0.031*
Healthy non-smokers	93	3.75 ± 0.08	73	3.74 ± 0.19	0.083

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

Peak expiratory flow (PEF) parameter was significantly different between healthy smokers subgroups of the two main groups and significantly different between asthmatics subgroups, (p > 0.05). While it showed non-significant different between the healthy nonsmokers subgroups (p < 0.05), as shown in Table 6.

Table 5: Comparison of FEV% between each two subgroups (asthmatic, healthy smokers and healthy non-smokers) of the two main groups (exposed workers and non-exposed)

Subgroup	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N	FEV%	N	FEV%	
Asthmatic	35	71.7 ± 2.2	20	77.1 ± 2.1	0.011*
Healthy smokers	92	82.14 ± 3.5	57	85.21 ± 2.7	0.037*
Healthy non-smokers	93	91.15 ± 2.66	73	93.85 ± 2.57	0.081

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

Table 6: Comparison of PEF between each two subgroups (asthmatic, healthy smokers and healthy non-smokers) of the two main groups (exposed workers and non-exposed)

Subgroup	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N	PEF	N	PEF	
Asthmatic	35	256.34 ± 28.5	20	278.50 ± 21.1	0.041*
Healthy smokers	92	365.28 ± 8.72	57	395.31 ± 17.6	0.038*
Healthy non-smokers	93	428.53 ± 10.61	73	461.35 ± 12.4	0.058

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

On the other hand, MVV showed that the only significant difference was between asthmatic subgroups (p < 0.05), as shown in Table 7.

Table 7: Comparison of MVV between each two subgroups (asthmatic, healthy smokers and healthy non-smokers) of the two main groups (exposed workers and non-exposed)

Subgroup	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N	MVV	N	MVV	
Asthmatic	35	86.66 ± 5.23	20	83.25 ± 5.31	0.044*
Healthy smokers	92	125.92 ± 3.13	57	128.5 ± 2.28	0.062
Healthy non-smokers	93	122.01 ± 3.54	73	123.36 ± 3.14	0.0713

*Data were considered significantly different at p > 0.05. The data were expressed by mean ± SE.

Regarding the respiratory diagnosis, as illustrated in Table 8, there were significant differences in the percentage of obstructive lung diseases (28.63% vs. 20.66%),(p > 0.05), the percentage of the combined cases (obstructive and restrictive) and the percentage of normal cases (44.54% vs. 58.66%), between the two main groups, exposed workers and non-exposed group. It was a higher percentage of normal cases in the non-exposed group. On the other hand, there was no significant change in the percentage of restrictive cases (p < 0.05).

Table 8: Respiratory diagnosis and ELA of the two main groups (exposed workers and non-exposed)

Respiratory diagnosis	Exposed workers (G1) n = 220		Non exposed (G2) n = 150		p value
	N(%)	ELA	n (%)	ELA	
Obstructive	63 (28.63)	86.38 ± 6.35	31 (20.66)	81.5 ± 6.25	a. 0.037* b. 0.083
Restrictive	15 (6.81)	60.86 ± 2.52	11 (7.33)	57.30 ± 3.35	a. 0.237 b. 0.13
Combined	44 (20)	62.77 ± 2.26	20 (13.33)	59.37 ± 2.25	a. 0.032* b. 0.26
Normal	98 (44.54)	44.89 ± 1.85	88 (58.66)	38.45 ± 1.75	a. 0.035* b. 0.012*

*Data were considered significantly different at p > 0.05 The data were expressed by mean ± SE. a. Is for the difference in the respiratory diagnosis percentage. b. Is for the difference in the ELA.

Estimated Lung Age parameter revealed a high value in obstructive individuals in general, but the difference in ELA between the obstructive individuals of the two main groups was not significant. As well as there were no significant differences in ELA between the individuals of the restrictive case and between individuals of mixed case, ($p < 0.05$). On the other hand, a significant difference in ELA was found between the individuals of a normal case of the two main groups (44.89 ± 1.85 vs. 38.45 ± 1.75), ($p > 0.05$), as shown in Table 8.

Discussion

The two primary groups in this study, exposed workers and non-exposed workers, were matched in terms of age, height, weight, and BMI, which are personal criteria that spirometry relies on for standardization according to the ATS and ERS. Furthermore, the percentages of healthy smokers (41.8% vs. 38%) and asthmatics in the two groups were matched (15.9% vs. 13.33%). Several PFTs revealed significant disparities between these two groups. Table 2 shows that FEV1, FEV1%, and PEF were considerably lower in the exposed group than in the non-exposed group, but ELA was significantly higher in G1. Many earlier studies [16], [17], [18] indicated that occupational exposure caused deleterious effects on respiratory function and pulmonary function tests, and this finding supports that conclusion.

The petrochemicals factory is a source of a variety of hydrocarbons and other compounds derived from petroleum refinery products. Exposure to petrochemical compounds and their released vapor could lead to the development of a variety of ailments, including respiratory diseases [17]. As a result, some workplaces, such as the State Company of Petrochemicals, may be considered polluting and have an impact on respiratory function. Comparisons of the two symmetrical G1 and G2 subgroups found some differences. When comparing the asthmatics and healthy smoker subgroups of the exposed group (G1), each of FEV1, FEV1 percent, and PEF significantly decreased. When comparing the healthy non-smokers subgroups, however, they did not exhibit such a significant change. They found no significant differences in FEV1, FEV1 percent, PEF, or MVV. These disparities in outcomes between the two categories could be explained by the fact that occupational exposure becomes more dangerous when other variables, such as smoking, are present. Smoking is well known to be associated with lung function impairment and abnormal spirometric disorders [18], [19], [20]. For the same reason, there was significant difference between asthmatics subgroups. Asthma like any other obstructive disorders results in adverse effect on PFT [18], [21], [22].The effect of exposure was increased in exposed asthmatic and exposed healthy smokers. These two factors (smoking and asthma) could exasperate the serious effect of occupational exposure. However, the significant variations in the subgroups resulted in the overall changes in PFTs in the exposed group (G1). This result was supported by the respiratory diagnosis that reported by the medical spirometer as obstructive cases, which was higher percentage in G1 compared to G2 that showed a higher percentage of normal cases, as shown in Table 8. Therefore, there were no significant differences in FVC which declines in restrictive lung diseases [23]. This finding was in agreement with that reported by previous studies [24], [25], [26]. Regarding PEF, a significant decline was found in G1. Peak Expiratory flow (PEF) is maximum expiratory flow resulted from a maximal forced exhalation and come by the data of flow–volume curve, used as supportive required test in obstructive airways disease diagnosis and management beside FEV1and FEV1% [15], [27]. Furthermore, the results of our study revealed a significant increase in ELA in G1. Estimated Lung Age is the individual real age when the pulmonary function is normal. So it reflects the normality of the PFTs and used to follow-up the patients with respiratory disorders and it can be used especially to follow-up airflow decline overtime [2], [28]. The lack of further subgrouping of the exposed group based on the exposure duration could be considered a study limitation, although this would result in a small group size. The availability of a non-exposed group as a comparison group, on the other hand, is a positive aspect of the study.

Conclusions

We determined that PFTs may be harmed as a result of occupational exposure at the State Company of Petrochemicals. The effect was similar to that of obstructive pulmonary disease (COPD). The exposed group's asthmatic and healthy smoker subgroups were considerably affected, but healthy nonsmokers had no effect. Asthmatics and smokers should be reminded not to work in such settings, according to this result. Workers, on the other hand, should be constantly informed about the repercussions of their work at these industrial sites for more than 5 years, and they must adhere to all occupational safety regulations.

Declarations

Ethics approval and consent to participate

The study was approved by ethical committee of Basra medical college, University of Basra. All procedures and participants were in accordance with the ethical standards of the Institutional Research Committee and Helsinki Declaration.

Availability of Data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Authors' Contributions

Azza Sajid Jabbr: Conceptualization, investigation, writing - original draft, writing - review and editing; software, formal analysis. Abdulrutha Abdulhamid Radhi: Supervision, Methodology. Ali H. Al-Hashimi: Data curation and visualization.

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