

The Influence of Working in Stone Crushing Factories on Specific Respiratory Parameters

أثر العمل في مناشير الحجارة على مقاييس تنفسية مختارة

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Abstract

Working in stone-cutting factories is a known source for silica dust exposure, which has pathogenic effects on the respiratory system resulting finally in silicosis which may end in malignancy. Many changes may occur in the pulmonary system including restrictive and obstructive respiratory patterns which can be detected by spirometrical testing. In this study, forced spirometry was used to measure the forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), FEV1/FVC and the respiratory pattern for 98 stone cutting factories in Palestine. Information about the use of breath protective methods, respiratory presenting complaints and occupational history were collected. The results showed that 20% of the workers complained from at least one respiratory symptom, including cough, sputum production and chest pain. The majority of the workers showed restrictive pattern accounting for 69% of all the workers, 67% of them showed only mild restriction. On the other hand, only 11.2% showed obstructive pattern, and the remaining had normal pattern. There was a non-significant decrease in the FEV1 values ($p = 0.76$), but a significant decrease in the FVC values ($p < 0.001$). The FEV1/FVC values were significantly high

($p < 0.001$). The results were compared to the mean of the measured predictive values. It is concluded that working in stone-cutting factories influences the respiratory function in a negative way, and so necessitates urgent intervention to prevent health complications.

Key word: Occupational lung disease, FVC, FEV1, silicosis and stone cutting factories.

ملخص

يعد العمل في مصانع تقطيع الحجر مصدرا معروفا للتعرض لغبار السيليكا، والتي لها أثر مرضي على الجهاز التنفسي مؤدية إلى الإصابة بمرض silicosis، والذي قد يؤدي إلى الإصابة بالأورام الخبيثة. قد ينتج عن ذلك التعرض تغيرات في الجهاز التنفسي بما فيها تغير نمط التنفس إلى تنفس محدود أو تنفس مغلق والتي يمكن اكتشافها باستخدام جهاز Spirometer. في هذه الدراسة، تم استخدام قياس التنفس القصري لحساب حجم الزفير القصري في الثانية الأولى (FEV1) والسعة الحيوية القصرية (FVC)، والنسبة بينهما (FEV1/FVC)، و نوع نمط التنفس ل 98 عاملا في مصانع تقطيع الحجر في فلسطين. ومن خلال المعلومات التي تم جمعها حول استخدام العمال لوسائل حماية الجهاز التنفسي و الأعراض المرضية المتعلقة بالجهاز التنفسي التي يعاني منها العمال و تاريخ العمل لديهم. أظهرت النتائج أن 20% من العمال كانوا يعانون من عرض مرضي تنفسي واحد على الأقل مثل القحة و البلغم و ألم الصدر و أظهرت القراءات أن معظم العمال يعانون من نمط تنفسي محدود ونسبتهم 69% من إجمالي عدد العمال، وعانى 67% منهم من النوع البسيط من التنفس المحدود و من جهة أخرى كان قراءات 11.2% من العمال تظهر وجود نمط تنفسي ضيق، أما بقية العمال فقد كانت قراءاتهم طبيعية. كما كان هناك انخفاض قليل في قراءات FEV1 لدى العمال ($P=0.07$)، وانخفاض مهم في قيمة FVC لديهم ($P<0.001$). أما قيم FEV1/FVC فقد كانت مرتفعة بشكل مهم ($P<0.001$). لقد تمت مقارنة نتائج الفحوص بمتوسط القيم المتوقعة عند العمال أنفسهم. يستنتج من هذه الدراسة أن العمل في مصانع تقطيع الحجر له تأثير سلبي على الجهاز التنفسي مما يستوجب تدخلا عاجلا للحد من هذه المشكلة الصحية.

الكلمات المفتاحية: الأمراض الرئوية المتعلقة بالمهنة، السعة الحيوية القصرية (FVC) وحجم الزفير القصري في الثانية الأولى (FEV1) و silicosis ومصانع تقطيع الحجر.

Introduction

Lung diseases can be classified into two major functional categories, obstructive and restrictive diseases. The obstructive pattern is characterized by partial or complete obstruction of the airways at any level resulting in an increase in resistance and airflow limitation. On the

other hand, the restrictive pattern, such as that found in idiopathic pulmonary fibrosis, are marked by a decrease in the level of expansion of the lung parenchyma or the chest wall like what happens in ankylosing spondylitis (Berdal, Halvorsen, van der Heijde, Mowe, & Dagfinrud, 2012; Kumar, Vinay, Robbins, & L, 2007).

Pneumoconiosis is a broad group of occupational lung diseases that are induced by exposure to organic and inorganic particulates, either in small amounts over a long period of time or a single extremely high exposure. They are termed occupational because the mineral dust pneumoconioses almost always result from chronic exposure in workplaces. The three most commonly described irritating substances are coal dust, asbestos and silica (Kumar et al., 2007; Longo D et al., 2011).

Silica, also called silicone dioxide, is an inorganic particulate that presents in crystalline or free amorphous forms is known to be highly fibrogenic to the lung parenchyma. It is found in the dusts that result from stone cutting, dressing and polishing industries, also exposure to silica dust occurs in other settings including working in mines, granite and steel production, pottery and ceramic industries among many other occupations (Colledge, R.Walker, & Ralston, 2010; Pelucchi et al., 2006). A study shows that dust from granite quarrying consists of 71% silica (Nwibo, Ugwuja, Nwambeke, Emelumadu, & Ogbonnaya, 2012). Chronic exposure to this material causes an occupational lung disease termed silicosis. In silicosis there is a release of various inflammatory mediators and the activation of macrophages in the lungs (Davis, 1986) causing irreversible damage to structure of the interstitium and alveoli (Sa et al., 2010). Quarry workers have common symptoms resulting from exposure to silica dust including, chest pain, non-productive cough, dyspnea and catarrh (Malmberg, Hedenstrom, & Sundblad, 1993). Furthermore, occupational silicosis can precede to malignancy as the crystalline silica has been classified carcinogenic to humans by the International Agency for Research on Cancer (IARC) (Pelucchi et al., 2006).

Lung function tests (LFTs) can be measured for assessment of various structural lung changes that cause alteration in the normal lung

function and to differentiate between the obstructive and restrictive patterns of lung diseases. They can be measured using an apparatus called a spirometer (Holguin, 2012; Longo D et al., 2011). These tests include Forced Expiratory Volume in the first second (FEV1) and Forced Vital Capacity (FVC). FEV1 is the maximum volume of air that can be forcibly exhaled after full inspiration in the first second. The Decrease of this value indicates ventilator limitation. FVC is the maximum air volume that can be forcibly exhaled after full inspiration. While this parameter is either normal or increases in obstructive diseases, it is reduced in restrictive ones because fibrotic changes render the lungs stiffer thus reducing the lung capacity. Nevertheless, FEV1/FVC ratio is characteristically decreased in obstructive patterns but is near normal or increased in restrictive diseases (Derom et al., 2008; Kumar et al., 2007; Longo D et al., 2012; Pellegrino et al., 2005).

In Palestine, there is a lack of studies describing and investigating the impact of working in stone crushing factories on the workers' health, especially the respiratory system health. Stone crushing workers are frequently reported to be suffering from various respiratory problems and complaints. This study aims to investigate the effluence of working in these factories on the pulmonary health among Palestinian workers. It intends to measure the respiratory function using spirometrical analysis as a reflection of the pulmonary system health status.

Material and Methods

In order to study the effect of working in stones crushing factories on the respiratory function, a cross sectional descriptive study was used to describe the pulmonary function of all the 98 stone crushing workers in Nablus, Ramallah, Hebron and Jenin governorates. All the workers were males who didn't work in any occupation that may affect their pulmonary function. These occupations include working with charcoal, domestic wood exposure, glass manufacturing, animal and birds farming or any occupation where the workers are exposed to toxic volatile chemicals. Any worker previously diagnosed with a respiratory disease, such as; asthma, chronic obstructive pulmonary disease (COPD), recent pneumonia (Kotz, Wesseling, Huibers, & van Schayck, 2009) or any

systematic condition that may affect the respiratory function; such as ankylosing spondylitis, was excluded from the study.

Before starting data collection, an Institutional Review Board (IRB) approval for conducting the study was obtained. After explaining all the study steps, benefits and possible risks, a signed consent form was obtained from all the participating subjects. Anonymity of the subjects was ensured, and codes were used instead. Additionally, confidentiality of the subject's personal information was strictly maintained during and after the study.

The first step in data collection was an interview-based questionnaire. The collected data include personal information about the age, gender, weight, height (Holguin, 2012), smoking status and number of cigarettes daily (Yeoh & Yang, 2002), which are all important data for measuring the spirometry parameters predictive values. Occupational history; including current and previous professions, with the durations of working in each and the use of respiratory protective methods were obtained. Other information regarding the health status; including respiratory symptoms and diseases and systemic conditions that may affect the lungs' function were obtained. These information are very important for the inclusion and exclusion criteria of the study population and data analysis.

Forced spirometry was performed for all the included workers in order to measure the FEV1, FVC, FEV1/FVC and to detect the respiratory function pattern, which can be normal, restrictive or obstructive. The latter two can be subdivided into mild, moderate or severe. During the test, the subjects were seated, with the lips firmly applied around the disposable mouth piece and nose clipped to prevent leakage of air through the nares. Three attempts for each subject were allowed, and the best spirograph was selected automatically by the spirometer. Spirometry was done using a Microlab Spirometer that is produced by CareFusion, which is compliant to ATS/ERS 2005 standards (Pellegrino et al., 2005), and the regular guidelines for spirometer were followed (Broekhuizen et al.).

Statistical analysis of the data was performed using SPSS Statistics V.17.0 (SPSS Inc, Chicago, Illinois, USA), where one sample T-test for measuring the P value to find out the significance of the associations between working in the stone factories and each of the used spirometry. The level of significance was considered to be 0.05%. The mean value for each of measured spirometry was compared to the mean of the predicted values for the same spirometry, corrected to the age, gender, height, weight and smoking habits.

Results

Before performing spirometrical testing for the workers, they answered an interview-based questionnaire. None of the workers used special respiratory protection methods from the stone crushing dust; such as breathing masks. When the workers were asked about the presence of daily respiratory complaints; including chronic cough, sputum production, recurrent rhinitis and shortness of breath, it was found that 20% of them had one or more of these symptoms in a way affecting their life negatively. The answers regarding the physical characteristics, including the height, weight, gender, age and smoking habits of the workers were entered to the spirometry for the purpose of measuring the predictive values for spirometrical parameters; FEV₁, FVC and FEV₁/FVC.

The results of spirometry performed on the stone crushing workers showed an abnormal pattern in 81% of them. The majority of them showed a restrictive pattern accounting for 69% of the total number of workers. 67% of the subjects showing restrictive pattern had only mild restriction accounting for 53.2% of all the workers. On the other hand, 11.2% of the workers showed an obstructive pattern, more than half of them had severe obstructive lung disease as shown in figure 1.

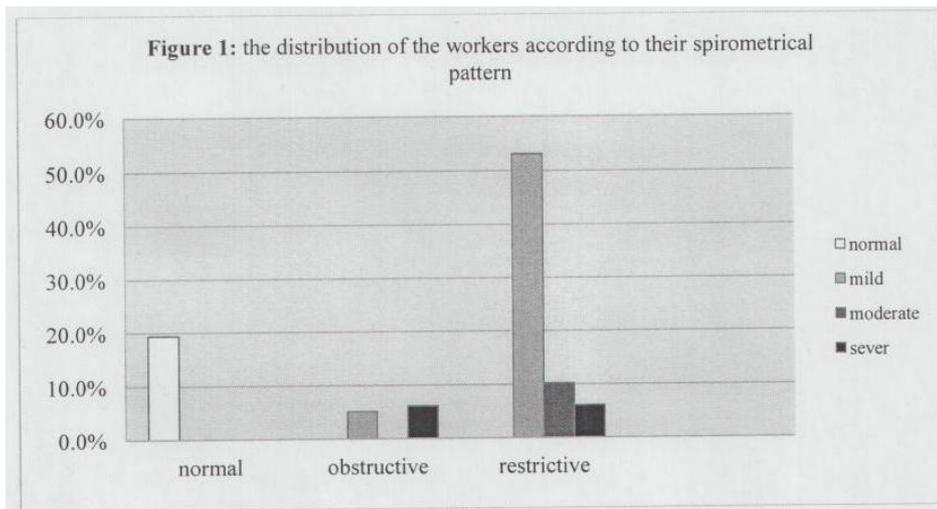


Table 1 shows the spirometrical values of the workers that were measured by the spirometer, which was also used to show the predictive values for each subject. These predictive values are corrected to the height, weight, age, gender and smoking habits for each case. The FEV1 values' mean is (3.2066), which is lower than the mean of the predicted values (4.0524), but this difference is not significance (P value= 0.076). 51% of the workers showed a decrease in the FEV1 values compared to the measured predicted values' mean. Regarding FVC values, 60.2% of the workers had decreased FVC values in comparison to the measured predicted values' mean (4.9705). The FVC values' mean is (3.8032), which significantly lower than the predicted values' mean (P values< 0.001). FEV1/FVC values' mean is (87.3469), which significantly higher than the measured predicted values' mean (P value < 00.1), as the predicted FEV1/FVC values' mean is (80.9592). 70.4% of the workers showed a significant increase in the FEV1/FVC values in comparison to the predicted values' mean for this ratio.

Table (1): The association between working in stone crushing factories and specific respiratory parameters.

Respiratory parameters	Mean values for the workers	Predicted mean values *	P values#
FEV1	3.2066	4.0524	0.076
FVC	3.8032	4.9705	0.001
FEV1/FVC	87.3469	80.9592	0.001

* These means were measured for the predicted values for the workers measured by the spirometer corrected to the height, weight, age, gender and smoking habit.

These values were measured using one sample T-test to compare mean value for the workers to the predicted values mean.

Discussion

The development of silicosis is usually slow and progressive. In the classic form of silicosis, the patient remains asymptomatic throughout the first 10-20 years of continuous exposure to silica. However, the progression of the disease continues even after the exposure ceases (Barthel, 1990; Colledge et al., 2010). Silicosis has been reported to be associated with spirometrical changes. In a previous study, it was shown that many silicotics have restrictive or obstructive structural lung changes. More than a fifth of the study sample had both restrictive and obstructive patterns, indicating the massive variation in the lung function (Rosenman, Reilly, & Gardiner, 2010).

Our data indicate that working in stone crushing factories is hazardous to the respiratory health of workers who don't use appropriate protective methods. The exposure to dust poses inflammatory changes to the lung parenchyma (Davis 1986) that result in massive variations in the pulmonary function (Rosenman, Reilly, & Gardiner, 2010). According to our results, while the decrease in FEV1 values among workers was not significant, changes in FVC and FEV1/FVC ratio values were significantly noted.

The measured FVC values' mean in workers is significantly lower than in those expected for the normal population. This result correlates with restrictive and fibrotic changes in the lung parenchyma of workers exposed to dust and silica. Furthermore, FEV1/FVC ratio values' mean is significantly increased, as what happens in restrictive diseases (Kumar et al., 2007). The most noted spirometrical pattern in this study is restrictive. However, about one tenth of workers have an obstructive pattern and a fifth show no abnormalities at all.

In a study performed on prediagnosed silicotic patients and aiming to address the nature of spirometrical changes among these patients; 30.1% and 28.1% of the sample showed restrictive and obstructive pattern of lungs function respectively. This more prominent restrictive pattern correlates with the decreased FVC values among workers in comparison with the non-workers, and the increased FEV1/FVC values among the workers in comparison to the non-workers, as a result of the chronic inflammatory response after exposure to the dust. Furthermore, both FVC and FEV1/FVC were significantly decreased among the patients (Rosenman et al., 2010). These differences from this study results may be attributed to the fact that; it is not known if the study sample used here has silicosis or not. However, in another study conducted on 41 workers exposed to silica dust in a large chemical plant engaged in amino acid and vitamin synthesis, it was shown that FEV1/FVC was significantly decreased when compared to a non-exposed control group (Choudat, Frisch, Barrat, el Kholti, & Conso, 1990).

Regarding the respiratory symptoms, some workers showed symptoms of chronic cough, sputum production, recurrent rhinitis and shortness of breath, which is compatible with the fact that quarry workers may show such symptoms as a result of exposure to silica dust (Malmberg, Hedenstrom, & Sundblad, 1993). In another study conducted on quarry workers testing their LFTs and the symptoms they suffer from; it was found that 79% of them suffered from varient degrees of chets pain and 55% complained from productive cought (Gupta, Chaswal, & Saxena, 1999). However, this represnts only a minority of the workers. And this correlates with tha fact that the progression of silicosis is slow

and the patients may remain asymptomatic for more than 10 years (Colledge et al., 2010).

Conclusion

Working in stones crushing factories and chronic exposure to silica dust pose serious effects on the respiratory system. Both restrictive and obstructive changes in the lungs have deleterious consequences on the respiratory health. In Palestinian stone crushing factories, no protective measures are pursued in this matter. Thus, the negative effects of silica dust exposure detected in this study necessitate rapid intervention and promotion of safety measures for workers in this field.

Recommendations

The negative influence of working in stone cutting factories as concluded from this study necessitates intervention to reduce this disastrous effect on the workers' pulmonary health. These interventions may include the use of pulmonary protective methods, working duration limitations and periodic clinical respiratory examination to evaluate the respiratory system health status. It's also recommended to conduct a follow up study evaluating the efficacy of the lung protective methods.

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