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International Journal of Current Research
Vol. 8, Issue, 07, pp.34727-34733, July, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

TO ASSESS THE EFFECTS OF STAINLESS STEEL DUST EXPOSURE ON LUNG FUNCTION BY SPIROMETRY

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ARTICLE INFO

Article History:
Received 10th May, 2016
Received in revised form
05th June, 2016
Accepted 20th June, 2016
Published online 31st July, 2016

Key words:

Spirometry, Pulmonary Function Test, Forced Vital Capacity, FEV1 as percentage of VC, Stainless steel, Chromium, Carbon black.

ABSTRACT

Ventilatory lung functions are reduced during occupational exposure to industrial air pollutants. The degree of functional impairment has a direct relationship with the dust concentration and duration of exposure. Spirometry is a valuable tool to investigate and assess the degree of pulmonary functional impairment caused by occupational dust. Periodic pulmonary function tests help in earlier detection and intervention.

Citation: Dr. Panneerselvam, T., Dr. Vishnu Priya, M., Dr. Kumudha, P. and Dr. Sangeetha, K. P. 2016. "To assess the effects of stainless steel dust exposure on lung function by Spirometry", *International Journal of Current Research*, 8, (07), 34727-34733.

INTRODUCTION

Ventilatory lung functions are reduced during prolonged exposure to industrial air pollutants from textile mills, coal mines and other occupations in which they are exposed to various forms of pollutants. The degree of functional impairment has a direct relationship with the dust concentration and duration of exposure. Spirometry is a valuable tool to investigate and assess the degree of pulmonary functional impairment caused by occupational dust and for earlier detection and intervention.

Spirometry

A simple method for studying pulmonary ventilation is to record the volume movement of air into and out of the lungs, a process called spirometry. A spirogram indicates changes in lung volume under different phases of breathing. For ease in describing the events of pulmonary ventilation, the air in the lungs has been subdivided in this spirogram into four volumes and four capacities, which are the average for a young adult man. Common clinical measurements of air flow are obtained from maneuvers in which the subject inspires to TLC and then forcibly exhales to RV. Three measurements are commonly made from a recording of forced exhaled volume versus time i.e., a spirogram.

1. The amount of air exhaled during the first second of FVC maneuver (Forced Expiratory Volume in 1 sec or FEV_1).
2. The total volume exhaled (Forced Vital Capacity or FVC).
3. The average expiratory flow rate during the middle 50% of the VC (Forced Expiratory Flow between 25% and 75% of the VC or $FEF_{25-75\%}$) also called the Mean Mid Expiratory Flow Rate (MMEF).

Ventilatory function is measured under static conditions for determination of lung volumes and dynamic conditions for determination of forced expiratory flow rates. Dynamic measurements of ventilatory functions are made by having the subject inhale to TLC and then perform a forced expiration to RV. If a subject performs a series of such expiratory maneuvers using increasing muscular intensity, expiratory flow rates will increase until a certain level of effort is reached. Beyond this level, additional effort at any given lung volume will not increase the forced expiratory flow rate. This phenomenon is known as the effort independence of forced expiratory flow.

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Lung volumes and measurements made during forced expiration are interpreted by comparing the values measured with the values expected for the given age, height, sex and weight of the patient. Regression curves have been constructed on the basis of data obtained from large numbers of normal, non smoking individuals without evidence of lung disease. Predicted values for a given patient can then be obtained by using the patient's age and height in the appropriate regression equation; different equations are used depending on the patient's race and sex. Because there is some variability among normal individuals, values between 80% and 120% of the predicted value have traditionally been considered normal. Increasingly calculated percentiles are used in determining normality. Specifically, values of individual measurements falling below the fifth percentile are considered to be below normal.

Factors Determining a Person's Pulmonary Function

Age

As a person ages, the natural elasticity of the lungs decrease. This translates into smaller and smaller lung volumes and capacities. When determining whether or not the patients have normal PFT findings, it would be important to compare the patient's values with the PFT results of a normal person of the same age and gender.

Gender

All pulmonary volumes and capacities are about 20 to 25 percent less in women than in men. Usually the lung volumes and capacities of males are larger than the lung volumes and capacities of females. Even when the males and females are matched for height and weight, males have larger PFT values than females. Because of this gender-dependent lung size difference, different normal tables must be used for males and females.

Body build

Body size has tremendous effect on PFT values. Thin built individuals will have smaller PFT results than well built individuals of the same age. Normal tables account for these variables by giving predicted PFT data for males and females of a certain age and height. Sometimes as people age, they begin to increase their body mass by increasing their body fat to lean body mass ratio. If they become too obese, the diaphragmatic movements are interfered with. Hence, the PFT results will demonstrate a smaller measured PFT outcome than expected- i.e. the observed values are actually smaller than the predicted values. PFT values are greater in large and athletic people than in small and asthenic people.

Race

Race affects the PFT values. Therefore a clinician must use a race appropriate table to compare the patient's measured pulmonary function against the results of the normal table written for the patient's racial group.

Other factors

Environmental factors and altitude, respiratory muscle strength and chest wall strength may have an effect on PFT results. Chronic smoking and occupational exposure to respirable dust significantly affect the lung functions.

Tests of ventilatory capacity

The primary instrument used in the pulmonary function testing is a spirometer. It is designed to measure changes in volume and can only measure lung volume compartments that exchange air with the atmosphere. The vital capacity (VC), expiratory reserve volume (ERV), inspiratory capacity (IC) are measured by having the subject breathe into and out of a spirometer, a device capable of measuring expired or inspired gas volume while plotting volume as a function of time. Other volumes- specifically, RV, FRC and TLC- cannot be measured in this way because they include the volume of air present in the lungs even after a maximal expiration. Two techniques commonly used to measure these volumes are Helium dilution method and body plethysmography.

Helium dilution method

The subject repeatedly breathes in and out from a reservoir with a known volume of gas containing a trace amount of helium. The helium is diluted by the gas previously present in the lungs and very little is absorbed into the pulmonary circulation. From the knowledge of the reservoir volume and the initial and final helium concentrations, the volume of gas present in the lungs (FRC) is calculated. The helium dilution method may underestimate the volume of gas in the lungs if there are slowly communicating air spaces, such as bullae. In this situation, lung volumes can be measured more accurately with a body plethysmograph, a sealed box in which the subject sits while panting against a closed mouth piece. By measuring the pressure changes in the plethysmograph and at the mouth piece, the volume of air in the thorax can be calculated using Boyle's law.

Pulmonary function test parameters

Vital Capacity (VC)

The largest amount of air that can be expired after a maximal inspiratory effort is called vital capacity. This equals the inspiratory reserve volume plus the tidal volume plus the expiratory reserve volume. The normal value is 4.8 litres in male and 3.2 litres in female. Clearly the vital capacity is related to the size and development of the subject. The vital capacity represents the patient's maximum breathing ability. This is frequently measured clinically as an index of pulmonary function. It gives useful information about the strength of the respiratory muscles and other aspects of pulmonary function. It is usually 2.6 lit/ sqm surface area in the male and 2.1 lit /sqm surface area in the female. It is increased in swimmers and divers. It is decreased in older people, pregnancy, diseases of the respiratory apparatus e.g. respiratory obstruction, pleural effusion, pneumothorax, pulmonary fibrosis, emphysema and pulmonary edema. The vital capacity is altered by posture, being greater when measured in the upright position owing to the decreased pulmonary volume in the standing subject.

Forced Vital Capacity (FVC)

One of the most useful tests to assess the overall lung function is FVC. This is the volume of air which can be forcibly and maximally exhaled out from the lungs after deepest inspiration until no more air can be expired. For normal individual FVC is equal to or often slightly lower than VC. FVC is approximately 5 litres in the normal adult. However, a well trained athlete can have a FVC of more than 7.0 litres, where as an asthmatic or emphysema patient may have a FVC no greater than 3 litres. The small airways of these patients collapse towards the end of forced expiration and results in trapped air in the lungs leading to a decrease in FVC and an increase in RV. FVC is determined primarily by four factors.

1. Strength of the respiratory muscles (decreased in poliomyelitis, diaphragm dysfunction, neuromuscular disease)
2. Airway resistance (increased in asthma, bronchitis)
3. Lung volumes (decreased in tuberculosis, pulmonary fibrosis, prior lung resection, marked pleural effusion)
4. Elastic properties of the lung (marked pleural thickening).

Forced Expiratory Volume (FEV)

FVC formerly called Timed Vital Capacity is the volume of FVC expelled in a specific time. The time is indicated by a subscript 't' for time (FEV_t) and thus the volume expelled in one second will be FEV_1. Though FEV_t can also be measured for 0.5, 0.75, 2 and 3 seconds, the most widely used measurement is FEV_1.

Forced Expiratory Volume in first second (FEV_1)

The fraction of the vital capacity expired during the first second of forced expiration is known as FEV_1or timed vital capacity. In a normal person between 20 and 30 years of age, it is expected that 83% of the total vital capacity will be expired in the first second. This FEV_1 is a much more sensitive index for assessing severity of the obstructive disease but it does not allow for the differentiation of the various causes of obstruction. The vital capacity may be normal but the FEV_1 is reduced in diseases such as asthma, in which airway resistance is increased because of bronchial constriction. The ratio of FEV_1 to FVC is often referred to as FEV_1% or FEV_1/FVC. The normal values of FEV_1% are 80-85% in young adults, 70-80% in older subjects and above 90% in children. $FEV_{0.75\%}$ is a more useful index in children as they blow out air very rapidly and their $FEV_{0.75\%}$ is about equal to FEV_1% in adults. Most young adults blow around 60% of FVC in 0.5 sec, 75% in 0.75 sec, 83% in 1 sec, 95% in 2 sec and 97% in 3 sec. FVC, FEV_1 and FEV_1% are reliable indices of ventilatory capacity and help to distinguish between restrictive and obstructive ventilatory defects. If the individual being tested displays a decreased FEV_1% less than 72%, it is a hall mark of obstructive lung disease. It may be increased in patients with restrictive lung disease. Obstructive dysfunction is marked by a reduction in air flow rates judged by a fall in the ratio of FEV_1 to FVC. Causes include asthma, COPD (chronic bronchitis, emphysema), bronchiectasis, bronchiolitis and upper airway obstruction. Restrictive dysfunction is marked by a reduction in lung volumes with a normal to increased FEV_1/FVC ratio. Severity is graded by the reduction in Total Lung Capacity.

Peak Expiratory Flow Rate (PEFR or PEF)

PEFR or PEF is the maximum rate of air flow which is sustained for a period of 10 milliseconds during a forced expiration after a maximal inspiration. It is not a spirometric measurement. It can be obtained by using a pneumotachograph, but is usually measured with a Wright's peak flow meter. Normal values are 6-10 litres/ second or 400-600 litres/ minute. PEFR is reduced in obstruction of larger airways. It is useful for monitoring functional changes in asthma.

Mean Forced Expiratory flow (FEF)

They are mean flow rates over specified volumes and are calculated from measuring the time (t) taken to expel the volumes (v) i.e., F= v/t. the most useful is the flow rate over the middle half of FVC i.e., between 25% and 75% of FVC ($FEF_{25-75\%}$) and was formerly called Maximal Mid Expiratory flow rate (MMEF). It is useful for detecting the response to bronchodilators. Normal values are 180 – 280 litres/ minute in men and 120- 200 litres/ minute in women. Other flow rates recommended are $FEF_{0.2-1.2}$ measured between initial 0.2 and 1.2 litres of FVC, formerly called Maximal Expiratory flow rate (MEF) and flow rates between 50% and 75%, 70% and 80%, 75% and 85% of FVC. The FVC expiratory curve is divided into quartiles. The quartiles are expressed as $FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$ of FVC.

FEF_{75}, FEF_{50}, FEF_{25}

The instantaneous flow rate, at which 75% of the VC has been exhaled, is called FEF_{75}. The flow rate at which 50% of VC remains to be exhaled is called FEF_{50} and the flow rate at which 25% of the VC has been exhaled is called the FEF_{25}.

Mean Mid Expiratory flow rate (MMEF or $FEF_{25-75\%}$)

This is a measure of the flow rate in litres/ second of the middle half of the FVC maneuver. It can be calculated from the spirogram by dividing the vital capacity into quarters, dropping a line from the first (25%) and the third (75%) quartiles and then connecting the lines and measuring the slope. This is often considered a more sensitive measurement of early air flow obstruction, particularly in smaller airways. However this measurement must be interpreted cautiously in patients with abnormally small lungs (low TLC and VC). These patients exhale less air during forced expiration and the $FEF_{25-75\%}$ may appear abnormal relative to the usual predicted value, even though it is normal relative to the size of the patient's lung.

The value of looking at the middle half becomes clear when one realizes that the first quarter of the FVC test is in part effected by the patient's effort in overcoming the inertial forces which resist thoracic wall expansion. Additionally, expiratory efforts in the last quarter of a FVC test is inadequate due to patient's diminishing physical effort and the breathlessness associated with the terminal completion of the FVC test. Hence the $FEF_{25-75\%}$ (i.e., middle 50% of the FVC) is the most reliable representative of true expiratory patency and is therefore a very sensitive test for the presence of smaller airway obstructive disease.

Flow – Volume Curve

The flow- volume curve is plotted using expiratory flow rates against lung volume. The close linkage of flow rates to lung volumes produces a typical flow- volume curve. In addition, the spirometric values mentioned above can be calculated from the flow- volume curve. Commonly, flow rates during a maximal inspiratory effort performed as rapidly as possible are plotted as well, making the flow- volume curve into a flow-volume loop. At TLC, before expiratory flow starts, the flow rate is zero. Once forced expiration has begun, a high peak flow rate is achieved. As expiration continues and lung volume approaches RV, the flow rate falls progressively in a linear fashion as a function of lung volume for a person with normal lung function. During maximal inspiration from RV to TLC, inspiratory flow is most rapid at the midpoint of inspiration, so the inspiratory portion of the loop is U- shaped or saddle shaped. The flow rates achieved during maximal expiration can be analysed quantitatively by comparing the flow rates at specified lung volumes with the predicted values or qualitatively by analyzing the shape of the descending limb of the expiratory curve.

Forced Expiratory Volume in Three Seconds (FEV_3)

This is the volume of air which can be forcibly exhaled in three seconds measured in litres. This volume is fairly close to the FVC since, in normal individual, most of the air in the lungs can be forcibly exhaled in three seconds.

Maximal Voluntary Ventilation (MVV)

It is formerly called Maximal Breathing Capacity. This is the largest volume of air that can be moved into and out of the lungs in one minute by voluntary effort. The volume of air moved is either recorded by a spirometer fitted with a writing point or is collected in a Douglas bag.

This test is effort dependent and the ability to reach a high MVV depends upon the muscular forces available, compliance of the thoracic walls and lungs and on the airway resistances setup. The normal value is 125- 170 lit/min. MVV is profoundly reduced in patients with airway obstruction such as emphysema and asthma. In obstructive airway diseases, the reduction in MVV is much greater than the reduction in VC, but in restrictive disorders VC is reduced to a greater extent than MVV. There are a number of systems which physicians use to determine the severity of the disease. Here is one way that is very commonly used.

Normal PFT outcomes - > 85% of predicted values
Mild disease - 65% - 85% of predicted values
Moderate disease - 50% - 65% of predicted values
Severe disease - < 50% of predicted values

In most spirometers in the market today, there is a set of normal tables which can be chosen while performing the PFT. Also there are interpretive microchips in the PFT machines which will give the diagnosis for the particular patient. These two features make it easy for the clinician to immediately see what the predicted values are for a specific patient and whether or not the PFT has a normal observed outcome. The PFT data are examined by the computerized spirometer and a diagnosis of obstructive or restrictive disease is made.

Patterns of Abnormal Function

The two major patterns of abnormal ventilator function, as measured by static lung volumes and spirometry, are restrictive and obstructive patterns. This grouping of defects is based on the fact that the routine spirogram measures two basic components, air flow and volume of air out of the lungs. Generally the idea is that if flow is impeded, the defect is obstructive and if volume is reduced a restrictive defect may be the reason for the pulmonary disorders.

Obstructed airflow

The patency is estimated by measuring the flow of air as the patient exhales as hard and as fast as possible. Flow through the tubular passageways of the lung can be reduced for a number of reasons.

1. Narrowing of the airways due to bronchial smooth muscle contraction as in asthma.
2. Narrowing of the airways due to inflammation and swelling of the bronchial mucosa as in chronic bronchitis, bronchiectasis, bronchiolitis and cystic fibrosis.
3. Materials inside the bronchial passageways physically obstructing the flow of air as in mucus plugging, foreign body and invasive tumors.
4. Destruction of lung tissue with loss of elasticity as in emphysema.
5. External compression of the airways by tumors and trauma.

In the obstructive airway disease VC is decreased, FEV_1 is markedly decreased and $FEV_1\%$ is very low. In the obstructive pattern, the hallmark is a decrease in expiratory flow rate. With fully established disease, the ratio of FEV_1/ FVC is decreased, as is the $FEF_{25-75\%}$.

With early obstructive disease, which originates in the small airways, FEV_1/FVC may be normal, the only abnormality being a depression in $FEF_{25-75\%}$ and coved configuration in the terminal portion of the forced expiratory flow/ volume curve. In obstructive disease VC is frequently decreased because of the striking elevation in RV with only minor changes in TLC (either normal or increased). The residual volume is increased as a result of airway closure during expiration and the ratio of RV/ TLC is increased.

Restricted air flow

The hallmark of a restrictive pattern is a decrease in lung volumes, primarily TLC and VC. In restrictive lung disease, lung inflation is restricted; FVC and FEV_1 are very much reduced, but FEV_1% is normal or may be slightly increased. Disorders resulting in a restrictive pattern can be broadly divided into two subgroups, depending on the location of the pathology: pulmonary parenchymal and extra parenchymal. In pulmonary parenchymal disease, RV is also generally decreased and forced expiratory flow rates are preserved. In fact, when FEV_1 is considered as a percentage of FVC, the flow rates are often supranormal i.e., disproportionately high relative to the size of the lungs. The expiratory portion of the flow/ volume curve appears relatively tall due to preserved flow rates and narrow due to decreased lung volumes. With extraparenchymal disease, dysfunction can be predominantly in inspiration or in both inspiration and expiration. In the extraparenchymal pattern characterized by inspiratory dysfunction caused by either inspiratory muscle weakness or a stiff chest wall, inadequate distending forces are exerted on an otherwise normal lung. As a result, TLC values are less than predicted, RV is often not significantly affected and expiratory flow rates are preserved. If inspiratory muscle weakness is the cause of this pattern, then MIP (maximal inspiratory pressure) is decreased. In the extraparenchymal pattern characterized by inspiratory and expiratory dysfunction, the ability to expire to a normal RV is also limited, because of either expiratory muscle weakness or a deformed chest wall that is abnormally rigid at volume below FRC. Consequently, RV is often elevated, the ratio FEV_1/FVC is variable and depends on expiratory muscle strength. If expiratory muscle strength is significantly decreased and MEP (maximal expiratory pressure) is decreased, the ability to expire rapidly is impaired and FEV_1/FVC may be decreased even though there is no air flow obstruction. If expiratory muscle strength is normal but the chest wall is abnormally stiff below FRC, then FEV_1/FVC is normal or increased.

Classification of the Restrictive Lung Diseases

1.Intrinsic restrictive lung diseases

a. Tuberculosis
b. Pneumonic consolidation
c. Pneumonectomy
d. Pneumoconiosis
e. Idiopathic pulmonary fibrosis
f. Pulmonary edema
g. Sarcoidosis

2.Extrinsic restrictive lung diseases

a. Kyphosis, scoliosis
b. Ankylosing spondylitis
c. Pleural effusion
d. Gross obesity
e. Tumors
f. Ascitis
g. Pain on inspiration- pleurisy, rib fractures

3.Neuromuscular restrictive lung diseases

a. Generalized weakness as in malnutrition
b. Diaphragmatic paralysis
c. Myasthenia gravis
d. Muscular dystrophy
e. Poliomyelitis
f. Amyotrophic lateral sclerosis

Pulmonary function in stainless steel workers

Stainless steel

Stainless steel is an alloy of iron which contains atleast 10% chromium (Cr). This addition of chromium defines the unique properties such as stainless, corrosion resistant and heat resistant by formation of chromium oxide film on the steel surface. The addition of other elements such as molybdenum, nickel and nitrogen enhances the corrosion resistance. For higher hardness and strength carbon is added. The manganese preserves the austenitic structure in the steel as does nickel but at a lower cost. The austenitic stainless steel comprises over 70% of the total stainless steel production. They contain maximum of 0.15% carbon, minimum of 16% chromium and either sufficient nickel or manganese to retain as austenitic structure at all temperatures. 18/10 stainless steel and 18/8 stainless steel contains 18% chromium and 10% or 8% nickel. Many studies have been carried out concerning the effects of stainless steel dust exposure on lung function.

Huvinen *et al.* Clinic of Occupational Medicine, Tampere University, Finland in their study monitored the lung function in workers exposed to different chromium species. Among the Cr^{3+} exposed people, the production of phlegm, shortness of breath and breathlessness on exertion were significantly more frequent than in the control group. The workers in the chromite group had lower lung function test results than the control group due to exposure to higher chromium dust concentration.

Hannu *et al.* Department of Occupational Medicine, Helsinki, Finland in their study found that occupational asthma was induced by fumes of special stainless steel with high chromium content.

Sobaszek *et al.* Institute de Medicine, du Travail, Lille, France in their study found that chronic exposure to stainless steel fumes and mild steel fumes decreases FVC, FEV_1 and PEF. These chronic effects have been related to the chromium and nickel concentration in stainless steel.

Kilburn *et al.* Environmental Sciences Laboratory, University of California, Los Angeles in their study found that baseline spirometric tests such as FEV_1, $FEF_{25-75\%}$ and PEFR values are significantly reduced in the workers exposed to stainless steel fumes due to chromium and nickel. Many workers had increased serum chromium level and urinary chromium level. The serum nickel level showed a little increase in some workers and urinary nickel level did not increase.

Chen *et al.* Institute of Occupational Medicine and Industrial Hygiene, National Taiwan University, Taiwan studied respirable dust exposure and respiratory health in male Taiwanese steel workers. A cross sectional study found that their respiratory symptoms such as cough, phlegm and wheezing had increased. Lung function test results showed a significant decrease in FVC and FEV_1.

Bogadi-Sare *et al.* Institute for Medical Research and Occupational Health, University of Zagreb in their study involved 106 workers exposed to stainless steel dust and found that they have more respiratory symptoms such as breathlessness, cough and wheezing. Lung function test results such as FEV_1, PEF, FEF_{75}, FEF_{50} and FEF_{25} were significantly lower in the exposed group than the control group and smoking did not contribute essentially to these changes. The result confirms that stainless steel dust is an important cause for the development of respiratory obstructive disorders in the industrial working population.

Wang *et al.* Section of Pulmonary and Critical Care Medicine, Morgantown, West Virginia studied longitudinal and cross sectional analysis of lung function in stainless steel dust exposed workers and found a gradual decrease of lung function test results such as FEV_1, FVC and FEV_1/ FVC per year of employment in the dusty area.

Kupper *et al.* Department of Occupational Medicine, Frankfurt, Germany studied the effect of exposure to carbon black dust on the lung function. They found bronchial hyper responsiveness and decreased lung function in the exposed workers than the control groups.

Sulotto *et al.* studied respiratory impairment due to stainless steel metal dust exposure in industrial workers and found decreased lung function test results such as FEV_1, MEF_{50} and MEF_{25}.

Oztemir *et al.* Department of Chest Disease, Ankara University, Turkey studied chronic effects of stainless steel fumes exposure on pulmonary function and found a significant decrease in FVC, FEV_1, PEF and MMEF.

Crosbie *et al.* studied the respiratory health of carbon black workers by questionnaire and spirometry. The result showed that the group of workers who were exposed to carbon black dust had a decrease of FVC, FEV_1 and $MMEF_{25-75\%}$ than the control groups.

Harber *et al.* Division of Occupational and Environmental Medicine, University of California, Los Angeles, studied the effect of long term carbon exposure on respiratory function and symptoms. They found reduction in forced expiratory volume in first second (FEV_1).

Gardiner *et al.* Institute of Occupational Health, University of Brimingham, UK studied respiratory health effects from exposure to carbon black in the European carbon black manufacturing industry. They found that the percentage of predicted lung function volumes exceeded 100% for FEV_1 and FVC where as $FEF_{25-75\%}$ and FEV_1/ FVC ratio were below 100%.

Van Tongeren *et al.* Institute of Occupational Health, University of Brimingham, UK studied assessment of the sensitivity of the relation between current exposure to carbon black and lung function parameters. FVC and FEV_1 were calculated for various exposure grouping schemes and found that the reduction in FVC and FEV_1 were statistically significant.

Gevenois *et al.* Dept of Radiology, Belgium studied coal mine dust or silica exposure in relation with lung function and significant correlations were found between the FEV_1% predicted and FEV_1/VC.

Carta *et al.* Institute di medicina del Lavoro, University di Cagliari, Italy studied dust exposure, respiratory symptoms and longitudinal decline of lung function in young coal miners. The cross sectional analysis showed significant association between individual cumulative exposure to dust and decrements in FEV_1 and MEFs. The results showed that even moderate exposure to coal dust significantly affect the lung function.

Osterman *et al.* Department of Environmental Science and Physiology, Harvard school of Public Health, Boston, USA studied the relation between the pulmonary function and exposure to mixed respirable dust containing silicon carbide and found significant decrements in FEV_1 and FVC.

Conclusion

Air pollution has significant effect on exacerbation of asthma, allergy and other respiratory diseases. The air quality in working circumstances is also being deteriorated day by day.
Among the industrial pollutants, the particulate matter particularly less than 10 µm size can pass through the natural protective mechanism of human respiratory system and play an important role in the genesis and augmentation of allergic disorders, restrictive lung disease and obstructive lung disease. The respiratory effects associated with stainless steel dust contaminated air include fever, phlegm, dyspnoea, chronic bronchitis, occupational asthma and decreased lung function. Hence early assessment and interpretation of pulmonary functions are valuable to increase to efficacy and performance of the industrial workers.

Abbreviations

PFT – Pulmonary Function Test
VC - Vital Capacity
TLC- Total Lung Capacity
RV- Residual Volume
FEV_1 - Forced Expiratory Volume in First Second
FVC - Forced Vital Capacity
PEF - Peak Expiratory Flow Rate
FEV_1/VC - FEV_1 as percentage of VC
MEF_{75}, MEF_{50}, MEF_{25} - Maximum Expired Flow Rate at 75%, 50%, 25% of FVC
MMEF or $FEF_{25-75\%}$ - Mean Mid Expiratory Flow Rate
MVV - Maximum Voluntary Ventilation
MEF_{50}/ MIF_{50} - Maximum Expiratory Flow Rate 50 / Maximum Inspiratory Flow Rate 50
MIP – Maximal Inspiratory Pressure
MEP - Maximal Expiratory Pressure

Acknowledgement

We thank the scholars whose articles are cited and included in references of this manuscript. I am grateful to authors/editors/ publishers of all those articles, journals, books from where the literature for this article has been viewed and discussed.

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