ASSESSMENT OF LUNG FUNCTION AMONG WORKERS OF AMMUNITION FACTORIES USING PULMONARY FUNCTION TEST-AN OBSERVATIONAL STUDY

Vaishnavi Ambep[1], Lavanya Ayyer[2]

[1]Intern, [2]Associate Professor Neuro Physiotherapy Department,
LSFPEF's College Physiotherapy, Nigdi, Pune, India.

Abstract: Background- Ammunition factory workers work on large scale in factories. Workers of ammunition factories work daily for 6 to 7 hours with continuous exposure to the chemicals. They are constant direct contact with chemicals which can be easily inhaled by them and cause ill health effects. Toxic substances like chlorine, ammonia, etc. are handled and workers get exposed to these chemicals. Occupational health diseases are proving to be a concerning factors nowadays. Millions of workers in a variety of occupational settings have a potential to get exposed to various hazardous substances.
Occupational respiratory diseases due to occupation are usually caused by the extended exposure by toxic substances which may lead to chronic or acute respiratory problems.
Thus, repeated exposure to dusty environment in an industry causes airway diseases which may affect the pulmonary function over a period.
The aim of this study is to assess the lung function in ammunition factory workers.
Methodology-Ethical approval had been obtained. An observational study was conducted on 96 workers with age in between 25-45 years in both genders. Pulmonary function test was performed by using the PFT software (parameters: FVC, FEV1, FEV1/FVC%, PEFR).
Result-In the present study, the result shows that out of 96 subjects 91% subjects had a significantly reduced Lung function due to their workplace environment, chemicals, metallic particles and duration of exposure.
Conclusion- This study concludes that ammunition factory workers are prone to develop lung disorders and exposure to ammunition is an important factor in deterioration of the pulmonary function. There is alteration in the pulmonary function of the subjects.

Keywords: Ammunition factory workers, PFT (Pulmonary Function Test), Altered Lung Function.

I. INTRODUCTION

Ammunition factory workers work on large scale in factories. Workers of ammunition factories work daily for 6 to 7 hours with continuous exposure to the chemicals. They are constant direct contact with chemicals which can be easily inhaled by them and cause ill health effects. Toxic substances like chlorine. ammonia, etc. are handled and workers get exposed to these chemicals. (1)
Occupational health diseases are proving to be a concerning factors nowadays. (2) Millions of workers in a variety of occupational settings have a potential to get exposed to various hazardous substances. (3)
Occupational respiratory diseases due to occupation are usually caused by the extended exposure by toxic substances which may lead to chronic or acute respiratory problems. (4)
Thus, repeated exposure to dusty environment in an industry causes airway diseases which may affect the pulmonary function over a period. (5)
Ammonia and chlorine due to inhalation can cause many effects as follows:

- Cough
- Chest tightness
- Dyspnea
- Airway obstruction
- Wheeze
- Severe bronchoconstriction (1)

Lung with its extensive surface area, high blood flow and thin alveolar epithelium is an important site of exposure with substances in environment. Severe single exposure can also generate chronic lung diseases. (6) The main important function of the lungs is gas exchange.

Pulmonary function tests give us a clear idea about the condition of pulmonary functions and can give us the assessment of respiratory problems suffered by the occupational workers. [7]
Other industrial workers such as stone crush workers were at a high risk of lung function deterioration due to exposure due to exposure to high dust concentrations for a prolonged period. The application of this test in public health and occupational medicine provides biological indices that are of value in assessing the effect of exposure of hazards. [8]
The application of these pulmonary function tests in public health and occupational medicine provide biological indices thar are of value in assessing the effect of exposure. [8] The primary purpose of pulmonary function testing is to identify pulmonary impairment and quantify severity of pulmonary impairments if present. [9]
Lung function tests are based on the measurement of volume of air breathed out and in in quite breathing and forced breathing. [10] These tests are carried out mostly by using spirometry. [9]

The main uses of lung function tests are:

- To help define more clearly the type of functional
- To measure serially natural progression (or regression with therapy) of the disorder.
- To assess the degree of respiratory failure.

❖ **Indications for Pulmonary Function Testing: -**

A. Diagnose the presence or absence of lung disease:

- ➢ History of pulmonary symptoms a. Dyspnea, wheezing b. Cough, phlegm production c. Chest discomfort, orthopnea
- ➢ Abnormal laboratory findings a. Chest x-ray or CT studies b. Blood gases or pulse oximetry
- ➢ Before beginning strenuous physical activities.
- Determine beneficial or negative effects of therapy:

1. Bronchodilators or steroids
2. Cardiac drugs (antiarrhythmics, diuretics)
3. Lung resection, reduction, or transplant
4. Pulmonary rehabilitation.

- Assess risk for surgical procedures:

1 .Lung resection (lobectomy, pneumonectomy)
2 .Thoracic procedures
3. Upper abdominal procedures

- Evaluate disability or impairment:

1. Social security or other compensation programs
2. Legal or insurance evaluation
3. Cardiopulmonary rehabilitation assessment.

- Epidemiologic or clinical research involving lung health. [15]

Obstructive Airway Diseases: An obstructive airway is one in which airflow into or out of the lungs is reduced. This includes variety of pathological condition and chronic obstructive pulmonary diseases which includes emphysema, chronic bronchitis, or asthma [11]
Restrictive Lung Disease: Restrictive lung disease is characterized by the reduction of lung volumes. The vital capacity and total lung capacity are both reduced below the lower limit of normal. Restriction is often associated with interstitial lung disease, congestive heart failure, obesity, lung resection, pleural effusion, etc.[11]

AIM

To assess the pulmonary function among workers of ammunition factories.

OBJECTIVE

1) To assess the lung function in workers of ammunition factories using pulmonary function testing.
2) To assess the parameters:

a) FVC
b) FEV1
c) FEV1/FVC
d) PEFR

METHODOLOGY AND MATERIALS

a) Study type – Observational study
b) Sampling technique – Convenient sampling
b) Sample size – 109
c) Study duration – 6 months

d) Study area – Maval region
e) Pulmonary function testing software
f) Laptop
g) USB portable wire
h) Mouthpiece
i) Consent form
j) Pen/ pencil

INCLUSION CRITERIA

Age- 25-45 years old
Gender – Male and female subjects
Workers in direct contact with the explosives.
Work experience – more than 6 months.

EXCLUSION CRITERIA

History of – chronic smoking and tobacco chewing
Presence of any structural deformities
Presence of any pre-existing respiratory comdition

OUTCOME MEASURE

- Pulmonary Function Testing (PFT machine)
- Parameters: FVC, FEV1, FEV1/FVC %, PEFR.
- Operational definitions:
  1. FVC (Forced vital capacity) - It is the maximum volume of gas the patient can exhale as forcefully and as quickly as possible.
  2. FEV1(Forced expiratory volume) – It is the volume of air that is exhaled during the first second of the FVC and reflects the airflow in the large airways.
  3 .FEV1/FVC ratio – It is the ratio to measure the amount of air that can be exhaled in 1 second as a percentage of the total amount of air that can be forcefully exhaled. [16]
  4 .PEFR (Peak Expiratory Flow Rate) – It is a measure of the highest expiratory flow that can be generated following maximal inspiration. [24]

PROCEDURE

Permission from the head of the ammunition factory was taken. as. Subjects were chosen based on inclusion and exclusion criteria. The subjects were explained about the procedure prior. The subjects were instructed to sit and take a deep breath and then form a tight seal with lips around the mouthpiece of the spirometer. Exhale maximally by the mouth. Three maneuvers were performed .Readings were recorded in the software and noted. Data was analyzed using statistical tests.

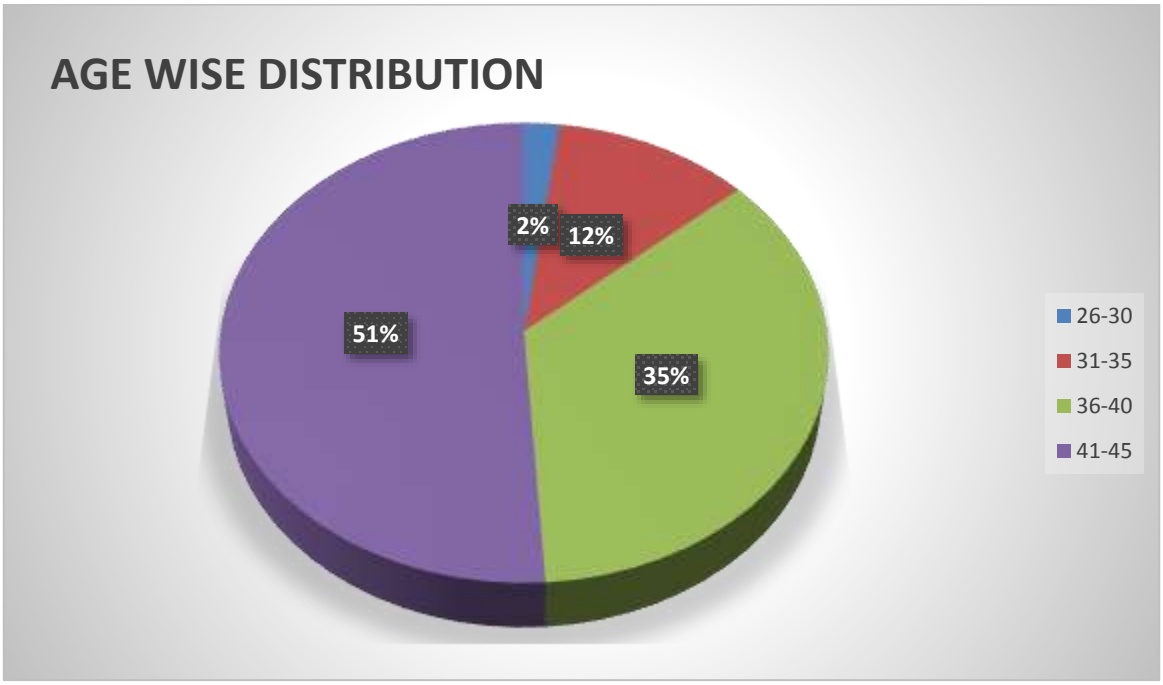
DATA ANALYSIS AND INTERPRETATION

Table 1: AGE WISE DISTRIBUTION

AGE GROUP	NO OF SUBJECTS
26 – 30 YEARS	2
31 – 35 YEARS	11
36 – 40 YEARS	34
41 – 45 YEARS	49

Table 1 shows that, out of 96 subjects,2 subjects are included in age group between 26 to 30 years ,11 are included in age group between 31 to 35 years, 34 subjects are included in age group between 36 – 40 years and 49 subjects are included in age group between 41 – 45 years.

Graph 1: Age wise distribution



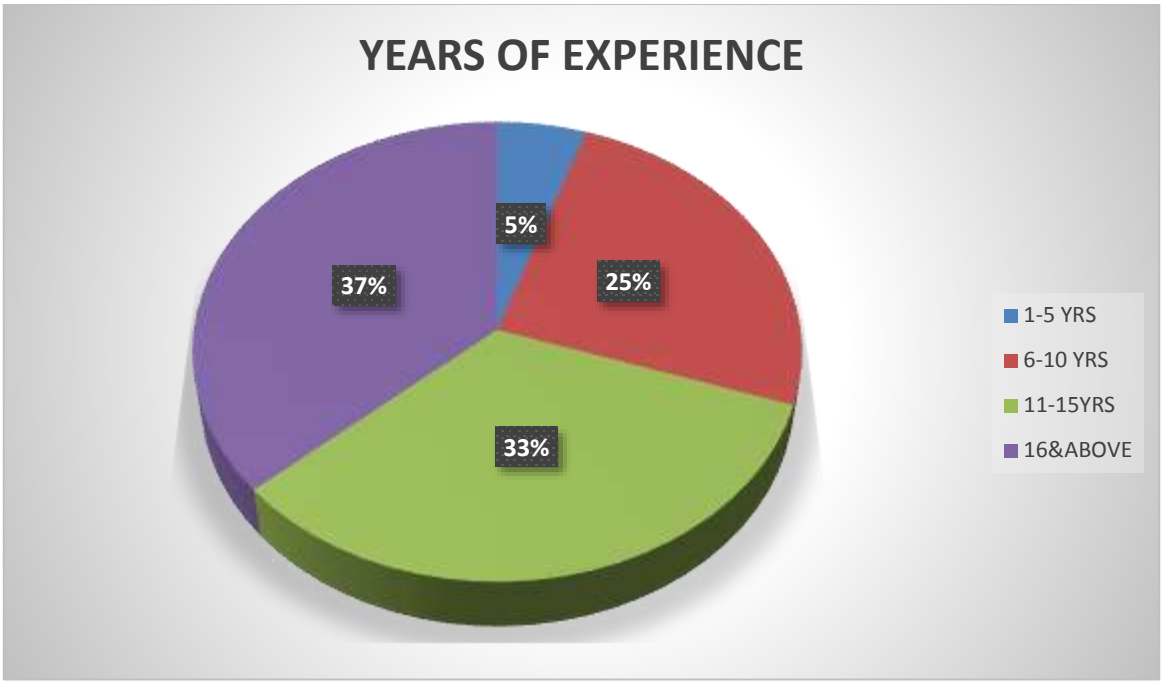
Graph :1 shows that out of 96 subjects, 2% subjects are between age group 26 to 30, 12% subjects are between 31 to 35 age group, 35%subjects between age group 36 to 40 age group and 51% subjects are between 41 to 45 age group.

Table 2: YEARS OF EXPERIENCE

YEARS OF EXPERIENCE	NUMBER OF SUBJECTS
1 – 5 YEARS	5
6 – 10 YEARS	24
11 – 15 YEARS	32
16 YEARS AND ABOVE	35

Table 2 shows that, out of 96 subjects, 5 subjects are included in 1 – 5 years of experience, 24 subjects are included in 6 – 10 years of experience, 32 subjects are included in 11 – 15 years of experience, 35 subjects are included in 16 years and above group.

Graph 2: Years of experience



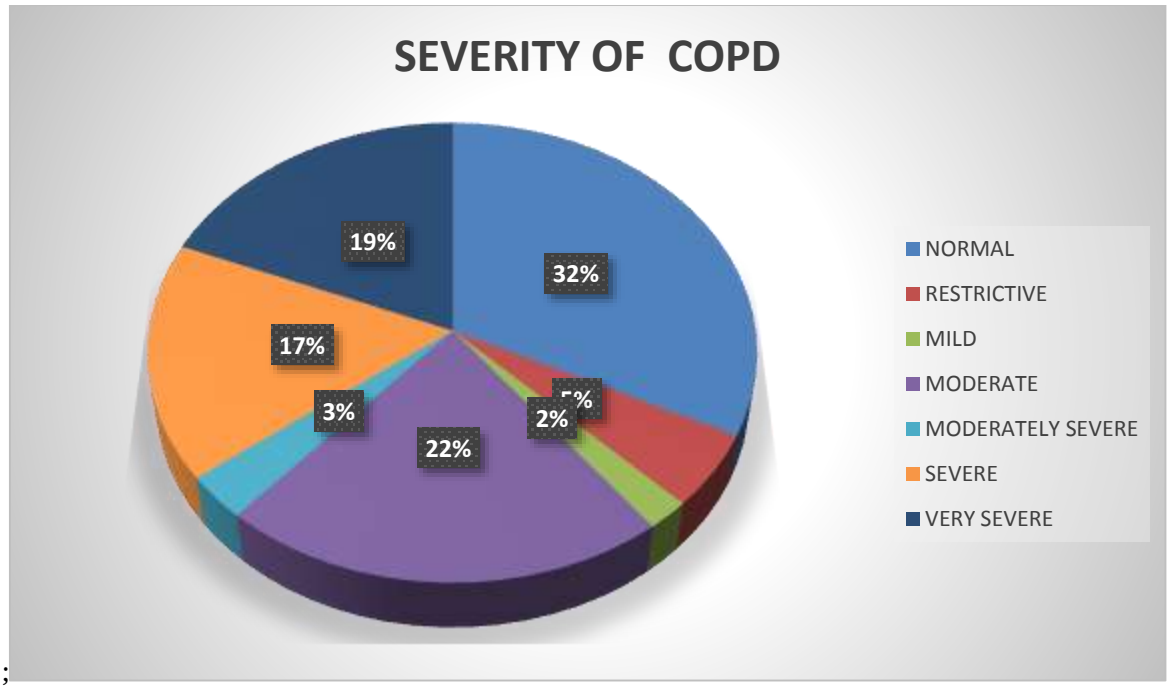
Graph 2 shows that, out of 96 subjects, 5% subjects are included in the 1- 5years of experience,25% subjects are included in 6-10 years of experience,33% subjects are included in 11-15years of experience, 37% subjects are included in 16 years and above years of experience.

Table 3: SEVERITY OF PULMONARY FUNCTION

SEVERITY	NUMBER OF SUBJECTS
NORMAL	31
RESTRICTIVE	5
MILD	2
MODERATE	21
MODERATELY SEVERE	3
SEVERE	16
VERY SEVERE	18

Table 3 shows that, out of 96 subjects, 31 subjects are normal,5 subjects are having restrictive type, 2 are having mild severity, 21 are having moderate severity, 3 are having moderately severe type of severity, 16 are having severe type of severity and 18 subjects are having very severe type of severity.

Graph 3: Severity of COPD



;

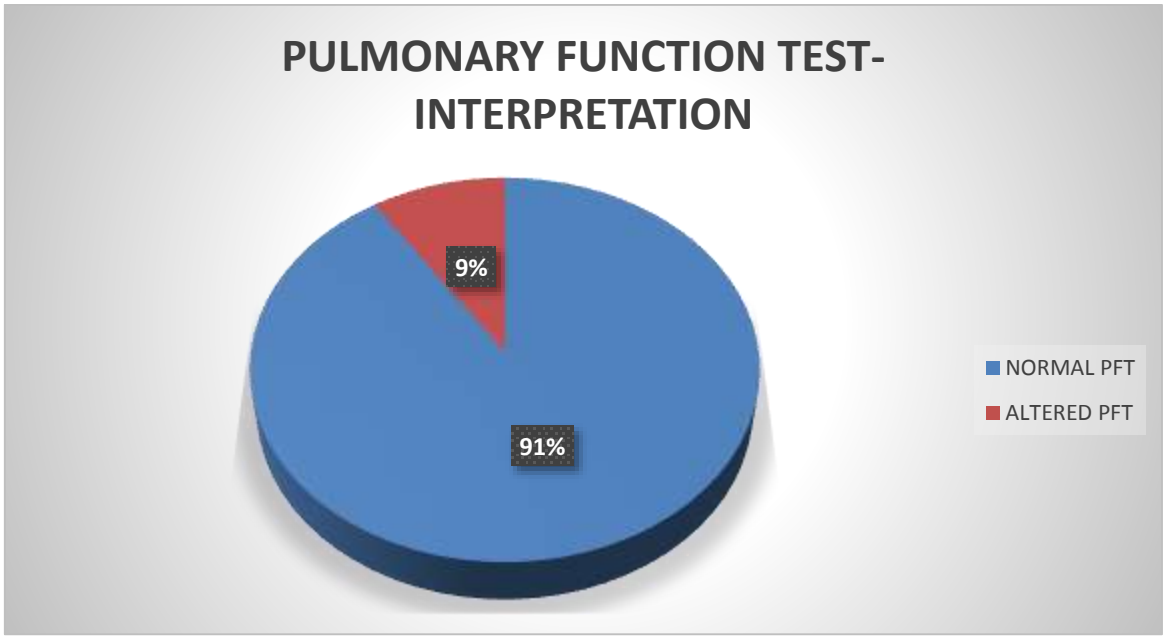
Graph 3 shows that, out of 96 subjects, 32% subjects are normal,5% subjects are restrictive type, 2% subjects are having mild type of severity, 22% subjects are having moderate type of severity, 3% subjects are moderately severe type of severity, 17% subjects are having severe type of severity and 19% subjects are having very severe type of severity.

Table 4: PULMONARY FUNCTION TEST – INTERPRETATION

PULMONARY FUNCTION	NUMBER OF SUBJECTS
NORMAL	31
ALTERED	65

Table 4 shows that, out of 96 subjects, 31 subjects were having normal pulmonary function and 66 subjects were having altered pulmonary function.

Graph: 4 Pulmonary function test – Interpretation



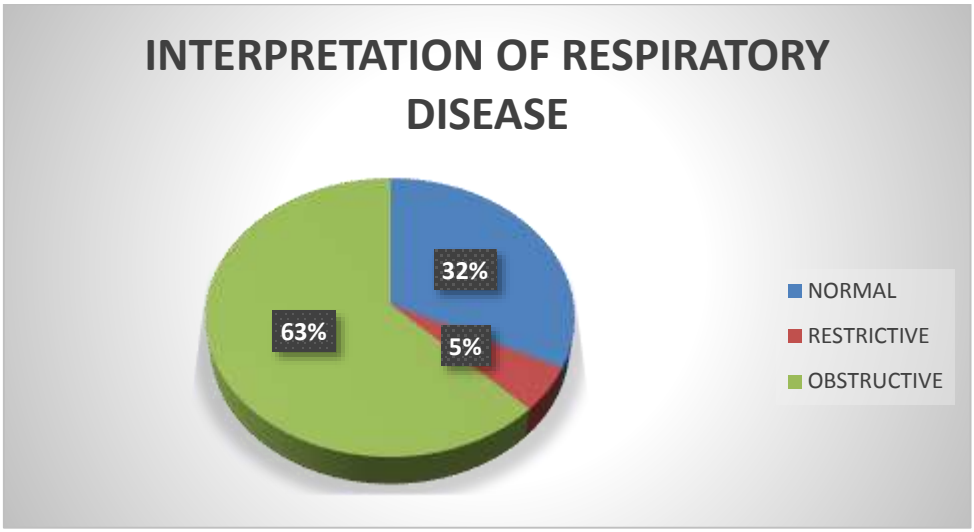
Graph 4 shows that, out of 96 subjects, 9% subjects were having normal pulmonary function and 91% subjects were having altered pulmonary function.

Table 5: INTERPRETATION OF RESPIRATORY DISEASE

INTERPRETATION	NUMBER OF SUBJECTS
NORMAL	31
RESTRICTIVE DISEASE	5
OBSTRUCTIVE DISEASE	60

Table 5 shows that, out of 96 subjects, 31 subjects are normal, 5 subjects are having obstructive condition and 60 subjects are having restrictive condition.

Graph: 6 Interpretation of respiratory disease



Graph 5 shows that, out of 96 subjects, 32% subjects are normal, 5% subjects are having obstructive condition and 63% subjects are having obstructive condition.

RESULTS AND INTERPRETATION

Table 3 shows that, out of 96 subjects, 31 subjects are normal,5 subjects are having restrictive type, 2 are having mild severity, 21 are having moderate severity, 3 are having moderately severe type of severity, 16 are having severe type of severity and 18 subjects are having very severe type of severity.

Graph 3 shows that, out of 96 subjects, 32% subjects are normal,5% subjects are restrictive type, 2% subjects are having mild type of severity, 22% subjects are having moderate type of severity, 3% subjects are moderately severe type of severity, 17% subjects are having severe type of severity and 19% subjects are having very severe type of severity.

Table 4 shows that, out of 96 subjects, 31 subjects were having normal pulmonary function and 65 subjects were having altered pulmonary function.

Figure 4 shows that, out of 96 subjects, 9% subjects were having normal pulmonary function and 91% subjects were having altered pulmonary function.

Table 5 shows that, out of 96 subjects, 31 subjects are normal, 5 subjects are having obstructive condition and 60 subjects are having restrictive condition.

Figure 5 shows that, out of 96 subjects, 32% subjects are normal, 5% subjects are having obstructive condition and 63% subjects are having obstructive condition.

DISCUSSION

The modern definition of occupational health (ILO and WHO) is: “The promotion and maintenance of highest degree of physical, mental and social well-being of workers in all occupation- total health for all at work.” [7]

Respiratory disorders constitute 60% of total occupational diseases in the world and 70% of morbidities are respiratory related.

Occupational lung diseases remain one of the most common work-related injuries. **Inhaled dust can result in a range of tissue injury in the lung and can lead to significant respiratory insufficiency.** [(13)] This study aimed to assess the pulmonary function of ammunition factory workers exposed to various chemicals for prolong hours.

In this study, a total of 109 subjects were screened, out of which 96 subjects were selected based on the criteria. The procedure and purpose of the study were explained to the subjects and prior consent was taken from all the participants. Several maneuvers were taught and performed by the subject. There were 3 maneuvers included, firstly was to perform a maneuver for finding the FVC (forced vital capacity), continuing with SVC (slow vital capacity) maneuver and lastly, the MVV (maximum voluntary ventilation) maneuver.

Forced vital capacity is the maximum amount of gas that can be expelled from lungs by forceful effort following a maximum inspiration. In FVC, a normal individual can exhale 75% of the vital capacity in the first second of exhalation (FEV1). [(15)]

Slow vital capacity is vital capacity which has lower values than FVC because SVC is measured through an unforced maneuver. There is less intrathoracic pressure and larger air can be mobilized. [(17)]Maximum voluntary ventilation measures the maximal breathing capacity of the patient. It reflects strengths and endurance of the respiratory muscles. This is often examined pre-operatively with the other results to determine a patient's prognosis after surgery and to enhance airway clearance. [(15)]

Above mentioned maneuvers were performed in sitting position with 2 minutes interval between each. It concluded that, there was altered pulmonary function of maximum subjects. Huge number were falling into the obstructive respiratory disease category. The severity of the pulmonary function was likely to be moderate type. Irrespective of the duration of exposure of the subjects, there is affection on the lung function.

In the study done by **Asawari Kumawat, Neha Deshpande, Assessment of lung function in goldsmiths showed that, the goldsmith workers** who were exposed to fumes, workplace environment, chemicals and acids had reduced lung function. There was an alteration in the FEV1, FEV1/FVC, FEV1 and PEFR which showed significant differences which could lead to various types of pulmonary diseases. Due to exposure to various irritants and chemicals the goldsmiths had higher prevalence of respiratory disturbances and altered lung function. [(14)]

One of the study done by **Piyush M Kherde et al on saw mill workers which assessed PEFR using spirometer** concluded that inflammatory changes in the respiratory tracts lead to increase airway resistance thereby bringing about the remodeling of the airway, it can elicit pulmonary inflammation and is accompanied by several cytokines and chemokines, micro-organisms and toxins present in different chemicals which are potentially implicated in occurrence of asthma by inducing increased bronchial responsiveness or by damaging bronchial epithelial cells . It also showed that the mechanism of pathogenesis involving the lungs in woodworkers may be due to exposure to airborne dust of different particle sizes and different compositions, which become a cause of impairment and worsening of lung function. [(4)]

Study by Meo, Sultan et al also shows the hazardous effects of metal and metal fumes on various organs and especially lungs that may lead to acute or chronic respiratory diseases. [(18)] A study done by Chattopadhyay among stone-crushing workers found that there was a significant decrease in FVC, FEV1/FVC ratio with the increase in the duration of exposure. [(19)]

A similar study done by Kaushik Saha and Supriya Sarkar concluded that there are respiratory impairments seen in the dry cell battery factory workers due to exposure to the work environment and prolong exposure can decline the pulmonary function. [(20)]

Pulmonary function test provides information about the integrity of the airways, the function of respiratory musculature and the condition lung tissues. It measures the lung volumes, capacities, gas distribution and gas exchange. [(16)]

Inhalation of irritants such as chemicals, air pollutants and occupational dusts can play a role in the development of obstructive diseases. Inhalation exposure is often an initiating factor to an inflammatory response in the airways and the alveoli which leads to disease. There is increase in the protease activity and decrease in the anti-protease activity which initiates inflammatory response, which ultimately breaks down elastin and connective tissue and hyperplasia of mucus secreting cells. Due to long term exposure, the inflammatory damage may be irreversible despite removal of inhalation exposure, if exposure continues. [(16)]

Thus, this concluded that the workers have a high prevalence of altered pulmonary function and are at a risk of obstructive respiratory diseases.

CONCLUSION

This study concludes that ammunition factory workers are prone to develop lung disorders and exposure to ammunition is an important factor in deterioration of the pulmonary function. There is alteration in the pulmonary function of the subjects.

CLINICAL IMPLICATION

- Out of 96 subjects, 9% have normal and 91% were having altered pulmonary function which includes 63% subjects are prone to respiratory diseases. This shows higher prevalence of reduced lung function in the ammunition factory workers.
- To dwindle this prevalence and to prevent further respiratory dysfunction in these ammunition factory workers, we can educate and suggest them to use proper preventive measures such mask and gloves. Recommend them to have proper periodic health check-up including pulmonary function test.
- Those who have come under the altered lung function must start practicing breathing exercises and incentive spirometry for better lung function.

REFERENCES

1) Bathrinath S, Devaganesh J, Santhi B, Saravanasankar S. The Adverse Human Health Effects Due to Ammonia, Hydrogen Sulphide and Chlorine in Process Industry: A Review. Int. J. Mech. Prod. 2018; 8:394-402.
2) Singhvi SD, Singh PT, Khan RM. Assessment, and association of various factors affecting pulmonary function of workers of a factory. Int J Community Med Public Health;2020, 7:1954-9,
3) Smita VP, Patil S, Kanitkar S. Study of Peak Expiratory Flow Rate as the Assessment of Lung Function in Occupationally Exposed Petrol Pump Workers of Western Maharashtra. Journal of Krishna Institute of Medical Sciences (JKIMSU).2016 Apr 1;5(2).
4) Kherde PM, Mishra NV, Chitta SS, Gahukar SD. Influence of sawdust on peak expiratory flow rate in sawmill workers of central India working in unprotected environment and its correlation with duration of exposure. National Journal of Physiology, Pharmacy and Pharmacology.1970, 1;7(1):68-68.
5) Poonam P, Suraj K. The Effect of Structured Physiotherapy Exercise programme on Lung Function in Industrial Workers. Indian Journal of Forensic Medicine & Toxicology. 2020 Apr 29 ;14(2):236-41.
6) PS G. Effect of duration & severity of exposure on peak expiratory flow rate among workers exposed to wood dust in Central India (Nagpur). Physiology. 2013 Oct;2(10).
7) Jani C, Jain K, Joshi A, Bala DV, Jadav H, Jetpariya D. Assessment of pulmonary function of industrial workers in four different industries of Gujarat. Medip Academy publisher. International Journal of Community Medicine and Public Health. 2019 August.
8) Somade PM, Patil SN, Chopade AR, Patil PA. Assessment of Pulmonary Functions in Stone Crusher Workers in Western Maharashtra. Journal of Pharmaceutical Sciences and Research. 2019 Dec 1;11(12):3721-4.
9) Egan's. fundamentals of respiratory care. Elsevier publication. 11th edition, pulmonary function test, chapter no.20, pg. no 400-427.
10) K. Sembulingam. Prerna sembulingam's Essentials of medical physiology, Jaypee publication. 7th edition, pulmonary function test chapter 118, pg.no 721-730.
11) Carl d. Mottram, Ruppel's. Manual of pulmonary function testing. Elsevier publication. 11th edition.
12) Padaki SK, Amrut D, Kokiwar P. Peak expiratory flow rate in asymptomatic male workers exposed to chemical fumes in various industries of Hyderabad. International Journal of Medical Research & Health Sciences. 2014;3(4):870-5
13) Sirajuddin A, Kanne JP. Occupational lung disease. Journal of thoracic imaging. 1;24(4):310-20, 2009 Nov.
14) Asawari Kumawat, Neha Deshpande, Assessment of lung function in goldsmiths- an observational study. IJSDR, ISSN: 2455-2631, Issue- 1, Vol- 8, pg.no- 1192-1201, January 2024.
15) Donna Frownfelter, Elizabeth Dean, Principles and practice of cardiopulmonary physical therapy, Mosby, 1996, 3rd edition, chapter 8, pg.no 146-151.
16) Ellen Hillegass, Essential of cardiopulmonary physical therapy, Elvesier, 2017, ISBN: 978-0-323-43054-8, 4TH edition, Chapter- 6&10, pg.no 187-190 & 346-347.
17) J Bras.pneumol, Importance of slow vital capacity in the detection of airway obstruction, Scielo Brazil, 2013, 39(3), pg.no 317-322.
18) Meo SA, Al-Khlaiwi T. Health hazards of welding fumes. Saudi Med J. 2003;24(11):1176-82.
19) 18. Chattopadhyay BP, Gangopadhyay PK, Bandopadhyay TS Alam J: Comparison of pulmonary function test abnormalities between stone crushing dust exposed and non-exposed agricultural workers. Environ Health Preventive Med. 2006, 11:191-198.
20) Kaushik Saha, Supriya Sarkar, Pulmonary function impairments among dry cell battery factory workers, Journal of Clinical and Diagnostic Research 6(3):342-345, 2012 May.
21) J. Pryor, A. Prasad, Cardiorespiratory Physiotherapy Adults and Paediatrics, Elvesier,1993, 1st edition, pg.no 63.