STUDY ON CORRELATION BETWEEN WORKING EXPOSURE, 3-MINUTE WALK DISTANCE AND PULMONARY FUNCTION TESTS IN INDUSTRIAL WORKERS.

Riddhi D. Thakkar¹, Poonam S. Thorave², Dr. Poonam Patil³

¹IV B.P.Th, Krishna college of Physiotherapy, Krishna Institute of Medical Sciences “Deemed to be” University, Karad, Maharashtra, India.
Mail.id: rdthakkar98@gmail.com

²IV B.P.Th, Krishna college of Physiotherapy, Krishna Institute of Medical Sciences “Deemed to be” University, Karad, Maharashtra, India.

³Assistant Professor Cardiopulmonary Sciences, Faculty Krishna college of Physiotherapy Krishna Institute of Medical Sciences “Deemed to be” University, Karad, Maharashtra, India.

ABSTRACT

Purpose: Occupational lung diseases also known as interstitial lung diseases have been defined as diseases arising out of or in the course of employment. Occupational exposure to particulate matter is responsible for increase in mortality & morbidity rates in workers by cardiorespiratory diseases. Occupational factors may interact with other factors (smoking and genetic risks), Byssinosis, Bagassosis and Asbestosis their respiratory symptoms range from acute dyspnea with cough, reversible breathlessness & chest tightness on one or more days of working week to permanent respiratory disability due to irreversible airflow obstruction. Exercise testing should be done for all the patients at risk for an occupational interstitial lung disease and its measurement with pulmonary function and gas exchange parameters is needed to evaluate dyspnea and quantitate exercise impairment.

Methods: An observational study, with a sum of 48 participants whose age ranging from 35-45 years, working in sugarcane, textile and cement industries voluntarily participated for the study. The study was analytical and took place in and around Karad city in Maharashtra, India. Organic as well as inorganic particulate matter involvement was to be observed in the respective industry worker. Those fulfilling the inclusion criteria were recruited and they underwent pulmonary function testing along with the 3 min walk test.

Result and conclusion: The results suggest that prolonged exposure to everyday dust particles, bagasse and asbestos has resulted not only in reduction of the parameters like FEV1/FVC, MVV & PEFR but also a significant reduction in the exercise tolerance in workers working for various industries.

Keywords: Fibrotic lung, Industrial workers, Pulmonary function test, 3-min walk distance.

I. INTRODUCTION

The rapid increase in the field of technology, communication, agriculture, building material and textiles has led to an increasingly advanced industrial development. The cause for improvement in the economy and the demand from the market can be accredited to this rapidly increasing development[1]. Occupational lung diseases also known as interstitial lung diseases have been defined as diseases arising out of or in the course of employment. Occupational exposure to particulate matter is responsible for increase in mortality & morbidity rates in workers via cardiorespiratory diseases.[2] Such diseases form major categories of pulmonary impairments, they usually present clinically in a manner indistinguishable from that of the disease not caused by such agents. Occupational factors may interact with other factors (smoking and genetic risks).[3]

The changes that take place in the upper respiratory as well as lower respiratory tracts due to deposition of particles are: Nasal airflow is turbulent, increases with rising rates of ventilation. Inspired air which enters the
Exercise testing with measurement of blood gas and gas exchange parameters is needed to evaluate dyspnea and there is hindrance in establishing appropriate preventive measures. Knowledge of dose response relationship is biased assessment of the cause as well as the severity of the functional damage. Due to scarcity of information substance escalating other risks respectively. Testing the response of the participants to exercise magnifies the uncondition of the worker who is already a patient of fibrosis and may be exposed to one or more than one impairment caused by the effects of the occupational exposure is a necessity since it may deteriorate the state which is the stalk. It heats to 54 degree in 5 days then it cools to 40 degree before rising again to 49 degree after 3 days when fresh bagasse is stored in bales. However, bagasse with water content of 27 % heats to 49-degree c in 3 days. [3] hence the growth of fungi, thermophilic and mesophilic actinomycetes is favoured in bagasse with this degree of moisture. Potential risk of bagassosis exists in the following process if bagasse is dry and mouldy. [2,3]

1 Byssinosis: respiratory symptoms occur due to exposure to cotton. This ranges from acute dyspnea with cough, reversible breathlessness & chest tightness on one or more days of working week to permanent respiratory disability due to irreversible airflow obstruction. [6]

2 Bagassosis: Bagasse is the fibrous cellulose residue of sugarcane stalk after it has been crushed & its juice is extracted. It is composed of two major components: one is the tough true fiber and the other being the soft pith tissue which is the stalk. It heats to 54 degree in 5 days then it cools to 40 degree before rising again to 49 degree after 3 days when fresh bagasse is stored in bales. However, bagasse with water content of 27 % heats to 49-degree c in 3 days. [3] hence the growth of fungi, thermophilic and mesophilic actinomycetes is favoured in bagasse with this degree of moisture. Potential risk of bagassosis exists in the following process if bagasse is dry and mouldy. [2,3]

3 Asbestosis & silicosis: Sources of this exposure are mining, quarrying (slate, sandstone, granite etc.), tunneling, stone working, cement building products, and abrasive blasting, etc. Progression is variable, some workers do not seem to develop permanent respiratory disability whereas others reach this stage within a few years. These differences may be influenced by the smoking habits. [7] These are incurable and may be progressive even after the cessation of the dust exposure.

Exercise testing with measurement of blood gas and gas exchange parameters is needed to evaluate dyspnea and quantitate exercise impairment. How well our heart responds to vigorous workouts can be determined by using the exercise tolerance testing. While you exercise your heart beats faster and needs more oxygen which it gets from blood. The test shows if your heart can supply itself with enough blood during exercise. The ability to perform sustained exercise requires tight integration of multiple systems, diseases within any of the systems can manifest as dyspnea during exertion or as limitation of the exercise. The tools that can be used to test the exercise tolerance in the individual include a 6-minute walk test, 3-minute walk test, bicycle ergometer & treadmill test etc. As the evidence states, performance during standardized exercise test with associated pathophysiological responses are of considerable importance in the multidimensional evaluation of most of the respiratory diseases. [8] It is also used to identify underlying mechanisms leading to exercise intolerance particularly pertaining to those activities that have a significant aerobic energetic requirement. [9] Exercise tolerance testing continues to be an extremely valuable diagnostic tool in the non-invasive evaluation of patients. The morbidity and mortality of exercise testing has been documented to be low. 2 factors are of paramount importance in minimizing complications during exercise testing: Proper screening of patients prior to the initiation of exercise and Prompt termination of exercise when appropriate end limits have been reached. [10] These are safe and remain one of the most important non-invasive tests for evaluation. In a retrospective manner, workers of similar age, years of employment had different amounts or physiological abnormalities depending on their smoking habits. Thus, this research finds association between respiratory symptoms & duration of work. Evaluation of the impairment caused by the effects of the occupational exposure is a necessity since it may deteriorate the condition of the worker who is already a patient of fibrosis and may be exposed to one or more than one substance escalating other risks respectively. Testing the response of the participants to exercise magnifies the un-biased assessment of the cause as well as the severity of the functional damage. Due to scarcity of information there is hindrance in establishing appropriate preventive measures. Knowledge of dose response relationship is
essential in understanding the safe concentrations and to set effective control methods to meet this concentration. The chief prerequisite of this study focuses on the assessment of the severity of the damage and to prevent further pulmonary complications.[11]

II. METHOD

Eligibility:
An observational study, with a sum of 48 participants, smokers and non-smokers, age ranging from 35-45 years, working in sugarcane, textile and cement industries voluntarily participated in the study. The study was analytical and took place in and around Karad city in Maharashtra, India. The total time span required for the study was 6 months. Purposeful sampling was done using the Pearson correlation coefficient formula \( c = 0.5 \ln \left( \frac{1 + 0.4}{1 - 0.4} \right) \)

\[
N = \left( \frac{c \cdot r}{c - r} \right)^2 + 3, \text{ Assuming } r = 0.4, c = 0.5 \ln(1.4/0.6), c = 0.42. \]
Both males and females were involved in the study. The workers were only included if they had been working for more than 6 years. Therefore, the materials required in order to commence the study were Pulse oximeter, Sphygmomanometer, 2 small Cones, Stopwatch, Measuring tape, chairs, stethoscope and lastly the computerized spirometer.

Exclusion Criteria:
- Any recent injury to the lower limb
- Hypertension at rest
- Known case of cardiorespiratory disorder
- Any serious medical disorder which worsens on exertion.
- Disorders of spine
- Known case of cancer
- Dementia and progressive neurological disease

Objectives:
1. To determine correlation between the working experience of the industrial workers (working in cement, sugarcane, cotton, etc industries) & their exercise tolerance.
2. To evaluate the correlation between demographic variables & exercise tolerance in industrial workers.
3. To assess the severity of damage & prevent further pulmonary complications.
4. To ascertain the fitness to work using exercise tolerance tests.

III. PROCEDURE:

After obtaining an approval from the institutional ethical committee, Industrial workers working in various industries such as (cotton, cement & sugarcane) were approached and those fulfilling the inclusion criteria were included in the study. The procedure & the purpose of the study was illustrated in detail and a written informed consent was obtained for the same. Demographic variables of the subjects were noted (name, age, gender, education, years of working, etc). Before proceeding with the 3 min walk test, Participants were made to undergo pulmonary function tests via computerized spirometry and the parameters like FEV1, FEV1/FVC, MVV & PEFR were noted. Later, moving forward to the 3 min walk test, before advancing, a detailed explanation about the test and the performance of the test was explained to all participants. The safety measures and the precautions were also elucidated. Participants were asked to perform the 3 min walk test which is a simple measure of the distance a person can walk in 3 minutes. Rest breaks were permitted and the participants were advised to walk as fast as they could without running, safely, for 3 minutes. Walking aids, assistive devices and oxygen were provided as required. Participants were encouraged to take part effectively. Pulse rate, blood pressure, respiratory rate and percentage of oxygen saturation were noted before and after the test. After the completion of the test the vitals along with their rate of perceived exertion was cited by the modified Borg scale and the distance the participant has covered was mentioned as well. The obtained values were compared with the normal values of the particular
age group respectively. The score was calculated and the Data was recorded MS EXCEL. Later statistical analysis was obtained in accordance to the years of exposure and the forced expiratory value in 1 sec (table no .7).

IV. STATISTICAL ANALYSIS

Arithmetic mean & standard deviation was calculated for each outcome measure. Arithmetic mean was derived from adding all the values together and dividing the total number of values. MS Word was used for drawing various graphs with given frequencies and the various percentages, Standard deviation (SD) that were calculated using the software INSTAT version 3.1.

\[ SD = \sqrt{\frac{\sum (X-\bar{X})^2}{N}} \]

Where, \( \sqrt{ } \) = Square root of all the calculations under this symbol.

\( X \) = the individual score.

\( \bar{X} \) = the mean score.

\( \sum \) = sum of all the calculations to the right.

\( N \) = the total number of frequency.

V. RESULTS

The results indicate that out of the 48 industrial workers 93% were males and 6.25% were females with 18 males & 3 females (table no.1) observed to have a normal BMI, 18 males to be overweight and 9 males to be obese (table no.3). The above 33% workers working in each: textile, cement and sugarcane industries (table & graph no.2) respectively showed reduced FEV1/FVC ratio with the obtained p value 0.5639 considered not significant and reduced PEFR & MVV with the p values 0.5468 and 0.5356 respectively and were considered as not significant (table no.5.1, 5.2 & 5.3). Out of the total 16 individuals having more than 8 years of exposure, 3 had light RPE, 5 had moderate RPE and 8 had severe RPE out of the total 32 individuals having less than 8 years of exposure, 13 had light RPE, 9 had moderate RPE and 10 had severe RPE (table no.6) and P is 0.0461 considered significant for correlation between the years of exposure and 3 min walk distance (table no.5.4).

VI. DISCUSSION

This study found significant associations between long working hours and years of exposure with exercise tolerance and pulmonary function tests among a sample inclusive of industrial workers from three different industries. The associations remained constant if the years of exposure exceeded 6 years. Many studies have been undertaken on pulmonary function tests in workers working in various industries but there is paucity of research in correlation between the three. Our study highlighted prolonged exposures to both organic dusts and inorganic dusts to rule out for dyspnea pathology as inhalation of these dusts have ought to reduce pulmonary function and exercise tolerance in individuals. This study recreates the findings from previous studies showing reduced lung function on prolonged exposure. Our study also imparts to the literature emphasizing on its correlation with the exercise tolerance of the subject. Total number of males and females whose working exposure was less than 8 years were 29 and 3 respectively, while 16 males and no female had exposure above 8 years (table no.4). Further studies focusing on a prolonged exposure greater than 8 years and High- resolution computed tomography is highly recommended to rule out the underlying pathology. Thus, the principal aspect of the study focusing on the correlation between years of exposure and FEV1/FVC ratio, the correlation value obtained was -0.08538, and the P value is 0.5639 considered not significant. Thus, aligning with the [ Goran et al. International archives of occupational and environmental health] in the latter, dyspnea and chest oppression were significantly increased in the exposed subjects compared to the unexposed controls. Another study had also shown cross shift changes in FEV1 and their significance with personal exposures to dust, endotoxin and ammonia. Hence confirming the dose response relationship of changes in workers with more than 6 years of exposure. 0.08916 correlation coefficient with the p value 0.5468 considered not significant when comparing PEFR with years of exposure. Therefore, we can conclude that as the years of exposure increases the peak expiratory flow rate and the FEV1/FVC ratio.
The present world of competition there is a race of existence in which those who are having will and potential to come forward shall succeed. A research reconciles theoretical and practical aspects. Firstly, we would like to thank the supreme power, the god almighty who has always guided us to work on the right path of life, without his bestowed blessings, this project could not become a reality. Next to him, our parents, whom we are greatly indebted for, bringing us up with love and encouragement up to this stage. We would like to thank honourable Dean sir, Dr. G. Varadharaaju, faculty of physiotherapy for providing us with this beautiful opportunity to work on this project as well as present it. His dynamism, vision, sincerity & motivation has deeply inspired us. We would like to express our deep and sincere gratitude to our research guide Dr. Poonam Patil for providing invaluable guidance throughout this research. We wish to express our sincere thanks to Dhiraj sir for providing us with statistical guidance. We would also like to extend our sincere thanks to the physiology department of Krishna college of physiotherapy for helping us with the spirometric testing. We would like to take the privilege to thank all the industrial workers who volunteered for our project. We are obliged in taking the opportunity to sincerely thank all our staff members of Krishna college of physiotherapy for their generous attitude and a friendly behaviour. At last, but not the least, we would like to thank our friends who have always been helpful and encouraging. we have no valuable words to express our thanks, but our heart is still full of thanks from the favours received from each and every individual.

VII. CONCLUSION

The results suggest that prolonged exposure to everyday dust particles, bagasse and asbestos has resulted not only in reduction of the parameters like FEV1/FVC, MVV & PEFR but also a significant reduction in the exercise tolerance in workers working for various industries. The findings of this study have important innumedios for prevention and management of further pulmonary complications. Therefore, years of exposure was significantly correlated with the pulmonary function and exercise tolerance of the individual.

SOURCE OF SUPPORT: Department of Physiology, KIMSDU, Karad

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REFERENCES

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Table no. 1:  Gender and Age wise distribution

<table>
<thead>
<tr>
<th>GENDER</th>
<th>AGE IN YEARS</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ABOVE 35</td>
<td>BELOW 35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEAN ± SD</td>
<td>MEAN ± SD</td>
<td></td>
</tr>
<tr>
<td>MALES</td>
<td>39.87 ± 3.041</td>
<td>31.57 ± 1.785</td>
<td></td>
</tr>
<tr>
<td>(n=45)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEMALES</td>
<td>40 ± 4.243</td>
<td>34 ± 0.00</td>
<td></td>
</tr>
<tr>
<td>(n=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL(n)=48</td>
<td>79.87 ± 7.284</td>
<td>65.57 ± 1.785</td>
<td></td>
</tr>
</tbody>
</table>

Table No. 3: Distribution according to BMI

<table>
<thead>
<tr>
<th>SR NO</th>
<th>GRADE 1</th>
<th>GRADE 2</th>
<th>GRADE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td>18</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>FEMALES</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>total</td>
<td>21</td>
<td>18</td>
<td>9</td>
</tr>
</tbody>
</table>

Table No. 2: Distribution of industry

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Table No.5.1: correlation between years of exposure & FEV1/FVC.

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>CORRELATION COEFFICIENT(r)</th>
<th>R² Value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE VS FEV1/FVC RATIO</td>
<td>-0.08538</td>
<td>0.007290</td>
<td>0.5639</td>
</tr>
</tbody>
</table>

Inference: As P is 0.5639 considered not significant.

Table No.5.2: correlation between years of exposure & PEFR.

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>CORRELATION COEFFICIENT(r)</th>
<th>R² Value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE VS PEFR</td>
<td>-0.08916</td>
<td>0.007949</td>
<td>0.5468</td>
</tr>
</tbody>
</table>

Inference: As P is 0.5468 considered not significant.

Table No.5.3: Correlation between years of exposure & MVV.
### Table No. 5.4: Correlation between years of exposure & 3MWD.

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>CORRELATION COEFFICIENT(r)</th>
<th>R² Value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE VS 3 MWD</td>
<td>-0.2893</td>
<td>0.08369</td>
<td>0.0461</td>
</tr>
</tbody>
</table>

**Inference:** As $P$ is 0.0461 considered significant.

### Table No. 4: Years of exposure

<table>
<thead>
<tr>
<th>SR.NO</th>
<th>ABOVE 8 YEARS</th>
<th>BELOW 8 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td>FEMALES</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**ABBREVIATIONS:** FEV1: forced expiratory volume, FVC forced vital capacity MVV – maximum voluntary ventilation, PEFR: peak expiratory flow rate, RPE: rate of perceived exertion.