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Assessing Pulmonary Function in Workers Exposed to Rice Threshing Processes

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Abstract

The economic significance of rice cultivation in India is vast, spanning diverse agro-climatic zones. Threshing, a crucial aspect of rice farming traditionally involves manual or motor-operated methods. Despite the prevalent adoption of tractor-operated axial flow threshers, the process remains inherently dusty, predominantly comprising organic dust particles, posing a substantial health risk to workers. This study aims to evaluate and compare the lung functions of individuals exposed to rice dust with an unexposed control group, while investigating the correlation between the duration of exposure in threshing operations and observed respiratory parameters. Thirty agricultural workers aged 30-45, with varying threshing experience (3, 5, and 7 years), were selected alongside thirty non-agricultural workers for Pulmonary Function Tests (PFT), including Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 second (FEV1). Spirometry, a vital diagnostic tool for occupational respiratory diseases was utilised to measure dynamic lung functions. The findings revealed relatively constant FVC values with increasing years of experience, while both FEV1 and FEV1/FVC values demonstrated a decline with prolonged exposure, indicating an escalated susceptibility to obstructive lung diseases such as asthma, emphysema, chronic bronchitis and bronchiectasis among workers in this occupation.

Keywords: FEV1/FVC, Obstructive Pattern Lung Diseases, PPE, Pulmonary Function Test, Spirometer

Abbreviations Used: FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in 1 second), PM_{10} (Particulate Matter 10), O.U.A.T (Odisha University of Agriculture and Technology), COPD (Chronic Obstructive Pulmonary Disease), PFT (Pulmonary Function Test), and PPE (Personal Protective Equipment)

1. Introduction

Rice is a major crop in our country, with prominent rice-producing states such as West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Odisha and Bihar. In Odisha, rice is cultivated extensively, covering a net cultivable area of around 5.5 million hectares, yielding approximately 7.61 million tons annually[1-3]. Threshing, a crucial post-harvest operation, is a predominant activity in rice cultivation. Axial flow threshers are widely utilised in Odisha for rice threshing with 17,800 units sold between 1997-2021 through government subsidy programs[2,3]. Threshing involves separating the edible part of the grain from the husks and straw, commonly achieved in axial flow threshers through shearing and beating actions on rice straws, generating dust particles. These are expelled from various thresher outlets, including the sieve outlet, the *bhusa* outlet and the main outlet. Dust, defined as small solid particles typically below 75 μm in diameter, may remain suspended in the air for some time. Threshing

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processes contribute to dust emission, consisting of particles below 100 microns in diameter, known as thoracic dust or PM10 which can reach the lungs while breathing. Respirable dust, approximately 4 microns or less, poses the greatest health risk as it penetrates the gas exchange region of the lungs. Workers engage in threshing operations for over 100 days annually, working over 8 hours per day, exposing them to organic dust. Prolonged dust exposure may adversely affect the workers' health, with increased risks of respiratory diseases like asthma, chronic bronchitis and other conditions dependent on dust concentration and exposure duration. Occupational safety guidelines such as those from the Swedish National Board, prescribe the exposure limits for normal and organic dust.

Numerous studies, including Tageldin *et al.*, Schivinski *et al.*, and Jové *et al.*, have suggested a link between unprotected dust exposure in agricultural settings and pulmonary fibrosis. Grain dust, with a long history of association with diseases, has adverse effects on various organs, including the eyes, nose, skin, lungs and airways, leading to conditions like asthma[4-13]. Given these considerations, this study investigates the impact of organic dust exposure from threshing operations on the lung and respiratory functions of workers.

2. Materials and Methods

The research was conducted within the premises of the Central Farm, College of Agricultural Engineering and Technology, Orissa University of Agriculture and Technology (O.U.A.T) Bhubaneswar, focusing on evaluating the impact of organic dust exposure during axial flow thresher operations on workers' pulmonary function. Spirometry, a crucial diagnostic tool for occupational respiratory diseases was employed to measure the dynamic lung functions, providing valuable insights into conditions such as asthma, pulmonary fibrosis, cystic fibrosis and Chronic Obstructive Pulmonary Disease (COPD). The test conducted using a spirometer is referred to as a Pulmonary Function Test (PFT).

Key terms integral to the study include Forced Vital Capacity (FVC), representing the volume of air forcibly expelled after full inspiration, measured in litres and serving as a fundamental manoeuvre in spirometry tests. Forced Expiratory Volume in 1 Second (FEV1) measures the volume of air expelled within the first second after full inspiration, with average values dependent on sex and age. FEV1/FVC (percentage) is the ratio of FEV1 to FVC, typically around 80% in healthy adults and diminishing with age. This ratio is crucial in identifying obstructive and restrictive pattern diseases, with a decrease indicating obstructive diseases and an increase indicating restrictive diseases (Figure 1).

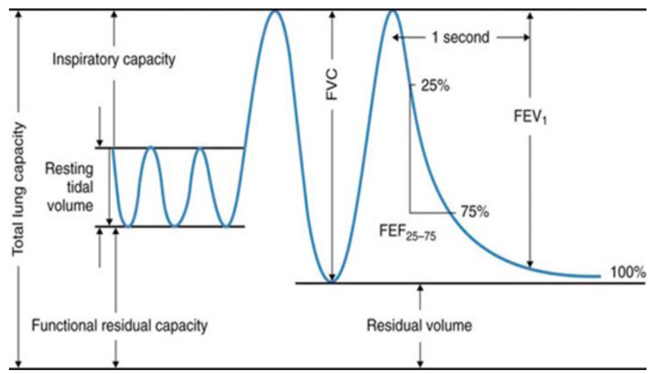

Figure 1. Graph depicting the relationship between lung capacity and time.

The study involved thirty agricultural workers (categorised as an exposed group) aged 30-45 years, selected based on their years of working experience (3, 5 and 7 years) and thirty non-agricultural workers (categorised as an unexposed group). Detailed history-taking and physical examinations were conducted, excluding individuals with asthma, chronic lung infections, persistent cough, recent respiratory illness treatment, abdominal/chest surgery and smokers. Subjects cooperatively participated in the investigation and pulmonary function tests, including FVC, FEV1 and FEV1/FVC were performed using a computerised spirometer (Figure 2).

Throughout the examination, participants were instructed to inhale deeply and subsequently exhale into the sensor for an extended duration, ideally lasting a minimum of 6 seconds. In specific instances, a prompt inhalation followed, particularly when evaluating potential upper airway obstruction. To ensure accuracy, soft nose clips were employed to prevent air leakage through the nose. Additionally, filter mouthpieces were used to mitigate the dissemination of micro-organisms during the testing procedure.

3. Results and Discussions

The FVC values in litres were assessed for both the control group and the worker cohort, followed by a t-test conducted with a significance level set at 0.05. The corresponding FVC values are depicted in Figure 3, while Figure 4 illustrates the associated P-values.

Examining Figure 3 reveals a discernible pattern wherein there is a lack of variation in the FVC with an increase in years of experience. The outcomes of the t-test are presented in Figure 4, with a predetermined significance level of 0.05. Statistical analysis indicates that the P-values exceed 0.05, signifying an absence of significant differences among the observed values. In essence, as workers accumulate more years of experience, the FVC values exhibit a nearly constant trend.

Figure 2. Pulmonary function assessments conducted on the labour force through spirometry.

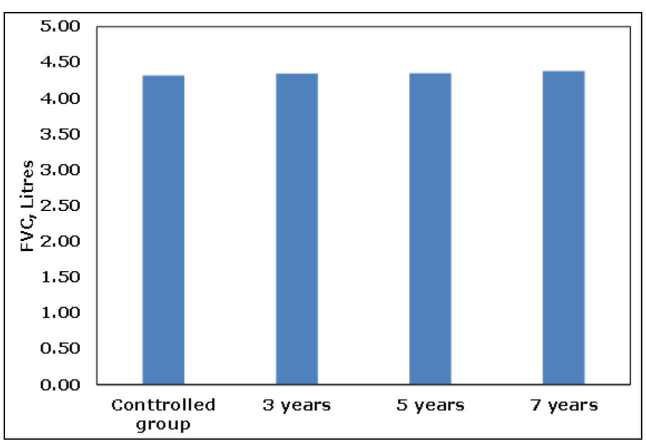

Figure 3. Forced Vital Capacity (FVC) values measured in litres.

Figure 5 illustrates the gradual decrease in the FEV1 values for the subjects in litres, indicating an obstructive pattern of diseases. This suggests an increased likelihood of conditions such as asthma, emphysema, chronic bronchitis and bronchiectasis among the working individuals after 3 years of experience. In Figure 6, the results of the t-test with a significance interval of 0.05 are presented. A comparison between the controlled group and individuals with 1-3 years of experience yields a p-value of approximately 0.75, signifying no significant difference. This suggests that during the initial three years of work, the lung condition remained favourable. However, for cases with 5 and 7 years of experience, the

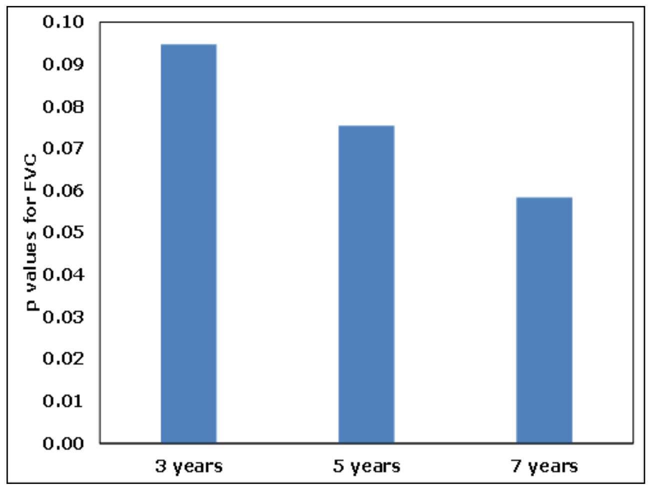

Figure 4. P-values corresponding to Forced Vital Capacity (FVC) values measured in litres for the cases.

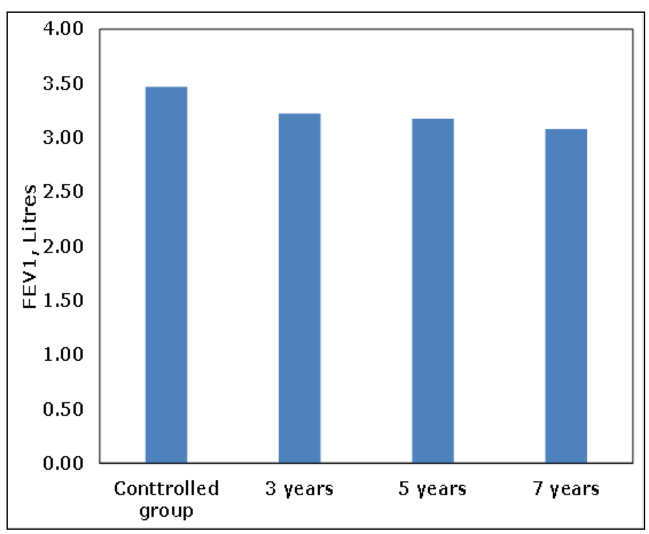

Figure 5. Forced Expiratory Volume in 1 second (FEV1) values measured in litres.

Table 1. Anthropometric data of the subjects

Parameters	Exposed Group (n=30)	Unexposed Group (n=30)	P-Value
Mean age, years	39.6 ± 6.27	40.2 ± 6.54	0.063
Mean height, cm	161.0 ± 4.23	160.5 ± 3.63	0.126
Mean Weight, kg	65.31 ± 1.92	39.6 ± 6.54	0.052
Mean BMI, kg/m^2	20.93 ± 2.32	19.5 ± 4.57	0.258
Mean HR_{rest}, beats/min	71.5 ± 2.36	71.7 ± 1.51	0.0357
Mean HR_{max}, beats/min	194.6 ± 5.36	192.3 ± 1.85	0.168
Mean VO_{2rest}, lit/min	0.23 ± 0.12	0.23 ± 0.10	0.026
Mean VO_{2max}, lit/min	2.03 ± 0.35	2.1 ± 0.15	0.157

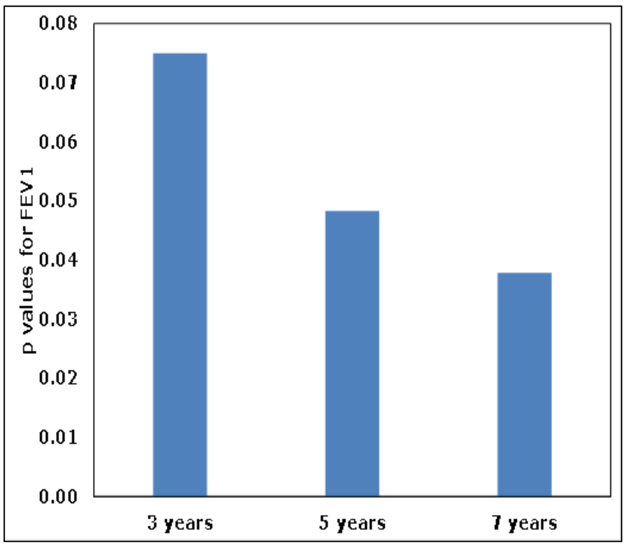

Figure 6. P-values associated with Forced Expiratory Volume in 1 second (FEV1) values measured in litres for the cases.

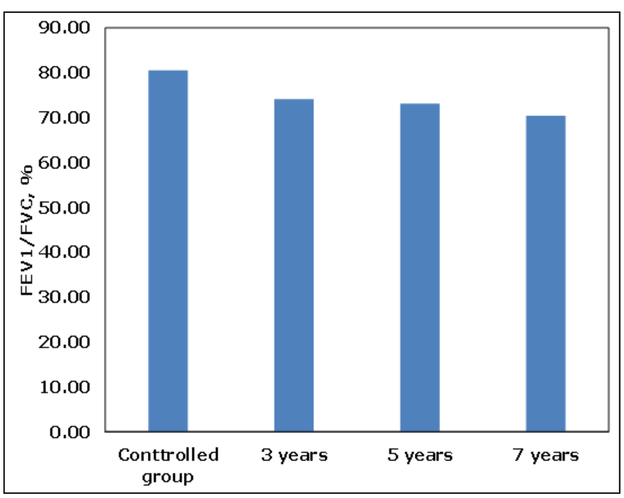

Figure 7. The ratio of Forced Expiratory Volume in 1 second to Forced Vital Capacity (FEV1/FVC) values measured in litres.

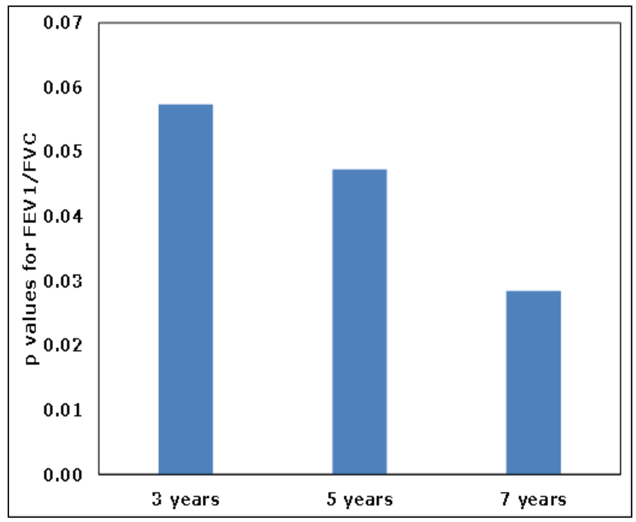

Figure 8. P-values associated with the Forced Expiratory Volume in 1 second to Forced Vital Capacity (FEV1/FVC) values measured in litres for the cases.

p-values were found to be 0.04 and 0.03, respectively, indicating a significant difference compared to the control group. This analysis leads to the conclusion that an increase in years of experience correlates with the impact of the organic dust environment on the lungs, resulting in obstructive pattern diseases.

The FEV1/FVC ratio values in litres were measured for both the controlled group and the working subjects. A t-test was conducted with a significance level of 0.05 to analyse the FEV1/FVC values, and the results are presented in Figure 7 for values and Figure 8 for corresponding P-values. Figure 7 illustrates the percentage of the FEV1/FVC value, showcasing a gradual decrease with an increase in years of experience. This decline is attributed to the reduction in FEV1 value. Meanwhile, Figure 8 displays the outcomes of the t-test for FEV1/FVC, revealing P-values consistently below 0.05 in all cases, signifying a distinction in FEV1/FVC values between the controlled group and the subjects under scrutiny. Given that the values fall below 80 per cent, this suggests the presence of obstructive pattern diseases.

4. Conclusions

Spirometer experiments were carried out post rice threshing operations in the Central Farm, OUAT, Bhubaneswar, Odisha, to conduct pulmonary function tests and assess the lung function of workers. Prior to the experiments, age, height, weight and BMI were individually measured for each worker. Throughout the testing process, FVC, FEV1 and their ratio were computed. The FVC values exhibited no change with an increase in the years of experience, a finding corroborated by statistical analysis where all p-values for the different experience durations (3 years, 5 years and 7 years) exceeded 0.05. The statistical analysis revealed a significant difference between the controlled group and the subjects under consideration for FEV1 values and FEV1/FVC. Both values decreased with an increase in the years of experience, indicating a heightened susceptibility of workers to obstructive pattern lung diseases like asthma, emphysema, chronic bronchitis and bronchiectasis. Notably, there was no statistical difference in FEV1 between the controlled group and workers with less than 3 years of experience, suggesting reduced susceptibility to obstructive pattern diseases owing to their shorter exposure period to the dusty environment compared to others with higher exposure durations.

Hence, it is recommended to equip workers with Personal Protective Equipment (PPE), such as masks and goggles during threshing operations. The installation of a lubricating pad at the blower outlet to absorb minute dust particles is suggested. Maintaining intermittent moisture in the threshing atmosphere is advised to prevent the accumulation of dust. Workers are also cautioned against smoking, as it diminishes lung capacity to clear dust and elevates the risk of cancer-related diseases.

5. Acknowledgements

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