Industrial Health 2007, **45**, 449–461 **Original Article**

Exposure to Varying Concentration of Fungal Spores in Grain Storage Godowns and its Effect on the Respiratory Function Status among the Workers

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Received January 24, 2005 and accepted February 20, 2007

Abstract: Grain storage depot workers suffer from different respiratory problems after getting the exposure to storage grain dust. Which is a mixture of pesticides, fungi, silica, bacteria, spores, storage mites, animal hairs, pollens etc. The present study was under taken to evaluate the fungal spore concentration in summer and winter season as well as the pulmonary function status of the workers; studies are limited in our country. In summer and winter seasons, air sampling was done to measure the airborne fungal spore concentration inside the godowns by Rotorod sampler, UK. Aspergilla, Alternaria, Drechslera, Epicoccum, Nigrospora, Periconia were very much common and found higher in winter compared to summer. The respiratory functional status was assessed in two groups of workers of the same storage grain depot (total n=316) in summer (n=136) and in winter (n=180). List of the workers was collected from the authority and randomly selected every alternate worker and divide them for the studies in summer and winter seasons. Slow Vital Capacity (SVC), Forced Vital Capacity (FVC), and Peak Expiratory Flow Rate (PEFR) were recorded and Forced Expiratory Volume in one second (FEV_1), FEV_1% and different flow rates were calculated. The Immunoglobulin- E (IgE) level in the blood serum was assessed on post shift pulmonary function tests (PFT) decreased workers. The age, height and weight of the same categories of workers of both studies are highly comparable. Mean PFT values in summer found higher than winter. A gradual decrement of values were found as age was increased but not with duration of exposure. Post-shift PFT was carried in 21.8% (69) workers of which 46.4% (32) workers showed the decrement of values. The serum IgE level of the post-shift PFT decreased subjects was found more than 250 IU/ml in 53.1% (17) workers. Restrictive, obstructive and combined types of respiratory impairments were noticed among the workers. Presence of different spores in varying concentration in the working atmosphere may be responsible for the post shift decrement of PFT, allergic symptoms, high IgE level and respiratory impairments among the workers.

Key words: Fungal Spores, Grain Dust, Pre-shift and Post-shift, Pulmonary Function Test, Immunoglobulin-E (IgE)

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Introduction

Food grains are produced in our country in different seasons and are stored by different organizations after processing. The Food Corporation of India (FCI), Central Warehousing Corporation (CWC) and State Warehousing Corporation (SWC) are the main organizations. Earlier reports mostly from the abroad revealed that grain dust exposure caused both acute and chronic respiratory impairments[1–3]. It was also reported that grain dust fever and asthma were very much common amongst the workers exposed to grain dust[4]. However, prolonged exposure may induce both cough and sputum[5]. A survey in Britain indicated high prevalence of chronic bronchitis and asthma[6]. Other symptoms related to conjunctiva, larynx, nose was also reported by them including grain fever and allergic skin manifestations. Pesticides exposure might lead to acute neurobehavioral changes. Moreover, the combined effect of smoking and grain dust exposure on grain handlers exhibited higher percentage of chest tightness and dyspnoea[3]. The levels of airborne grain dust are related to the presence of bronchial hyper reactivity as well as to the development of airflow limitation across a work shift[7]. Chronic inhalation of grain dust has been shown to adversely affect pulmonary health[8]. Exposure to grain dust was associated with significant reduction in forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC). Grain workers had more respiratory symptoms and lower lung function compared to civic workers[9]. Respiratory diseases and syndromes including hypersensitivity pneumonitis, chronic bronchitis, organic dust toxic syndrome and asthma like syndrome results from acute and chronic exposures[10].

Changes in pulmonary function and nervous systems in storage grain handlers and high percentage of dusts and airborne fungal spores in godowns had been reported by different authors[3, 5, 7, 11–14] but there are very few reports on the pulmonary function status of storage grain handling workers. Looking in to these problems among the storage grain handlers the present study was planned to concentrate the investigation on respiratory problems. Hence the present study was undertaken to measure the concentration of airborne fungal spores inside and outside the godowns in summer and winter season and to assess the pulmonary function status of the workers exposed to storage grain dust during their work.

Materials and Methods

The study was carried out in summer in the month of May and in winter in the month of January in a same grain storage depot situated at the surroundings of Kolkata. The workers were categorically divided into four following groups according to their job. (1) Load handling workers—Engaged in loading and unloading, stacking and rearranging of grain sacs. (2) Quality control—Picking the samples of food grains from bags, categorically divide them according to quality, identified the grains for pesticide treatment. (3) Ancillary—Refilling of bags, sweeping the floor, brushing over sacs, pesticide spraying, covering the plastic sheets over the stacks for fumigation etc. (4) Depot administration—Posted in godowns looking after the entry and outgoing of grain sacs, supervise loading and unloading etc. List of the workers was collected from the authority (n=395) and computed; every alternate worker was randomly selected and divides them for the studies in summer and winter seasons. Out of these 395 subjects first 197 was asked for the summer season study and rest for the winter season. All alternate selected workers was not agreed to do the tests, they are unwilling and avoid testing by raising different reasons, it was found mostly in summer season study. Because of non co-operation the number has been reduced in summer season (n=136) and in winter season (n=180) good co-operation came from the workers and detailed pulmonary function tests were done. The smoking history of the workers as well as the frequency of smoking number of cigarette or biddies smoked per day was noted by questionnaire noted. Workers who were smoked at least five cigarettes or biddies per day are included in the smoker category and those who were not smoked throughout his lifetime was considered as non-smokers and those who left smoking are considered as ex-smokers. In storage food grain depot mainly the male workers are working, there are a few female workers in grain storage depot those who were appointed in death cases. So they are not considered into the study.

In the medical study a precoded proforma is used for collection of history with the emphasis on occupational exposure history. Due care is given to note the allergic symptoms specially related to conjunctiva, larynx, nose, skin etc. All subjects were clinically examined.

Rotorod sampler, UK was used for fungal spore sampling. It was operated for 30 min in every godowns. As a whole sampling were done in 17 godowns of the above depot in summer season and in winter season in each godown one time sampling was done during work. Total one hundred and thirty six sampling was done in seventeen godowns in both seasons, inside, outside and during work (loading and unloading) and resting condition. In each godown, spore concentration was found higher in winter compared to summer. The Rotorod sampler consists of a pair of vertical arms (a brass rod with 1/16 inch square cross section and about 7.5 cm long), which rotated at 2,900 rpm by a small electric motor. Spores were impacted on a sticky surface of cello tape strip (coated with clear transparent petroleum jelly) mounted on the leading edge of the rotating arms. After exposure cello tape strips of each arm were divided into four halves and mounted on a clean glass slide and examined under the high resolutions microscopes (Labophot-2, Nikon, Japan). Total 20 fields were counted (i.e. 5 fields in 4 equal pieces of a strip). The sampling for thirty minutes was done in each godown during loading and unloading and at the resting stage between the normal total working time schedule at the godown from 11 am to 3.30 pm both in summer and winter, the sampling height ranged between 4 ft. to 5.6 ft. The temperature varied from 34–38°C in summer and 27–31°C in winter.

The environmental monitoring for measuring the total and respirable dust concentration in different grain storage godowns were done by collecting multiple number (3–5) of area sampling inside the godowns, using high volume sampler APM 410 (Envirotech, India) at the rate of 1–2m^3/min on glass fiber filter paper (GF/A, Watman, UK) for 6–8 h. The respirable dust concentration in godowns are monitored by using 8- stage Marpel Cascade Impactor (Model-298), Andersen, USA with a constant flow pump, HFS-113A (Gillan) at a fixed flow rate of 2LPM (litre per minute). The mean values for total and respirable dust concentrations are (2.67 ± 1.89 mg/m^3, n=13 and 1.77 ± 0.61 mg/m^3, n=15) respectively [unpublished]. The concentration of respirable and total dust in different godowns and their mean values are well with in American Conferences on Governmental Industrial Hygienist (ACGIH-1995–'96) prescribed threshold limit values (TLV) 4 mg/m^3. So the PFT values are evaluated based on the fungal spore concentration and that was found higher inside the godown.

The PFT were done by Spirovit- SP-10, Schiller Health Care Pvt. Ltd, Switzerland. VC and FVC were recorded. FEV_1, FEV_1% and different flow rates were calculated from the same tracings. PEFR were measured from Wright's Peak Flow meter, UK. Before the recordings were taken all subjects were made well motivated thus ensuring recording at optimum levels[15]. The PFT measurements were made in a comfortable standing position. The body height and body weight were measured with a standard scale without footwear. All measured lung volumes obtained was expressed in body temperature pressure saturated with water vapour (BTPS[16]). Body surface area (BSA) was calculated from the Du-Bois and Du-Bois[17] formula. Pulmonary function test values were predicted from the standard prediction equation of the Kolkata normal subjects[18]. The criteria followed for categorization of the severity of restrictive impairment are based upon the ratios between predicted and observed values of VC and obstructive impairment based on observed values of FEV_1%[19].

Post-shift PFT were measured in 69 (21.8%) workers as whole to evaluate the diurnal effect of exposure in the work environments. The workers who were interested and able to do the PFT second time after performing their job are voluntarily participated for the post shift PFT measurement. The Immunoglobulin E (IgE) level in the blood serum was assessed who had allergic symptoms, reported the feeling of breathless and chest tightness after work and post shift decrement of PFT values. The identification of reagins as immunoglobulin-E and the characterization of this class of immunoglobulins has contributed considerably to the understanding of the mechanisms involved in allergic reactions. On contact with a specific antigen (allergen) the cell bound IgE antibodies mediate the release of pharmacologically active substances from the mast cells and basophils resulting in the allergic symptoms. Elevated serum levels of IgE are normally found in patients suffering from asthma. In each case, blood samples are drawn by disposable syringes and needles. Enzyme immunoassay was done by Enzyme-linked Immunosorbent Assay (ELISA) method[20] and the test kit of Biocheck Inc. 837, Cowan Road, Burlingame CA94010 was used for the quantitative determination of IgE concentration in blood serum. The statistical significance of the values in both studies was done by unpaired and paired *t* test and chi-square test. The project has got approval by the ethical committee.

Results

Aspergilla, Alternaria, Curvularia, Drechslera, Epicocum, Nigrospora, Periconia were very much common and dominating fungal spore inside godown. Cladosporium was found considerably higher in summer season but it was almost absent in winter season. In the present study the different spores concentration inside the godowns were higher in winter compared to summer. The concentrations of airborne fungal spores at the ambient air adjacent to the godown were found lower than inside godowns in both summer and winter season.

Table 1 represents the concentration of fungal spores inside

Table 1. Concentration of fungal spores present in seventeen godowns in summer and winter season (Number / m³ of air)

Godown No.	Season: Summer	Season: Winter
19B	231.0 ± 497.8 (86–1,663)	573.1 ± 821.3 (33–2,699)
23C	506.9 ± 999.7 (8–3,150)	600.0 ± 1,127.1 (33–3,732)
6A	110.1 ± 84.2 (17–428)	140.6 ± 140.6 (33–466)
5C	257.5 ± 431.5 (17–1,455)	322.0 ± 259.8 (100–966)
17A	96.3 ± 137.4 (17–428)	259.1 ± 492.0 (33–1,566)
21B	219.8 ± 400.2 (4–1,194)	233.2 ± 227.7 (66–833)
4C	206.4 ± 261.7 (75–1,106)	294.5 ± 455.0 (95–1,051)
5A	1,250.0 ± 450.8 (29–1,054)	573.5 ± 676.70 (33–1,225)
5B	111.8 ± 145.0 (16–456)	170.8 ± 292.1 (38–1,022)
5D	253.7 ± 441.5 (33–916)	273.8 ± 272.5 (100–675)
6C	145.8 ± 238.7 (15–625)	256.8 ± 378.1 (95–1,070)
7C	264.0 ± 293.3 (39–895)	358.7 ± 445.6 (88–1,005)
19A	293.3 ± 460.4 (33–983)	403.7 ± 576.4 (56–1,069)
19C	240.5 ± 351.7 (19–765)	258.5 ± 367.1 (26–1,015)
21A	71.0 ± 91.5 (14–289)	254.7 ± 363.3 (35–780)
27A	271.5 ± 401.1 (58–873)	366.0 ± 537.3 (37–986)
27B	364.7 ± 489.6 (78–930)	369.3 ± 498.8 (96–1,006)

Values are Mean ± SD, within the parentheses are ranges of the mean maximum and minimum among the four values (Outside and Inside; during work and Rest). None of the comparisons found statistically significant by paired *t* test.

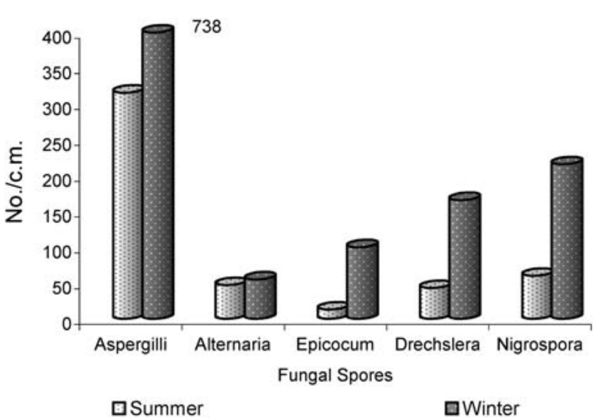

Fig. 1. Concentration of five major fungal spores outside the grain storage godown in summer and winter season (17 godowns).

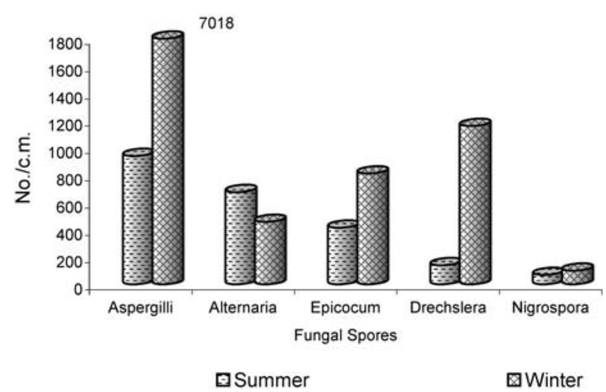

Fig. 2. Concentration of fungal spores inside grain storage godown in summer and winter season (17 godowns).

and outside the grain storage godown in summer and winter season (17 godowns). The concentrations of most of the spores are found higher in winter season. The spore's concentrations in each godown are found higher in winter compared to summer. The mean values of different spores are compared between summer and winter seasons by paired *t* tests in same godown but none of the differences are found statistically significant. Mean difference of values is found between the two seasons and that is higher in winter compared to summer. The concentration range of spores in some godowns is varied from very low to high, it depends upon the quality of grains, duration of storing, how much preventive measure has been taken up etc.

Figure 1 depicted the concentration of five major fungal spores outside the grain storage godown in summer and winter season. It has been observed that the concentrations of the fungal spores are higher in winter than summer in outside the godowns. Similarly the concentrations of fungal

Table 2. Physical characteristics of storage grain handlers

Department	Season	Age (yr)	Height (Cm)	Weight (Kg)
Handling Worker n=169	Summer n=46	33.0 ± 7.5	167.7 ± 5.5	60.0 ± 8.9
	Winter n=123	32.3 ± 9.1	170.8 ± 5.0	58.1 ± 9.0
Ancillary n=52	Summer n=29	45.1 ± 1.5	166.3 ± 6.8	58.3 ± 9.8
	Winter n=23	46.4 ± 6.2	163.7 ± 6.6	57.9 ± 9.1
Quality Control n=41	Summer n=39	46.7 ± 5.2	168.6 ± 6.1	66.2 ± 9.2
	Winter n=2	48.0 ± 2.8	165.0 ± 0.0	61.5 ± 2.1
Depot Administration n=54	Summer n=22	49.4 ± 7.1	168.3 ± 5.5	61.8 ± 9.8
	Winter n=32	48.5 ± 5.9	169.3 ± 6.4	64.6 ± 9.9

(Mean ± SD)

spores inside the grain storage godowns in summer and winter season (17 godowns) are presented in Fig. 2. It has been also found that the concentrations of most of the fungal spores are higher in winter compared to summer season. Each bar in both the figures represents the average of thirty-four values (seventeen godowns multiplied by two) of the fungal spores.

Table 2 represented the mean age, height, weight of the entire study population in summer (n=136) study were ranged from 33.0 ± 7.5 yr, 166.3 ± 6.8 cm and 58.3 ± 9.8 kg to 49.4 ± 7.1 yr, 168.6 ± 6.1 cm and 66.2 ± 9.2 kg and in winter (n=180) study 32.3 ± 9.1 yr, 163.7 ± 6.6 cm to 57.9 ± 9.1 kg to 48.5 ± 5.9 yr, 170.8 ± 5.0 cm and 64.6 ± 9.9 kg respectively The load-handling workers had lower mean age in both the studies. Physical parameters age, height and weight were highly comparable in the same categories of workers in summer and winter study. There were no significant differences of the physical parameters were found in two studies among the same categories of workers.

In the above workers the clinical studies have revealed that the allergic symptoms were found among the workers are redness, itchiness and watering of eyes in 12.87%, 16.17% and 29.34% workers respectively. Similarly the respiratory symptoms like cough, sputum and breathlessness were noticed in 13.17%, 16.17% and 29.34% workers. Besides these sneezing and stuffiness in 6.28% and 26.05% as well as the joint pain and low back pain in 10.18%, and 26.35% were noticed (ROHC [E]- ongoing report 2001)[21].

It has been found that with the increase of work duration the prevalence of symptoms showed a downward trend, except sputum production, which usually occurred in the winter season morning are increases with the increase of work duration. These symptoms were found more in ancillary workers because they were exposed to more grain dust as they were engaged in sweeping and refilling of the bags where greater amount of dust is being airborne. The pulmonary function test results also supported the involvement of the respiratory system. The joint pain and low back pain showed an upward trend with the increase of age and duration of work (ROHC [E]- ongoing report 2001)[21].

The mean pulmonary function test values of different categories of workers are presented separately for summer and winter and it was compared in between the same category of workers in Table 3. The mean values for VC, FVC, FEV_1, $FEF_{0.2-1.2l}$ and $FEF_{25-75\%}$ were found higher in load handling workers than the other categories. The mean values of these above parameters in summer and winter study were compared between the same categories of workers. In load handling workers except $FEV_1\%$ and $FEF_{25-75\%}$ all other parameters showed significantly higher values in summer compared to winter. In other categories of workers the mean values of summer was also found higher than the winter. Their level of significances was presented in the table.

The PFT values of the workers according to different age groups in all categories of workers were presented in Tables 4 and 5. Workers were categorized in different age groups

Table 3. Pulmonary function test values of storage grain handlers

	Season	SVC (l)	FVC (l)	FEV_1 (l)	FEV_1%	$FEF_{0.2-1.2l}$ (l/sec)	$FEF_{25-75\%}$ (l/sec)	PEFR (l/min)
Handling Worker n=169	Summer n=46	4.32*** ± 0.83	4.13** ± 0.80	3.68** ± 0.80	890 ± 7.02	7.76*** ± 1.98	4.48 ±1.46	480* ± 84.07
	Winter n=123	3.91 ± 0.69	3.77 ± 0.70	3.29 ± 0.70	87 ± 7.11	6.39 ± 1.66	4.04 ± 1.66	448 ± 70.98
Ancillary n=52	Summer n=29	3.75** ± 1.10	3.85** ± 1.10	3.38** ± 0.90	88 ± 6.96	6.96* ± 2.32	4.04 ± 1.40	477* ± 105.9
	Winter n=23	3.23 ± 0.64	3.07 ± 0.67	2.64 ± 0.64	86 ± 7.16	5.41 ± 2.17	3.10 ± 1.15	418 ± 94.89
Quality Control n=41	Summer n=39	3.78* ± 0.71	3.55 ± 0.74	3.14 ± 0.70	88 ± 6.45	7.0 ± 1.81	4.07 ± 1.27	513 ± 77.67
	Winter n=2	2.75 ± 0.06	2.79 ± 0.09	2.38 ± 0.08	85 ± 5.84	5.99 ± 0.09	2.81 ± 0.70	440 ± 42.42
Depot Administration n=54	Summer n=22	3.92* ± 0.86	3.74* ± 0.84	3.32** ± 0.73	89* ± 8.39	6.60 ± 1.92	4.09 ± 1.52	507** ± 57.97
	Winter n=32	3.42 ± 0.50	3.25 ± 0.51	2.74 ± 0.51	84 ± 7.12	5.64 ± 1.81	3.26 ± 2.80	435 ± 100.4

Mean ± SD. *p<0.05, **p<0.01, *** p<0.001 as compared to winter study in same category of workers. Other comparisons are not significant, SVC: Slow vital Capacity, FVC: Forced Vital capacity, FEV_1: Forced Expiratory Volume in one second, FEV_1%: Percentage of FVC, FEF Forced Expiratory Flow at $_{0.2-1.2l,\ 25-75\%}$, PEFR: Peak Expiratory Flow Rate.

Table 4. Lung volumes of different categories of storage grain handlers according to different age groups

	Yr	SVC (l) Summer	SVC (l) Winter	FVC (l) Summer	FVC (l) Winter	FEV_1 (l) Summer	FEV_1 (l) Winter	FEV_1% Summer	FEV_1% Winter
Handling labour	20–29, S (13) W (40)	4.55 ± 0.90	4.24 ± 0.71	4.27 ± 0.85	4.05 ± 0.72	3.90 ± 0.77	3.60 ± 0.68	91 ± 5.42	89 ± 6.38
	30–39, S (28) W (32)	4.40 ± 0.68*	4.03 ± 0.67	4.16 ± 0.70	3.87 ± 0.62	3.71 ± 0.72	3.37 ± 0.67	89 ± 6.91	87 ± 6.71
	40–49, S (3) W (25)	4.34 ± 1.26**	3.42 ± 0.39	4.04 ± 1.38	3.46 ± 0.87	3.13 ± 1.17	2.88 ± 0.75	77 ± 4.93	83 ± 5.44
	50 & above, S (2) W (26)	2.70 ± 1.11	3.14 ± 0.66	2.95 ± 1.10	3.06 ± 0.72	2.68 ± 1.11	2.60 ± 0.74	90 ± 4.19	84 ± 10.91
Ancillary	30–39, S (7),W (13)	4.00 ± 0.77**	3.47 ± 0.13	3.09 ± 0.16*	3.27 ± 0.19	3.01 ± 0.31	2.88 ± 0.23	97 ± 6.35**	88 ± 7.76
	40–49, S (14), W (6)	3.80 ± 1.06	3.64 ± 0.61	3.81 ± 1.03	3.49 ± 0.64	3.37 ± 0.83	3.00 ± 0.59	89 ± 7.44	86 ± 6.76
	50 & above, S (8) W (4)	3.32 ± 0.23	3.59 ± 0.87	3.75 ± 0.77	3.40 ± 0.84	3.29 ± 0.71	2.91 ± 0.80	88 ± 8.93	86 ± 9.80
Quality control	30–39, S (3) W (2)	4.02 ± 0.53*	2.75 ± 0.06	3.80 ± 0.65	2.79 ± 0.09	3.58 ± 0.53	2.38 ± 0.08	94 ± 2.62	85 ± 5.84
	40–49, S (23)	3.98 ± 0.71	–	3.76 ± 3.76	–	3.35 ± 0.63	–	89 ± 5.40	–
	50 & above, S (13)	3.38 ± 0.58	–	3.12 ± 0.74	–	2.66 ± 0.61	–	86 ± 7.64	–
Depot Administration	20–29, S (3) W (8)	3.30 ± 0.06	4.50 ± 1.54	3.04 ± 1.00	4.30 ± 1.60	2.79 ± 0.03	3.83 ± 1.31	92 ± 1.16	90 ± 2.64
	30–39, S (3) W (12)	4.70 ± 1.88	4.24 ± 1.74	4.45 ± 1.83	4.02 ± 1.65	3.72 ± 1.55	3.36 ± 1.35	84 ± 9.92	85 ± 9.16
	40–49, S (10) W (9)	4.06 ± 0.63	3.72 ± 0.75	3.95 ± 0.62	3.57 ± 0.78	3.51 ± 0.60	3.11 ± 0.78	89 ± 6.31	87 ± 7.71
	50 & above, S (6) W (3)	2.93 ± 0.80	3.15 ± 0.49	2.56 ± 0.80	2.95 ± 0.49	2.22 ± 0.85	2.60 ± 0.42	85 ± 8.81	88 ± 5.12

Mean ± SD. S: Summer study, W: Winter study. Figures in parenthesis are number of subjects. *p<0.05; **p<0.01 compared to winter study.

Table 5. Flow rates different categories of storage grain handlers according to different age groups

		$FEF_{0.2–1.21}$ (l/sec)		$FEF_{25–75\%}$ (l/sec)		PEFR (l/min)	
	Years	Summer	Winter	Summer	Winter	Summer	Winter
Handling Labour n=169	20–29, S (13), W (40)	7.93 ± 1.20	7.03 ± 1.59	4.96 ± 1.48	4.57 ± 1.65	483 ± 73.18	475 ± 56.95
	30–39, S (28), W (32)	7.96 ± 1.88*	6.84 ± 1.82	4.51 ± 1.33	3.97 ± 1.44	499 ± 63.87*	456 ± 74.70
	40–49, S (3), W (25)	6.42 ± 3.74	6.06 ± 2.17	2.69 ± 1.06	3.10 ± 1.20	382 ± 146.31	416 ± 87.76
	50 & above, S (2), W (26)	5.82 ± 4.48	5.36 ± 2.54	3.54 ± 2.39	3.08 ± 1.47	330 ± 127.27	374 ± 56.38
Ancillary n=52	30–39, S (7),W (13)	6.88 ± 3.34	6.33 ± 2.73	3.80 ± 1.87*	3.58 ± 1.65	474 ± 146.72	457 ± 130.22
	40–49, S (14),W (6)	7.34 ± 2.07	6.40 ± 2.40	4.22 ± 1.34	3.73 ± 1.45	482 ± 92.67	449 ± 107.00
	50 & above, S (8), W (4)	4.02 ± 2.48	5.22 ± 1.55	2.82 ± 1.75	3.14 ± 1.00	355 ± 129.50	420 ± 79.64
Quality control n=41	30–39, S (3), W (2)	8.88 ± 1.73	5.77 ± 0.09	5.48 ± 0.78*	2.81 ± 0.70	600 ± 81.85	440 ± 42.42
	40–49, S (23)	7.46 ± 1.60	–	4.40 ± 1.09	–	529 ± 70.03	–
	50 & above, S (13)	5.76 ± 1.59	–	3.18 ± 1.10	–	464 ± 63.05	–
Depot administr. n=54	20–29, S (3), W (8)	5.46 ± 2.64	6.96 ± 2.05	4.25 ± 2.35	4.83 ± 1.78	540 ± 40.65	550 ± 31.54
	30–39, S (3), W (12)	6.56 ± 1.56	5.67 ± 1.64	4.71 ± 1.48	3.69 ± 1.21	520 ± 20.00	440 ± 112.25
	40–49, S (10), W (9)	6.67 ± 2.45	6.16 ± 1.85	3.63 ± 1.65	3.44 ± 1.23	536 ± 40.07	479 ± 80.87
	50 & above, S (6), W (3)	6.54 ± 1.71	5.89 ± 2.09	4.18 ± 1.50	3.15 ± 1.36	484 ± 67.15	444 ± 103.26

Mean ± SD. S: Summer study, W: Winter study. Figures in parenthesis are number of subjects. SVC: Slow vital Capacity, FVC: Forced Vital capacity, FEV_1: Forced Expiratory Volume in one second, $FEV_1\%$: Percentage of FVC, $FEF_{0.2–1.2l,\ 25–75\%}$: Forced Expiratory Flow at $_{0.2–1.2l,\ 25–75\%}$, PEFR: Peak Expiratory Flow Rate. $*p<0.05$ as compared to winter study.

Table 6. Pulmonary function test results according to smoking habit

Category	Smoking habit	SVC (l)	FVC (l)	FEV_1 (l)	$FEV_1\%$	$FEF_{0.2–1.21}$ (l/sec)	$FEF_{25–75\%}$ (l/sec)	PEFR (l/min)
Handling labour n=169	NSM (n=111)	4.05 ± 0.70	3.87 ± 0.68	3.41 ± 0.68	87.89 ± 7.42	6.82 ± 1.69	4.25 ± 1.69	465 ± 66.59
	SM (n=53)	4.02 ± 0.84	3.90 ± 0.88	3.42 ± 0.86	87.12 ± 6.69	6.79 ± 2.14	3.96 ± 1.39	441 ± 90.64
	ESM (n=5)	3.50 ± 0.83	3.33 ± 0.78	2.88 ± 0.80	86.02 ± 4.52	4.92 ± 1.53*	4.00 ± 2.31	414 ± 74.02
Ancillary n=52	NSM (n=19)	3.60 ± 0.65	3.37 ± 0.66	2.93 ± 0.57	87.36 ± 6.57	5.92 ± 1.53	3.75 ± 1.41	476 ± 78.14
	SM (n=29)	3.82 ± 1.22	3.66 ± 1.19	3.19 ± 1.05	86.99 ± 7.05	6.65 ± 2.70	2.75 ± 1.89	467 ± 85.46
	ESM (n=4)	3.15 ± 0.44	3.00 ± 0.80	2.63 ± 0.92	86.54 ± 11.66	5.26 ± 3.05	1.65 ± 0.98	260 ± 169.70***
Quality Control n=41	NSM (n=13)	3.62 ± 0.59	3.48 ± 0.66	3.00 ± 0.67	86.06 ± 8.37	6.78 ± 2.12	3.75 ± 1.39	493 ± 95.90
	SM (n=23)	3.66 ± 0.78	3.39 ± 0.77	3.05 ± 0.71	89.83 ± 5.08	6.76 ± 1.61	4.00 ± 1.08	500 ± 57.60
	ESM (n=5)	4.67 ± 0.50**	4.17 ± 0.60	3.62 ± 0.57	86.88 ± 4.97	8.46 ± 1.75	4.74 ± 1.74	594 ± 64.65*
Depot Administration n=54	NSM (n=26)	3.68 ± 0.63	3.50 ± 0.54	3.02 ± 0.56	86.47 ± 9.26	6.21 ± 1.78	3.69 ± 1.25	469 ± 86.95
	SM (n=26)	3.66 ± 0.73	3.49 ± 0.79	3.02 ± 0.71	86.40 ± 6.15	6.11 ± 1.85	3.65 ± 1.42	442 ± 109.50
	ESM (n=2)	2.47 ± 0.63**	2.26 ± 0.32**	1.76 ± 0.54**	77.16 ± 12.99	2.76 ± 1.78*	3.15 ± 1.78	417 ± 155.43

Mean ± SD. NSM: Non-smoker, SM: Smoker, ESM: Ex-smoker. $*p<0.05$; $**p<0.01$; $***p<0.001$ as Non-smokers are compared to smokers and Ex-smokers.

by decade that was up to 30 yr, 31–40 yr, 41–50 yr and above 50 yr. The lung volumes and all flow rates of load handling, ancillary and quality control workers showed gradual reduction with the increase of age. Higher PFT values were obtained in lower age ranges than it gradually declines.

PFT results were also evaluated according to smoking habit and presented in Table 6. Workers were categorically divided in to non-smokers, smokers and ex-smokers category. Amongst the total workers 169 (53.5%) persons were non-smokers, 131 (41.4%) were smokers and 16 (5.1%) persons were ex-smokers. Ex-smokers had lowered lung volumes and flow rates among load handling, depot administration

Table 7. Pulmonary function test results according to duration of exposure

Category	Duration of exposure	SVC (l)	FVC (l)	FEV_1 (l)	$FEV_{1\%}$
Handling Labour n=169	≤5 (n=59)	4.14 ± 0.74	3.95 ± 0.74	3.55 ± 0.72	89.90 ± 6.52
	6–10 (n=41)	4.25 ± 0.67	4.07 ± 0.62	3.57 ± 0.60	87.85 ± 6.43
	11–15 (n=31)	4.22 ± 0.70	4.01 ± 0.74	3.46 ± 0.77	85.93 ± 6.93
	16–20 (n=10)	3.81 ± 0.53	3.69 ± 0.50	3.21 ± 0.59	86.57 ± 5.42
	21–25 (n=3)	3.71 ± 0.38	3.76 ± 0.53	3.39 ± 0.46	90.16 ± 4.21
	26–30 (n=14)	3.25 ± 0.58	3.20 ± 0.98	2.60 ± 0.88	80.84 ± 9.30
	>30 (n=11)	3.21 ± 0.57	3.26 ± 0.55	2.87 ± 0.55	87.84 ± 6.66
Ancillary n=52	≤5 (n=0)	–	–	–	–
	6–10 (n=9)	4.48 ± 1.70	4.30 ± 1.62	3.65 ± 1.39	85.56 ± 8.22
	11–15 (n=0)	–	–	–	–
	16–20 (n=2)	3.15 ± 0.26	3.01 ± 0.46	2.78 ± 0.33	92.78 ± 3.34
	21–25 (n=11)	3.71 ± 0.69	3.56 ± 0.80	3.06 ± 0.76	85.48 ± 8.89
	26–30 (n=21)	3.53 ± 0.69	3.40 ± 0.65	2.99 ± 0.60	87.87 ± 5.50
	>30 (n=9)	3.33 ± 0.88	3.00 ± 0.92	2.65 ± 0.95	87.50 ± 7.88
Quality control n=41	≤5 (n=0)	–	–	–	–
	6–10 (n=0)	–	–	–	–
	11–15 (n=5)	4.11 ± 0.56	3.84 ± 0.65	3.55 ± 0.60	92.65 ± 3.55
	16–20 (n=4)	4.52 ± 0.37	4.87 ± 0.21	3.90 ± 0.15	91.30 ± 6.48
	21–25 (n=10)	3.65 ± 0.87	3.44 ± 0.78	3.02 ± 0.78	87.80 ± 6.90
	26–30 (n=19)	3.34 ± 0.68	3.34 ± 0.79	2.90 ± 0.66	86.93 ± 6.58
	>30 (n=3)	3.55 ± 0.34	3.32 ± 0.26	2.90 ± 0.40	87.84 ± 6.66
Depot Administration n=53	≤5 (n=0)	–	–	–	–
	6–10 (n=0)	–	–	–	–
	11–15 (n=5)	3.37 ± 0.24	3.18 ± 0.24	3.46 ± 0.77	89.50 ± 7.12
	16–20 (n=6)	3.58 ± 0.37	3.33 ± 0.36	2.81 ± 0.14	85.08 ± 6.58
	21–25 (n=20)	3.63 ± 0.76	3.52 ± 0.80	3.07 ± 0.71	87.23 ± 7.47
	26–30 (n=9)	3.50 ± 0.62	3.34 ± 0.58	2.92 ± 0.70	87.10 ± 9.09
	>30 (n=13)	3.72 ± 0.88	3.50 ± 0.87	2.90 ± 0.82	82.23 ± 8.83

Mean ± SD. Figures in parenthesis are number of subjects.

and ancillary workers compared to non-smokers and smokers. Heavy smokers (smoked >15 cigarettes per day) PFT values were found lowered compared to non-smokers but the PFT values of the light (<5 cigarettes per day) and moderate (>6 <15 cigarettes per day) smokers are equal sometimes little higher in smokers compared to non-smokers. In quality control category smokers and ex-smokers had little higher lung volumes and flow rates than non-smokers. In the study the PFT values of smokers in some category of workers found higher which does not corroborate with the established hypothesis. All workers studied in summer and winter were combined together and then categorically divided according to smoking habit to establish the smoking effect than seasonal effect. It has been established smoking causes deterioration of PFT values.

PFT values were assessed according to duration of exposures and their mean values were presented in Tables 7 and 8. Workers were grouped together by five years of duration of exposure that is up to 5 yr, 6–10 yr, 11–15 yr, 16–20 yr, 21–25 yr, and 26–30 yr and above 30 yr in different categories of workers respectively. The values were presented combined of both the seasons. There was no definite trend of reduction of PFT values were found in all categories of workers as duration of exposure increased but most of the highly exposed group of workers had lower PFT values obviously with some exception where higher exposure group have little higher values compared to the immediate lowered duration of exposure group. The restrictive, obstructive and combined restrictive and obstructive types of respiratory impairments were noticed. Among the total workers the restrictive impairment was found in 5 (3.7%) workers and obstructive impairment in 8 (5.9%) workers in summer and the corresponding figure in winter was 13 (7.2%) and 8 (4.4%) respectively. Besides

Table 8. Pulmonary function test results according to duration of exposure

Category	Duration of exposure (yrs)	$FEF_{0.2-1.2l}$ (l/sec)	$FEF_{25-75\%}$ (l/sec)	PEFR (l/min)
	≤5 (n=59)	6.90 ± 1.46	4.77 ± 1.82	464 ± 65.84
	6–10 (n=41)	7.08 ± 1.84	4.18 ± 1.30	477 ± 58.36
Handling	11–15 (n=31)	6.99 ± 1.95	3.99 ± 1.57	469 ± 78.82
Labour	16–20 (n=10)	6.65 ± 1.65	3.68 ± 1.11	452 ± 43.66
n=169	21–25 (n=3)	6.56 ± 0.97	3.85 ± 0.55	428 ± 67.14
	26–30 (n=14)	5.34 ± 2.68	2.80 ± 1.30	380 ± 113.14
	>30 (n=11)	6.22 ± 2.11	3.48 ± 1.24	412 ± 83.64
	≤5 (n=0)	–	–	–
	6–10 (n=9)	7.79 ± 2.88	3.91 ± 1.71	485 ± 132.19
Ancillary	11–15 (n=0)	–	–	–
n=52	16–20 (n=2)	6.88 ± 1.03	3.71 ± 1.06	460 ± 84.85
	21–25 (n=11)	6.30 ± 2.66	3.39 ± 1.33	441 ± 142.22
	26–30 (n=21)	6.11 ± 1.92	3.69 ± 1.10	458 ± 62.57
	>30 (n=9)	5.02 ± 2.17	3.46 ± 1.84	409 ± 112.29
	≤5 (n=0)	–	–	–
	6–10 (n=0)	–	–	–
Quality control	11–15 (n=5)	8.31 ± 1.85	5.08 ± 1.12	574 ± 75.03
n=41	16–20 (n=4)	8.28 ± 2.10	4.96 ± 0.54	518 ± 72.28
	21–25 (n=10)	6.72 ± 1.44	4.17 ± 1.48	528 ± 66.46
	26–30 (n=19)	6.69 ± 1.90	3.53 ± 1.10	488 ± 82.61
	>30 (n=3)	5.65 ± 1.26	3.51 ± 1.05	463 ± 20.81
	≤5 (n=0)	–	–	–
	6–10 (n=0)	–	–	–
Depot	11–15 (n=5)	5.52 ± 1.46	3.76 ± 1.06	462 ± 108.95
Administration	16–20 (n=6)	5.94 ± 1.3	3.31 ± 0.83	478 ± 37.10
n=53	21–25 (n=20)	6.21 ± 2.21	3.52 ± 0.80	474 ± 86.73
	26–30 (n=9)	6.38 ± 1.66	3.70 ± 1.70	471 ± 94.94
	>30 (n=13)	5.70 ± 2.10	3.27 ± 1.59	433 ± 115.24

Mean ± SD. Figures in parenthesis are number of workers.

these in winter study 2 (1.1%) workers have noticed combined type of disorder. The respiratory impairments of the storage grain handlers were depicted in Table 9.

The post-shift PFT were done in 69 (21.8%) workers of which 32 (46.4%) workers showed decrement of post-shift values. The decrements were more in those who had minimum duration of work that is newly appointed workers. As the duration of work is gradually increased the number of workers with post shift decrement of PFT values were decreased. Variations of respiratory function during the work shift were more in newly appointed workers than the old workers.

The mean IgE level of allergic symptomatic with post shift PFT decreased workers was 249 ± 71.54 IU/ml (range 114 to 367 IU /ml), their mean duration of work were 10.08 ± 3.79 yr. The range of IgE level and the PFT results of the workers as whole was presented in Table 10. The workers were grouped whose IgE level is up to 250 IU/ml and above 250 IU/ml. The mean PFT values were found little higher among the workers whose IgE level was higher but the differences are statistically non-significant. Only the $FEV_1\%$ was found little higher in low IgE level workers. Post-shift PFT was carried in 21.8% (69) workers of which 46.4% (32) workers showed the decrement of PFT values. The serum IgE level of the post-shift PFT decreased subjects was found more than 250 IU/ml in 17 workers out of the total of 32 workers (53.1%)

Discussion

The total number of fungal spores in different godowns both in summer and winter seasons are different. It is very much essential and needs to be mentioned that the exposure level of the four different categories of workers working

Table 9. Spirometric assessment of Respiratory impairments among Storage Grain Handlers

Category	Season	Restrictive Impairment	Obstructive Impairment	Combined Restrictive &. Obstructive
Handling worker	Summer, n=46	2 (4.3)	3 (6.5)	–
n=169	Winter, n=123	7 (5.7)	3 (2.4)	–
Ancillary n=52	Summer, n=29	2 (6.9)	2 (6.9)	–
	Winter, n=23	3 (13.0)	2 (8.7)	1 (4.3)
Quality Control	Summer, n=39	–	2 (5.1)	–
n=41	Winter, n=2	–	–	–
Depot Admin.	Summer, n=22	1 (4.5)	1 (4.5)	–
n=54	Winter, n=32	3 (9.4)	3 (9.4)	1 (3.1)
Total in Summer, n=136		5 (3.7)	8 (5.9)	
Total in Winter, n=180		13 (7.2)	8 (4.4)	2 (1.1)
Total in both studies, n=316		18 (5.7)	16 (5.1)	2 (0.6)

Depot. Admin.-Depot administration. n-Number of subjects.
Figures with in the parentheses are percentages.

Table 10. Pulmonary function test values of the storage grain workers according to their Serum Immunoglobulin-E (IgE) level

Parameters	IgE level up to 250 IU/ml n=15	IgE level above 250 IU/ml n=17
SVC (l)	3.80 ± 0.84	3.85 ± 0.92
FVC (l)	3.55 ± 0.79	3.69 ± 0.96
FEV_1 (l)	3.14 ± 0.69	3.25 ± 0.89
FEV_1%	82.95 ± 7.24	79.64 ± 17.01
$FEF_{0.2-1.2L}$ (l/Sec)	6.50 ± 1.66	7.25 ± 2.33
$FEF_{25-75\%}$ (l/Sec)	3.85 ± 1.08	4.02 ± 1.58
$FEF_{75-85\%}$ (l/Sec)	1.48 ± 0.54	1.62 ± 0.80
PEFR (l/min)	476 ± 82.61	492 ± 93.80

Mean ± SD.

inside the storage food grain godowns are not restricted to any particular godown for the same concentration of spores. Everyday or even in the same day they worked in more than a number of godowns. There is no fixed worker for a particular godown. All workers were allotted duty by the labour department through out storage food grain depot in different godowns according to the work schedule where the loading unloading and other work are required.

The comparisons of the pulmonary function test values are made between the workers of same category in two different seasonal studies when concentrations of fungal spores are varying. The load handling workers of the present study are belonged to lower mean age category with good physique and they are having high PFT values compared to the other categories of workers having higher mean age. When the comparisons are made in between the same category of workers in summer and winter the significant differences were noticed in most the PFT values. The mean PFT values are with in normal range in all categories of workers. The exposures to airborne fungal spores causing more PFT changes in winter compared to summer.

The pulmonary function abnormalities among the storage food grain handling workers were obstructive, restrictive and combined restrictive and obstructive type. The presence of airborne fungal spores in working environment might be responsible for these respiratory impairments. It has been established that more than 80 genera of fungi have been associated with respiratory tract allergy[23]. It was stated that there is a relationship between fungal bio-aerosol and different occupational diseases like bronchitis, asthma, extrinsic allergic alveolitis, mycotoxicosis etc. Rao *et al.*[24] reported that an environment should be considered as contaminated if total concentration of fungal spores exceeds the limit 1,000^{-m3}. In the present study in most of the godowns had higher spore concentration. The subjects were exposed to the dust and the hot humid working condition and exposure to the different fungal spores may be responsible for the pulmonary function impairments. The storage grains acts as substrates for fungal growth inside godowns. The present epidemiological and pulmonary function study revealed that storage food grain handling workers had allergic manifestations and pulmonary function impairments. The high concentration of different fungal spores might be one of the leading causes of this type of respiratory problems; it is more in winter season might be due to higher fungal spore concentration in the godown air in winter.

The clinically important type of allergy is caused by antibodies are commonly called as reagins and that is belonged to immunoglobulin E class. Cytophilicity is a characteristic of regains that is a strong tendency to attach to the mast cells. In human, mast cells are found in lungs and in membrane of upper respiratory tract. These mast cells are rich in granules, which contain histamine and several other biologically active substances. The cell bound regains are directly responsible for the allergic symptoms. Histamine is released in the immediate type of allergic reactions. In the bronchi histamine contracts the smooth muscles, swells the membrane and produces thick mucus. This results in congestion and making breathing particularly expiration more difficult. The IgE level was found higher who had post-shift decrement of PFT values and less duration of work. Verma and Gangal[25] stated that these fungal spores are not only causing the respiratory problems individually but they are very much cross-reactive.

The workers had allergic symptoms like redness, itching and watering of eyes, sneezing, stuffiness, cough, sputum and breathlessness as well as post-shift decrement of PFT values. It has been found that the decrement of post shift PFT values were more whose duration of work was less. The results showed that the variation of respiratory function during the work shift were more in those who were fresh to their job than the old workers. The present study results stated that the fungal spore concentration in godowns were more in winter than summer and in old stock grains than the fresh stock. Varying concentrations of airborne fungal spores in occupational environments caused different types of respiratory impairments. A good number of workers had post-shift PFT changes and bronchodilator study established that changes are reversible in many cases. Prolonged exposure caused respiratory diseases. Newly appointed workers had more allergic manifestations with post-shift decrement of PFT values.

In a similar type of study, Nag *et al.*[13] on grain storage workers found significantly lower lung function values compared to control. The total dust concentrations of the present study are more than the study carried out at Bangalore, India[14]. Although both mean values was below TLV according to ACGIH 1995–96 standard. Respirable dust level was also well with in the prescribed limit but the continuous exposure may be responsible as one of the leading cause of adverse health effects[5].

The higher level of Immunoglobulin E (53.1%) among the workers might be due to the allergic manifestations. It has been established that the mean serum IgE level of allergy free Kolkata normal ranged between 120–160 IU/ml. Recently, it was further established by the same group of scientists that the IgE level of the people of environmentally polluted city Kolkata was much higher (up to 250 IU/ml) because different types of environmental exposures (unpublished). It has been proved that few exposures of fungal spores with high doses of antigen were less efficient than multiple exposures with low doses[26]. The workers of the present study were continuously exposed to their work environment for a long time resulting the effect. Allergic reactions associated with fungi involve the lower respiratory tract more frequently[27]. It was established that the smokers had higher IgE level than non-smokers and subjects with occupational dust or gas exposure had a higher total IgE level than non exposed[28]. The present study results were comparable to their study. The subjects were exposed to the dust and the hot humid working condition and exposure to the different fungal spores may be responsible for the above-mentioned symptoms.

Lower mean values in winter season might be due to higher fungal spore concentration in the godown air in winter. It is reported that subjects sensitized to a single fungal species are quite rare; the common pattern was to react to many species. Furthermore, fungal allergies are more difficult to diagnose and treat than other allergies since fungi are far more numerous and antigenically variable than other allergens and are exceedingly difficult to avoid. Lewis *et al.*[28] determined the prevalence of IgE antibodies to grain dust in grain elevator workers. It was established from the present study that the workers exposed to storage grain dust had obstructive, restrictive and combined obstructive and restrictive type of respiratory impairments. Different allergic manifestations with post-shift PFT changes were more among the newly appointed workers. Higher IgE level was found in good numbers of workers. Varying concentration of fungal spores in the godowns might be one of the reasons of this type of changes.

To prevent the respiratory problems among storage grain handlers, the control of airborne spores is necessary, which can be achieved by good storage conditions of the grains and adequate drying. If release of spores were unavoidable good ventilation should be provided as close as possible at the point of release of spores to prevent dispersal through out the work environment. The accumulation of dirt and stagnant water should be avoided and the whole system to be maintained to a high degree of cleanliness.

Acknowledgement

The authors are grateful to the Director, National Institute of Occupational Health, Ahmedabad and the Officer- in-charge Regional Occupational Health Centre (Eastern), Kolkata for their kind permission and encouragement in conducting the study. We are also grateful to the management to provide us the facilities and the workers whose cooperation made this study possible. We are thankful to Mr. A Mahata and Mr. S. Kundu for helping in statistical analysis and preparing the manuscripts. We are indebted to Indian Council of Medical Research, New-Delhi for funding the project.

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