

A pulmonary survey of grain handlers in the West of Scotland

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Summary

A pulmonary survey was undertaken in a large granary in the West of Scotland. The lung functions and respiratory symptoms were compared in nineteen atopic and fifty-six non-atopic grain handlers with reference to their smoking habits and also to forty-eight control subjects with no previous exposure to grain dust. Cigarette smokers from the granary workers and the control group had more respiratory symptoms and significantly lower PF, FEV₁, V₂₅ and V₅₀. The atopic grain handlers, on the other hand, had better ventilatory functions compared to non-atopic workers. This difference in the atopic group may be related to their lower cigarette consumption, shorter service in the granary or the process of self selection. The grain handlers with wheeze or breathlessness at work had significantly higher incidence of restrictive type MEFV curves and this could not be attributed to increased cigarette consumption, atopy or longer duration of employment and there was no correlation between severity of symptoms and occupational exposure. Although PF, FEV₁, FVC, V₂₅, V₅₀ and V₇₅ failed to show significant differences in granary workers and controls, the shape of MEFV curve may have significance as a sensitive indicator of the effect of grain dust as a preclinical stage.

Introduction

Ramazzini first described adverse effects of grain dust as early as 1713 and since then other studies have reported a variety of respiratory and clinical presentations related to occupational grain dust exposure. These reactions include allergic asthma, wheezing, febrile illness after massive exposure to grain dust (grain fever), pulmonary fibrosis, rhinitis and allergic alveolitis (Hunter, 1969; Williams, Skoulas & Merriman, 1964; Skoulas, Williams & Merriman, 1964). Smith, Greenberg & Siegel (1941) attributed the higher incidence of respiratory symptoms in grain handlers to grain dust itself,

exposure to inclement climate and also heavy consumption of alcohol. Subsequent reports however, have failed to confirm the relationship of climate and alcohol to respiratory symptoms (Williams *et al.*, 1964; Skoulas *et al.*, 1964). Tse and co-workers (1973) postulated that a chemical airway reaction as seen in byssinosis, rather than a precipitin-mediated hyper-sensitivity reaction was the likely pathogenic mechanism in producing symptoms. In contrast Cohen & Osgood (1953) suggested that the inhalation of crude grain dust was capable of inducing disabling respiratory symptoms and pulmonary changes in sensitized workers and Warren, Cherniack & Tse, (1974) have shown a clear relationship in subjects with skin hypersensitivity to grain dust and immediate and late asthmatic reactions in response to bronchial challenge.

In addition to grain allergens contaminants of grains are also allergenic. These include the wheat weevil (*Sitophilus granarius*), debris from the mite, *Tyroglyphus farinae*, fungal spores of *Penicillium*, *Aspergillus*, *Mucor* and *Pullularia* species (Williams *et al.*, 1964), and a high concentration of thermophilic bacteria known to cause allergic alveolitis (Dickie & Rankin, 1968).

In order to determine the prevalence of respiratory symptoms in grain handlers, a preliminary investigation was undertaken in the west of Scotland in a large granary which is the largest grain store in Europe and with a relatively stable working population. The lung functions and respiratory symptoms were compared in atopic and non atopic grain handlers with reference to their smoking habits and also to a control group with no previous exposure to grain dust.

Materials and methods

The granary handles mainly wheat, barley, and maize imported from all over the world. The grain is removed from the holds of ships and is discharged on to conveyors for transfer to grain elevators for storage. The dust is generated through unloading of ships, transport of grain to elevators, moving grain within the elevator, manual sweeping of floors and by loading trucks from the elevators. All employees at this granary were invited to take part in the survey and, of these, seventy-five (85%) were examined. The control group consisted of forty-eight male subjects attending an independent cardiorespiratory survey in the West of Scotland. The data on all subjects attending on a randomly selected day was used. It was known in advance that these subjects did not have a history of exposure to grain dust. An extended version of the MRC questionnaire (1966) on respiratory symptoms was used to cover grain dust exposure and related symptoms. The questionnaire was also used to identify workers who developed acute chest tightness, wheezing or dyspnoea in relation to their work. These workers were defined as the symptomatic at work group. The grain workers were skin prick-tested to control, house dust mite (*Dermatophagoides pteronyssinus*), grass pollen and *Aspergillus fumigatus*. In addition the grain handlers were skin prick-tested to barley threshings, maize, oat, wheat and rye. Prick test solutions were obtained from Bencard.

The maximum expiratory flow volume (MEFV) curves were recorded using a heated pneumotachograph, a differential pressure transducer and a volume integrator (Nelson, Burrows & Knudson, 1973; Shaw *et al.*, 1976; Pollock *et al.* 1977). The equipment was calibrated before and after each session. The MEFV curves for analysis were only accepted if two or more reproducible curves were obtained. All tests were carried out in the mid part of a working week in the morning before any occupational

exposure had occurred. Smokers were requested to refrain from smoking for at least 2 h prior to tests.

Measurements computed from MEFV curves included peak flow (PF), forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV_1) and maximum expiratory flow rate at 25, 50 and 75% of expired volume (V_{25} , V_{50} and V_{75}). Additionally, the shape and magnitude of MEFV curve was analysed by one of us (K.R.P.) following guidelines previously described (Bass, 1973; Gelb & Mekanally, 1973). The curves for all grain handlers and control subjects were coded and mixed together so that the investigator undertaking the analysis was unaware as to whom or to which group of workers each curve belonged.

The predicted equations of Cherniack & Raber (1972) were used to compare the results with expected normal values of PF, FVC, FEV_1 , V_{25} , V_{50} and V_{75} . By dividing the measured value of each subject by the calculated predicted value, a series of percentages of predicted values were obtained.

Results

The average age of seventy-five grain handlers was 48.2 yr and average length of continuous employment in the granary 11.8 yr. The control group consisted of forty-eight male subjects whose mean age was 52.2 yr. Although the mean age of the control group was greater by 4 yr, there was no significant statistical difference between the two groups.

There were forty-seven cigarette smokers amongst grain handlers and the average number of cigarettes smoked was 20–25 per day. For analysis, five pipe-smokers and one cigar-smoker were included in the non-smoking group and so were ex-smokers who had not smoked for at least one year (Do Pico *et al.*, 1977). The control group consisted of forty-eight subjects mainly professional people and office workers. Fifteen of these were cigarette-smokers. Three pipe-smokers, three cigar-smokers and four ex-smokers were classed with the non-smoking group.

Figure 1 is a histogram showing respiratory symptoms in smokers and non-smokers among the grain workers. There was a significant difference in respiratory

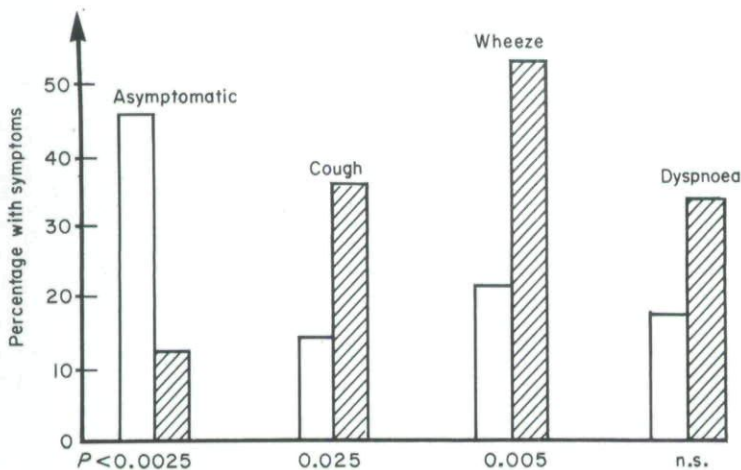


Fig. 1. Respiratory symptoms in granary workers: smokers vs non-smokers. □, Non-smokers; ▨, smokers.

symptoms between smokers and non-smokers except for dyspnoea which was not significant using 2×2 chi contingency table.

Atopy and occupational risk

Nineteen granary workers with one or more positive prick tests (weal greater than 2 mm) to common allergens were considered to be atopic. Of these, nine workers gave positive reactions to one or more occupational allergens. Table 1 shows minor eye or upper respiratory tract symptoms and chest tightness in atopic and non-atopic grain workers. There were two workers in the non-atopic group who showed positive prick tests to occupational allergens and one of these had chest symptoms. Although the incidence of minor respiratory symptoms and chest tightness was high in atopic workers who were positive to occupational allergens, thirty-one of the fifty-four non-atopic workers with negative prick tests to occupational allergens also had symptoms.

Figure 2 shows the relationship of the symptoms to the type of grain dust handled. Upper and lower respiratory symptoms were most common with barley and least with rye and soya beans. Barley formed 17% of all grain handled at the time of the survey.

Table 1. Symptoms at work and atopic status in seventy-five granary workers

Group	Prick tests to occupational allergens		Chest symptoms	Eye, nose, throat symptoms	Asymptomatic
Atopic	+ ve	9	6	2	1
	- ve	10	1	4	5
Non-atopic	+ ve	2	1	0	1
	- ve	54	16	25	14
Percentage			32	41	27

Positive prick test indicating a weal of 2 mm or greater.

Occupational allergens: barley threshings, maize, oat, wheat and rye.

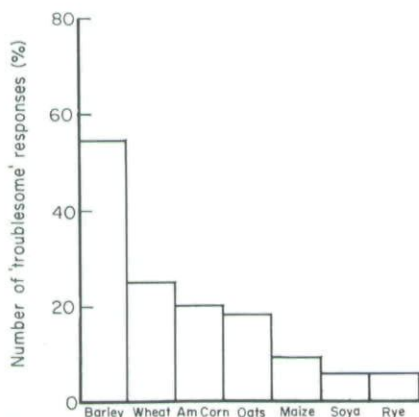


Fig. 2. Subjective impression of 'troublesome' responses to different types of dust

There was no significant difference in respiratory symptoms between the atopics and the rest of the workers (Wilcoxon rank test).

The proportion of smokers was also broadly similar. Fifty-eight percent of the atopics and 62% of all grain handlers were current cigarette-smokers. Seven of the workers who were symptomatic at work had respiratory symptoms which persisted for long periods after exposure to grain dust. A high proportion (70.8%) of the symptomatic at-work group suffered from wheezing, 50.6% from dyspnoea and 45.8% from cough and sputum production ($P < 0.012$ Wilcoxon rank test).

Lung functions

The normal values of Cherniack & Raber (1972) were used to express PF, FEV₁; FVC, V₂₅, V₅₀ and V₇₅ as the percentage of mean predicted values. The results (Table 2) indicate that non-smokers in both granary and in the control group had consistently better ventilatory functions than the smokers. The ventilatory function of the control non-smokers and the granary non-smokers did not vary significantly. Essentially, the results show that smoking had a major influence on ventilatory function for both grain

Table 2. Ventilatory functions in granary workers and control subjects

	Granary non-smokers (n = 28)	Granary smokers (n = 47)	P	Control non-smokers (n = 33)	Control smokers (n = 15)	P
PF	71.5	63.3	0.02	72.8	64.0	0.05
FEV ₁	90.2	81.6	0.004	94.5	79.0	0.02
FVC	90.3	89.6	n.s.	92.2	84.0	0.001
V ₂₅	61.5	52.9	0.03	63.7	47.8	0.004
V ₅₀	52.6	44.8	0.03	55.2	40.7	0.03
V ₇₅	42.8	37.2	n.s.	47.2	37.7	n.s.

Results are expressed as percentage of mean predicted values.

n.s. = Not significant.

handlers and the control group. There was no significant systematic deterioration in these measurements between controls and grain handlers to suggest that cigarette smoking had additional significant effect on lung functions of grain handlers.

Table 3 gives the ventilatory functions of the atopic and non-atopic granary workers. The mean PF, FEV₁, V₂₅, V₅₀ and V₇₅ were significantly higher in the atopic group in comparison with the rest of the grain handlers (Wilcoxon rank test).

In the symptomatic at-work group (Table 4) the mean values of PF, FEV₁, FVC, V₂₅, V₅₀ and V₇₅ were not significantly different from the rest of granary workers.

Analysis of the MEFV curves

There were four types of curves and examples of these are illustrated in Fig. 3. Table 5 shows the percentage of subjects in each category. The significance in relation to the control is also stated. The proportion of normal curves was similar for the controls and all grain handlers. There were fewer in the atopic group and the symptomatic at-work

Table 3. Ventilatory functions in atopic and non-atopic granary workers

	Non-atopic (<i>n</i> = 56)	Atopic (<i>n</i> = 19)	<i>P</i>
PF	64.2	73.0	0.005
FEV ₁	81.9	93.3	0.042
FVC	89.7	93.2	n.s.
V ₂₅	52.4	67.0	0.031
V ₅₀	44.6	56.9	0.007
V ₇₅	37.6	44.4	0.027

Results expressed as percentage of mean predicted value.

n.s. = Not significant.

Table 4. Ventilatory functions in symptomatic and non-symptomatic granary workers

	Non-Symptomatic at work (<i>n</i> = 51)	Symptomatic at work (<i>n</i> = 24)	<i>P</i>
PF	68.3	62.4	n.s.
FEV ₁	85.1	84.2	n.s.
FVC	91.1	89.5	n.s.
V ₂₅	58.7	50.5	n.s.
V ₅₀	50.3	42.2	n.s.
V ₇₅	37.4	43.3	n.s.

Results expressed as percentage of mediated value.

n.s. = Not significant.

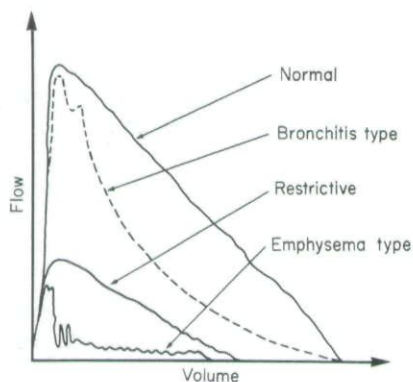
**Fig. 3.** Patterns of flow-volume curves

Table 5. Distribution of different types of MEFV curves in control subjects and granary workers

	Control (n=48)	All grain handlers (n=75)	Atopics (n=19)	Symptomatic at work (n=24)
Normal	50.0	50.7 (n.s.)	42.1 (n.s.)	41.7 (n.s.)
Bronchitis	35.4	18.6 (0.025)	36.8 (n.s.)	8.3 (0.0125)
Restrictive	6.2	18.6 (0.05)	15.8 (n.s.)	33.3 (0.0025)
Emphysema	8.3	12.0 (n.s.)	5.3 (n.s.)	16.7 (n.s.)

Figures in parentheses indicate statistical significance.

n.s. = Not significant.

group with normal MEFV curves but the differences were not statistically significant for either group. The incidence of the bronchitis type curve was significantly higher in the control group compared with all grain handlers or the symptomatic at-work group. In addition, the incidence of the restrictive type of curve was significantly higher for both the grain handlers and the symptomatic at-work group. Although the prevalence of emphysema type curve was higher in the grain workers compared to the control subjects the difference was not statistically significant. The mean predicted FEV₁ was significantly lower in the restrictive group as compared to subjects with normal MEFV curves ($P < 0.05$ Wilcoxon rank test). The FEV₁/FVC ratio, however, in the restrictive group was 96.3% and was comparable with normals.

Discussion

Most of the previous clinical and physiological investigations in grain handlers have been undertaken in North America (Williams *et al.*, 1964; Skoulas *et al.*, 1964; Tse *et al.*, 1973; Do Pico *et al.*, 1977) and this has an important bearing in comparing our results with these studies. The interpretation of data based on surveys of occupational groups must be considered in relation to the process of self selection and the present study is restricted to workers still employed in the granary. Unlike other workers, however, we have assessed our grain handlers in relation to a control group from the same area.

Cigarette smokers from the granary workers and the control group had more respiratory symptoms and significantly lower ventilatory function particularly in terms of PF, FEV₁, V₂₅ and V₅₀. For grain handlers our findings in cigarette smokers are similar to Kleinfeldt *et al.* (1968) and Do Pico *et al.* (1977). Like Do Pico, we combined the data for ex-smokers and non-smokers because no significant differences were observed between these two groups. Our symptomatic sub-group was limited to the subjects with acute symptoms of wheeze, dyspnoea and chest tightness solely at work (32%). For our grain handlers the prevalence of specific symptoms on exposure was rather lower than Do Pico *et al.* (1977) who had 42% with wheezing, and Tse *et al.* (1973) who had 43% with dyspnoea on exposure. Our results are comparable to Williams *et al.* (1964) who had 18.5% with wheezing and 15.5% with dyspnoea.

The most important disparity in our findings from previous reports is that there was no graded deterioration in the ventilatory function in the atopic group. In

contrast, this group had better ventilatory measurements compared to non-atopic subjects. This difference may be related in part to lower cigarette consumption, 26.9 pack years compared to 34.6 pack years for the grain handlers who were smokers. Secondly, to a small number of atopic individuals with long service, the mean length of employment for atopic group being 7.7 years compared to 13.5 years for the granary workers. Thirdly, the atopic individuals with more severe symptoms may be leaving their employment in the granary. The present study has not included these subjects and a retrospective study on former workers has not been attempted. This observation in atopic group may have industrial implications on the employment of these subjects in granaries. In the symptomatic at work group the significantly increased proportion of restrictive type MEFV curves could not be attributed to increased cigarette consumption, atopy or longer duration of employment and there was no correlation between severity of symptoms and occupational exposure in this group. The mean length of employment being 6.0 years for the normal, 10.5 years for symptomatic subjects with restrictive type MEFV curve and 14.0 years for granary workers with the emphysema type of curve. In two of the grain handlers, the onset of dyspnoea and other symptoms suggested a precipitin-mediated (type III) reaction, however, we were unable to identify the allergens involved both on skin and serological tests when these individuals were reassessed in detail at a chest clinic. A further four grain-handlers with symptoms and restrictive type of MEFV curve had negative prick tests both to common and occupational allergens. The non-specific irritant and chemical effects of grain dust and its contaminants may be responsible for causing symptoms in these workers and a possibility of humoral or cell-mediated immunological reaction to numerous allergenic constituents of grain dust also cannot be excluded.

It has been suggested that the shape of the MEFV curve is a sensitive indicator of respiratory disease (Abboud & Morton, 1975; Sobel, 1976) although some workers consider it to be of limited usefulness mainly because of intra-subject variability (McCarthy, Craig & Cherniack, 1975; Cochrane, Prieto & Clarke, 1977). Our results tend to confirm the sensitivity of the test and there were no major intra-subject variations when a sample group was retested in the laboratory environment. Unlike individual respiratory measurement the analysis of the flow volume manoeuvre takes into account a number of factors including the magnitude of PF and FVC and the concavity of the curve. It is probably the cumulative significance of these factors which gives results comparable to our interpretation of the flow volume curve. There is, however, additional evidence to support this view. The FEV_1/FVC ratios expressed as percentage of predicated for the normals and emphysema categories were 105.6 and 66% respectively ($P < 0.03$). The average percentage of predicted FEV_1/FVC for the restrictive category was 96.3% and was comparable with that of the normal subjects. However, the absolute mean FEV_1 in the restrictive group was significantly lower ($P < 0.05$) consistent with a restrictive pattern of disease. This pattern of curve was particularly prevalent in our symptomatic at-work group and although the standard parameters of lung function (FEV_1 , FVC, V_{25} , V_{50} , V_{75}) failed to show significant differences in granary workers *vs* controls, this interpretation of MEFV curve type is worthy of further assessment and may have significance as a sensitive indicator of the effect of grain dust at a pre-clinical stage. The adverse effects of grain dust in lung are multifactorial and clearly investigations into the immunological, physiological and mycological aspects together with environmental study would be required to determine the pathogenesis of the condition.

References

- ABBOUD, R.T. & MORTON, J.W. (1975) Comparison of maximal mid-expiratory flow, flow-volume curves and nitrogen closing volumes in patients with mild airway obstruction. *American Review of Respiratory Diseases*, **111**, 405.
- BASS, H. (1973) The flow-volume loop; normal standards and abnormalities in chronic obstructive pulmonary disease. *Chest*, **63**, 171.
- CHERNIACK, R.M. & RABER, M.B. (1972) Normal standards for ventilatory function using an automated wedge spirometer. *American Review of Respiratory Diseases*, **106**, 38.
- COCHRANE, G.M., PRIETO, F. & CLARK, T.J.H. (1977) Intrasubject variability of maximal expiratory flow-volume curve. *Thorax*, **32**, 171.
- COHEN, V.L. & OSGOOD, H. (1953) Disability due to inhalation of grain dust. *Journal of Allergy*, **24**, 103.
- DICKIE, H.A., & RANKIN, J.R. (1968) Farmer's lung. An acute granulomatous interstitial pneumonitis occurring in agricultural workers. *Journal of American Medical Association*, **167**, 1069.
- DO PICO, G.A., REDDAN W., FLAHERTY, D., TSIATIS, A., PETERS, M.E., PRADEEP, R. & RANKIN, J. (1977) Respiratory abnormalities among grain handlers. *American Review of Respiratory Diseases*, **115**, 915.
- GELB, A.F. & MECANALLY, B.J. (1973) Early detection of obstructive lung disease by analysis of maximal expiratory flow-volume curves. *Chest*, **64**, 749.
- HUNTER, D. (1969) *The Disease of Occupations*, p. 1072. English Universities Press Limited, London.
- KLEINFELDT, M., MESSITE, J., SWENCICKI, R.E. & SHAPIRO, J. (1968) A clinical and physiological study of grain handlers. *Archives of Environment Health*, **16**, 380.
- MCCARTHY, D.S., CRAIG, D.B. & CHERNIACK, R.M. (1975) Intraindividual variability in maximal expiratory flow-volume and closing volume in asymptomatic subjects. *American Review of Respiratory Diseases*, **112**, 407.
- NELSON, D.C., BURROWS, B., & KNUDSON, R.J. (1973) A device for recording flow and volume data in population surveys. *Journal of Applied Physiology*, **35**, 304.
- POLLOCK, R., GREGORY, N.L., SHAW, A. & PATEL, K.R. (1977) Improved technique for recording respiratory data. *Medical Biology and Engineering*, **15**, 541.
- RAMAZZINI, B. (1713) *Demorbis Artificum Diatriba* (transl. C. Wright) (1940). University of Chicago Press, Chicago, Illinois.
- SHAW, A., GREGORY, N.L., DAVIES, P.D. & PATEL, K.R. (1976) Flow-volume integrator for respiratory studies. *Medical Biology and Engineering*, **14**, 695.
- SKOULAS, A., WILLIAMS, N. & MERRIMAN, J.E. (1964) Exposure to grain dust. II. A clinical study of the effects. *Journal of Occupational Medicine*, **6**, 359.
- SMITH, A.R., GREENBERG, L. & SIEGEL, W. (1941) Respiratory disease among grain handlers. *Industrial Bulletin*, **20**, 33.
- SOBEL, B.J. (1976) The early detection of airway obstruction; another perspective. *American Journal of Medicine*, **60**, 619.
- TSE, K.S., WARREN, P., JANUSZ, M., MCCARTHY, D.S. & CHERNIACK, R.M. (1973) Respiratory abnormalities in workers exposed to grain dust. *Archives of Environmental Health*, **27**, 74.
- WARREN, P., CHERNIACK, R.M. & TSE, K.S. (1974) Hypersensitivity reactions to grain dust. *Journal of Allergy and Clinical Immunology*, **53**, 139.
- WILLIAMS, N., SKOULAS, A. & MERRIMAN, J.E. (1964) Exposure to grain dust. I. A survey of the effects. *Journal of Occupational Medicine*, **6**, 319.

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