Byssinosis and serum IgE concentrations in textile workers in an Italian cotton mill

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ABSTRACT The relationship between serum concentrations of total IgE and byssinosis and other respiratory symptoms was evaluated in 352 textile workers (90 men, 262 women) at a cotton mill in Friuli-Venezia Giulia, Italy. The subjects were aged from 20 to 61 (mean 44) and the mean duration of employment was 20 years. One hundred and eight subjects (30.7%) were smokers. Only 2% had a positive history of atopy. A standardised questionnaire showed chronic bronchitis in 96 textile workers (27.3%) and byssinosis in 63 (17.9%). The prevalence of respiratory disorders was the same for men and women but was higher in the carding room than in other work areas. Total serum IgE concentrations (RIST, Phadebas) were analysed after log transformation. The geometric mean was 192.7 IU/ml, with no significant difference between the two sexes. This mean concentration of IgE is much higher than that reported internationally for non-atopic subjects, but similar to values found in the Italian population. The IgE concentrations of the workers in the main departments (carding, spinning, and weaving) showed no significant difference. The geometric means were not different in subsamples stratified according to respiratory diseases (cases of pure and cases of mixed forms of chronic bronchitis and byssinosis). A negative result was obtained when IgE concentrations of 289 subjects without byssinosis ($\bar{x}$ = 188.4 IU/ml) and 63 with byssinosis ($\bar{x}$ = 212.6 IU/ml) were compared; there was also no trend when the results were analysed by clinical grade of byssinosis. The same negative pattern occurred when the serum IgE concentrations were examined in patients with byssinosis with different grades of chronic change in FEV₁. The results of this study support the hypothesis that there is no relationship between total serum IgE concentrations and byssinosis.

Cotton textile workers may complain both of non-specific lung disease (chronic bronchitis) and the specific syndrome known as byssinosis. Not all findings are in agreement about the prevalence rates of byssinosis. Thus one can find prevalence rates reported from as low as 0.8%,¹ to as high as 40%.²⁻⁴ In Italian surveys, frequencies of 6.3%,⁵ 24-27.7%,^{6,7} up to 42.5%⁸ are reported. A higher prevalence in the first phases of cotton manufacture is, however, undisputed.^{2,5-8}

One of the major problems debated is the causal agent, or agents, of byssinosis. At least three hypotheses have been put forward.

Pharmacological theory—This assumes that the cotton dust has a direct constricting effect on the airways⁹ or an action mediated by histamine release

agents.^{10,11} Other authors propose the intervention of proteolytic enzymes which act also by immune mechanisms.¹²

Endotoxin theory—Pernis *et al*¹³ suggested that byssinosis may be due to endotoxins present in Gram-negative bacteria normally found on cotton plant bracts. The endotoxins are also responsible for "mill fever."

Immunological theory—The pathogenesis of byssinosis has been attributed to a type III immune mechanism in response to specific antigens in the cotton dusts^{14,15} or bacterial or fungal contamination. Others^{16,17} have claimed a type I, IgE mediated immunological reaction with the release of pharmacological mediators by mast cells and basophils.

The present study was designed to see whether cotton textile workers have raised concentrations of total serum IgE and if there is an association between IgE concentrations and the severity of byssinosis. There are few reports, and the groups of workers examined are often small. Ainsworth *et al*

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Table 1 *Distribution of cotton textile workers by sex, work area, age, duration of employment, and smoking habits*

Group	No of workers	Work area			Age (years) (mean $\pm$ SD)	Duration of employment (years) (mean $\pm$ SD)	Smoking habits	
		Carding No (%)	Spinning No (%)	Weaving No (%)			All smokers (%)	≥ 15 cigarettes/day (%)
Total	352	24 (6.8)	148 (42.0)	180 (51.1)	43.9 $\pm$ 8.5	20.0 $\pm$ 9.5	30.7	11.1
Men	90	14 (15.5)	27 (30.0)	49 (54.4)	46.5 $\pm$ 8.3	20.2 $\pm$ 10.8	53.3	30.0
Women	262	10 (3.8)	121 (46.1)	131 (50.0)	42.9 $\pm$ 8.4	20.0 $\pm$ 9.0	22.9	4.6

have reported (at a symposium on cotton dust at Atlanta in 1974) that when studying serum IgE concentrations in 19 mill workers they found that 14 (with no history of allergy) had raised IgE concentrations not related to the severity of byssinosis. We found similar results in the preliminary analysis of the data of a cross-sectional survey in mill workers.¹⁸ We have examined these data further because the IgE values are not normally distributed and are therefore more correctly analysed after logarithmic ($\log_{10}$) transformation.

Materials and methods

PATIENTS

In 1978 352 textile workers at a cotton mill in Gorizia, Italy, were examined at the Institute of Occupational Health of the University of Trieste. They underwent a series of examinations including a medical history, a physical examination, chest x-ray examination, pulmonary function tests, determination of the main haematological and biochemical variables and total serum IgE concentrations. The study was triggered by a claim of the workers' unions.* The mill processes cotton for the whole cycle (from the raw cotton to the finished product) passing through carding process to spinning, up to weaving. The population under study was composed of 90 men and 262 women, aged between 20 and 61. About 7% of the workers (24/352) were in the carding area, 42% (148/352) in spinning, and 51% (180/352) in weaving (table 1). Their mean age was 44, with men slightly older (three years) than women; 65% of the study population was aged 40 and over. The average period of employment at the cotton mill was 20 years, the same for both sexes. One hundred and eight workers (30.7%) smoked; more men smoked than women (48/90 versus 60/262) and they smoked more heavily.

*Since 1975 in Italy the scheduled occupational diseases have been extended and cotton dust has been recognised as a hazard to be covered by workers' compensation.

RESPIRATORY DISEASES

A standardised questionnaire was administered to investigate the frequency of respiratory diseases. The questionnaire satisfied the Medical Research Council criteria for chronic bronchitis, with additional questions on byssinosis.¹⁹ Pulmonary function was evaluated with a Jaeger Spirotest Junior bellows spirometer. Predicted normal values were taken from Council of European Communities.²⁰ The details of the respiratory function tests have been presented elsewhere¹⁹ and will not be referred to here.

Altogether 223 workers (63.3%) gave no history of respiratory ailments. Among the other 129 subjects, 30 (8.5% of the entire sample) responded affirmatively to questions on both chronic bronchitis and byssinosis: 96 subjects (27.3%) gave answers compatible with a diagnosis of chronic bronchitis and 63 (17.9%) with a diagnosis of byssinosis according to Schilling's criteria.¹⁹ In the carding area the prevalence of respiratory diseases (byssinosis 37.5%, chronic bronchitis 50.0%) was significantly higher than in the spinning (byssinosis 15.5%, chronic bronchitis 26.3%) and weaving areas (byssinosis 17.2%, chronic bronchitis 25.0%). Of the 63 subjects who reported symptoms of byssinosis, 48 were grade 1/2 or 1 and 15 were graded 2-3 (table 2). This distribution was similar in both men and women.

Table 2 *Prevalence of clinical grades of byssinosis in textile workers by sex*

	Clinical grades of byssinosis*			
	0	1/2	1	2 + 3
Total (n = 352)	289 (82.1)	27 (7.7)	21 (5.9)	15 (4.2)
Men (n = 90)	71 (78.8)	8 (8.9)	7 (7.8)	4 (4.4)
Women (n = 262)	218 (83.2)	19 (7.2)	14 (5.3)	11 (4.2)

*Clinical grading according to Roach and Schilling.¹⁹

Grade 0: No symptoms of byssinosis.

Grade 1/2: Occasional chest tightness or cough, or both, on first day of the working week.

Grade 1: Chest tightness on every first day of the working week.

Grade 2: Chest tightness on first and other days of the working week.

Grade 3: Grade 2 symptoms accompanied by evidence of permanent incapacity.

Significance (Chi square): Men v women χ^2 (2.4) = 1.059, NS.

Table 3 Chronic changes in FEV₁ in textile workers complaining of pure and mixed forms of byssinosis and chronic bronchitis

	Byssinosis (n = 33)	Chronic bronchitis (n = 66)	Byssinosis and chronic bronchitis (n = 30)
*FEV ₁ % ≥ 82	30 (90.9)	50 (75.7)	22 (73.3)
FEV ₁ % < 82	3 (9.0)	16 (24.2)	8 (26.6)

*FEV₁ observed as percentage of predicted CECA value.²⁰

Only a small proportion of those workers with symptoms of byssinosis had a chronic ventilatory impairment, as defined by a FEV₁ < 82% of the predicted value (table 3).

ATOPY

Only 2% of the workers had a positive history of atopy. No standardised questionnaire was administered, but the reporting of complaints of hay fever, childhood history of asthma, and atopic dermatitis was considered accurate.

IgE DETERMINATION

Serum IgE concentrations were determined by the radioimmunosorbent technique (RIST, Phadebas) performed as recommended by Pharmacia Diagnostics AB, Uppsala. The IgE concentration are reported in international units (IU/ml).*

STATISTICAL ANALYSIS

Statistical analysis was made after logarithmic (log₁₀) transformation of the IgE values. In this way a more normal distribution was reached, and the parametric statistical tests could be used. The data analysis was performed using SPSS (statistical package for the social sciences) computer programs. A p value greater than 0.05 was considered not significant.

Results

The IgE concentration determined in 352 cotton workers has a log-normal distribution with a wide scatter from 10 to 4498 IU/ml. The arithmetical mean was 371.2 IU/ml, the logarithmic mean 2.285 IU/ml (SD ± 0.504), and the geometric mean 192.7 IU/ml. We feel that transformation was justified because the original distribution was asymmetrical (skewed to the right) whereas the distribution of the transformed data is more nearly normal (fig 1).

There was no statistically significant difference in the IgE concentrations found in men (mean of log₁₀

Fig 1 Percentage distribution and mean value ($\bar{x}$) of total serum IgE concentrations (IU/ml) in textile workers expressed in raw numbers and after log₁₀ transformation.

Table 4 Serum IgE concentrations (IU/ml) in relation to work area

Work area	No of workers	Mean Log ₁₀ IgE	SD	Geometric mean IgE (IU/ml)
Carding	24	2.318	0.712	207.9
Spinning	148	2.298	0.445	198.6
Weaving	180	2.269	0.519	185.8

Significance (Student's *t* test): Carding *v* spinning *t* = 0.136, NS; carding *v* weaving *t* = 0.327, NS; spinning *v* weaving *t* = 0.54, NS.

= 2.224, SD ± 0.584; geometric mean = 167.5 IU/ml) or women (mean of log₁₀ = 2.305, SD ± 0.473; geometric mean = 201.9 IU/ml). Student's *t* value was 1.19, *p* > 0.05. There was also no significant difference between the IgE concentrations of the workers from the three main areas (carding, spinning, weaving) (table 4).

To evaluate the relationship between IgE concentrations and respiratory diseases, we divided the workers into four subgroups: workers without respiratory ailments (223), workers suffering from chronic bronchitis (66), workers with symptoms of byssinosis (33), and workers complaining of both byssinosis and chronic bronchitis (30). The geometric mean and the standard deviation (SD) were determined for each group but no statistically significant differences were found (fig 2). A negative result was also found when the IgE concentrations of patients complaining of byssinosis and the remainder of the work force were compared (fig 3), and when IgE concentrations were examined according to clinical grading.

Finally, IgE concentrations were compared in workers with byssinosis with and without chronic

*1 IU = 2.4 nanograms.

Fig 2 Geometric mean values ($\pm$ SD) of total serum IgE in textile workers with or without symptoms of byssinosis or chronic bronchitis or both. Significances (t test): (A) v (By), $t = 0.88$, NS; (A) v (CB), $t = 0.35$, NS; (A) v (By + CB), $t = 0.28$, NS; (By) v (CB), $t = 0.97$, NS; (By) v (By + CB), $t = 0.40$, NS; (CB) v (By + CB), $t = 0.42$, NS.

Fig 3 Serum IgE concentrations (geometric mean $\pm$ SD) in workers with (63) or without (289) byssinosis and in relation to clinical grades of byssinosis: 1/2 (27), 1 (21), 2+3 (15). Significances (t test): all By v non-By, $t = 0.75$, NS; 1/2 v 1, $t = 0.01$, NS; 1/2 v 2+3, $t = 1.35$, NS; 1 v 2+3, $t = 1.02$, NS.

Fig 4 Serum IgE concentrations (geometric mean $\pm$ SD) in patients with byssinosis with ($FEV_1 < 82\%$, $n = 11$) or without ($FEV_1 \geq 82\%$, $n = 52$) ventilatory impairment. Significance (t test): $t = 1.18$, NS.

impairment of pulmonary function. Workers with an FEV_1 greater than 82% of the predicted value were considered to have borderline or no chronic ventilatory impairment whereas those with an FEV_1 less than 82% were considered to have moderate to severe impairment. No significant difference in IgE concentrations could be found between the groups (fig 4).

Discussion

In the group of 352 textile workers the geometric mean serum IgE concentration was 192.7 IU/ml. Our first question was, is such a mean value different from that of the general population? At first sight, a comparison with reported normal values suggests that the answer is yes.

Johansson and Foucard²¹ report that in adults the normal mean concentrations of IgE are between 15 and 100 U/ml, underlining the fact that the variability is dependent on the methodology and selection of the normal subjects. One hundred and two individuals of the United Kingdom aged from 18 to 83, accurately selected by Nye *et al*²² with respect to atopy, were found to have a mean total serum IgE concentration of 36.3 U/ml (geometric mean 21.2). The method of measurement of IgE was based on a highly sensitive double antibody assay. Burr *et al*²³ in an epidemiological survey, once again in the United Kingdom, with the same method of measurement, found a mean value of 31 U/ml. Higher values are reported by American authors, however. In a com-

munity population sample of Tucson (Arizona) Brown *et al*²⁴ reported that in 148 subjects defined as "non-allergic" with a mean age of 35, the mean value of total IgE measured with Phadebas PRIST was 107 IU/ml.

When comparing data from different studies, however, it must be remembered that the test techniques for the determination of total serum IgE are very different (radioimmunosorbent test, RIST, double-antibody radioimmunoassay, RIA, paper disc immunosorbent test, PRIST) and that socioeconomic and constitutional factors may differ; Anglo-Saxon and Scandinavian populations may not be the same in respect of these factors as Italians.

More correctly we should have compared the total IgE concentrations of our textile workers with those of a control group. It was not possible for us to perform a survey in the general population but in a recent investigation of total IgE concentrations (PRIST Phadebas) performed in the general population in Rome²⁵ the concentrations reported were considerably higher compared with those reported internationally but were not very different from our own. In 134 "apparently healthy" subjects with no family history of allergy, aged between 7 and 94, the mean value of IgE in the entire sample (male and female) was 138.1 U/ml with standard deviation of ± 215.5 . In those aged between 40 and 60 the mean IgE concentration was 154.8 U/ml. This age group comprised 65% of the patients we examined.

Although our sample is biased by a small "contamination" with atopic subjects and our method (RIST) tends to overestimate the low IgE concentrations,²² we can feel justified in assuming that total serum IgE concentrations in our textile workers are higher than the values reported internationally but not dissimilar from values reported for other Italian subjects.

When interpreting the raised total serum IgE found in the Italian samples, an account must be taken of the high frequency of parasitic infestations of minor clinical relevance (and then not recorded in the personal history).

The main purpose of this study, however, was to see if there was a relation between total serum IgE and respiratory diseases, particularly byssinosis, in textile workers.

To do this, we first divided our sample of cotton textile workers into three subgroups according to their working area (carding, spinning, or weaving). The results of the questionnaire on respiratory symptoms (table 2) were agreed with other reports.²⁻⁸ Both chronic bronchitis and byssinosis had a high prevalence in the workers of the carding area; among 24 carders nine subjects complained of byssinosis and 12 were affected by chronic bron-

chitis. The mean concentration of IgE in the carding room workers, however, was not significantly different from that of the workers in the other areas.

Secondly, we considered the concentrations of IgE in the various forms of respiratory syndrome. The subjects affected only by byssinosis presented higher concentrations of total IgE than healthy workers or those affected only by bronchitis. The total serum IgE had an intermediate concentration in the subjects complaining of both byssinosis and chronic bronchitis; this trend did not reach conventional levels of statistical significance, however.

In two subgroups of the sample, one consisting of all 63 subjects suffering from byssinosis (with or without bronchitis) and the other of all the workers with grade 0, there was no significant difference in the geometric mean value of total serum IgE. Further analysis of the byssinotic group showed that the different clinical grades (1/2, 1, 2 + 3) are not associated with significantly different total serum IgE concentrations; the most severe forms the IgE have, on average, the lower value.

In a recent study Jones *et al*²⁶ reported that atopy and cotton dust exposure have a significant interaction in the acute decline of expiratory flow rates (FEF₂₅₋₇₅) and in FEV₁ over working shifts. They conclude that atopy represents a risk factor in byssinosis. We did not have the opportunity to investigate the acute effect of cotton dust on pulmonary function. Therefore we cannot state if an increased bronchoconstrictive response is associated with raised concentrations of total serum IgE.

Our cotton textile workers were not examined in the mill, thus we can consider only chronic respiratory impairment, and we did not find a significant association between the IgE concentration of patients with byssinosis and then loss of lung function (FEV₁).

In conclusion, with all the reservations noted, the statistical analysis of total serum IgE concentrations in different subgroups of textile workers does not give support for an association between total IgE and byssinosis.

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