THE INFLUENCE OF PERSONAL CHARACTERISTICS, CURRENT AND RETROSPECTIVE DUST EXPOSURE AND CIGARETTE SMOKING ON DAILY AND WEEKLY VARIATIONS OF LUNG FUNCTION IN TEXTILE SPINNERS

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Abstract

196 textile spinning operatives from Lancashire were interviewed using a modified Medical Research Council Respiratory Symptoms Questionairre. All performed spirometry at the beginning and at the end of their first and fourth shifts of the working week. 155 also performed bronchial reactivity (BR) testing at the same time. Across shift changes on both days, and across week changes in spirometry and BR were calculated.

No difference between the sexes could be demonstrated. Asian operatives demonstrate smaller across shift and across week variations in spirometry than whites. Current cotton (as opposed to manmade fibre) exposure was associated with lower baseline lung function but no differences between the cotton and manmade fibre groups were demonstrated during the working week. Current high cotton exposure was associated with an significant rise in bronchial reactivity across the first shift of the working week, and an increase across the working week. Those operatives who had a long history of cotton dust exposure demonstrated the smallest across week changes in spirometry suggesting either a tolerance or a self-selection effect. Cigarette smoking was associated with reduced baseline spirometry and raised baseline BR. Significant across week decreases in spirometry were seen in smokers only.

Cigarette smoking has the most consistent effect upon the physiological response to textile dust exposure. Asian operatives may have a reduced susceptibility to the acute and possibly the chronic effects of dust exposure. High current cotton dust exposure is associated with acute increases in BR, however since the physiology of cotton and manmade fibre exposed operatives is similar during the working week, other factors (in particular smoking) seem to be more important than the current type and level of dust exposure in producing across shift and across week variations in spirometry.

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Introduction

The variations in lung function during the working week of textile spinners have been studied many times since Schilling's original work in 1955[1]. Schilling et al demonstrated that larger across shift decrements in lung function were seen in symptomatic as opposed to asymptomatic operatives, and this association has been demonstrated many times since. Despite this wealth of literature, the effects of personal characteristics such as sex, race and smoking habit are still unclear. In addition, the effects of the level and length of exposure to cotton upon acute lung function changes are poorly understood. It seems likely that a number of factors may influence the production and size of across week variations in lung function in textile workers, and that their inter-relationship is complex. The aim of the present study is to look at the influence of a number of these variables in groups which are largely matched for any other potential confounding factors.

Methods

A modified Medical Research Council Respiratory Symptoms Questionnaire was administered to one hundred and ninety six cotton or manmade fibre spinning operatives. The questionnaire was modified to enquire about the work-relatedness of any respiratory symptoms present. In addition, questions regarding current and previous employment in the cotton industry and cigarette smoking were included.

All operatives performed the following lung function tests at the beginning and towards the end of the first and fourth shifts of their working week;

1) forced expiratory manoeuvres were performed on a single dry-wedge spirometer (Vitalograph, U.K.)

2) bronchial reactivity testing to histamine was also performed using the technique described by Yan et al. [2], and using glass hand-held nebulisers (DeVilbis, U.S.A.). Several operatives did not complete four such tests during the working week for a variety of reasons including their baseline FEV_1 being too low and intolerance of the pharyngeal side-effects of histamine. In total 155 operatives completed all four bronchial reactivity tests during the week, and only their results have been used in the analysis of reactivity changes across the working week.

Work-area sampling for cotton dust was carried out in accordance with the guidelines described by the Health and Safety Executive [3]. All operatives are assigned a current cotton dust exposure in mg/m^3.

From the forced expiratory curves before the first shift of the working week, baseline values for the forced expiratory volume in the first second (FEV), forced vital capacity (FVC), forced expiratory flow averaged between 25 and

75% of vital capacity (FMEF) and forced expiratory flow averaged between 75 and 85% of vital capacity (FEEF) were calculated for each operative. The percentage of predicted for FEV, FVC and FMEF for white operatives was calculated from regression equations described by Quanjer [4]. These regression equations, however, were found to perform poorly for asian operatives, therefore regression equations were derived from a larger population of asymptomatic lifelong non-smoking asian operatives also under study in our department. These predicted equations were then used in the present study for all asian operatives. Percentage of predicted values for FEEF were derived from the regression equations described by Morris et al[5].

Absolute changes in FEV, FVC, FMEF and FEEF across the two shifts under study were calculated, and in addition, using the start of shift values on the two days, the across week changes in these spirometric parameters was also calculated. Negative values indicate a decrease across shift or week, whilst positive values indicate an increase. Percentage changes across shift and across week have also been calculated, but these have only been presented if different from the absolute changes. For each of the bronchial reactivity tests, a dose response (DR) value of FEV to histamine was calculated in %/µmol histamine using the formula

$$\text{DR to histamine} = \frac{\text{Percentage fall in } FEV_1}{\text{Total dose histamine administered}}$$

The BR values for the population demonstrate a positively skewed distribution, therefore natural logarithms have been used for calculations and the results detransformed for presentation. In a similar manner to the spirometry, across shift and across week changes in BR have been calculated for each operative. Again a positive value indicates an increase in BR across shift or week, and a negative value indicates a decrease.

The symptom score for a group of operatives was calculated by dividing the total number of work-related respiratory symptoms in that group by the number of operatives. One operative may therefore contribute more than one symptom to the total number of symptoms. It is expressed in symptoms per operative.

From the questionnaire data, three comparisons were made on basic demographic grounds. Male operatives were compared to females, white operatives were compared to asian operatives, and those operatives who had ever smoked were compared to the lifelong non-smoking operatives. Three further comparisons regarding cotton dust exposure were also made. Operatives currently exposed to cotton dust were compared to those currently exposed to manmade fibre, those currently exposed to less than the current standard for cotton dust exposure (0.5 mg/m^3) were compared to those exposed currently to more than this amount, and operatives with 20 years or more of cotton dust exposure were compared to those with less exposure than this. In the latter two comparisons, operatives who are currently exposed to manmade fibre have been excluded.

The means (geometric means for BR, current cotton dust exposure, packyears of smoking and time in the cotton industry) of the relevant pairs of groups have been compared using unpaired Student's t-tests. Comparison of proportions have been performed using a 2x2 Chi-squared test incorporating the Yates' correction.

Statistical significance has been arbitrarily set at the 5% level.

Results

The male and female groups were comparable for all of the demographic details other than there being significantly fewer white males. Similar proportions were symptomatic, the symptom score was similar in both groups, and similar proportions were smokers. There was no statistical difference between the mean packyears of cigarettes in both groups, and their current cotton dust exposure was also similar (Table 1). The percentage of predicted for all four spirometric parameters was almost identical in both groups. No significant differences are demonstrated between males and females for changes in spirometric parameters and BR across either working shift nor across the working week (Tables 2 and 3).

Apart from the significant excess of asian male workers, there are no demographic differences between white and asian groups (Table 1). Despite this, the percentage of predicted of all four spirometric parameters was lower in the white operatives, and they demonstrated higher baseline BR. The difference was statistically significant for PPFMEF (Table 2). No differences between whites and asians could be demonstrated for across shift changes in spirometry or BR on either day (Tables 2 and 3). The white operatives demonstrate falls in all four spirometric parameters across the working week with a small decrease in BR. Asian operatives however, show small increases in FEV and FVC with decreases in FMEF and FEEF. They also demonstrate a rise in BR across the week. The differences for FVC and BR between the racial groups is statistically significant (Table 3).

Operatives who had ever smoked were significantly older than those who had not, and were more symptomatic (although this difference was not significant). The two groups were well matched for the time spent in the cotton industry, and their current cotton dust exposure (Table 1). The smokers demonstrated significant bronchial obstruction in comparison to the non-smokers, with significantly lowered PPFEV, PPFMEF and PPFEEF along with equivalent values of PPFVC. The smokers also demonstrated significantly higher baseline BR than the non-smokers (Table 2). The spirometric changes across the two shifts are inconsistent. On Day 1, the smokers demonstrate falls in all spirometric parameters, whilst the non-smokers exhibit no change in FEV, a decrease in FVC and a rise in FMEF and FEEF. The difference for FEEF is statistically significant (Table 2). On Day 4, however the non-smokers this time show falls in all four spirometric parameters, with the smokers having smaller falls in FEV and FVC, and rises in FMEF and FEEF (Table 3). Highly significant differences between the two smoking groups are demonstrated across the week with the smokers demonstrating decreases in the four spirometric parameters, and the non-smokers showing rises (Table 3). No difference between the groups can be demonstrated for across shift or across week changes in bronchial reactivity.

The operatives currently exposed to cotton dust are significantly older and have smoked more cigarettes than those exposed to manmade fibre (although the latter is not significant). Similar numbers in each group are symptomatic, however those who are symptomatic in the cotton group have roughly twice the number of work-related respiratory symptoms per operative than the manmade fibre group giving a significant difference in their symptom scores (Table 4). The manmade fibre group have spent virtually no time exposed to cotton dust as compared to in excess of 15 years in the cotton group. The cotton exposed group have lower values for percentage predicted of all four spirometric parameters and this difference is significant for PPFEV and PPFMEF. They also demonstrate significantly higher baseline BR (Table 5). Despite these differences, the two groups perform almost identically during the working week as far as changes in spirometry and BR is concerned (Tables 5 and 6).

Similarly, the operatives who have spent over 20 years in the cotton industry are significantly older (not surprisingly) and have a significantly higher symptom score than those with less cumulative cotton dust exposure. The two groups are well-matched for smoking with similar proportions being ever-smokers, and similar packyears of smoking. There is no difference between the groups for the level of current cotton dust exposure, but the long servers have spent on average 24 years longer exposed to cotton dust (Table 4). The long servers have significantly lower percentage predicted values for all four spirometric parameters and demonstrate significantly higher baseline bronchial reactivity (Table 5). Again despite these differences the two groups perform throughout the week in a very similar manner (Tables 5 and 6).

The only demographic difference between operatives exposed to above and below the current cotton dust exposure standard of $0.5 mg/m^3$ was a significant excess of males in the high exposure group (Table 4). The two groups were well matched for smoking habit, packyears of smoking, length of cotton dust exposure and symptom status. The percentage predicted of all four spirometric parameters was not different between the two groups, and they demonstrated similar baseline bronchial reactivity (Table 5). Spirometric changes across the first shift of the week were similar in both groups, however BR increased in the high exposure group as compared to a reduction in BR in the low exposure group. This difference was statistically significant (Table 5). No differences for spirometry and BR could be demonstrated on Day 4 or across the working week (Table 6), however the change in BR across the fourth shift and across the working week is numerically larger in the high cotton exposure group.

Discussion

The operatives selected for study were not selected specifically because of their demographic characteristics, but were initially recruited for a case-control study of lung function during the working week in symptomatic and asymptomatic textile spinners from a large number of operatives originally seen for questionairre (n=1547). For this reason some of the comparisons involve groups of quite disparate numbers. Despite this, the six sets of paired groups in this study are relatively well-matched demographically. There are however, a number of differences in demographic characteristics between groups. Firstly, there is an excess in the proportion of asian males as compared to the proportion of white males. This may be explainable in terms of cultural and historical differences in the work patterns of males and females in these two ethnic groups, with fewer asian females working than white females. Secondly, operatives who have ever smoked are significantly older than the lifelong non-smokers. The reason for this difference is obscure but may be representative of the reduction in smoking in the population of Britain as a whole in recent years. Thirdly, there are more male workers in the high current cotton exposure group as compared to the low exposure group. This undoubtedly reflects the traditional working patterns within the mills with male operatives working in the earlier (and dustier) processes. Despite these demographic differences, we feel that all the data comparisons remain valid.

All working shifts were studied including the night shift. Controlling for diurnal variation in lung function has not been performed since only small numbers were actually studied on shifts other than a day shift, and in a recent large study of unexposed blue collar workers from America [6] across shift changes in lung function were not affected by which shift was actually worked.

It is clear from this study that there is absolutely no difference between the sex groups in terms of the physiological response to textile dust during the working week, and indeed the long term effects of dust exposure on lung function loss.

Asian operatives appear to be less susceptible to the effects of dust exposure than white operatives. The percentage predicted for all four lung function parameters is higher in asians as compared to whites. The asian operatives have smoked cumulatively fewer cigarettes (although this difference is small - 1 packyear on average) and both groups have similar lengths of cotton dust exposure. The difference demonstrated in baseline lung function may therefore represent a true difference in susceptibility to the chronic effects of dust exposure. In addition, there is a trend towards smaller across shift changes in spirometry in the asians on Day 1 and in FEV and FVC across the working week which may represent in addition a reduced susceptibility to acute lung function effects of dust exposure. A similar reduced acute effect with black operatives was postulated in one previous study [7] with larger percentages of black operatives being found in the dustier areas of the mills under study. No formal assessment of lung function differences in response to cotton dust was performed in that study, and we are not aware of any other such studies in the literature.

Smoking appears to be exerting strong influences upon lung function in this population. Operatives who have ever smoked not surprisingly demonstrate significantly more bronchial obstruction before dust exposure than non-smokers and demonstrate significantly higher bronchial reactivity. There is no real difference between the smokers and non-smokers however in terms of changes in FEV and FVC across both shifts.

The smokers demonstrate significant decreases in all four spirometric parameters across the working week as compared to non-smokers. This phenomenon has been demonstrated in only one previous study [8] and we are not aware of any other studies which address this. A large number of studies have looked at the effect of smoking on the physiological response to cotton dust exposure with variable results. Two recent studies have suggested that acute across shift falls in FEV_1 are predictive of longitudinal lung function loss in cotton workers [9,10]. Our study raises the possibility that across <u>week</u> changes in lung function may be more reliable than across shift measurements and as such may be more important in terms of correlation with longitudinal lung function loss. Further work in this area is required.

The differences in baseline lung function between operatives currently exposed to cotton and to manmade fibre dust may merely be a reflection of their smoking differences, but it is also possible that the cumulative cotton dust exposure is also having some effect. During the working week however, the two groups perform almost identically in terms of across shift and across week changes in lung function. Across shift falls in FEV_1 have been shown in some studies to be greater in cotton exposed as opposed to manmade fibre exposed populations, but these studies were performed at least 20 years ago. Dust exposures have certainly reduced since then. It would seem likely that the physiological response to manmade fibre and to cotton dust exposure during the working week on the strength of the current study at today's cotton dust exposure levels is therefore very similar and may be a reflection of factors other than current exposure (in particular cigarette smoking).

When the cotton exposed operatives are sub-divided into low and high exposure groups they again perform in a very similar manner. This has been the case in a number of previous studies which have found no effect of current level of cotton dust exposure upon across shift variations in lung function. Of significance however is the significant rise in bronchial reactivity across the first shift of the working week in the high exposure group. Witek et al [11] have demonstrated that exposure to cotton bract extract under laboratory conditions can cause a transient rise in bronchial reactivity, but we believe this has not previously been demonstrated within the mill environment.

The length of cotton dust exposure appears to be exerting some effect in these operatives. Despite similar smoking histories, the long servers (with more than twenty years of cotton dust exposure) have significantly lower baseline spirometry and higher baseline bronchial reactivity (the latter probably being a reflection of the former). The across week changes in spirometry are numerically lower in the long servers than those with less exposure, and this may represent either a tolerance or a survivor effect. This tolerance/survivor effect has been demonstrated in a number of previous studies for across shift measurements but not for across week values.

In summary, therefore, this study has demonstrated that the level of baseline lung function in this group of operatives is affected by both cigarette smoking and the number of years exposed to cotton dust. Asian operatives may have a lesser susceptibility to the effects of textile dust exposure than white operatives, and high current cotton dust exposure is associated with a rise in bronchial reactivity on Day 1 of the working week and across the working week.

None of the factors studied appears to be having an isolated effect on across shift variations in spirometry, however cigarette smoking has a major effect upon the change in spirometry across the working week.

Further work looking at the racial susceptibilities to textile dusts, and which marker of lung function (such as across shift or across week decrement in lung function) best predicts longitudinal lung function loss in these operatives is needed.

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Table 1. Demographic, symptom and smoking details of the different sex, ethnic and smoking groups.

	Male n=128	Female n=68	White n=168	Asian n=28	Ever Smoked n=159	Non Smoker n=37
Age (yrs)	44.1 (12.9)	46.8 (10.0)	45.1 (12.5)	44.6 (8.9)	46.0~ (11.8)	41.1~ (12.4)
White (%)	79~	99~	-	-	87	81
Male (%)	-	-	60~	96~	66	62
Symptoms (%)	59	50	55	60	58	46
Symptom score	0.68 (0.99)	0.72 (1.10)	0.70 (1.05)	0.68 (0.90)	0.73 (1.04)	0.54 (0.99)
Ever Smoked (%)	82	79	82	75	-	-
Packyrs (SD)	1.75 (3.47)	2.05 (3.83)	2.07 (3.40)	1.00 (4.82)	-	-
Current cotton (%)	80	75	78	79	79	76
Mean exposure (mg/m^3)	0.15 (16.6)	0.10 (16.1)	0.12 (16.5)	0.17 (16.6)	0.14 (16.9)	0.10 (14.7)
Time in industry (yrs)	7.4 (6.8)	10.0 (6.2)	8.1 (6.8)	9.3 (5.2)	8.9 (6.3)	5.7 (8.3)

~ - $p<0.05$

Table 2. Baseline spirometric parameters, baseline bronchial reactivity and changes across the first shift of the working week in these parameters of the different sex, ethnic and smoking groups.

	Male n=128	Female n=68	White n=168	Asian n=28	Ever Smoked n=159	Non Smoker n=37
PPFEV (%)(SD)	85.4 (18.8)	86.6 (18.8)	84.9 (18.7)	91.1 (18.6)	84.6~ (19.2)	91.3~ (16.0)
PPFVC (%)(SD)	94.5 (15.4)	97.4 (17.7)	95.1 (16.5)	98.4 (14.9)	95.6 (16.3)	95.1 (16.3)
PPFMEF (%)(SD)	66.4 (28.1)	61.5 (24.7)	63.0~ (26.5)	74.9~ (28.3)	62.2~ (27.7)	75.4~ (20.7)
PPFEEF (%)(SD)	80.8 (42.5)	74.2 (50.6)	76.7 (44.9)	89.5 (48.2)	75.1~ (42.6)	93.0~ (54.3)
Baseline BR (SD) (%/μmol)	1.53 (16.6)	2.36 (10.8)	1.93 (13.6)	0.98 (23.1)	2.26~ (11.9)	0.49~ (28.0)
D1FEV (l)(SD)	-0.03 (0.23)	-0.03 (0.16)	-0.04 (0.22)	+0.01 (0.13)	-0.04 (0.20)	0.00 (0.22)
D1FVC (l)(SD)	-0.07 (0.28)	-0.08 (0.20)	-0.09 (0.26)	-0.01 (0.18)	-0.08 (0.25)	-0.07 (0.28)
D1FMEF (l/s)(SD)	-0.07 (0.49)	-0.01 (0.51)	-0.06 (0.46)	-0.01 (0.67)	-0.07 (0.50)	+0.06 (0.46)
D1FEEF (l/s)(SD)	-0.05 (0.31)	-0.01 (0.53)	-0.04 (0.41)	0.00 (0.33)	-0.06~ (0.39)	+0.09~ (0.43)
D1BR (SD) (%/μmol)	1.42 (11.6)	1.21 (12.0)	1.29 (11.7)	1.77 (11.6)	1.24 (10.1)	2.09 (21.5)

~ - $p<0.05$

Table 3. Changes in spirometric parameters and bronchial reactivity across the fourth shift of the working week, and across the working week of the different sex, ethnic and smoking groups.

	Male	Female	White	Asian	Ever Smoked	Non Smoker
	n=128	n=68	n=168	n=28	n=159	n=37
D4FEV (l)(SD)	-0.02 (0.23)	-0.02 (0.18)	-0.02 (0.22)	-0.03 (0.13)	-0.01 (0.19)	-0.06 (0.27)
D4FVC (l)(SD)	-0.04 (0.27)	-0.07 (0.22)	-0.05 (0.26)	-0.06 (0.17)	-0.04 (0.22)	-0.10 (0.36)
D4FMEF (l/s)(SD)	+0.06 (0.49)	+0.16 (0.56)	+0.12 (0.54)	-0.03 (0.39)	+0.13~ (0.52)	-0.04~ (0.51)
D4FEEF (l/s)(SD)	+0.03 (0.34)	+0.07 (0.31)	+0.06 (0.35)	0.00 (0.20)	+0.07~ (0.34)	-0.03~ (0.30)
D4BR (SD) (%/μmol)	-1.00 (6.8)	1.54 (11.1)	1.17 (8.7)	-1.09 (4.5)	1.02 (6.6)	1.85 (16.3)
DXFEV (l)(SD)	-0.02 (0.22)	-0.03 (0.17)	-0.03 (0.21)	+0.01 (0.15)	-0.04~ (0.19)	+0.05~ (0.25)
DXFVC (l)(SD)	-0.03 (0.28)	-0.04 (0.23)	-0.05~ (0.28)	+0.06~ (0.14)	-0.06~ (0.22)	+0.08~ (0.39)
DXFMEF (l/s)(SD)	-0.15 (0.55)	-0.08 (0.42)	-0.12 (0.49)	-0.15 (0.61)	-0.16~ (0.50)	+0.05~ (0.49)
DXFEEF (l/s)(SD)	-0.05 (0.31)	-0.06 (0.35)	-0.05 (0.33)	-0.12 (0.28)	-0.08~ (0.32)	+0.06~ (0.32)
DXBR (SD) (%/μmol)	1.29 (11.8)	-1.45 (9.5)	-1.06~ (11.1)	2.31~ (10.4)	1.05 (8.7)	1.18 (31.7)

~ - $p<0.05$

Table 4. Demographic, symptom and smoking details of different cotton exposure groups.

	Cotton	MMF	Low Cotton	High Cotton	TCOTT <20 yr	TCOTT >20 yr
	n=153	n=43	n=70	n=83	n=66	n=89
Age (yrs)(SD)	46.2~ (12.0)	40.9~ (11.8)	45.9 (12.6)	46.5 (11.7)	37.4~ (11.5)	52.7~ (7.2)
White (%)	86	86	91	81	80	89
Male (%)	66	60	57~	75~	74	61
Symptoms (%)	54	60	60	49	48	58
Symptom score(SD)	0.77~ (1.10)	0.42~ (0.66)	0.77 (1.07)	0.77 (1.13)	0.47~ (0.68)	0.98~ (1.28)
Ever smoked(%)	82	79	81	82	80	83
Packyrs (SD)	2.11 (3.40)	1.19 (4.24)	2.48 (3.27)	1.84 (3.61)	1.52 (3.61)	1.22 (3.14)
Mean (SD) exposure (mg/m^3)	-	-	0.22~ (3.4)	1.06~ (4.7)	0.49 (3.2)	0.45 (4.7)
Time in industry (yrs)(SD)	15.8~ (2.9)	0.8~ (10.2)	13.9 (3.3)	17.6 (2.6)	6.5~ (3.0)	30.8~ (1.3)

~ - $p<0.05$

Table 5. Baseline spirometric parameters, baseline bronchial reactivity and changes across the first shift of the working week in these parameters of the different cotton exposure groups.

	Cotton	MMF	Low Cotton	High Cotton	TCOTT <20 yr	TCOTT >20 yr
	n=153	n=43	n=70	n=83	n=66	n=89
PPFEV (%)(SD)	84.5~ (19.8)	90.4~ (13.7)	85.0 (21.8)	84.1 (18.1)	90.2~ (17.4)	80.4~ (20.3)
PPFVC (%)(SD)	94.6 (16.9)	98.6 (13.4)	94.5 (18.7)	94.8 (15.4)	98.1~ (15.6)	92.1~ (17.3)
PPFMEF (%)(SD)	62.7~ (27.6)	72.1~ (23.5)	64.0 (30.9)	61.5 (24.6)	71.6~ (25.6)	55.8~ (27.1)
PPFEEF (%)(SD)	76.6 (42.1)	85.3 (55.8)	79.0 (47.3)	74.6 (37.4)	87.5~ (40.3)	68.0~ (41.4)
Baseline BR (SD) (%/μmol)	2.09~ (14.9)	0.81~ (13.0)	2.58 (6.5)	1.76 (25.4)	1.29~ (11.7)	2.95~ (16.7)
D1FEV (l)(SD)	-0.03 (0.18)	-0.03 (0.29)	-0.01 (0.16)	-0.04 (0.19)	-0.01 (0.15)	-0.04 (0.19)
D1FVC (l)(SD)	-0.06 (0.23)	-0.13 (0.33)	-0.04 (0.20)	-0.08 (0.25)	-0.04 (0.21)	-0.07 (0.24)
D1FMEF (l/s)(SD)	-0.04 (0.47)	-0.10 (0.57)	-0.01 (0.55)	-0.06 (0.41)	-0.02 (0.47)	-0.03 (0.50)
D1FEEF (l/s)(SD)	-0.03 (0.30)	-0.04 (0.65)	-0.02 (0.31)	-0.04 (0.29)	-0.06 (0.30)	0.00 (0.31)
D1BR (SD) (%/μmol)	1.32 (8.9)	1.51 (29.9)	-1.25~ (7.9)	2.01~ (9.3)	1.08 (12.2)	1.72 (6.4)

~ - $p<0.05$

Table 6. Changes in spirometric parameters and bronchial reactivity across the fourth shift of the working week, and across the working week of the different cotton exposure groups.

	Cotton	MMF	Low Cotton	High Cotton	TCOTT <20 yr	TCOTT >20 yr
	n=153	n=43	n=70	n=83	n=66	n=89
D4FEV (l)(SD)	-0.03 (0.16)	0.00 (0.33)	-0.01 (0.14)	-0.04 (0.19)	-0.02 (0.16)	-0.04 (0.16)
D4FVC (l)(SD)	-0.05 (0.20)	-0.03 (0.39)	-0.03 (0.17)	-0.08 (0.25)	-0.06 (0.18)	-0.05 (0.21)
D4FMEF (l/s)(SD)	+0.09 (0.50)	+0.11 (0.60)	+0.06 (0.36)	+0.12 (0.59)	+0.14 (0.57)	+0.06 (0.43)
D4FEEF (l/s)(SD)	+0.05 (0.32)	+0.04 (0.36)	+0.02 (0.26)	+0.07 (0.37)	+0.07 (0.35)	+0.04 (0.30)
D4BR (SD) (%/μmol)	1.16 (7.3)	1.00 (12.7)	1.06 (8.9)	1.25 (6.8)	-1.02 (7.2)	1.31 (7.1)
DXFEV (l)(SD)	-0.03 (0.18)	-0.01 (0.28)	-0.04 (0.17)	-0.02 (0.19)	-0.04 (0.17)	-0.02 (0.18)
DXFVC (l)(SD)	-0.04 (0.22)	-0.01 (0.37)	-0.05 (0.21)	-0.02 (0.24)	-0.05 (0.22)	-0.03 (0.23)
DXFMEF (l/s)(SD)	-0.11 (0.49)	-0.16 (0.55)	-0.15 (0.53)	-0.08 (0.46)	-0.18 (0.58)	-0.06 (0.40)
DXFEEF (l/s)(SD)	-0.05 (0.29)	-0.09 (0.43)	-0.05 (0.29)	-0.04 (0.29)	-0.09 (0.39)	-0.01 (0.18)
DXBR (SD) (%/μmol)	-1.01 (9.8)	1.52 (18.6)	-1.10 (5.2)	1.07 (15.1)	-1.20 (11.4)	1.17 (8.6)