A CASE CONTROL STUDY OF VARIATIONS IN LUNG PHYSIOLOGY ACROSS THE WORKING WEEK IN SYMPTOMATIC AND ASYMPTOMATIC TEXTILE WORKERS

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Abstract

The physiological response to textile dust exposure has been studied during the working week in a group of spinning operatives with work-related respiratory symptoms and a group of asymptomatic control operatives. Across shift variations in spirometry and bronchial reactivity on Day 1 and Day 4 of the working week have been compared in a case-control study. In addition across week variations have also been studied. Despite well-matched groups, the symptomatics had lower baseline spirometry and higher baseline bronchial reactivity. Very little difference between the two groups was noted for across shift variations, however the symptomatics demonstrated significantly larger across week falls in spirometry than the asymptomatics. The differences between the two groups may be due to factors other than textile dust and cigarette exposure.

Introduction

Vegetable fibre exposure has been implicated in the production of respiratory symptoms since 1700 when Ramazzini first described symptoms in flax workers [1]. Cotton dust exposure was described as causing symptoms by Kay in 1831 [2] in a group of spinners in Manchester, England but meaningful epidemiological studies in this field however only began in the 1950s with the work of Schilling and his co-workers [3]. Since then numerous studies have been performed in cotton exposed workers with reference to the prevalence rates of byssinosis and bronchitis, and to acute and longitudinal changes in lung function. In a number of the more recent studies a cluster of other work-related respiratory symptoms which do not conform to a diagnosis of byssinosis and which occur more frequently in cotton exposed workers have been described [4]. The response of this group of symptomatic operatives to dust exposure is poorly described in the literature, with most studies concentrating on operatives with byssinosis. A previous study from our own unit[4] has demonstrated that textile spinners with symptoms have significantly higher bronchial reactivity than asymptomatic controls but changes in bronchial reactivity across shifts and working week have to our knowledge never been studied in textile spinners.

The aim of the present study is to look in detail at the differences between spinning operatives with and without work-related respiratory symptoms in terms of their physiological response to textile dust exposure.

Methods

A modified Medical Research Council Respiratory Symptoms Questionnaire was administered to all consenting cotton and manmade fibre spinning operatives from eight mills in the North West of England (five cotton and three manmade fibre). 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. Cumulative cigarette exposure has been calculated for each operative and expressed in pack-years (PACKYRS).

From the questionairre data, all operatives with one or more work-related respiratory symptoms were identified, and for each, a control asymptomatic operative was also selected. The control operatives were matched as far as possible for age, sex, current smoking habit and whether or not they were currently exposed to cotton or manmade fibre.

At a subsequent mill visit, symptomatic and control 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.) until Due to the large variation in ambient temperature in the mill environment, all lung volumes and flow rates have been corrected from ambient (ATPS) to body temperature (BTPS).

2) bronchial reactivity (BR) testing to histamine was also performed using the technique described by Yan et al.[5], 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. Only those completing four tests have been included in the subsequent analysis.

Work-area sampling for cotton dust was carried out in accordance with the guidelines described by the Health and Safety Executive [6] using high-flow samplers (Rothero & Mitchell L60) at a height of 1.5m in the workplace. Gravimetric analysis of the filter papers before and after sampling along with calculation of the volume of air sampled allows operatives in a particular work-area to be

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assigned a current work area cotton dust exposure (SDPRES) in mg/m^3.

In addition to a current work-area cotton dust exposure, an estimate of cumulative work-area cotton dust exposure derived from previous employment history and historical cotton dust measurements performed by the mills involved has been made (SDPAST), and this is expressed in mg.years/m^3.

The percentage of predicted for FEV and FVC were calculated from regression equations described by Quanjer [7]. 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.

Absolute changes in FEV and FVC across the two shifts under study were calculated for each operative, and in addition, using the start of shift values on the two days, the across week changes in these spirometric parameters were also calculated.

For each of the four BR tests performed during the working week, a dose response (DR) value of FEV to histamine was calculated in %/µmol histamine using the formula:

$$\text{DR to histamine} = \frac{\text{Percentage fall in FEV}_1}{\text{Dose of histamine administered}}$$

Comparisons between symptomatic operative and their asymptomatic control have been made for baseline spirometric parameters, baseline BR, across shift changes in spirometric parameters and BR on both days, and across week changes in spirometric parameters and BR using Paired t-tests. BR, SDPRES, SDPAST and PACKYRS all demonstrate positively skewed distributions, therefore natural logarithms have been used for calculation and the results detransformed for presentation. Statistical significance has been arbitrarily set at the 5% level.

Results

The demographic characteristics of the symptomatic and control populations is shown in Table 1. The symptomatic group are only 2.3 years older than the controls on average, however this small difference is statistically significant. There is no significant difference between the groups for the other parameters presented, including smoking habits, past and present cotton dust exposure.

Table 2 shows the baseline (beginning of week) lung function in the two groups. The symptomatic group demonstrate lower levels expressed as percentage of predicted for both spirometric parameters, with this difference being of borderline significance for PPFEV. The symptomatics show significantly more bronchial obstruction measured by FEV/FVC ($p<0.001$), and significantly higher baseline BR ($p<0.001$) than the controls.

Table 3 shows the trends in spirometry and BR during the working week for the symptomatic and the control groups. The absolute changes across shift and working week are presented in Table 4 along with an indication of the statistical analysis of these differences between the two groups. The symptomatic group demonstrate falls in FEV and FVC across both shifts studied (being larger on Day 1 than on Day 4) and a fall across the working week in pre-shift values. The control group demonstrate small decreases in FEV across both shifts but no across week changes. The differences between the two groups for across shift changes in FEV and FVC are not significant, however the symptomatics demonstrate significantly larger across week reductions in FEV and FVC than the controls ($p<0.05$).

Both the symptomatics and the controls demonstrate an increase in BR across the shift on Day 1, however on Day 4, the symptomatics show a decrease in BR across shift. The controls show a rise in BR across shift on Day 4 equivalent to Day 1. The difference in across shift change in BR between the symptomatics and the controls on Day 4 is statistically significant ($p<0.05$). The symptomatic group demonstrate a fall in BR across the working week with the controls showing an increase. This difference is not however statistically significant.

Discussion

The symptomatic and the control group of asymptomatic operatives were well matched for demographic details, in particular current and retrospective estimated cumulative cotton dust exposure. The symptomatics had smoked more cigarettes cumulatively, however this difference was not statistically significant. Despite these similar cotton and cigarette exposures, the symptomatic operatives demonstrated lower baseline lung function, higher physiological bronchial obstruction and higher baseline BR. This suggests that there may be an additional factor which predisposes certain operatives to lose lung function. This factor may be external (in other words an additional exposure which is not controlled for) or it may be intrinsic to the individual (for example atopy).

The across shift changes in spirometry are similar for both groups on both days, with falls in FEV_1 and FVC across both shifts. The falls are slightly larger on Day 1 than Day 4, and on the whole are slightly larger in the symptomatic group. None of these differences is statistically significant.

Both groups demonstrate a rise in BR across Day 1, however the symptomatics demonstrate a fall in BR across Day 4 despite a decrease in spirometry. This may represent some tolerance to the effects of cotton dust exposure by Day 4 of the working week.

Significant differences occur between the symptomatic and the asymptomatic groups when across week changes in spirometry are studied. The symptomatic group demonstrate falls in spirometry in excess of the asymptomatics who demonstrate no real change in spirometry across the working week. The symptomatics also demonstrate a reduction in BR despite the fall in spirometry, and again this may represent some tolerance to textile dust.

In conclusion therefore, the main physiological difference between the two groups is that the symptomatic group lose FEV_1 and FVC progressively during the working week, with the asymptomatics showing no real change. Some tolerance to the effects of textile dust exposure are demonstrated in the symptomatic group (in terms of BR). These changes may be related to the lower baseline lung function and/or the higher baseline BR in the symptomatic workers, and as such may be related to factors other than cotton dust and cigarette exposure. The production of symptoms and the lung function changes during the working week we have demonstrated may both merely reflect lowered lung function and/or bronchial hyperreactivity.

References

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Table 1. Demographic details of Symptomatic and Control operatives.

	Symptomatic n=84	Controls n=84
Age (SD)	46.5~ (12.4)	44.2~ (11.7)
Male (%)	55 (65)	53 (63)
White (%)	71 (85)	73 (87)
Ever smoked (%)	71 (85)	67 (80)
Packyrs (SD)	3.40 (2.44)	1.44 (3.65)
Yrs in cotton (SD)	10.7 (6.1)	8.1 (6.5)
SDPRES (SD) (mg/m^3)	0.16 (14.7)	0.19 (12.9)
SDPAST (SD) ($mg.yrs/m^3$)	4.24 (21.2)	3.14 (20.5)

Table 2. Baseline percentage predicted spirometry, bronchial reactivity and FEV/FVC ratio for Symptomatic and Control operatives.

n=84	PPFEV (%)	PPFVC (%)	Ratio FEV/FVC (%)	BR (%/μmol)
Symptomatic	83.9* (22.3)	95.4 (19.0)	72# (11)	3.95# (8.42)
Controls	88.2* (14.8)	96.3 (13.6)	77# (9)	0.75# (19.7)

- $p<0.001$
* - $0.10>p>0.05$

Table 3. Lung function and bronchial reactivity measurements during the week in Symptomatic and Control operatives.

n=84	Day 1 Pre	Day 1 Post-shift	Day 4 Pre-shift	Day 4 Post-shift
Symp				
FEV(1)	2.61	2.55	2.53	2.50
FVC(1)	3.56	3.44	3.47	3.43
BR(%/μmo) (n=69)	3.95	4.75	3.89	3.15
Controls				
FEV(1)	2.86	2.84	2.87	2.85
FVC(1)	3.72	3.66	3.72	3.66
BR(%/μmo) (n=69)	0.75	1.28	0.82	1.44

Table 4. Across shift and across week variations in lung function and bronchial reactivity in Symptomatic and Control operatives.

n=84	FEV (1)	FVC (1)	BR (%/μmol)
SHIFT 1			
Symptomatic	-0.05	-0.12	1.20
Controls	-0.02	-0.06	1.71
SHIFT 4			
Symptomatic	-0.03	-0.04	-1.24~
Controls	-0.02	-0.06	1.76~
ACROSS-WEEK			
Symptomatic	-0.07~	-0.09~	-1.02
Controls	+0.01~	0.00~	1.09

~ - $p<0.05$