Comparison of various airflow measurements in symptomatic textile workers

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Introduction

Cotton dust exposure in healthy volunteers may cause acute and reversible airflow limitation [1,2]. Chronic exposure in textile mills is known to be associated with a number of respiratory conditions, including chronic obstructive pulmonary disease, byssinosis and occupational asthma (OA) [3,4].

Central to the recent British Occupational Health Research Foundation guidance, a diagnosis of OA should be considered in any worker reporting work-related respiratory symptoms [5]. However, symptom reporting is subjective and consequently open to potential recall bias. Previous epidemiological studies have thus explored the use of more objective tests of lung function such as serial peak expiratory flow (sPEF) measurements, across-shift spirometry and non-specific airway responsiveness measurements. While sPEF measurements are recommended for the investigation of OA in recent guidance [6,7], there are no published studies describing the relationship between work-related respiratory symptoms and OASYS-2 scores in conjunction with other airway physiology measures.

In order to specifically investigate the relationship between work-related respiratory symptoms and objective measures of lung function including sPEF measurements and airway reactivity, we have therefore retrospectively analysed data collected as part of a large epidemiological survey of textile workers, given the high previously described levels of work-related respiratory problems in this group [8–10].
**Methods**

The study population was taken from a larger study population enrolled into a longitudinal study of respiratory ill-health between 1989 and 2000 [8]. All those who had previously reported work-related respiratory symptoms, defined as worse at work or improving on rest days, were approached to perform further more detailed investigations including lung function testing, sPEF measurements and bronchial challenge testing to assess non-specific airway responsiveness. A control group of asymptomatic subjects matched for age and gender was also recruited.

All subjects underwent spirometry before and after work shifts on both the first and the fourth day of the working week according to American Thoracic Society standards [11].

Subjects were asked to record measurements at two-hourly intervals over a 4 week period, which included time away from the workplace, analysed by the OASYS-2 software, and the work effect index (WEI) was calculated. Good quality readings for a shorter duration were also analysed if workers had recorded a minimum of four peak expiratory flow (PEF) readings per day. The WEI was calculated and used to classify each chart as either positive (showing significant work-related effect, WEI > 2.5) or negative (WEI ≤ 2.5).

Non-specific airway challenge using histamine was performed before and after work shifts to assess non-specific airway responsiveness and completed on both the first and last day of the working week using a portable technique [12].

Chi squared testing was used to investigate the relationships between work-related respiratory symptoms, positive sPEF scores and airway responsiveness. The Mann–Whitney U-test and paired students t-test were used to compare across-shift changes in lung function. Statistical significance was taken at the 5% level and all statistics were carried out using SPSS (version 12.1).

**Results**

The total population studied for the larger epidemiological study was 1766 workers, of whom 1547 (88%) completed a study questionnaire. Of this group, 179 workers (12%) complained of at least one work-related respiratory symptom. Of these 179 workers, 84 workers had further physiological measures made in the workplace, and 84 controls with no symptoms were matched where possible to the workers with symptoms for further comparison.

Of the 168 workers and controls, 53 (32%) performed serial peak flow recordings according to the OASYS-2 protocol (25 controls and 28 with symptoms). Thirty-four workers were male (64%) and just under half were current smokers (49%); 28% were ex-smokers. The mean age of the controls was 44.2 years and of the symptomatic group 46.6 years, not significantly differing. The median duration of cotton exposure for the whole group [including all workers currently exposed to man-made fibre (MMF)] was 15 years (range 0–46).

Work-related respiratory symptoms were more prevalent in cotton-exposed subjects, except for work-related cough, which was more common in those currently exposed to MMFs.

Table 1 displays lung function data, showing no significant difference at baseline between cotton- and MMF-exposed workers. The overall across-shift changes were small, with nine subjects (17%) showing >5% fall in FEV₁ on either day and only two (4%) with >10% fall.

Table 2 shows the mean cross-shift percentage change in FEV₁ on the first day of the working week according to the presence or absence of each work-related respiratory symptom. The presence of work-related cough and chest tightness was associated with significantly greater percentage falls in FEV₁ across shift, compared with subjects without those symptoms. The corresponding data for the last day of the working week (not shown) found that work-related chest tightness and wheeze were associated with significantly greater falls in FEV₁.

Seven subjects had a positive WEI of >2.5. There was no apparent relationship between the presence of work-related symptoms and sPEF patterns. Similarly, there was no significant relationship between fall in FEV₁ on the first working day and WEI. For example, the mean across-shift change in FEV₁ on the first working day was +9.9% from baseline in those with a WEI of >2.5 and −0.72% in those with a negative WEI (P = 0.30 assuming unequal variances).

Six cotton-exposed subjects (18%) and one MMF-exposed subject (5%) had a positive histamine challenge.

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**Table 1. Lung function measurements and across-shift percentage change in FEV₁ for all workers**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Cotton exposed</th>
<th>MMF exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV₁ % predicted, mean (SD)</td>
<td>88.6 (19.2)</td>
<td>89.3 (21.0)</td>
<td>87.3 (15.9)</td>
</tr>
<tr>
<td>FEV₁/FVC, mean (SD)</td>
<td>0.74 (0.1)</td>
<td>0.74 (0.1)</td>
<td>0.74 (0.1)</td>
</tr>
<tr>
<td>Day 1 across shift, mean % (SD)</td>
<td>+0.7 (11.1)</td>
<td>+0.5 (6.9)</td>
<td>+1.1 (16.3)</td>
</tr>
<tr>
<td>Day 4 across shift, mean % (SD)</td>
<td>+0.6 (11.3)</td>
<td>−0.9 (6.9)</td>
<td>−3.4 (16.4)</td>
</tr>
<tr>
<td>Number with &gt;5% across-shift fall</td>
<td>9</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

FVC, forced vital capacity. Plus sign denotes increase in FEV₁ across shift. Minus sign denotes fall in FEV₁ across shift.
test. There was a general relationship between increased airway responsiveness and increased levels of work-related symptoms, although this difference was only statistically significant for work-related wheeze (67% wheeze in those with increased responsiveness and 25% wheeze in those without, \( P < 0.05 \)).

Airway responsiveness was also associated with the results of the sPEF analysis. Five of the 7 subjects with a WEI >2.5 had a positive bronchial challenge test (71%) compared with 12 of 46 (26.1%) without (\( P < 0.05 \)).

### Discussion

The main finding of this study was that both cross-shift change in FEV\(_1\) and the presence of bronchial hyperreactivity were associated with the presence of work-related respiratory symptoms in this group of textile workers. While the data also confirm a relationship between airway reactivity and a positive work effect seen in peak flow recordings, the latter does not appear to relate significantly to the presence of work-related symptoms.

There was an observed relationship between the relatively small cross-shift fall in FEV\(_1\) and work-related symptoms. Previous studies have also shown that such changes in FEV\(_1\) are clinically significant and subsequently associated with significantly greater annual lung function decline in cotton textile workers. For example, Christiani et al. [13] showed that a 5% across-shift drop in FEV\(_1\) was predictive of 5 year decline in FEV\(_1\), whereas Glindmeyer et al. found an across-shift fall of \( \geq 200 \) ml to be significant [14].

Despite the moderate sensitivity and high specificity of sPEF to identify OA, there was no relationship in this study between the WEI of sPEF measurement and the presence of work-related respiratory symptoms. This may be due to under-reporting of symptoms or due to the possibility that cotton exposure causes work-related respiratory symptoms independently of the development of OA.

Absolute patterns of PEF were difficult to interpret in this study due to low numbers. However, of the seven workers with a positive work effect seen on PEF assessment, three showed no consistent pattern and four workers had charts that each showed a mix of PEF increase and decrease through the working week.

While heightened airway responsiveness is considered to be a characteristic feature of asthma, previous studies have shown that non-specific airway responsiveness may be normal in up to 40% of specific occupational bronchial-challenge-positive workers [15,16]. In spite of this, we observed a clear relationship between responsiveness and work-related respiratory symptoms and, in particular, a significant relationship to work-related wheeze. Increased responsiveness was also significantly associated with sPEF patterns. It has previously been demonstrated that airway responsiveness and non-specific respiratory symptoms are strongly associated with across-shift falls in FEV\(_1\) in cotton workers [17].

This study has significant weaknesses. Many of the subjects had been employed in the mills for many years, and the ‘healthy worker effect’ may have influenced the nature of the study group. Similarly, selection bias may have defined a study group that are less representative of the whole population. The relatively small number of workers studied may also limit the generalization of these findings to other workers, although the intent of this study was to make comparisons within subject. Small numbers also did not allow more complex analyses to estimate the potential effects of cofounders.

In summary, this study has identified airway responsiveness and across-shift changes in FEV\(_1\) as the best predictors of work-related respiratory symptoms in textile-dust-exposed workers. These symptoms are likely to be a function of the repeated acute pulmonary response to inhaled dust. A positive sPEF chart was associated with increased airway responsiveness but not work-related symptoms. Further studies are required of sPEF and their relationship to respiratory symptoms and airway reactivity in the occupational setting.

### Key points

- Despite a substantial evidence base relating to the investigation of occupational asthma, little is known about how various measures of airway physiology relate to each other in workers complaining of work-related respiratory symptoms.
- In this group of textile-dust-exposed workers, the presence of work-related respiratory symptoms related to cross-shift falls in lung function but not to serial peak expiratory flow patterns normally related to the presence of occupational asthma. Serial peak expiratory flow patterns did relate to the presence of heightened airway reactivity.
- Understanding these relationships is important in order to best define health surveillance strategies and to best investigate those developing symptoms that might suggest an occupational respiratory problem.
Conflicts of interest

None declared.

References