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Across-shift lung function variation in cottonseed oil workers

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Background The effects of cotton dust on pulmonary function among workers employed in cotton-spinning mills are well known. However, little data exist on the prevalence of this disorder in 'non-textile' cotton industries, including cottonseed oil mills, where high levels of exposure to dust have been demonstrated.

Aims This study was performed in order to determine the across-shift and across-week decline of FEV_1 and respiratory symptoms among workers in a cottonseed oil mill.

Methods Sixty-six exposed and 48 unexposed workers of a cottonseed oil mill in Turkey were investigated by questionnaire and lung function test (LFT). LFTs were performed before and after shift on all the working days of the week. Acute airway response was defined as an across-shift decline in FEV_1 of 5% or more on the first working day.

Results Smoking was the only risk factor for having respiratory symptoms. Acute airway response was more frequently observed in the exposed group as compared to the unexposed group (OR = 6.2, 95% CI = 2.3–16.7). The median across-shift decline in FEV_1 on the first day (120 ml) significantly improved on the following days (10, 50, 60 and −30 ml).

Conclusion Smoking appears to be the main risk factor for having respiratory symptoms. Cottonseed dust may cause an acute pulmonary function decline on the first working day, but not on the following days of the week. This decline is associated with respiratory symptoms in exposed workers.

Key words Byssinosis; cottonseed dust; lung function; occupational health; respiratory symptoms.

Introduction

Workers in the cotton industry are susceptible to the development of both chronic lung diseases and acute respiratory problems. Many studies have documented the effects of cotton dust on pulmonary function among workers employed in cotton-spinning mills. However, little data exist on the prevalence of this disorder in non-textile cotton industries, including cottonseed oil mills, where high levels of exposure to dust have been demonstrated [1,2].

Beside the chronic symptoms and lung function decline among the cotton workers after long-term exposure [3], acute airway responses such as cough, wheeze, shortness of breath and acute lung function decline are observed following short-term exposure [4]. In cotton dust-exposed workers, acute and chronic pulmonary function changes have been demonstrated. Jones *et al.* [5] showed that mean functional declines over the working shift were present on the first working day of the week and absent on the last day, indicating an acute bronchoconstrictor response of the workers in cottonseed mills.

The main products of cottonseed mills are oil for human consumption, hulls for farm animals and lint as an industrial source for paper and cellulose. When cottonseed reaches the mill, it is cleaned and foreign material is separated from the seeds by shakers and separators. After treatment, cottonseeds are transported by pneumatic conveyors to machines where lint is separated from the surface of the seed by a process called 'delinting'. During this process, considerable dust is released into the working environment. Lint is then conveyed to another department for baling, an open process, where workers are exposed to considerable quantities of dust when they feed the baling machines. Delinted seed comes to the hulling–separation area to hull and prepare the kernel for pressing and oil extraction.

This study was performed in order to determine the effect of cottonseed dust on respiratory health in a

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cottonseed oil mill in Izmir, Turkey. In detail, we aimed to detect the prevalence of respiratory symptoms and across-shift lung function changes throughout a complete working week.

Methods

This study was performed in a cottonseed oil mill in Izmir, Turkey. Sixty-six cotton dust-exposed workers who work in the dusty sections (delinting, hulling–separation and baling) were examined. Forty-eight unexposed workers were selected from the tin box production section in the same mill as the control group. All the workers who participated in the study were males.

Dusty sections (up to 0.2 mg/m^3) were selected based on the cotton dust level records of the National Occupational Health and Safety Institute in Izmir. The measurements were performed with a vertical elutriator in the mill. The mean respirable dust levels of selected sections were 1.05 mg/m^3 in delinting, 1.87 mg/m^3 in hulling–separation and 0.61 mg/m^3 in the baling area.

A structured questionnaire was administered by face-to-face interview to collect demographic data, work history, respiratory symptoms (cough, phlegm, wheezing and shortness of breath) and smoking history. Those workers who reported any respiratory symptoms were defined as symptomatic and those who had no respiratory symptoms were defined as asymptomatic.

With regards to the smoking history, workers were classified as current smokers, never smokers and ex-smokers. The history of smoking was calculated in pack-years for both current and ex-smokers and analysed in the groups of 'never smoked', 'history of 20 or less pack-years' and 'history of >20 pack-years'.

Lung function tests (LFTs) were performed by a trained physician using a portable spirometer (MIR Spirobank) in accordance with the American Thoracic Society recommendations [6]. A minimum of three acceptable tests were performed on each worker. A test was defined as acceptable if the worker did not show any sign of hesitation at the start of the manoeuvre, if he did not cough or hesitate during the manoeuvre, if there was no leak from the mouthpiece and if the exhalation lasted at least 6 s. Besides, the tests were deemed acceptable if the difference in the FEV_1 levels between manoeuvres was <100 ml. The highest level of FEV_1 obtained in any of the three tests was recorded. The absolute values of the measurements were used in the calculation of the across-shift change. FEV_1 was defined as the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration.

The tests were performed before and after the shift on every day of the working week. Across-shift changes of FEV_1 were calculated for 5 working days. Acute airway response (acute effect on pulmonary function) was defined as the difference between before-shift and after-shift FEV_1 values on the first working day based on the World Health Organization classification strategy [7]. Those with more than a 5% fall in FEV_1 and those with 5% or less drop of FEV_1 across the first shift of the working week were accepted as affected and unaffected, respectively.

The statistical analyses were performed using SPSS for Windows software (SPSS Inc. Release 11.0, Chicago, IL, USA). The significance of univariate differences was assessed by chi-square test for categorical variables. Mann–Whitney *U*-test was used to compare medians of the across-shift decline of FEV_1 in the exposed and unexposed groups. The Wilcoxon test was used to compare before-shift and after-shift values of FEV_1 and to analyse the changing across-shift declines of FEV_1 on a daily basis. For multivariate analyses, the backward elimination logistic regression method was used. Age, smoking history, dust exposure and duration of employment were included in the multivariate analyses. Odds ratios and 95% confidence intervals (CIs) were calculated. A *P*-value <0.05 was considered significant.

Results

The distributions of the workers' age in exposed and unexposed workers were not statistically different. Although the current smoker proportion was not different between the two groups, there was a higher number of workers with a history of ≤20 pack-years in the exposed group. The rate of the workers who were employed for 10 years or more was higher in the unexposed group (Table 1).

Table 2 demonstrates the prevalence of respiratory symptoms. Fifty percent of workers had at least one respiratory symptom. The most frequent symptoms were

Table 1. Some characteristics of exposed and unexposed groups

	Exposed group (N = 66)	Unexposed group (N = 47)	P-values
Age (n, %)			
<35 years	23 (35)	7 (15)	NS
35–39 years	15 (23)	12 (26)	
40–44 years	15 (23)	17 (36)	
≥45 years	13 (19)	11 (23)	
Male (n, %)	66 (100)	47 (100)	NA
Current smokers (n, %)	52 (79)	30 (64)	NS
Smoking habit (n, %)			
Never smoked	11 (17)	17 (36)	<0.05
≤20 pack-years	43 (65)	14 (30)	
>20 pack-years	12 (18)	16 (34)	
Duration of employment (n, %)			
<10 years	38 (58)	10 (21)	<0.05
≥10 years	28 (42)	37 (79)	

Table 2. Prevalence of respiratory symptoms

	Cough, *n* (%)	Phlegm, *n* (%)	Wheezing, *n* (%)	SOB, *n* (%)	Any symptom, *n* (%)
Number ($N = 113$)	42 (37)	42 (37)	25 (32)	13 (12)	56 (50)
Age					
<35 years ($n = 30$)	9 (30)	13 (43)	4 (13)	2 (7)	14 (47)
35–39 years ($n = 27$)	14 (52)	11 (41)	7 (26)	4 (15)	15 (56)
40–44 years ($n = 32$)	10 (31)	7 (3)	6 (19)	3 (9)	13 (41)
≥45 years ($n = 24$)	9 (38)	11 (46)	8 (33)	4 (17)	14 (58)
Exposure					
Exposed workers ($n = 66$)	25 (38)	29 (44)	14 (21)	8 (12)	36 (55)
Unexposed workers ($n = 47$)	17 (36)	13 (28)	11 (23)	5 (11)	20 (43)
Workrooms in exposed group					
Delinting ($n = 34$)	13 (38)	17 (50)	8 (24)	4 (12)	20 (59)
Hulling–separation ($n = 20$)	7 (33)	8 (38)	5 (24)	3 (14)	10 (48)
Baling ($n = 11$)	5 (46)	4 (36)	1 (9)	1 (9)	6 (55)
Non-smokers ($n = 31$)	3 (10)	4 (13)	3 (10)	2 (7)	4 (13)
Current smokers ($n = 82$)	39 (48)***	38 (46)***	22 (27)*	11 (13)	52 (63)***
Smoking history					
Never smoked ($n = 28$)	2 (7)***	2 (4)***	2 (7)	1 (4)	2 (7)***
≤20 pack-years ($n = 57$)	26 (45.6)	27 (47.4)	11 (13.3)	4 (7.0)	34 (60)
>20 pack-years ($n = 28$)	14 (50.0)	13 (46.4)	12 (42.9)[a]**	8 (28.6)**	20 (71)
Duration of employment					
<10 years ($n = 48$)	19 (40)	22 (46)	10 (21)	5 (10)	25 (52)
≥10 years ($n = 65$)	23 (35)	20 (31)	15 (23)	8 (12)	31 (48)

SOB = shortness of breath.

[a]Never smoked and ≤20 pack-year groups were merged and Yates' correction was used.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

cough and phlegm (37%). There was a tendency for exposed workers to be symptomatic, but this did not reach statistical significance. The prevalence of cough, phlegm and wheezing were significantly higher among current smokers. The prevalence of shortness of breath and wheezing was higher among the smokers with a history of >20 pack-years.

The frequency of acute effect on pulmonary function was 48% in the exposed group versus 13% in the unexposed group ($P < 0.001$). Age, smoking, exposure time, duration of employment or workrooms in the exposed group was not related to the acute change in FEV_1 (Table 3).

Multiple logistic regression results of all the symptoms and LFTs are presented in Table 4. The symptoms were related to smoking history only. Cotton dust exposure predicted acute change of FEV_1 (OR = 6.2, CI = 2.3–16.7).

Across-shift decline of FEV_1 on every day of the working week is demonstrated by mean values and 95% CI in Figure 1. The first day decline of FEV_1 in the exposed group was significantly higher than that in the unexposed group (200 versus −20 ml). For the exposed group, there was a significant difference between the first and second, third and fifth day across-shift decline (200, 10, 50, 60 and −30 ml).

In the first working day, the post-shift FEV_1 value (median = 2.92 l) was significantly lower than the pre-shift

Table 3. Across-shift fall in FEV_1 on the first working day

	Across-shift fall in FEV_1		*P*-value
	≥5%, *n* (%)	<5%, *n* (%)	
Age			
<35 years ($n = 30$)	13 (43)	17 (5)	NS
35–39 years ($n = 27$)	9 (33)	18 (67)	
40–44 years ($n = 32$)	9 (28)	23 (72)	
≥45 years ($n = 23$)	6 (26)	17 (74)	
Non-smokers ($n = 31$)	8 (26)	23 (74)	NS
Current smokers ($n = 81$)	29 (36)	52 (64)	
Smoking history			
Never smoked ($n = 28$)	7 (25)	21 (75)	NS
≤20 pack-years ($n = 57$)	23 (40)	34 (60)	
>20 pack-years ($n = 27$)	7 (26)	20 (74)	
Exposure			
Exposed workers ($n = 55$)	31 (48)	34 (52)	<0.001
Unexposed workers ($n = 47$)	6 (13)	41 (87)	
Workrooms in exposed group			
Delinting ($n = 34$)	19 (56)	15 (44)	NS
Hulling–separation ($n = 20$)	10 (50)	10 (50)	
Baling ($n = 11$)	2 (18)	9 (82)	
Exposure time (*n*, %)[a]			
≤4 years ($n = 20$)	9 (45)	11 (55)	NS
5–9 years ($n = 18$)	9 (50)	9 (50)	
≥10 years ($n = 27$)	13 (48)	14 (52)	
Duration of employment			
<10 years ($n = 48$)	21 (44)	27 (56)	NS
≥10 years ($n = 64$)	21 (33)	43 (67)	

[a]In exposed group.

Table 4. Multiple logistic regression model of respiratory symptoms and lung function changes

Dependent variables	Factors[a]	*B*	*P*-value	OR (95% CI)
Cough	Smoking history			
	Never smoked			
	≤20 pack-years	2.4	0.002	10.9 (2.5–50.3)
	>20 pack-years	2.6	0.002	13.0 (2.6–65.6)
Phlegm	Smoking history			
	Never smoked			
	≤20 pack-years	2.5	0.002	11.7 (2.6–53.9)
	>20 pack-years	2.4	0.003	11.3 (2.6–65.8)
SOB	Smoking history			
	Never smoked			
	≤20 pack-years	0.7	0.533	2.1 (0.2–19.1)
	>20 pack-years	2.4	0.031	10.8 (1.3–93.4)
Wheezing	Smoking history			
	Never smoked			
	≤20 pack-years	1.1	0.160	3.1 (0.6–15.1)
	>20 pack-years	2.3	0.006	9.7 (1.9–49.3)
Any symptom	Smoking history			
	Never smoked			
	≤20 pack-years	2.9	0.000	19.2 (4.2–88.9)
	>20 pack-years	3.5	0.000	32.5 (6.2–170.1)
First day across-shift fall in FEV_1 (>5%)	Dust exposure			
	No			
	Yes	1.8	0.0001	6.2 (2.3–16.7)

SOB = shortness of breath.

[a]Age, smoking history, dust exposure and duration of employment included in the model.

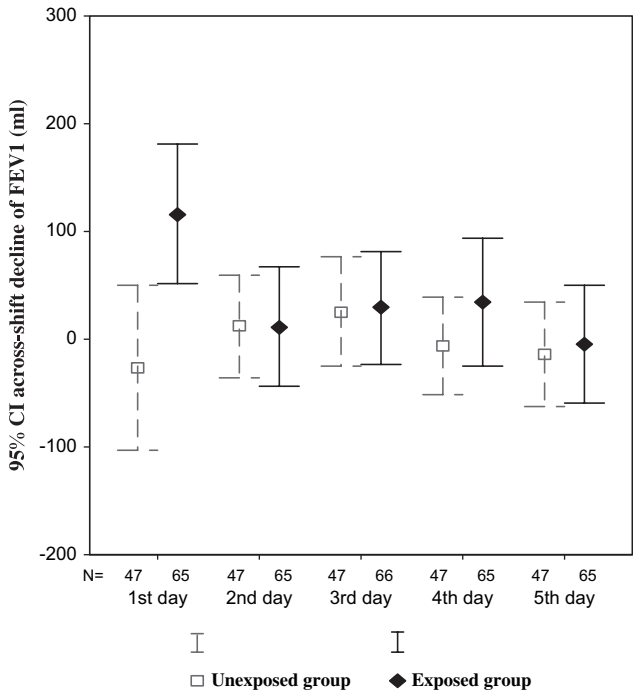

Figure 1. Mean values and 95% CI of across-shift decline of FEV_1 on the working days in exposed and unexposed groups.

value in the exposed workers with respiratory symptoms. This across-shift decline in FEV_1 was not statistically significant in asymptomatic exposed workers (3.18 versus 3.07 l) (Table 5).

Discussion

This study has defined the prevalence of respiratory symptoms and across-shift decline of FEV_1 due to cottonseed dust by comparing the exposed and unexposed workers in a cottonseed mill. It has assessed the across-shift FEV_1 decline on every day of a working week. There are a lot of studies about the respiratory health of the workers in spinning mills but few studies have been performed in cottonseed mills.

The prevalence of respiratory symptoms was very high both in the exposed and unexposed groups and there was no statistically significant difference between them. This finding shows that cottonseed dust exposure was not a determining factor for having respiratory symptoms in this study population. This is in contrast to the findings of a recent study, where Wang *et al.* [8] showed that the respiratory symptoms were more common and persistent in the cotton group than in the silk group. Although higher respiratory symptoms were expected in the exposed group, very high smoking rates in both possibly masked the dust effect. Furthermore, in univariate and multivariate analyses, smoking appeared to be the main risk factor for having respiratory symptoms. Similarly, Raza *et al.* [9] demonstrated that smoking was the most important factor in determining the presence of symptoms in Lancashire textile weavers. Besides, there was no consistent relationship between dust exposure and the prevalence of symptoms in their study population.

Table 5. First working day before-shift and after-shift values of FEV_1 in symptomatic and asymptomatic workers

		Before-shift FEV_1		After-shift FEV_1		*P*-value
		Median (l)	IQR	Median (l)	IQR	
Exposed group	Symptomatic	2.92	2.45–3.21	2.78	2.22–3.15	0.002
	Asymptomatic	3.18	2.81–3.47	3.07	2.68–3.34	0.07
Unexposed group	Symptomatic	2.98	2.45–3.09	3.02	2.46–3.29	0.53
	Asymptomatic	3.33	2.83–3.82	3.41	2.85–3.77	0.25

IQR = inter-quartile range (25–75%).

In this study, the dust exposure caused a significant decline in FEV_1 levels over a work shift on the first day of the working week. This is consistent with the previous observations in workers exposed to cotton dust [10–12]. The mean first shift FEV_1 decline in the exposed group was 120 ml, which was reversible and did not recur on the ensuing workdays. The few studies that were conducted in cottonseed mills similarly demonstrated that across-shift lung function decline was present on Monday and absent on Friday [13]. In the same line, Rylander *et al.* [14] showed in a small cotton mill workers group that the FEV_1 decrease over the work shift was significantly greater on Monday than on Wednesday and Friday.

Merchant *et al.* [15] recorded the mean FEV_1 of 25 carders with different grades of byssinosis during 5 days of dust exposure. They showed that the across-shift FEV_1 decline was higher in byssinotic than in asymptomatic workers and that the decline on the first day of the working week would resolve in mild byssinotics, whereas it would remain unchanged throughout the week in Grade 2 byssinotics. In a study from the cottonseed industry, workers with bronchitis had greater decline in FEV_1 (0.141 l) than workers without bronchitis (0.099 l) [16]. In accordance with these results, our study shows that acute pulmonary function decline on the first working day was more prevalent in symptomatic workers than in asymptomatic workers in the exposed group.

It has been reported that the risk of byssinosis is related to the cumulative exposure to cotton dust [17,18]. This study was limited by the lack of exposure assessment in different dust concentrations. The National Occupational Health and Safety records were used to indicate that the workers in the exposed group were under a high dust level, but unfortunately the hygiene data did not allow us to make personal exposure assessments.

Another limitation of the study was the composition of the control group. We selected the control group from the tin box production section in the same mill since we wanted both exposed and unexposed groups to be from similar work conditions (work organization, health services, etc.). However, it was not possible to match all demographic characteristics. Although workers in both groups were males and from similar age groups, the smoking habit and duration of employment were different between the two groups. To adjust for this unmatched nature of the populations, we used multivariate analyses by including age as well. A final limitation was that the unexposed group had fewer numbers of workers than the exposed group.

In conclusion, smoking appears to be the main risk factor for having respiratory symptoms. Cottonseed dust may cause an acute pulmonary function decline on the first working day, but not on the following days of the week. This decline is associated with respiratory symptoms in exposed workers.

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Conflicts of interest

None declared.

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