EVALUATION OF THE EFFECTS OF 12 HOUR WORKSHIFTS ON THE PULMONARY FUNCTION OF COTTON TEXTILE WORKERS

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Abstract

A study was conducted at a large textile mill in North Carolina to address the question: is the acute pulmonary function response of workers exposed to cotton dust for 12 hours, at a dust level greater than 2/3 the PEL (133 µg/m^3) significantly different than that of workers exposed to cotton dust for 8 hours at or below the PEL (200 µg/m^3). Pulmonary function tests were done on 156 workers at the following times: 1) after a break of 36 hours from work and prior to beginning a 12 hour work shift (time = 0); 2) at 8 hours into the workshift; 3) at 12 hours into the workshift; and 4) at 24 hours, prior to beginning the next 12 hour workshift. Overall, there were small but statistically significant declines from baseline (time=0) in both FEV_1 and FVC at 8, 12, and 24 hours. The mean percent changes in FEV_1 were -2.83% for 0-8 hours, -3.02% for 0-12 hours, and -1.19% for 0-24 hours. For FVC the changes were -3.11, -2.93, and -1.02 for 8, 12, and 24 hours respectively. The mean percent change in FEV_1 between 8 and 12 hours was -0.06% and for FVC +0.29%.

Introduction

Over the past several years much of the cotton textile industry has changed from an 8 hour workshift to 12 hour shifts. The 12 hour shifts vary from week to week, either 3 days on-2 days off or 4 days on- 2 days off. Over two weeks this gives an average of 42 hours per week. Occupational exposure limits (OEL's), such as threshold limit values (TLV's) and permissible exposure limits (PEL's) are time weighted averages (TWA) which are generally applied to work places with conventional 8 hours per day, 5 days per week workshifts. They were not specifically designed for novel work shifts which include work shifts other than eight hours per day for five consecutive days followed by two days off. [1] Therefore the question arises, do 8 hr TWAs, designed to protect employees who work conventional 8 hour shifts from chronic risk, protect employees who work novel work shifts.

Glindmeyer *et.al.* observed an association of an increased chronic loss in lung function with the acute drop in lung function over the workshift for cotton textile workers[2]. This study corroborates the assumptions of the OSHA cotton dust standard that acute overshift changes in FEV_1 are related to the risk for chronic impairment. Based on this assumption, the OSHA cotton dust standard seeks to protect against chronic risk by requiring retesting of workers who show overshift changes in FEV_1 of greater than 5% at 6 month intervals [3]. Also, OSHA has implemented an exemption to the Cotton Dust Standard for washed cotton based in part on experimental evidence of a lack of an acute change in FEV_1 after exposure to washed cotton. Therefore this study used the assumption that an acute overshift change is a marker of risk for chronic effects to evaluate the difference in the acute pulmonary response of workers exposed to cotton dust for 8 hours compared to the response of those same workers exposed for 12 hours.

Methods

A textile trade organization assisted in identifying a large textile mill that utilized 12 hour workshifts and which had dust levels in excess of 133 µg/m^3, the dust level that would be required if the cotton dust standard was reduced by 33% to account for a 12 hour work day. The mill employed 212 persons on 12 hour shifts according schedule of 3 days on, 4 days off for one week, and 4 days on and 3 days off the second week. The average work week for a worker over a two week period was 42 hours. There were two day and two night shifts with approximately equal numbers of workers per shift. Day shifts arrived at 7 A.M. and departed at 7 P.M. and night shifts from 7 P.M. to 7 A.M.

A total of 156 workers agreed to participate in the study and completed a study protocol was approved by the University of Alabama at Birmingham Institutional Review Board for the use of human subjects. Workers were evaluated from two areas of the mill, ring spinning (RS) and open end spinning (OE-3) which included some cardroom workers. Prior to beginning the study participating workers were asked to complete a demographic questionnaire and a screening questionnaire.

The study began at 6 am Monday morning after a minimum break of 36 hours from the previous workday. Prior to spirometry each participant was asked to complete a pre-spirometry questionnaire which asked questions regarding conditions that may affect their pulmonary function test (PFT). Following spirometry, each worker entered the workplace. At 7-8 hours, 11-12 hours, and at 24 hours after the initial spirometry each worker again completed the pre-spirometry questionnaire and spirometry.

All pulmonary function test (PFT) were done with a dry rolling seal spirometers by technicians who had completed a NIOSH approved course in pulmonary function testing. Spirometers were calibrated before and after each testing session. Each worker performed a minimum of four tests at

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:170-172 (1999)
National Cotton Council, Memphis TN

each session to assure that three acceptable curves were generated, with no more than 5% variation between two tests. The best FEV_1 and FVC from each session was recorded and used to determine each worker's percent predicted values for FEV_1 and FVC , the FEV_1/FVC ratio and the overshift change in FEV_1 and FVC. The quality of the individual PFT tracings were evaluated by a qualified pulmonary physician from at the UNC School of Medicine.

Limited cotton dust sampling was conducted using a PCAM aerosol monitor and Vertical Elutriators (Ves). On initial screening of mills for inclusion in the study the dust levels at the target Mill met our inclusion criteria (>133µg/m^3). However, when the study was done in November of 1997, the dust levels were lower than those from the August 1997 survey.
Historical data for the mill showed that the cotton dust levels in ring spinning were generally over 160 ng/m^3 and consistently higher than in OE-3 which are between 130 and 140 ng/m^3. These differences were attributed to both the process and a more efficient air filtration system in OE-3. Also, the historical dust levels were generally lower in the winter months, because the air conditioning and filtration systems automatically adjust the amount of outside air based on the temperature and more outside air is introduced in the winter thus lowering the dust levels. This may explain the lower dust levels seen in November when the study was done. All dust levels were below the OSHA 8 hour PEL of 200 ng/m^3 and marginally above the study criteria of 133 µg/m^3.

Descriptive statistics are presented as means with variation expressed as the standard deviation. Absolute lung volumes (liters) for each worker were used in a general linear model procedure of SAS (Statistical Analysis System, v6.12) to determine if there were significant changes in FVC and FEV_1 between 0-8 hrs, 0-12 hours, 0-24 hours, and 8-12 hours.

Results

Study Population

Demographic data are given in Table 1. The average age of the study population was 43.9 years and was predominantly African-American (71%) and female (69%). Forty-three percent of the population were non-smokers and 36% current smokers. The mean years worked in the cotton textile industry was 18.5 with 48% having worked in the cotton industry for greater than 20 years. There were equal numbers of workers on day and night shifts and an equal distribution based on gender and race within each shift. Overall, the percent predicted for FEV_1 and FVC and the FEV_1 /FVC ratio were 99.1%, 102.4%, and 79.1, respectively.

Lung Function Assessment

The absolute lung volumes from PFT were used to determine if there were significant differences in FEV_1 and FVC measurements between baseline (0 hours) and 8, 12, and 24 hours and between 8 and 12 hours. Table 2 shows the mean absolute lung volumes (liters) and Table 3 shows the mean change in ml for FEV_1 and FVC for each time interval (e.g. 0-8 hours). Two workers did not have PFT's at 8 or 12 hours (n=154) and five did not have PFTs at 24 hours (n=151). Although the absolute changes were small, there were significant declines in both FEV_1 and FVC between 0 and 8, 0 and 12, and 0 and 24 hours. There was no significant difference in the change from 8 to 12 hours for either FEV_1 or FVC.

To confirm the differences seen using the absolute volumes, we first compared the average percent change for the entire study population at different time periods (Table 4). The overall mean percent change from 0-8 hours in FEV_1 was -2.83%. The decline for 0-12 hours was slightly larger, however the change at 12 hours was not significantly different from that seen at 8 hours. A similar trend was seen for FVC with the largest drop occurring between 0-8 hours and some recovery between 8 and 12 hours. Although there was some recovery at 24 hours, both the FEV_1 and FVC were significantly lower than the baseline spirometry done after 36 hours away from work (time = 0).

Discussion

This study sought to determine if the acute pulmonary function response of workers exposed to cotton dust for 12 hours is different from that of workers exposed to cotton dust for 8 hours at or below the PEL (200 ug/m^3). We observed that workers exposed for 12 hours to cotton dust levels below the OSHA PEL show small but significant drops from baseline in both FEV_1 and FVC, at 8 and 12 hours. There was no significant change in either FEV_1 or FVC between 8 and 12 hours. However, while some recovery was observed at 12 hours after termination of exposure (24 hours after the baseline spirometry) both the FEV_1 and FVC were significantly below baseline.

The lack of a change in either FEV_1 or FVC between 8 and 12 hours suggest that at these dust levels there is no difference between 8 hour and 12 hour exposures. However, the observation that workers did not return to baseline after 24 hours suggest there may be a carryover effect from the 12 hour exposure. Because there was no 8 hour control group for this study, we were unable to determine if this carryover effect is unique to the 12 hour shift workers or would also occur in 8 hour shift workers.

Previous studies suggest that the FEV_1 of 8 hour workers does not return to baseline by the following day. Merchant *et. al*. evaluated the FEV_1 of aymptomatic workers (n=14), grade 1/2 byssinotics (n=4), and grade 2 byssinotics (n=7) over the workweek[5]. The acute overshift declines on the first day back to work were 400 ml for the grade two byssinotics, 298 ml for the grade 1/2 byssinotics, and 127 ml for the asymptomatics workers. All of these declines were greater than the mean of 70 ml observed in this study. Merchant *et. al*. observed some recovery to baseline at 24 hours for all three groups. The asymptomatic workers regained 66% of their baseline, grade 1/2 46%, and grade 2, 71%. The workers in this study regained 35% of their baseline FEV_1 and FVC. These data would suggest that 8 hour workers do not recover to baseline at 24 hours; however, caution must be used when interpreting this finding because the dust levels in the study by Merchant *et.al*. were near 1 mg/m^3, whereas the dust levels in this study were less than 0.2 $mg/\ m^3$.

In an unpublished study for the United States Department of Agriculture (Cooperative Agreement 58-43YK-0-0025) Jacobs and Boehlecke observed that volunteers exposed to 0.5 $mg/\ m^3$ rayon for 4-5 hours did not recover to baseline at 24 hours[6]. Similar observations were seen for exposures to 1 $mg/\ m^3$ of an unwashed Texas cotton, a washed Texas cotton, and a blended cotton. These data would suggest that workers exposed either to an inert dust (rayon) or an active dust (cotton) for 4-8 hours, after a break of 36 hours or more, do not recover to there baseline FEV_1 and FVC after 24 hours. If this is a correct conclusion, then there is no difference in the spirometric response of 8 hour and 12 hour workers at the 0.2 $mg/\ m^3$ dust levels of this study. Furthermore, if there is no difference in these acute spirometric responses then there is no need to reduce the dust levels by 1/3 for 12 hour work shifts or to require partial shift respirator use. However, this conclusion remains tentative until either of the following studies can be done: 1) the acute spirometric response of both 8 and 12 hour shift workers are evaluated under the same exposure conditions simultaneously or; 2) the response of 12 hour shift workers without a respirator is compared to their response after using a respirator for 4 hours to mimic an 8 hour exposure.

In summary, this study demonstrated: 1) that after a break of 36 hours, 12 hour shift workers experienced small but significant group mean declines in FEV_1 and FVC at 8 and 12 hours; 2) that prior to beginning work the following shift there was some recovery in both FEV_1 and FVC, but as a group they were still significantly below their pre-exposure baseline levels and 3) that there was no significant difference in either FEV_1 and FVC between 8 and 12 hours.

Literature Cited

1. Hickey, J.L.S., and P.C. Reist: **Application of Occupational Exposure Limits to Unusual Work Schedules. *Am Ind Hyg Assoc J*. 38:613-621 (1977).**
2. Glindmeyer, H.W., J.J. Lefante, R.N. Jones, R.J. Rando, and H. Weill: Cotton Dust and Across-Shift Change in FEV_1 and Predictors of Annual Change in FEV_1. *Am J Respir Crit Care Med.* 149:584-590 (1994).
3. Occupational Safety and Health Administration: 1910.1043. Cotton Dust Standard. (1985).
4. Washed Cotton: A Review and Recommendations Regarding Batch Kier Washed Cotton, **Current Intelligence Bulletin 56, (with the Task Force for Byssinosis Prevention), Department of Health and Human Services (NIOSH) Publication 95-113, August 1995**.
5. Merchant, J.A., G.M. Halprin, A.R. Hudson et. al.: Evaluation Before and After Exposure – The Pattern of Physiological Response to Cotton Dust. ***Annals New York Academy of Sciences.*** 221:38-43 (1974)
6. Jacobs R. and B. Boehlecke: USDA Cooperative Agreement 58-43YK- 0-0025, ARS Clemson South Carolina, 1994.

Table 1. Demographic Summary of the Study Population

	N	Mean	Std Dev/%
Age (years)	156	44.0	11.2
Years in Cotton	154	18.5	10.1
Predicted FEV_1 (%)	156	99.1	17.2
Predicted FEV_1 (%)	156	102.4	16.6
FEV_1 /FVC Ratio	156	79.1	7.4
Gender	156		
Male		48	31%
Female		108	69%
Race	156		
Black		110	71%
Oriental		5	3%
White		41	41%
Job	155		
OE-3		62	40%
RS		93	60%
Shift	156		
Day		77	49%
Night		79	51%
Smoking			
Never		67	43%
Ex		33	21%
Current		56	36%

Table 2. Absolute PFT Values at 0, 8, 12 , and 24 Hours

Time (hr)	N	FEV_1 (± sem) (liters)	FVC (±sem) (liters)
0	154	2.577 (0.054)	3.264 (0.07)
8	154	2.509 (0.054)	3.169 (0.07)
12	154	2.507 (0.054)	3.176 (0.07)
24	151	2.533 (0.055)	3.213 (0.07)

Table 3. Absolute change (ml) and P-values from the specific comparisons for FEV_1 and FVC

Time (hr)	ΔFEV_1 (ml)	P	ΔFVC (ml)	P
0-8	-68	0.0001	-95	0.0001
0-12	-69	0.0001	-88	0.0001
0-24	-44	0.0026	-51	0.0158
8-12	-1	0.9793	+7	0.8795

Table 4. Percent Change in FEV_1 and FVC Baseline at 8, 12, and 24 hours.

Time (hrs)	N	[illegible]FEV_1±(sem) (%)	p	[illegible]FVC±(sem) (%)	p
0-8	154	-2.83 (0.56)	<0.0001	-3.11 (0.46)	<0.0001
0-12	154	-3.02 (o.59)	<0.0001	-2.93 (0.51)	<0.0001
0-24	151	-1.19 (0.57)	<0.05	-1.02 (0.53)	<0.05
8-12	154	-0.06 (0.48)	0.897	+0.29 (0.44)	0.514