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Respiratory Findings in Synthetic Textile Workers

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We studied 308 female and 92 male textile workers employed in a factory that produced synthetic fiber hosiery. The mean age of the women was 38 years, their mean duration of employment 16 years. The mean age of the men was 39 years with a mean duration of employment of 16 years. A control group of 160 female and 78 male nonexposed workers was also studied. Chronic and acute work related symptoms were recorded for all workers. Ventilatory capacity was measured by recording maximum expiratory flow-volume (MEFV) curves from which the forced vital capacity (FVC), the 1-sec forced expiratory volume (FEV_1) and maximum expiratory flow rates at 50% and the last 25% (FEF_{50}, FEF_{75}) were read. There was a higher prevalence of all chronic respiratory symptoms in exposed than in control workers, although the differences were statistically significant only for dyspnea, sinusitis, and nasal catarrh ($P < 0.01$) in female synthetic textile workers, and for nasal catarrh ($P < 0.01$) in male synthetic textile workers. Occupational asthma was recorded in 3 (0.9%) of the women textile workers, and in 1 (1.1%) of male textile workers. There was a high prevalence of acute symptoms during the work shift, which was greatest for cough (female: 46%; male: 59%), dryness of the throat (female: 49%; male: 40%), dryness of the nose (female: 53%; male: 43%) and eye irritation (female: 46%; male: 36%). Ventilatory capacity data among the synthetic textile workers demonstrated significantly decreased FEF_{75} compared to predicted ($P < 0.05$). Our data suggest that inhalation of dust in synthetic textile plants causes the respiratory impairment. Am. J. Ind. Med. 33:263–273, 1998. *© 1998 Wiley-Liss, Inc.*

KEY WORDS: synthetic textile fibers; respiratory symptoms; lung function

INTRODUCTION

The respiratory consequences of working with synthetic fibers have been infrequently studied. Winkle et al. [1978] reported that, 100 years ago, all textile items were made uniquely of natural fibers, such as cotton, wool, linen, and silk. Although synthetic fibers were produced as early as 1850, it was not until the advent of nylon, in 1939, that products made of synthetic fibers became widely available. The use of man-made fibers is increasing at the rate of 8% per year and in many applications has displaced natural fibers.

In 1975, Pimentel et al. [1975] first described bronchopulmonary symptoms (e.g., asthma, chronic bronchitis, alveolitis) in seven textile workers who made clothes from synthetic fabrics. Susequent epidemiologic studies of rayon workers documented only a few workers with mild respiratory symptoms; no significant across-shift change in lung function were found [Tiller, 1958; Tiller and Schilling, 1958; Chwat and Mordish, 1963]. By contrast, Simonin [1961] described irritation of the mucous membranes and bronchial asthma in workers employed in the nylon industry.

Muittari and Veneskoski [1976] reported that 20% of synthetic textile workers demonstrated positive bronchoprovocation testing, and that 30% had positive nasal provocation testing with synthetic fibers (rayon, nylon, orlon, terylene). They also documented positive skin prick tests

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with extracts from synthetic fibers. They suggested that synthetic fibers may act as haptens and cause IgE-mediated allergy.

A high prevalence of chronic respiratory symptoms and lung function changes in textile workers processing synthetic fibers compared to control workers was reported by Valic and Zuskin [1977]. Recently, Fletcher et al. [1997] described that the presence of work-related respiratory symptoms in cotton and man-made fiber workers is a predictive factor of increased lung function decline for both FEV_1 and FVC. The same authors found annual declines of FEV_1 in cotton workers of -13 ml/year and in man-made fibers of -17 ml/year.

Abe and Ishikawa [1967] described animal experiments in which intratracheal instillation of synthetic fibers produced alveolar-inflamatory foci in the lung. In experimental studies with rats [Zuskin et al., 1968, 1969], inhalation of viscose rayon fibers caused significant changes in lung function. In these studies measurements of lung clearance in rats suggested that significant amounts of particles were deposited in peripheral lung tissue. In vitro experimental studies by Marsh et al. [1994] demonstrated that synthetic fibers exhibited many of the same effects of asbestos on epithelial cells. Sano [1967] reported that the inhalation of nylon dust in textile workers can give rise to fibrotic nodules in the lung. The present study was undertaken to investigate the respiratory effects of polyester in textile workers exposed to dust in the manufacture of stockings.

SUBJECTS AND METHODS

Environmental Conditions

The studied workers were employed in a textile plant making stockings from synthetic fiber (polyester). The factory is located in Zagreb, Croatia. The manufacturing process includes spinning and weaving of the fibers and cutting and finishing the stockings. The workers were located in three large rooms only partially separated from each other. There was no installed ventilation system for any of the areas. Workers frequently changed jobs so that they were all exposed to similar concentrations of respiratory irritants.

Subjects

The study included a group of 308 female and 92 male synthetic textile workers. These workers represent 95% of all workers employed in this synthetic processing industry. The mean age of the women workers was 38 years (range: 18–57 years), the mean height was 162 cm (range: 158–177 cm) and the mean duration of employment was 16 years (range: 1–22 years). Most of the women workers were nonsmokers; 41% were smokers, smoking an average 10 cigarettes or less daily. The mean age of the male workers was 39 years (range: 19–61 years), their mean height was 174 cm (range: 161–182 cm), and their mean duration of employment was 16 years (range: 2–15 years). Among the men 45% were regular smokers, smoking on the average 20 cigarettes daily. In addition, a group of 160 female and 78 male nonexposed workers was studied as a control for the prevalence of acute and chronic respiratory symptoms. These workers were selected from a cohort of 806 workers studied in various industries, unexposed to dust, fumes, or chemicals [Zuskin et al., 1996]. These workers were selected so that age, duration of employment and smoking habits were not significantly different from those of the exposed group.

Respiratory Symptoms

Chronic respiratory symptoms were recorded using the British Medical Research Council questionnaire on respiratory symptoms [Medical Research Council Committee on the Aetiology of Chronic Bronchitis, 1960] with additional questions on occupational asthma [World Health Organization, 1986; Maestrelli et al., 1992; Godnic-Cvar, 1995]. In all workers, a detailed occupational history as well as the questions about their smoking habits were recorded. Medical records from the company health surveillance program were also reviewed. The following definitions were used:

Chronic cough or phlegm: cough and/or phlegm for a minimum of 3 months per year

Chronic bronchitis: cough and phlegm for a minimum of 3 months per year and for not less than 2 successive years

Dyspnea grades: 3, shortness of breath when walking with other people at an ordinary pace on level ground; grade 4, shortness of breath when waling at their own pace on level ground

Occupational asthma: recurring attacks of dyspnea, chest tightness, and pulmonary function impairment of the obstructive type, diagnosed by physical examination and spirometric measurements during exposure to dust at or following work (decrease of $FEV_1 > 15\%$) and confirmed by company medical records

Acute symptoms that developed during the work shift were also recorded in all studied workers. These acute symptoms included cough, dyspnea, irritation of the nose, throat, and eyes, or dryness of the throat, secretion, dryness, or bleeding of the nose, eye irritation, and headache noted during the workshift.

Ventilatory Capacity

Ventilatory capacity measurements were performed by recording worker maximum expiratory flow-volume (MEFV)

TABLE I. Prevalence of Chronic Respiratory Symptoms in Synthetic Textile Workers and Control Workers: Croatia, 1995

Sex	Group	Mean age	Mean employment	Smoking habit	Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 and 4	Occupational asthma	Chest tightness	Sinusitis	Nasal catarrh
Female	Exposed	38 ± 8	16 ± 8	126	46	28	24	151	3	13	66	78
	n = 308			40.9%	14.9%	9.1%	7.8%	49.0%	0.9%	4.2%	21.4%	25.3%
				NS	NS	NS	<0.01	NS	NS	<0.01	<0.01	
	Control	38 ± 9	16 ± 10	67	16	13	11	8	0	0	1	0
	n = 160			41.7%	10.0%	8.1%	6.9%	5.0%	0%	0%	0.6%	0%
Male	Exposed	39 ± 9	16 ± 9	45	23	16	15	32	1	4	15	25
	n = 92			48.9%	25.0%	17.4%	16.3%	34.8%	1.1%	4.4%	16.3%	27.2%
				NS	NS	NS	NS	<0.01	NS	NS	NS	<0.01
	Control	40 ± 8	17 ± 7	38	15	12	11	4	0	0	1	0
	n = 78			48.7%	19.2%	15.4%	14.1%	5.1%	0%	0%	1.3%	0%

NS, difference statistically not significant ($P > 0.05$).

curves on a the Pneumoscreen (Jaeger, Wurzburg, Germany) spirometer. The forced vital capacity (FVC), one-second forced expiratory volume (FEV_1), and maximum flow rates at 50% and the last 25% of the vital capacity (FEF_{50}, FEF_{75}) were read on these MEFV curves. Measurements were performed on the first work day of the week (Monday) during the morning workshift. The spirometer was calibrated on a daily basis. Lung function testing was performed according to the recommendation of Quanjer et al. [1993]. At least three MEFV curves were recorded for each subject, and the best (highest FVC and FEV_1) reproducible value of three technically satisfactory MEFV curves was used as the result of the test. The measured values of ventilatory capacity were compared with the predicted normal values as reported by Mustajbegovic [1992].

Environmental Dust Measurement

Airborne dust in the two textile synthetic fiber mills was sampled with two Hexhlet horizontal two-stage samplers over an 8-hr workshift in the workplace of the examined workers. A total of 23 samples were performed for this study. Dust concentrations were expressed separately for the total and respirable dust fractions as the arithmetic mean and range. At least three measurements were made at each location. Dust measurements were noted to be similar in all areas, presumably because of the open nature of the workplace.

Statistical Analysis

The results of ventilatory capacity measurements were analyzed as in our previous studies by standard paired t-test when comparing baseline to predicted values. Analysis of the differences in lung function tests as a percent of predicted between different groups was performed using the testing of the equality of independent samples by the Kruskal–Wallis analysis of variance (ANOVA) test [Gibbons, 1971]. As in our previous analyses, the chi-square test (or when appropriate Fisher's exact test), was used for testing differences in the prevalence of respiratory symptoms between groups. A level of <0.05 was considered statistically significant.

RESULTS

Respiratory Symptoms

Prevalences of chronic respiratory symptoms are presented in Table I for male and female synthetic textile workers and for the control workers. There were significant differences in the prevalences between exposed and control workers for dyspnea ($P < 0.01$), sinusitis ($P < 0.01$), and nasal catarrh ($P < 0.01$) for female workers and for nasal catarrh ($P < 0.01$) in male workers. Occupational asthma was recorded in 3 (0.9%) female synthetic workers, in 1 (1.1%) in male synthetic workers and in none of the control workers (NS).

Table II shows the prevalence of chronic respiratory symptoms in synthetic textile workers by smoking habit. Significantly higher prevalences of chronic cough, chronic phlegm, and chronic bronchitis were documented in female smokers and significantly higher prevalences of chronic cough, chronic phlegm, chronic bronchitis, and dyspnea in male smokers ($P < 0.01$), when compared to exposed nonsmoking workers.

Table III presents the prevalence of chronic respiratory symptoms in female and male synthetic textile workers by age (≤40 years and >40 years) and Table IV by duration of

TABLE II. Prevalence of Chronic Respiratory Symptoms in Synthetic Textile Workers by Sex and Smoking Habit: Croatia, 1995

Sex	Smoking habit	Mean age	Mean employment	Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 and 4	Occupational asthma	Chest tightness	Sinusitis	Nasal catarrh
Female	Smokers	36 ± 7	15 ± 7	20	13	11	44	1	2	13	17
	n = 126			23.5%	15.3%	12.9%	51.8%	1.2%	2.4%	15.3%	20.0%
				<0.01	<0.01	<0.01	NS	NS	NS	NS	NS
	Nonsmokers	39 ± 8	17 ± 8	15	5	5	82	2	7	43	43
	n = 182			8.2%	2.8%	2.8%	45.1%	1.1%	3.9%	23.6%	23.6%
Male	Smokers	41 ± 9	17 ± 10	20	15	14	22	1	2	8	13
	n = 45			44.4%	33.3%	31.1%	48.9%	2.2%	4.4%	17.8%	28.9%
				<0.01	<0.01	<0.01	<0.01	NS	NS	NS	NS
	Nonsmokers	38 ± 9	16 ± 9	3	1	1	10	0	2	7	12
	n = 47			6.4%	2.1	2.1%	21.3%	0%	4.3%	14.9%	25.5%

NS, difference statistically not significant ($P > 0.05$).

TABLE III. Prevalence of Chronic Respiratory Symptoms in Synthetic Textile Workers by Sex, Smoking Habit, and Age: Croatia, 1995

Sex	Smoking habit	Age (yr)	n	Chronic cought	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 and 4	Occupational asthma	Chest tightness	Sinusitis	Nasal catarrh
Female	Smokers	≤40	85	20	13	11	44	1	2	13	17
				23.5%	15.3%	12.9%	51.8%	1.2%	2.4%	15.3%	20.0%
				NS	NS	NS	NS	NS	NS	NS	<0.05
		>40	41	11	10	8	25	0	3	10	18
				26.85%	24.4%	19.5%	60.9%	0%	7.3%	24.4%	43.9%
	Nonsmokers	≤40	90	6	3	3	32	1	2	21	17
				6.7%	3.3%	3.3%	35.6%	1.1%	2.2%	23.3%	18.9%
				NS	NS	NS	<0.01	NS	NS	NS	NS
		>40	92	9	2	2	50	1	5	22	26
				9.8%	2.2%	2.2%	54.4%	1.1%	5.4%	23.9%	28.2%
Male	Smokers	≤40	19	5	3	2	8	1	1	3	5
				26.3%	15.8%	10.3%	42.1%	5.3%	5.3%	15.8%	26.3%
				NS	NS	NS	NS	NS	NS	NS	NS
		>40	26	15	12	12	14	0	1	5	8
				57.7%	46.2%	46.2%	53.9%	0%	3.8%	19.2%	30.8%
	Nonsmokers	≤40	19	1	0	0	3	0	2	3	7
				3.6%	0%	0%	10.7%	0%	4.1%	10.7%	25.0%
				NS	NS	NS	NS	NS	NS	NS	NS
		>40	19	2	1	1	7	0	0	4	5
				10.5%	5.3%	5.3%	36.8%	0%	0%	21.1%	26.3%

NS, difference statistically not significant ($P > 0.05$).

employment (≤10 years and >10 years). Older workers as well as those with longer duration of employment demonstrated a higher prevalence of all chronic respiratory symptoms than younger workers and those with shorter employment, but the differences were not statistically significant (NS).

Table V shows the prevalence of acute work-related symptoms which developed during the work shift by smoking

TABLE IV. Prevalence of Chronic Respiratory Symptoms in Synthetic Textile Workers by Sex, Smoking Habit, and Duration of Employment: Croatia, 1995

Sex	Smoking habit	Employment (yr)	n	Chronic cought	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 and 4	Occupational asthma	Chest tightness	Sinusitis	Nasal catarrh
Female	Smokers	≤10	38	8	5	4	17	0	1	6	8
	n = 126			21.1%	13.2%	10.5%	44.7%	0.0%	2.6%	15.8%	21.0%
				NS	NS	NS	NS	NS	NS	NS	NS
		>10	88	23	18	15	52	1	5	17	27
				26.1%	20.5%	17.1%	59.1%	1.1%	5.7%	19.3%	30.7%
	Nonsmokers	≤10	49	2	2	14	0	1	12	12	
	n = 182			10.2%	4.1%	4.1%	28.6%	0%	2.0%	24.5%	24.4%
				NS	NS	NS	<0.01	NS	NS	h	NS
		>10	133	10	3	3	68	2	6	31	31
				7.5%	2.3%	2.3%	51.1%	]1.5%	4.5%	23.3%	23.3%
Male	Smokers	≤10	12	3	2	1	4	0	0	1	3
	n = 45			25.0%	16.7%	8.3%	33.3%	0%	0%	8.3%	25.0%
				NS	NS	NS	NS	NS	NS	NS	NS
		>10	33	17	13	13	18	1	2	7	8
				51.5%	39.4%	39.4%	54.6%	3.0%	6.1%	21.2%	24.2%
	Nonsmokers	≤10	20	0	0	0	1	0	2	1	4
	n = 47			0%	0%	0%	5.0%	0%	10.1%	5.0%	20.0%
				NS	NS	NS	NS	NS	NS	NS	NS
		>10	27	3	1	1	9	0	0	6	8
				11.1%	3.7%	3.7%	33.3%	0%	0%	22.2%	29.6%

NS, difference statistically not significant ($P > 0.05$).

TABLE V. Prevalence of Acute Symptoms in Synthetic Textile Workers by Sex and Smoking Habit: Croatia, 1995

				Throat		Nose					
Sex	Smoking habit	Cough	Dyspnea	Irritation	Dryness	Secretion	Dryness	Bleeding	Eye irritation	Headache	Hoarseness
Female	Smokers	69	20	44	66	7	69	35	56	70	45
n = 308	n = 126	54.5%	15.9%	43.9%	52.4%	5.6%	54.8%	27.8%	44.4%	55.6%	35.7%
		<0.05	NS	<0.05	NS	NS	NS	NS	NS	<0.05	NS
	Nonsmokers	75	26	42	86	5	95	46	85	76	68
	n = 182	41.2%	14.3%	23.1%	47.3%	2.8%	52.2%	25.3%	46.7%	41.8%	37.4%
Male	Smokers	29	7	13	21	0	20	6	17	8	12
n = 92	n = 45	64.4%	15.6%	28.9%	46.8%	0%	44.4%	13.3%	37.8%	17.8%	26.7%
		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Nonsmokers	25	4	9	16	0	20	6	16	8	16
	n = 47	53.2%	8.5%	19.2%	34.0%	0%	42.6%	12.8%	34.0%	17.0%	34.0%

NS, difference statistically not significant ($P > 0.05$).

habit. The highest prevalences were recorded for cough, dryness of the throat, dryness of the nose, and eye irritation. In addition, a large percentage of female workers complained of workshift-related headache. There were no differences in these prevalences between smokers and nonsmokers. Comparisons of these frequencies to those of previously studied unexposed workers [Zuskin et al., 1996] showed significant differences for all recorded acute symptoms ($P < 0.01$).

Ventilatory Capacity

Table VI presents measured and predicted ventilatory capacity data in female and male synthetic textile workers by smoking habit. For the group of 126 female smokers and 182 nonsmokers, there was a statistically significant reduction in FVC ($P < 0.05$) and FEF_{75} ($P < 0.05$) compared to predicted values. In men, only the FEF_{75} was significantly decreased ($P < 0.05$) compared to predicted in the 45 smokers and 47 nonsmokers.

Table VII shows the measured and predicted ventilatory capacity tests in synthetic textile female and male workers by smoking habit and age (≤40 years and >40 years). The measured values were lower than predicted, although the differences were statistically significant only for FEF_{75} in female smokers and nonsmokers, and for FEF_{75} in male nonsmokers ($P < 0.05$).

Table VIII shows the measured and predicted ventilatory capacity values in synthetic textile female and male workers by smoking habit and duration of employment (≤10 years and >10 years). Female smoking and nonsmoking workers had significantly lower FEF_{75} than predicted ($P < 0.05$); this difference was statistically significant only in male smokers for FEF_{75} with longer employment (>10 years) ($P < 0.05$).

The analysis of ventilatory capacity data in synthetic textile workers by sex and smoking habit as a percentage of predicted is presented in Table IX. The data demonstrate that the lowest mean percentages were obtained for FEF_{75} in female and male smokers; nonsmokers varied from 77% to 72% of predicted. Additional analysis by age and duration of employment indicated that younger workers and those with shorter employment had considerably larger measured FEF_{75} (range: 89–71%) than older workers and those with longer employment history (range: 76–62%). The differences for FEF_{75} (percentage of predicted) between these groups were however, not statistically significant (NS).

Analysis of the individual measured FEF_{75} data compared to predicted for the synthetic textile workers demonstrated that the FEF_{75} values were less than 70% of predicted in 41% of female smokers and in 41% of female nonsmokers; in men these values were found in 40% of nonsmokers and in 29% of smokers.

Environmental Measurements

The mean concentration of total dust was 12 mg/m^3 (range 1–16 mg/m^3). The mean concentration of respirable dust was 4 mg/m^3 (range 0.5–6.7 mg/m^3). These concentrations were higher than those recommended by the Croatian standards for man-made fibers (total dust: 1 mg/m^3; respirable: 0.4 mg/m^3).

DISCUSSION

In our study the synthetic textile workers had only minimal exposure to cotton. This is in contrast to many previous epidemiological studies in which synthetic fiber workers were significantly exposed to cotton [Molyneux and Tombleson, 1970; Berry et al., 1973, 1974; Merchant et al., 1972]. Berry et al. [1974] studied two man-made fiber spinning mills and found an increased prevalence of bronchitis among the workers of cotton mills when compared with man-made fiber mill workers. Fishwick et al. [1994, 1996] reported considerably lower prevalences of work-related respiratory symptoms in man-made fiber mill operators than in cotton mill workers. The prevalences of respiratory symptoms among synthetic fiber workers is similar to that of jute and sisal workers [Zuskin et al., 1994a,b; Chattopadhyay et al., 1994, 1995].

The current study found higher prevalences of chronic respiratory symptoms in synthetic textile workers than in controls. No case of byssinosis was found among our workers. Merchant et al. [1972] studied a modern cotton-synthetic blend mill and found the prevalence of byssinosis varying from 2% to 6%. Niven et al. [1995] studied textile workers in cotton and man-made fiber mills and found a higher prevalence of chronic bronchitis in cotton workers (7.15%) than in man-made fiber workers (4.25%) ($P < 0.01$). The same authors also demonstrated that in synthetic mills, workers over the age of 45 were at risk of chronic bronchitis and that this risk was as high in nonsmoking workers as in lifetime smoking workers. In our workers we found an increased prevalences of chronic respiratory symptoms in workers age 40 and older for both smokers and nonsmokers but these differences (for chronic bronchitis in particular) were not statistically significant.

Muittari and Veneskoski [1976, 1978] reported that synthetic fibers may act like haptens and cause IgE-mediated allergic rhinitis and asthma. These investigators consider synthetic fibers as an important cause of occupational asthma among textile workers. Among our workers, occupational asthma was found in only 0.9% of female and 1.1% of male synthetic textile workers. By contrast, a high prevalence of nonspecific nasal catarrh was found among our female exposed workers (25.3%) as well as in male workers (27.2%).

Our workers complained of acute work-related symptoms, being particularly pronounced for cough, dryness of the throat, dryness of the nose, and eye irritation. In an epidemiological study of viscose rayon fiber products, workers exposed to hydrogen sulfide and carbon disulfide were found to have high prevalences of eye pain, burning, and photophobia [Vanhoorne et al., 1995]. Since many toxic agents are used in the processing of synthetic fibers, it is possible that some of them may be released and inhaled by

TABLE VI. Ventilatory Capacity in Synthetic Textile Workers by Smoking Habit: Croatia, 1995*

					FVC			FEV_1			FEF_{50}			FEF_{75}		
Sex	Smoking habit	Mean age (yr)	Mean height (cm)	Employment (yr)	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*
Female	Smokers n = 126	36 ± 7	161 ± 6	15 ± 7	3.57 ± 0.32	3.64 ± 0.59	<0.05	2.98 ± 0.30	3.03 ± 0.50	NS	3.99 ± 0.16	4.30 ± 1.00	NS	1.70 ± 0.58	2.23 ± 2.23	<0.05
	Nonsmokers n = 182	39 ± 8	160 ± 8	17 ± 8	3.33 ± 0.60	3.53 ± 0.36	<0.05	2.87 ± 0.34	2.89 ± 0.52	NS	4.00 ± 0.97	4.24 ± 0.19	NS	1.67 ± 0.59	2.15 ± 0.21	<0.05
Male	Smokers n = 45	41 ± 9	174 ± 6	17 ± 10	4.32 ± 0.98	4.74 ± 0.57	NS	3.71 ± 0.87	3.76 ± 0.50	NS	4.47 ± 1.64	5.21 ± 0.50	NS	1.86 ± 0.95	2.50 ± 0.33	<0.05
	Nonsmokers n = 47	38 ± 9	174 ± 7	16 ± 9	4.64 ± 0.87	4.89 ± 0.66	NS	3.90 ± 0.74	3.95 ± 0.57	NS	4.66 ± 1.15	5.37 ± 0.56	NS	1.90 ± 0.70	2.62 ± 0.37	<0.05

*Ventilatory capacity data are presented as mean ± SE.
NS, difference statistically not significant ($P > 0.05$).

TABLE VII. Ventilatory Capacity in Synthetic Textile Workers by Smoking Habit and Age: Croatia, 1995*

					FVC			FEV_1			FEF_{50}			FEF_{75}		
Sex	Smoking habit	Age (yr)	Mean height (cm)	n	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*
Female	Smokers	≤40	162 ± 6	85	3.68 ± 0.69	3.75 ± 0.28	NS	3.10 ± 0.49	3.12 ± 0.25	NS	4.15 ± 1.00	4.37 ± 0.13	NS	1.83 ± 0.60	2.32 ± 0.13	<0.05
	n = 126	>40	160 ± 6	41	3.35 ± 0.53	3.40 ± 0.26	NS	2.72 ± 0.48	2.82 ± 0.21	NS	3.67 ± 0.93	4.16 ± 0.11	NS	1.43 ± 0.42	2.04 ± 0.07	<0.05
	Nonsmokers	≤40	162 ± 7	9	3.50 ± 0.59	3.74 ± 0.32	NS	3.07 ± 0.47	3.10 ± 0.10	NS	4.10 ± 0.93	4.37 ± 0.16	NS	1.89 ± 0.64	2.33 ± 0.16	<0.05
	n = 182	>40	160 ± 8	92	3.16 ± 0.56	3.33 ± 0.26	NS	2.63 ± 0.50	2.71 ± 0.21	NS	3.90 ± 1.00	4.11 ± 0.11	NS	1.46 ± 0.45	1.98 ± 0.08	<0.05
Male	Smokers	≤40	173 ± 6	19	4.91 ± 0.83	5.20 ± 0.39	NS	4.18 ± 0.79	4.22 ± 0.22	NS	5.24 ± 1.53	5.66 ± 0.28	NS	2.45 ± 1.03	2.82 ± 0.18	<0.05
	n = 45	>40	170 ± 7	26	4.01 ± 0.91	4.41 ± 0.46	NS	3.34 ± 0.72	3.45 ± 0.37	NS	3.92 ± 1.52	4.87 ± 0.33	NS	1.43 ± 0.60	2.28 ± 0.21	<0.05
	Nonsmokers	≤40	173 ± 6	28	507 ± 0.76	5.31 ± 0.45	NS	4.28 ± 0.65	4.32 ± 0.35	NS	4.93 ± 1.11	5.77 ± 0.26	NS	2.06 ± 0.71	2.89 ± 0.18	NS
	n = 47	>40	169 ± 8	19	4.00 ± 0.60	4.28 ± 0.28	NS	3.34 ± 0.51	3.42 ± 0.30	NS	4.26 ± 1.13	4.78 ± 0.26	NS	1.65 ± 0.62	2.23 ± 0.16	NS

*Ventilatory capacity data are presented as mean ± SE.
NS, difference statistically not significant ($P > 0.05$).

TABLE VIII. Ventilatory Capacity in Synthetic Textile Workers by Smoking Habit and Duration of Employment: Croatia, 1995*

					FVC			FEV_1			FEF_{50}			FEF_{75}		
Sex	Smoking habit	Employment (yr)	Mean height (cm)	n	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L)	Predicted (L)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*	Measured (L/sec)	Predicted (L/sec)	Difference measured-predicted *P*
Female	Smokers	≤10	162 ± 5	38	3.63 ± 0.56	3.81 ± 0.28	NS	3.15 ± 0.47	3.18 ± 0.26	NS	4.27 ± 0.89	4.41 ± 0.14	NS	1.97 ± 0.67	2.39 ± .16	<0.05
	n = 126	>10	161 ± 6	88	3.54 ± 0.60	3.56 ± 0.31	NS	2.89 ± 0.51	2.97 ± 0.27	NS	3.87 ± 1.03	4.25 ± 0.13	NS	1.58 ± 0.49	2.16 ± 0.13	<0.05
	Nonsmokers	≤10	164	49	3.71 ± 0.61	3.89 ± 0.30	NS	3.22 ± 0.51	3.25 ± 0.27	NS	4.08 ± 0.93	4.45 ± 0.15	NS	1.93 ± 0.17	2.41 ± 0.17	<0.05
	n = 182	>10	160	133	3.19 ± 0.53	3.40 ± 0.28	NS	2.76 ± 0.47	2.77 ± 0.25	NS	3.97 ± 0.99	4.16 ± 0.13	NS	1.58 ± 0.52	2.06 ± 0.14	<0.05
Male	Smokers	≤10	172 ± 7	12	4.88 ± 0.88	5.21 ± 0.46	NS	4.19 ± 1.00	4.26 ± 0.42	NS	5.08 ± 0.47	5.67 ± 1.01	NS	2.52 ± 1.26	2.82 ± 0.34	NS
	n = 45	>10	170 ± 6	33	4.22 ± 1.00	4.57 ± 0.52	NS	3.51 ± 0.74	3.60 ± 0.43	NS	4.25 ± 1.46	5.04 ± 0.39	NS	1.63 ± 0.68	2.38 ± 0.25	<0.05
	Nonsmokers	≤10	172 ± 7	20	5.13 ± 0.83	5.37 ± 0.45	NS	4.35 ± 0.33	4.43 ± 0.63	NS	5.22 ± 1.03	5.86 ± 0.25	NS	2.22 ± 0.65	2.96 ± 0.15	NS
	n = 47	>10	168 ± 7	27	4.28 ± 0.72	4.54 ± 0.56	NS	3.57 ± 0.47	3.60 ± 0.60	NS	4.24 ± 1.08	5.01 ± 0.43	NS	1.66 ± 0.64	2.37 ± 0.27	NS

*Ventilatory capacity data are presented as mean ± SE.
NS, difference statistically not significant ($P > 0.05$).

TABLE IX. Ventilatory Capacity as Percentage of Predicted in Synthetic Textile Workers by Sex and Smoking Habit, Croatia, 1995*

Sex	Smoking habit	n	FVC	FEV_1	FEF_{50}	FEF_{75}
Female	Smokers	126	98.1% ± 14.0	98.3% ± 13.1	92.8% ± 19.3	76.2% ± 22.5
			NS	NS	NS	NS
	Nonsmokers	182	49.3% ± 11.2	99.3% ± 10.3	94.3% ± 18.5	77.6% ± 20.2
Male	Smokers	45	91.1% ± 13.1	98.7% ± 10.5	85.8% ± 18.5	74.4% ± 20.2
			NS	NS	NS	NS
	Nonsmokers	47	94.9% ± 12.5	98.7% ± 11.6	86.8% ± 19.3	72.5% ± 23.5

*Ventilatory capacity data are presented as mean ± SD.
NS, difference statistically not significant ($P > 0.05$).

textile workers during the workshift causing acute and/or chronic respiratory symptoms.

Our present study showed that exposure to synthetic fibers may cause a decrease in lung function; the abnormalities in FVC, and particularly FEF_{75}, indicate the possibility of restrictive and obstructive changes most likely in smaller airways. Valic and Zuskin [1977] reported that in textile workers processing synthetic fibers, significant across-shift reductions on Monday and the following Thursday occurred. Their lung function was significantly reduced in comparison to prediced values. Berry et al. [1973] reported that Monday across-shift decreases in FEV_1 were greater in cotton mills than in man-made fiber mills. In their study the mean annual decline in FEV_1 for cotton workers was 54 ml/year compared to 32 ml/year for workers in the man-made fiber mills. Glindmeyer et al. [1991] studied cotton and synthetic textile workers and found that these workers had larger declines of FEV_1 than did cotton workers. The expected effect of smoking on average annual changes in lung function was demonstrated for both cotton and synthetic workers. Fishwick et al. [1996] found that the mean percentage of predicted FVC (93.8%) in persons working with man-made fibers was significantly less than that of cotton workers (96.6%).

While this study is relatively unique in documenting findings among synthetic textile workers, there are obvious limitations to our methodology. This is a cross-sectional study and hence we are not able to examine changes over time in the same individuals. Moreover, because of possible worker self-selection, there is always the possibility of reporting bias contributing to our findings. This is attenuated by the fact that we studied a majority of the workers in this industry.

Our studies confirm that work with synthetic textile fibers may result in respiratory impairment. To prevent the development of respiratory and/or immunologic impairment, we suggest that it is necessary to carry out preemployment and periodic medical surveillance to identify susceptible workers and to improve technical preventive measures in order to decrease dust concentrations in this industry.

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