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Aeroallergens and Their Impact on Respiratory System of Kashmiri art Workers: A Clinical and Immunological Based Study

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Abstract

Background: The respiratory system is the most vulnerable system in the Kashmiri art industry workers. This study was conducted to determine the effects of occupational exposure to Kashmiri art on the respiratory system more thoroughly.

Methods: A total of 212 Kashmiri art workers engaged in various sub-occupations and a reference group of 23 subjects were studied for the prevalence of respiratory symptoms and lung function status. Respiratory functions were recorded by a portable electronic spirometer.

Results: The study conducted on Kashmiri art workers showed that among the various sub-groups the prevalence of respiratory symptoms ranged from 27.0-45.8% in comparison to 5.4% in control population. Respiratory symptoms were significantly higher in smoking workers as compared to that in non-smoking workers. Period of occupational exposure in Kashmiri art workers was found directly related with the prevalence of respiratory symptoms.

There was significant prevalence of pulmonary abnormalities in exposed workers in comparison to unexposed population. Among the sub-occupational groups of workers, wool yarn dyers, carpet washers and carpet weavers showed maximum prevalence of respiratory impairment. The carpet workers were primarily affected by the bronchial obstruction. Duration of exposure had a direct relation with the prevalence of respiratory impairment.

Conclusion: The impairment in the respiratory health of workers in various sub-occupations could be attributed to the exposure to fibres of cotton and wool as well as a variety of chemicals and dyes used in the Kashmiri art industries. The monitoring of air dust revealed prevalence of occupationally generated dust in most of the sub-occupations in key processing units of Kashmiri art industries at Srinagar and other adjacent districts viz Pulwama, Budgam, Bandipora and Baramulla.

Keywords: Respiratory disorders; Kashmiri art workers; Fibers; dyes

Introduction

Kashmiri art industries are of great economic importance in India. A survey of carpet industry at Srinagar and other adjacent districts viz Pulwama, Budgam, Bandipora and Baramulla demonstrated the prevalence of occupational dust in its sub-occupational units. Ambient dust monitoring and lung function studies were conducted in these units. A random industrial and health survey has been highly useful in understanding the key processes involved in the manufacture of carpet and potential health risk factors in different kinds of processing units in carpet industry [1]. The first step is the designing and it was observed that designers sometimes share the work places of other sub occupations; therefore, such designers could be at risk of non-occupational exposure there. Wool yarn dyeing is another sub-occupation involving sorting of wool yarn, their scouring and dyeing workers in their sub-occupation are exposed to dust, chemicals and dyes. Wool yarn rolling is performed on a cottage basis and dust is generated during this process. Tana making is a distinct sub-occupation wherein string of few cotton threads thick (Tana) are prepared by machine and Tanas makers are at risk of cotton dust inhalation [2]. Carpet weaving is the largest sub-occupation approximating 45% of total workers in the carpet industry. It was found that various types of carpets were being weaved namely Tibbati, Knotted Gabeh and Tufted [3]. During weaving of these carpets, dust is produced resulting risk of exposure to carpets dust. Carpet washing unit is another sub-occupation involving removal of odd fibres from carpet before their washing with a variety of chemicals. Carpet finishing is the last processing step in carpet manufacture involving lots of embossing and clipping work that generates dust [4]. It is estimated through this survey study that about 90% workers in this industry are exposed to dust generated in their sub-occupation units [5].

Materials and Methods

Environmental dust sampling

Monitoring of dust produced in different sub-occupational units of carpet industry was monitored [6]. Ambient dust samples were collected by Millipore high vaccum pump at a flow rate of 2l/min using membrane filter pore size 0.8 um. Dust concentrations were determined gravimetrically [7].

Study groups

A total of 212 workers was drawn from various processing units of carpet industry at Srinagar and other adjacent districts. A reference

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group of 23 subjects belonging to similar sex, age and socio-economic status was taken as controls [9].

Recording occupational and personal histories of exposed workers

A complete history of the workers was recorded with respect to duration and nature of occupation, respiratory symptoms, smoking and family on a pre-structured proforma.

Lung function testing

The spirometric functions were recorded in the standing position using an electronic computerized portable spirometer according to the guidelines recommended by American Thoracic Society. Each individual performed spirometry thrice to produce the best result. Following the lung function testing the standing height and weight of all workers were noted to predict the normal values of pulmonary function tests using Rastogi's prediction equations [10,11]. Spiro metric studies were performed in workers engaged in wool yarn dyeing, carpet weaving carpet washing and carpet finishing units including 23 matching controls. Respiratory symptoms were assessed as per British Medical Respiratory Questionnaire. The spirometer used was precalibrated each day prior to use [12]. The room temperature was recorded every day during the period of study. The following respiratory parameters were studied:

1. Forced vital capacity (FVC)

2. Forced expiratory volume in 1 sec (FEV1.0)

3. FEV1/FVC% ratio.

4. Peak expiratory flow rates at various levels of VC/FVC,

A FEF 25-75%

B FEF 25%

C FEF 50-75%

Table 1: Occupational dust concentration in different processes of carpet industry.

Process (N)	Total dust concentration (mg/m^3)	
	Range	Mean
Wool yarn sorting (3)	0.63-1.70	1.01
Wool yarn reeling (3)	0.33-0.95	0.61
Tana making (3)	0.93-1.83	1.38
Cotton yarn reeling (3)	0.55-1.25	0.90
Cotton cloth weaving (3)	1.28-4.03	2.84
Tibbati carpet weaving (4)	1.28-5.31	3.48
Tufted carpet weaving (4)	0.91-2.40	1.59
Knotted gabeh carpet weaving (3)	0.55-1.20	0.94
Carpet finishing (4)	4.03-11.25	6.86
N = Total number of processing units		

Results

Occupational dust concentration

Data on dust levels at work places in different processing units have been pooled in Table 1. Before dyeing of wool yarn, it is sorted out to make chains [13-15]. This process generates dust, which was sampled from three such wool yarn-sorting sections, which registered concentrations 0.63-1.70 mg/m^3 (mean concentration 1.01 mg/m^3) [16]. These dust samples were viewed under the microscope and found to be predominantly wool fibers. Similarly, wool yarn reeling produced a mean dust concentration of 0.61 mg/m3 [17]. Tana making units produced dust concentration ranging from 0.93-1.83 mg/m^3 (mean 1.38 mg/m^3) [18]. Cotton yarn reeling and cotton cloth weaving units were found with mean dust concentrations of 0.90 mg/m^3 and 2.84 mg/m^3, respectively [19,20]. Microscopic analysis showed that dust samples predominantly contained cotton fibers in the samples collected from Tana making, cotton yarn reeling and cotton cloth weaving units [21]. Mean dust concentration in carpet weaving units were 3.48 mg/m^3, 1.59 mg/m^3, and 0.94 mg/m^3 in Tibbati, Tufted and Knotted Gabeh types of carpet, respectively. Dust samples collected from the carpet weaving units were found to have mixtures of wool and cotton fibers. Dust samples were collected from four units involved in finishing carpets and a mean concentration of 6.86 mg/m^3 was recorded [22]. These samples predominantly contained wool fibers along with traces of cotton fibers (Table 1).

Prevalence of respiratory symptoms

For the purpose of lung function spirometry, the carpet workers included were wool yarn dyers (N=43), carpet weavers (N=145), carpet washers (N=36) and carpet finishers (N=50) alongwith controls (N=54). Data on the age and the height of exposed workers and controls have been shown in Table 2. It may be noted that these sub-occupational groups of subjects matched with controls with respect to age and height [23,24]. Smoking habit is another important co-factor related to lung function, therefore, recorded the prevalence of smoking among the carpet workers and the controls (Table 2). Most of the carpet workers were moderate cigarette smokers [25]. The prevalence of smoking was found to be minimum in the carpet washers (22.2%) and the maximum was noted among the wool yarn dyers (48.8%) [26]. The mean exposure period in different occupational sub-groups is also shown in Table 2. Respiratory symptoms such as wheezing, chest tightness, shortness of breath, cough etc., were scored as per British Medical Respiratory Questionnaire. The prevalence of the respiratory symptoms in workers of key occupational processes in the carpet industry is illustrated in Table 3. Among the various sub-groups, the prevalence of the respiratory symptoms ranged from 20.0% to 41.8%. The overall prevalence of respiratory symptoms was found to be 31.4% ($p<0.01$) in occupationally exposed carpet workers in comparison to 7.4% in control population [27]. Respiratory symptoms were significantly

Table 2: Demographic and occupational histories of workers in different units of carpet industry.

Sub-groups (N)	Age (years)	Height (cms)	Smoking Prevalence		Exposure (years) *
			N	%	
Wool Yarn dyers (43)	30.2 ± 8.4	163.7 ± 3.1	21	48.8	10.02 ± 7.38
Carpet weavers (145)	28.0 ± 7.9	162.9 ± 3.1	60	41.4	9.67 ± 8.29
Carpet washers (36)	30.5 ± 8.52	163.8 ± 2.2	8	22.2	5.11 ± 2.78
Carpet finishers (50)	28.0 ± 6.09	163.2 ± 2.5	17	34.0	7.22 ± 4.05
Controls (54)	32.6 ± 9.6	162.5 ± 2.6	22	40.7	
N = Total number of subjects n = Number of smoking subjects	% = Percent of smoking subjects * = Years of occupational exposure				

Table 3: Smoking wise and exposure wise prevalence of respiratory symptoms in workers of different units in carpet industry.

Sub-group (N) n		Respiratory %	Symptoms
Wool yarn dyers	(43)	18	41.8*
Carpet weavers	(145)	40	27.6*
Carpet washers	(36)	13	36.1*
Carpet finishers	(50)	10	20.0*
Total workers	(274)	81	31.4*
Controls	(54)	4	7.4
Non-smokers	(200)	28	14.0
Smokers	(128)	57	44.5*
<10 Years exposure	(186)	31	16.7
>10 Years exposure	(88)	50	56.8*

N = Total number of subjects
n = Number of subjects with respiratory symptoms
% = Percent of subjects with respiratory symptoms
* = Statistically significant

Table 4: Mean values of lung function of workers in different units of carpet industry.

Sub-group (N)	VC (ml)	FVC (ml)	FEVI (ml)	FEVI/FVC %
Wool yarn dyers (43)	3319 ± 393	3159 ± 339	2561 ± 433*	77.8 ± 8.6*
Carpet weavers (145)	3365 ± 272	3333 ± 295	2726 ± 334*	80.4 ± 7.9*
Carpet washers (36)	3380 ± 252	3361 ± 225	2712 ± 381*	78.5 ± 8.6*
Carpet finisher's (50)	3414 ± 279	3395 ± 239	2854 ± 329	82.0 ± 7.7
Controls (54)	3566 ± 366	3686 ± 367	2964 ± 329	83.4 ± 11.7

Values are means ± S.E. N = Total number of subjects * = Statistically significant

Table 5: Mean value of pulmonary flow rates of workers in different units of carpet industry.

Sub-groups (N)	MMEF (L/S)	FEF 25%	(L/S) FEF 50%	(L/S) FEF 75% (L/S)
Wool yarn dyers (43)	2.95 ± 0.41	3.21 ± 1.28	2.31 ± 0.85	1.75 ± 0.60
Carpet weavers (145)	2.97 ± 0.70	3.32 ± 1.18	2.25 ± 0.88	1.88 ± 0.58
Carpet washers (36)	2.95 ± 0.41	3.02 ± 0.56	2.52 ± 0.45	2.17 ± 0.58
Carpet finishers (50)	3.06 ± 0.59	3.28 ± 0.94	2.62 ± 0.62	2.16 ± 0.60
Controls (54)	3.09 ± 0.78	3.57 ± 0.98	2.98 ± 0.67	2.39 ± 0.63

Values are means ± S. E. N = Total number of subjects

Table 6: Mean values of various lung functions and flow rates in relation to smoking and Occupational exposure in carpet workers and controls.

Variables	Non – smokers (N = 200)	Smokers (N = 128)	<10 Years (N = 186)	>10 Years (N = 88)
VC (ml)	3387 ± 300	3355 ± 312	3403 ± 268	3319 ± 328
FVC (ml)	3356 ± 287	3317 ± 320	3368 ± 272	3319 ± 306
FEVI 1.0 (ml)	2828 ± 333	2650 ± 387*	2861 ± 304	2569 ± 406*
FEV 1.0%	82.2 ± 7.0	77.9 ± 10.6*	81.8 ± 6.5	76.2 ± 9.62*
MMEF (L/S)	3.10 ± 0.65	2.80 ± 0.66*	3.12 ± 0.58	2.68 ± 0.65*
FEF 25% (L/S)	3.52 ± 1.20	2.74 ± 0.91*	3.44 ± 1.13	2.84 ± 0.85*
FEF 50% (L/S)	2.75 ± 0.75	2.27 ± 0.73*	2.67 ± 0.76	2.19 ± 0.73*
FEF 75% (L/S)	2.12 ± 0.59	1.84 ± 0.61*	2.06 ± 0.63	1.69 ± 0.50*

N = Total number of exposed workers Values are means ± S.E. * = Statistical significant

higher in smoking subjects (44.5%, $p<0.01$) as compared with non-smoking subjects (14.0%) (Table3). Period of occupational exposure in carpet workers has been found directly related with the prevalence of respiratory symptoms. Carpet workers with <10 years exposure showed 16.7% respiratory symptoms and those with >10 years showed 56.8% (Table 3). Respiratory parameters of different suboccupational groups in carpet industry and control are shown in Table 4. There is no statistically significant difference among various groups with respect to their VC and FVC. In case of FEV 1.0, the mean observed values were significantly reduced in the dyers, washers and weavers as compared to that Table 2,3 values recorded in the reference group [28].

The mean lung function values recorded in the non-smokers and the smokers among the study populations are shown in Table 6. The mean observed value of VC and FVC did not differ significantly between the smoking and non-smoking workers. However FEV1, FEV1% ratio and the various flow rates declined significantly among the smokers as compared to non-smokers. Mean values of FEF were significantly reduced among the smokers in comparison to those noted among the non-smokers. To study the pulmonary effects of exposure, the carpet workers were divided into two exposure groups (i.e. <10 years and >10 years). The mean values of VC and FVC were unaffected with respect to duration of exposure (Table 6). However, other respiratory variables

Table 7: Pulmonary impairment in relation to smoking and occupational exposure in workers of different units in carpet industry.

Sub-groups (N)	Restrictive		Obstructive		Mixed		Total	
	n	%	n	%	n	%	n	%
Wool yarn dyers (43)	1	2.3	8	18.6	–	–	9	20.9
Carpet weavers (145)	16	11.0	18	12.4	2	1.4	36	24.8
Carpet washers (36)	2	5.5	6	6.0	2	5.2	10	27.7
Carpet finishers (50)	2	4.0	3	6.0	1	2.0	6	12.0
Total workers (274)	21	7.7	35	12.8	5	1.8	61	22.3
Controls (54)	4	7.4	–	–	1	1.8	5	9.3
Smokers (128)	7	5.5	23	18.0	4	3.1	34	26.6
Non-smokers (200)	14	7.0	12	6.0	1	0.5	27	13.5
<10 years exposed (186)	13	6.9	11	5.9	3	1.6	27	14.4
>10 years exposed (88)	8	9.1	24	27.3	2	2.3	34	38.6

N = Total number of subjects
n = Number of subjects with respiratory impairment
% = Percent of subjects with respiratory impairment

such as FEV1, FEV1% ratio and the various flow rates reduced significantly in the >10 year exposure group compared to <10 year exposure group [29].

Prevalence of pulmonary abnormalities

The prevalence and the type of pulmonary impairment observed among the carpet workers and the controls are shown in Table 7. The overall prevalence of respiratory impairment was found to be 22.3% ($p<0.01$) in exposed workers in comparison to 9.3% recorded among the controls. The high prevalence was solely due to bronchial obstruction recorded in the carpet workers. The occupational prevalence of respiratory impairment indicates the highest prevalence in the carpet washers (27.7%) recorded in the unexposed controls. These findings are further supported by the reduction observed in FE VI/FVC% ratio in case of dyers, washers and weavers compared to the respective mean value observed in the unexposed controls. The mean value of various flow rates in the carpet workers and the controls are shown in Table 5. The mean observed values of FEF 25%, FEF 50% and FEF 75% were reduced in all groups of carpet workers as compared with mean (Table 4-6) followed by weavers (24.8%) whereas the carpet finishers showed the minimum prevalence of pulmonary impairment (12.0%). The carpet workers predominantly indicated bronchial obstruction of small and central airways (12.8%) followed by restrictive pattern of pulmonary impairment in 7.7% cases while in the unexposed control there was no case of bronchial obstruction observed. Most of the control case suffered from lung restriction (7.4%). The pattern of mixed ventilatory defect was similar in magnitude between the exposed workers and the controls. Among the different sub-occupational groups, dyers were maximally affected from bronchial obstruction (18.6%) while weavers exhibited maximum cases of lung restriction (11.0%). The cases of mixed ventilatory defect were maximally recorded in the carpet washers. The prevalence of pulmonary impairment in relation to smoking habit is also shown in Table 7. The prevalence of respiratory functional abnormalities were found to be significantly higher ($p<0.01$) in the smoking workers as compared to that observed in non-smoking workers (26.6% *Vs* 13.5%). This is because of obstructive impairment, which was 3 times higher among the smokers than that noted in non-smokers (18.0% *Vs* 6.0%). The prevalence of pulmonary impairment in relation to duration of occupational exposure in the carpet workers is also shown in Table 7. The effect of exposure was seen in two groups; those exposed for <10 years and those exposed for >10 years. The overall prevalence of respiratory impairment was found to be significantly higher ($p<0.01$) among those exposed for >10 years (Table 7) than those exposed for <10 years (38.6% *Vs* 14.4%). However, the prevalence of restrictive and mixed ventilatory impairment was found to be insignificant between the two exposure groups. The cases of bronchial obstruction were almost five times higher in >10 years exposed group when compared to <10 years exposure group (27.3% *Vs* 5.9%).

Discussion

Carpet industry involves different sub-occupations, which are performed in distinct processing units necessary in the manufacture of finished carpets. It was also evident that occupationally generated dust poses potential risk to the health of industrial workers in various processing units. Air dust concentrations at these sub-occupational places were monitored. It was observed that similar type of units registered wide ranging dust concentrations (Table 1). For example, dust concentration ranges were 1.28-5.31 mg/m^3 and 4.03-11.25 mg/m^3 in Tibbati carpet weaving units and carpet finishing units, respectively. The apparent reasons for such a wide variation in dust concentrations in similar type of processing units include the quantum of work, work place area and the state of ventilation. The status of these units were unorganized, cottage and small scale. These units were found without any provision of dust control measures. Microscopically observations on the type of fibers in dust samples collected from these units showed that some were rich in wool fibers or cotton fibers whereas others a mixture of both. Wool yarn undergoes a series of chemical and dye treatments as per the color requirement. Wool fibers in dust samples collected from the carpet weaving and carpet finishing units have shown a variety of colors. It is likely that inhalation to occupational dust would lead respiratory exposure to multi-dye chemicals. In view of the industrial hygiene scenario in carpet industry, lung spirometric studies were conducted on some key cohorts namely, wool yarn dyers, carpet weavers, carpet washers and carpet finishers. Wool yarn dyers showed respiratory symptoms to the tune of 41.8% followed by carpet washers (36.1%), carpet weavers (27.6%) and carpet finishers (20.0%). This may be due to differential nature of occupational exposure e.g. a dyer and washers are predominantly exposed with a variety of chemicals. Carpet weavers and carpet finishers are primarily exposed to dust containing fibers of wool and cotton. On the contrary, dust concentration was higher in carpet finishing unit as compared with carpet weaving unit. This could be attributed to the removal of excessive chemicals and dyes due to washing from the wool yarn used in the carpet. If this holds true, it also explains the reason of higher degree of respiratory symptoms in wool yarn dyers as compared with other cohorts. Key ingredients used in the manufacture of carpet are known to be hazardous such as

cotton6-15, wool16-21, dyes22-28, dye-based chemicals and washing chemicals29-33. There are no systematic studies related to industrial hygiene and pulmonary hazards in key processing units of carpet industry thereby, making it difficult for comparison with the present data. Other parameters on lung function, therefore, could be viewed in the light of differential nature of exposure explained above. Smoking has been established as an important predisposing condition affecting the lung physiology34-36, therefore, study subjects were compared on the basis of smoking habit too. Smoking habit showed a clear impact on respiratory symptoms (Table 3). Occupational period of workers in different processes has shown a direct correlation with the degree of respiratory symptoms. Such type of observation appears a common phenomenon in occupational toxicity and has been largely recorded in matching industries such as cotton textiles and woolen textiles10-12. Significant reduction of FEV1.0 in wool yarn dyers, carpet washers and carpet weavers as compared with controls, indicated obstructive type of ventilatory abnormalities (Table 6). Reduced FEV1.0 has earlier been reported due to exposure of cotton dust12-13 and wool dust27, 28, 31, 33. Mean observed values of VC and FVC in carpet workers were significantly lower as compared with predicted values, thereby, showed effects of occupational exposure. Various flow rates (FEF25%, FEF50% and FEF75%) were reduced in all the exposed subjects, being higher in wool yarn dyers, thereby, showed maximum effect on peripheral airways obstruction (PAO) in wool yarn dyers (Table 6). Dyers are exposed to a variety of chemicals such as acids, alkalis, detergents and dyes that are reported to cause pulmonary impairment. Data also suggest that PAO is just the beginning of the early effects of dyes, dye-based chemicals, cotton and wool fibers on the lung airways preceding central airway obstruction (CAO). All sub-groups of carpet workers suffered with various profiles of restrictive, totalling 22.3% *Vs* 9.3% (Table 7). However, bronchial obstruction was the predominant pulmonary abnormality in sub-occupational cohorts, especially wool yarn dyers and carpet weavers. Carpet workers are generally exposed to organic dust, which is known to cause respiratory morbidity38-42. Direct correlation between the occupational period and the pulmonary abnormalities suggests that ventilator impairments are related with length and nature of the exposure such as cotton dust, wool dust, mixed dust and a variety of dyes, dye-based chemicals and detergents used in various key processes in carpet industry.

Conclusion

Carpet industry involves distinct sub-occupations; therefore it was of interest to monitor dust in these processing units. Nine kinds of sub-occupational units registered different dust concentrations ranging from 0.61 to 6.84 mg/m^3. Even similar type of units showed different concentrations and effective factors include the state of ventilation, area and quantum of work. Dust samples contained fibers either of cotton, wool or a mixture of both. Generally, 40-60% fibers had length <10 um in the air samples collected from work places of these units. The study demonstrated significant association between pulmonary function abnormalities and certain occupations in the carpet industry thereby suggesting that occupational exposure to cotton and wool dust and multiple dye chemicals lead to pulmonary impairment particularly of restrictive and mixed type.

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