Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI: 10.21474/IJAR01/5636
DOI URL: http://dx.doi.org/10.21474/IJAR01/5636

RESEARCH ARTICLE

EVALUATION OF PULMONARY FUNCTION IN A COMPOSITE TEXTILE PROCESSING UNIT IN PUNJAB (PAKISTAN).

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Manuscript Info

Manuscript History

Received: 16 August 2017
Final Accepted: 18 September 2017
Published: October 2017

Key words:-
Cotton Dust Exposure, $PM_{2.5}$, Pulmonary function, Respiratory ailment, Prevalence.

Abstract

This study explores the occurrence of chronic respiratory symptoms of exposure to cotton dust and $PM_{2.5}$ in the composite textile processing unit. Self-reported chronic respiratory symptoms and spirometric pulmonary function were measured in a cross sectional study among 303 textile processing employees. A detailed study of exposure to cotton dust and $PM_{2.5}$ had been carried out. Relations between exposure concentrations and respiratory health variables were investigated with the help of statistical tools and relationship among the factors was determined by performing linear regression analysis and correlation analysis. Evident relations between present exposure indices and respiratory pulmonary function in the entire study were found to be effective. Workers employed less than 5 years did not show any prevalence of respiratory symptoms and lower lung function than workers employed for more than 5 years. After stratification for duration of employment, negative effects of cotton dust on lung function among workers employed ≥ 5 years were observed. This study shows respiratory ailment in worker's health due to cotton dust and $PM_{2.5}$ working in textile processing unit. Workers were more prone where high concentration of cotton dust is observed.

Introduction:-

Over 60 million people are employed in the textile or clothing industry throughout the globe and for centuries, cotton dust has been associated with different disease states mostly involving lungs. Cotton dust is generated in variable concentrations throughout the various processes being undertaken in the textile industry and worker are exposed to airborne dust generating from natural and synthetic fibrous materials (cf. Nafees et al. (2013; The Economic Survey (2012-13)). Several studies have found an association between occupational exposure to dust, gases and fumes and respiratory health and the same studies have proved a prevalence of respiratory symptoms of 16%-46% (cf. Hedlund et al. (2008; Richerson (1990)). Chronic obstructive pulmonary disease (COPD) is a diverse group of lung disorders which is characterized by airflow obstruction and impede normal respiration. Literature presenting COPD disability, the total cost of COPD in developed countries is estimated at 5 to 25 billion US dollars (cf. Cui et al. (2011)). It is a serious morbidity and has emerged as a leading cause of death worldwide and

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according to World Health Organization, COPD will become the third leading cause of death, illness and disability worldwide by 2030 (see Würtz et al. (2014)).

According to Kennedy et al. (1987) tobacco smoking is the leading factor in the etiology of COPD with other factors such as inhalation of different gases and aerosols. Several studies have found an association between occupational exposure to dust, gases, and fumes and respiratory health with respect to chronic cough, chronic phlegm, persistent wheeze, breathlessness, asthma, chronic bronchitis, or chronic obstructive pulmonary disease (cf. Donham and Thorne (1994; Dutkiewicz (1994; Hollander et al. (1994; Zock et al. (1998)). According Würtz et al. (2014) the inhalation of these gases and particulates may initiate local inflammatory processes in the airways and lungs. Health effects on textile workers is rarely discussed and underestimated subject in society comparatively. The workers spend maximum time at their workplace during duty hours and are exposed to indoor dirty/noisy climate prevailing in the workplace (see Lai and Christiani (2013; Zock et al. (1995)). Working conditions in Pakistan and other developing countries are almost same; following erstwhile researches it is considered that COPD may highly be injurious disease among textile employees in Pakistan as well.

In above mentioned context some studies were carried out in Karachi, Pakistan to discuss burden of respiratory problems among textile worker but more detailed studies are required in Punjab, Pakistan such as Nafees et al. (2013; Tanzil and Nafees (2015)). So the aim of this cross sectional study was to describe chronic respiratory symptoms and lung function impairment, and their relations with socio-demographic factors, exposure to cotton dust and $PM_{2.5}$ in a composite textile processing unit in the Punjab.

Subjects and methods:-

This study comprises on 391 male and female workers having age 19 to 57 years selected with the help of stratified random sampling from one composite plant of a large textile processing group. Strata were constructed on the basis of factory sections due to variant dust and fumes concentrations. The workers who had work experience of one year were enrolled for trail and selected for the study from the list of attendance log maintained in the factory. The unit understudy is characterized by yarn manufacturing, dyeing, weaving, garment processing and sewing. Forty four workers (11.3%) could not join due to leaves, absenteeism and other unknown reasons. Among remaining 347 eligible employees thirty seven (88.7%) refused to participate, 3 (0.8%) had incomplete data were excluded and finally 303 subjects (participation rate 77.5%) participated in study. The subjects from Finishing, Mechanical Workshop, Sewing, Quality Control, Weaving, Card, Blow room, Washing, Rescreening, Trimming, Local Abrasion, Lazer, Scrapping, Spray, Grinding, Sizing, Store room, Ring, Rebeaming, Simplex, Dyeing, Chemical laboratory and Auto-cone were interviewed face to face. Mainly workers from sewing section constitute 29 percent of the sample while 19 percent from weaving and rest were from spinning and others sections of the unit. Total cotton dust, $PM_{2.5}$ measurement and lung function were performed in the facility from August 2015 to November 2015.

A modified version of questionnaire of the National Institute of Occupational Safety and Health (NIOSH) on occupational history of the workers in textile processing was administered. The questionnaire, initially used in English as part of epidemiological studies in the USA and other countries with questions for upper and lower respiratory tract, was directly translated into local language (Urdu). Blind reverse translation was performed by different translators and reviewed by the original investigator (hygienist) to verify accuracy of translation. Baseline socio-demographic questions were incorporated to determine age, sex, race, education, marital status, job security, insurance, number of persons at residential facility, cooking facilities, housing facilities, present and past work history, smoking and tobacco chewing habits and past respiratory and allergy symptoms. The administered questionnaire was pretested before use in the study by trained and experienced team of technicians and it took around 15 minutes on the average to complete. A written consent was sought from each subject in coordination with the management committee of the enterprise.

Lung Function:-

Pulmonary function test of the subjects in standing position were carried out with a handy portable Vitalograph's spirometer 2120 in accordance with American Thoracic Society criteria (cf. Landrigan et al. (2003)). A minimum of three satisfactory forced expiratory maneuvers was required of each subject without nose clip except for one subject and subjects who could not perform at least two times technically acceptable maneuvers after eight attempts were excluded from the trial. A satisfactory test required that the forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) of two maneuvers was reproducible within 5%(see Broder et al. (1985; Quanjer et al.

(1993)). The subjects who showed obstructive pattern on lung function were given a dose of bronchodilator and subjects were re-trialed after 15-20 minutes. Non-smokers were defined as those who had never smoked, smokers were currently smoking at least one cigarette a day during one year, ex-smokers were those who had smoked regularly but gave it up at least twelve months prior to the study. The subjects were requested to refrain from smoking at least one hour before carrying out the spirometric tests.

Personal Cotton Dust Exposure Sampling:-

A batch of eight to nine portable Gilian Hi-Flow Air Sampler HFS 513 pumps were attached to the worker's belt and the samplers head assembly to the lapel of their shirt from the operator's face to the right, the left or back depending on wherever the subject felt easy in their breathing zone to get total dust mass in the facility. The air flow rate of each pump was set at rate of 1.7-2.0 L/min and PVC samples were set in the breathing zone of the worker i.e. around at 5 feet high from the floor. The pump flow rate was checked periodically with a portable flow meter before and after each sampling activity and, if required, re-calibration was done. A digital lab stopwatch was used to check and record the time of flow (see Magagnotti et al. (2013)).

Gravimetric Concentration Measurement:-

Mettler AE 240-S (Mettler-Toledo Inc., Columbus, OH) analytical balance with sensitivity of 10 μg, located in a dust-free laboratory with ideal temperature and relative humidity set conditions, was used for weighing. Before the tests, filters were weighed in a laboratory and the tare samples were properly labelled for identification in a sampling container. The filters were weighed before and after sampling. The filter samples were placed into a three piece sampling cassettes assembly with the help of forceps to avoid any contamination. The subjects were advised to restrict to workstations and their neighborhoods during the sampling activity. The total dust samples were collected using 37 mm polyvinyl chloride filters with a 5 µm pore size (SKC Inc.) mounted in sampling heads. At the end of the tests, the filters were sent to the laboratory for post sampling weighing with the same scale.

The dust loaded samples were equilibrated in a desiccator for more than 2 hours prior to weighing. Three blank samples (control) were also weighed together with the filters to correct the weight of field samples(cf. Biersteker and Dijk van WH (1974; Smid et al. (1992)) and concentration of dust was calculated by dividing the mass collected on the filters by the volume of sampled air and weight of the filters was corrected by average weight of the field blanks. Finally, the concentration of cotton dust was measured using the formula as mentioned below

$C = (W_2 - W_1) - B/V$

Where C represents cotton dust concentration (mg/m^3), W_2 is post-test weight of the filter in mg; W_1 is the tare weight of the filter (mg); B is weight of blank samples; V is volume of air (m^3) which was calculated as $V = T \times F/1000$, (in this equation T is duration of the sample in minutes and F is the flow of air (L/min)). The duration of each sampling session varied from 5 to 8 hours in different sections of the facility under study.

$PM_{2.5}$ measurement:-

Workers in the textile industry are vulnerable to exposure to different respiratory, skin and chronic diseases by inhaling $PM_{2.5}$ at workplace. In this study measurement of particulate matter (PM) aerodynamic arrangement of 2.5 µ fraction were performed using a portable direct-reading equipment TSI DustTrak, Model 8520 (TSI Inc., Shoreview, MN USA)(cf. McNamara et al. (2011; Richerson (1990)). The instrument was zeroed before each sampling and mounted on indigenously fabricated tripod in the breathing zone just near each workstation for a working shift.

The emissions of particulate matter ($PM_{2.5}$) and other organic agents along with some factors are sources of pollution. $PM_{2.5}$ have respiratory and cardiac disorders hence more attention is being paid to the exposure assessment of $PM_{2.5}$ and its detrimental effects (see Chow et al. (1994; Goldberg et al. (2001; Janssen et al. (2002; Müller (1999)).

Statistical methods:-

Lung function values of the parameters such as FVC, FEV_1 and FEV_1/FVC ratio of randomly selected workers were obtained to evaluate their lung capacity. Obtained data was continuous and categorical in nature and analyzed with the help of Statistical Package for Social Sciences V.22.0 (SPSS Inc, Chicago, Illinois, USA) and R language.

Descriptive analysis based on frequencies for categorical variables, whereas for continuous variables mean and median are used to measure lungs capacity. Inferential portion of the study was carried out to compare the lung function with its predicted and different concentrations of cotton dust and $PM_{2.5}$. Shapiro-Wilk test was applied to test normality of the variables, a non-parametric Mann-Whitney test to compare measured versus predicted values and Analysis of Variance is used to compare lungs capacity of different workers on different concentrations of cotton dust and $PM_{2.5}$. Pearson correlation and Linear Regression analysis is used to determine linear relationship among different factors affecting lung capacity. For this study, we defined chronic cough or phlegm as the subjects having for 3 consecutive months for two years. Wheezing was explained as whistling sound from chest for 2 years while chronic bronchitis was considered as chronic cough and phlegm both.

Pulmonary function interpretation (consisted of percentage-predicted values) in categorizing the worker normal, obstructive, restrictive and mixed, the successive techniques were appliedNafees et al. (2013).We took lung function indices $FEV_1/FVC>0.7$ and FVC greater than 80% of predicted for normal, $FEV_1/FVC<0.7$ and FVC less than 80% of predicted for obstructive, $FEV_1/FVC>0.7$, FEV_1 and FVC<80% predicted for restrictive and combination of later both i.e. obstructive and restrictive pattern of disease after bronchodilator treatment to the subjects. COPD was defined in accordance with Global Initiative for chronic Obstructive Lung Disease (GOLD) Gerald and Bailey (2002).

Results:-

Among the considered 303 workers (23.4% female and 76.6% male) with average age 29.55 ± 7.59 years having height (cm) and weight (kg) 164.12 ± 11.32 and 62.08 ± 14.57 respectively. Table-1 presents the frequency distribution of the respondents with socio-demographic, anthropometrical measurements, life style and occupational factors of textile unit employees. The education level has significant impact on the health of an individual if person is aware from the workplace problem then the subject will be able to survive from workplace ailmentNafees et al. (2013). So in this study 231 (76%) workers had completed middle class and matric level whereas 34 (11.2%) were graduate and four (1.3%) completed their master.

Table 1:- Frequency distribution of Socio demographic, anthropometric, lifestyle and occupational factors of textile workers (n=303)

Variables		Frequency	Percent	Variables		Frequency	Percent
Gender	Female	71	23.4	Cough	Yes	43	14.2
	Male	232	76.6		No	260	85.8
Education	Primary	16	5.3	Phlegm	Yes	61	20.1
	Middle	125	41.3		No	242	79.9
	Matric	106	35.0	Pneumonia	Yes	13	4.3
	Intermediate	34	11.2		No	289	95.7
	Bachelor	18	5.9	Smoking*	Yes	75	24.8
	Master	4	1.3		No	228	75.2
Religion	Islam	296	97.7	Chronic Bronchitis	Yes	20	6.6
	Christian	7	2.3		No	283	93.4
Ethnicity	Punjabi	300	99.0	Emphysema	Yes	5	1.7
	Pakhtoon	2	.7		No	298	98.3
	Kashmiri	1	.3	Asthma	Yes	16	5.3
Marital	Single	131	43.2		No	287	94.7
	Married	169	55.8	Lung cancer	Yes	7	2.3
	Divorced	3	1.0		No	296	97.7

*Significant at $\alpha = 0.05$

The major study participants were Punjabi (99%) from Muslim community. Among these workers 14.2 percent having cough and 20 percent had phlegm. As far concerned with their past history 4 percent had problem of pneumonia, 6.6 % chronic bronchitis, 1.7 percent emphysema, 5.3 percent asthma and 2.3 percent lung cancer. It has been observed that 24.8% were smoker and 75.2 percent were non-smoker. Among these subjects 55.8 percent were married, 43.2 percent were single and three divorced with average monthly income 10335 ± 841 Pak rupees (cf. Table:1).

Table 2:- Section-wide pulmonary function, cotton dust (mg/m^3) and $PM_{2.5}$ (mg/m^3) concentration with work experience

Section	Median			Mean						No. of participants
	$FVC\%$	$FEV_1\%$	$\frac{FEV_1}{FVC}$ Measured	$FVC\%$	$FEV_1\%$	$\frac{FEV_1}{FVC}$ Measured	Dust	$PM_{2.5}$	Experience (years)	
Finishing	77.87	82.74	0.87	78.35	84.10	0.87	0.35	0.59	9.50	4
Mechanical Workshop	59.20	61.57	0.78	64.51	63.42	0.75	1.19	0.99	7.00	8
Sewing	76.58	75.79	0.80	79.09	75.39	0.79	0.66	0.22	6.10	89
Quality Control	46.73	45.38	0.77	46.73	45.38	0.77	0.63	0.58	18.00	1
Weaving	74.95	72.68	0.79	76.82	72.40	0.79	0.55	0.17	7.75	57
Card	88.88	84.88	0.81	85.83	81.83	0.80	1.12	0.84	4.00	4
Blow Room	88.70	78.32	0.72	88.70	78.32	0.72	5.42	1.78	8.00/	1
Washing	84.29	67.96	0.72	79.74	65.84	0.68	0.96	1.70	6.46	13
Rescreening	80.07	71.11	0.73	78.34	72.51	0.76	0.51	0.07	6.42	12
Trimming	73.09	80.73	0.83	83.61	84.59	0.83	6.21	0.57	2.40	5
Local Abrasion	93.46	98.25	0.83	87.02	82.79	0.78	1.98	1.26	5.00	5
Lazer	75.06	76.72	0.81	77.50	76.39	0.82	1.31	3.08	4.83	6
Scrapping	78.64	74.55	0.79	75.70	71.69	0.79	1.12	1.26	4.65	34
Spray	76.58	73.85	0.79	70.44	68.21	0.78	0.46	0.73	6.00	10
Grinding	73.27	65.70	0.76	84.05	81.82	0.77	1.29	0.89	6.00	4
Sizing	73.95	64.29	0.80	69.13	65.89	0.78	0.65	0.35	7.50	6
Store	68.40	69.67	0.83	68.40	69.67	0.83	0.91	1.21	7.00	1
Ring	92.23	77.73	0.76	92.95	83.15	0.72	1.85	0.73	4.00	7
Rebeaming	89.26	86.31	0.79	88.32	83.42	0.78	0.75	0.34	6.88	8
Simplex	69.65	73.80	0.84	66.29	69.09	0.85	1.46	0.99	9.50	10
Dyeing	94.62	83.50	0.75	90.89	84.76	0.75	0.58	0.45	13.80	5
Chemical Lab	76.32	70.59	0.83	76.32	70.59	0.83	0.72	0.86	2.00	1
Autocone	70.75	71.11	0.81	71.58	67.24	0.78	0.45	0.60	9.08	12
Average	**77.50**	**74.22**	**0.79**	**77.40 ***	**73.84 ***	**0.78**				

*Significant with respect to predicted lung function using Mann-Whitney test.

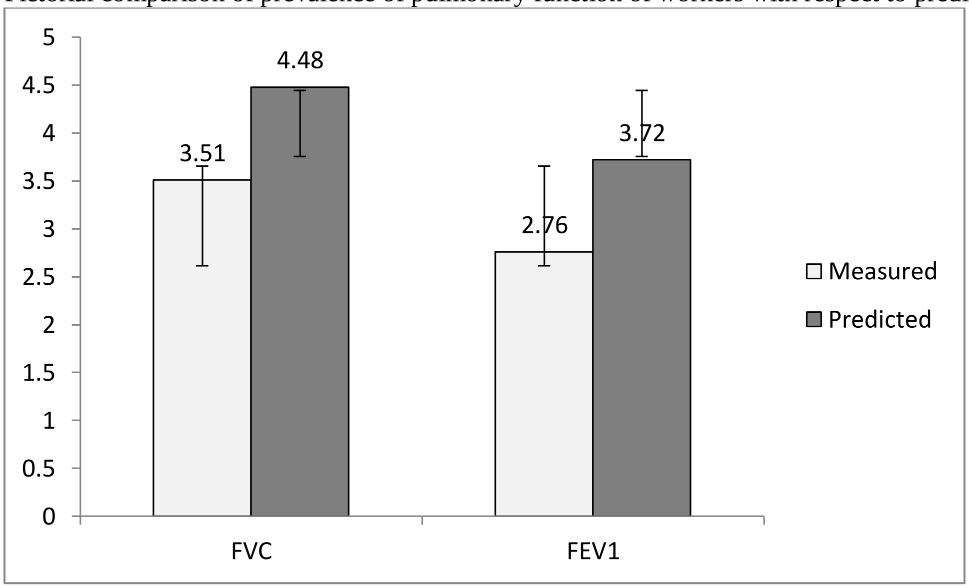
Textile workers are more vulnerable to respiratory illnesses and symptoms due to exposure to cotton dust and $PM_{2.5}$(cf. Nafees et al. (2013), Table: 2).The overall percentage of decrement in FVC and FEV_1 was 22.6% and 26.16 % respectively as presented in table-2. The decrease in lung function parameter is 35% in female, 24.0% in male subjects whereas prevalence with respect to measured value is presented in Figure: 1.

Table 3:- ANOVA table comparing pulmonary function with regard to average cotton dust and $PM_{2.5}$ having 5 or more years of cotton dust and $PM_{2.5}$ exposure

Factors	SOV	Average cotton Dust					$PM_{2.5}$				
		SS	df	MS	F	Sig.	SS	df	MS	F	Sig.
MFVC	Between Groups	30.840	19	1.623	1.710	0.048	31.273	17	1.840	1.991	0.017
	Within Groups	105.373	111	0.949			104.404	113	0.924		
	Total	135.677	130				135.677	130			
$MFEV_1$	Between Groups	19.583	19	1.031	2.145	0.007	20.350	17	1.197	2.573	0.002
	Within Groups	53.331	111	0.480			52.565	113	0.465		
	Total	72.915	130				72.915	130			

To evaluate the prevalence with regard to cotton dust and $PM_{2.5}$, analysis of variance (ANOVA) is applied and results are presented in table: 3. Following significant effect among measured values of FVC and FEV_1 (MFVC and MFVC) leads us in concluding deleterious effects of cotton dust and $PM_{2.5}$ on the health of workers of different sections of the enterprise.

Figure 1:- Pictorial comparison of prevalence of pulmonary function of workers with respect to predicted values



In this study correlation analysis is also used to determine the degree of linear association among different factors affecting pulmonary function. It is observed that age and height were significant factors having important relationship with pulmonary function. Related to objective of study, cotton dust and $PM_{2.5}$ has negative relationship with pulmonary function indicating larger the concentration of cotton dust greater the worker will suffer from chronic issues with increase in work experience. The subjects were selected with work experience of at least one year i.e. not less than 19 year of age as minimum age for employing as worker in Pakistan is 18. The relationship with chronic diseases is observed after confounding work exposure, the workers having 5 or more years work exposure show significant prevalence and it is evident from the study that respiratory symptoms take time to develop (cf. table: 4). Among three hundred three workers, using the schilling criteria cited above 51 (16.8%) had obstructive lung pattern, 69 (23%) subjects with restrictive pattern of pulmonary function, 23 (7.5%) were mixed type while rest of the workers were normal.

Table 4:- Correlation structure of the different pulmonary function with covariates

Correlation Structure		**Age**	**Height**	**weight**	**years worked**	$MFVC$	$MFEV_1$	$\frac{MFEV_1}{MFVC}$	**dust**	$PM_{2.5}$
Age	Pearson Correlation	1	.087	.383**	.753**	-.011	-.084	-.139*	-.108	-.062
	P-Value		.131	.000	.000	.847	.143	.016	.059	.285
Height	Pearson Correlation	.087	1	-.080	.130*	.469**	.443**	-.124*	.051	.011
	P-Value	.131		.164	.024	.000	.000	.030	.380	.851
Weight	Pearson Correlation	.383**	-.080	1	.297**	.143*	.100	-.076	-.031	.015
	P-Value	.000	.164		.000	.013	.081	.184	.595	.791
years worked	Pearson Correlation	.75**	.130*	.297**	1	.074	.000	-.157**	-.145*	-.099
	P-Value	.000	.024	.000		.201	.995	.006	.011	.086
$MFVC$	Pearson Correlation	-.011	.469**	.143*	.074	1	.906**	-.253**	-.095	-.022

	P-Value	.847	.000	.013	.201		.000	.000	.090	.691
$MFEV_1$	Pearson Correlation	-.084	.443**	.100	.000	.906**	1	.106	-.112*	-.023
	P-Value	.143	.000	.081	.995	.000		.065	.022	.695
$\frac{MFEV_1}{\text{MFVC}}$	Pearson Correlation	-.139*	-.124*	-.076	-.157**	-.253**	.106	1	-.022	-.046
	P-Value	.016	.030	.184	.006	.000	.065		.665	.425
Dust	Pearson Correlation	-.108	.051	-.031	-.145*	-.095	-.112*	-.022	1	.307**
	P-Value	.059	.380	.595	.011	.090	.022	.665		.000
$PM_{2.5}$	Pearson Correlation	-.062	.011	.015	-.099	-.022	-.023	-.046	.307**	1
	P-Value	.285	.851	.791	.086	.691	.695	.425	.000	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

A stepwise linear regression approach was adopted with backward elimination to select a suitable model with the help of adjusted R^2 and R^2. From table:5 it had been observed that for dependent variable FVC suitable model with regard to adjusted R^2 is depending upon age and height having 0.47 value of adjusted R^2. On similar lines for determining model for dependent variable FEV_1, suitable model based on all variables except $PM_{2.5}$ which is insignificant and having 0.40 value of adjusted R^2 was selected.

Table 5:- Stepwise regression based on backward elimination for the pulmonary function using independent variables

Dependent Variables											
FVC	**Independent Variables**	***β***	**P. Value**	***β***	**P. Value**	***β***	**P. Value**	***β***	**P. Value**	***β***	**P. Value**
	Intercept	-4.756	0.000	-6.254	0.000	-4.599	0.000	-11.652	0.000	-10.185	0.000
	Height	0.046	0.000	0.054	0.000	0.044	0.000	0.096	0.000	0.083	0.000
	Age	-0.022	0.058	-0.021	0.031	-0.025	0.024	-0.024	0.011		
	Weight	0.022	0.000	0.023	0.000	0.027	0.000				
	AVG dust	-0.206	0.025	-0.157	0.049						
	$PM_{2.5}$	-0.370	0.007								
	Adjusted R^2	0.299		0.340		0.265		**0.472**		0.383	
	R^2	0.323		0.323		0.280		**0.479**		0.387	
FEV_1	Intercept	-7.117	0.000	-3.244	0.000	-3.893	0.000	-6.775	0.000	-7.166	0.000
	Height	0.066	0.000	0.034	0.000	0.040	0.000	0.062	0.000	0.061	0.000
	Age	-0.016	0.037	-0.020	0.016	-0.033	0.000	-0.021	0.004		
	Weight	-	0.039	0.01	0.002	0.01	0.000				

		0.010		3		8			
	AVG dust	-0.111	0.075	-0.173	0.034				
	$PM_{2.5}$	-0.172	0.144						
	Adjusted R^2	**0.406**		0.273		0.280		0.388	0.341
	R^2	**0.426**		0.292		0.295		0.396	0.346

Discussion:-

This study was carried out to explore the prevalence of respiratory problems among textile workers. The frequency of chronic bronchitis and COPD among the workers was found to be 6.6% and 47% respectively. The prevalence of chronic bronchitis is low in comparison to the study carried out by Tanzil and Nafees (2015) in southern part of Pakistan which showed 7.8%. The percentage of COPD among the worker is high in comparison to the study carried out them. This shows high burden of respiratory problems among the population of central Pakistan in comparison to southern parts. High COPD pattern is also seen to be due to age factor.

Those workers with chronic respiratory ailment which had shown significant decline in pulmonary function in comparison to normal worker. We adjusted covariates (confounders) like total cotton dust (dust exposure), $PM_{2.5}$ (exposure), education level, respiratory ailment background of the subjects, duration of work experience ≥5 years except smoking, were main predictors of respiratory symptom among the target textile population of Punjab.

This study is unbiased on the basis of gender which comprised of a group of 71 female, containing 21(29.5%) normal, 12(16.9%) obstructive and 38 (53.5%) restrictive pattern while 135(58.1%) normal, 39 (16.8%) obstructive and 58 (25%) restrictive among male subjects and percentage of normal workers is higher in male in comparison to female group, whereas the percentage of chronic bronchitis is 7% and 12% in female and male respectively with overall prevalence of 11.2%. It was also observed that the rate of chronic bronchitis was higher in female than male which may be due to the fact that most of female worker complained, during trial, about empty abdomen (without breakfast), shortness of sleep and restlessness.

The analysis of data with variables (confounders) i.e. duration of work experience ≥ 5 years show association with COPD in older worker in comparison with younger worker which is in agreement with study conducted by Tanzil and Nafees (2015). It is well established that cigarette smoking is also a key factor in developing COPD in connection with other workplace factors (cf. table: 1). Anyhow this study could not prove any association of smoking with COPD as shown by other studies. This may be due to the fact that major part of the population size is young i.e. less than 30 year of age, had less smoking duration and less working experience in textile unit.

Overall decline in pulmonary function is 26.36% i.e. male (23.77%) and female (34.95%) for FEV_1 which is 23% i.e. 20% (male) and 42.0% (Female) for FVC. This factor was even more pronounced when we categorized worker above and below 40 years. The workers working in dusty areas had more decrement in pulmonary function and chronic bronchitis when compared to those working in less dusty area. Study conducted by Woldeyohannes et al. (1991) showed a prevalence of 23% of chronic bronchitis in Ethiopia is similar to this study as both of the studies were conducted in single unit but our study showed less prevalence of chronic bronchitis in comparison. Further, we measured workplace concentration of total dust and $PM_{2.5}$ in different section of the enterprise. In China, the prevalence of chronic bronchitis is reported to be 9.3% which is higher than this study and it is 6% among worker of Lancashire textile mill as reported by Raza et al. (1999).

We measured total dust containing cotton particles and $PM_{2.5}$ in different sections of the enterprise which was found to be the main predictor of COPD and chronic bronchitis as proved by other studies. This data is from a composite textile unit comprising spinning, weaving, sewing, wet processing, packing, finishing and administrative departments show quite high concentration in its sections. By comparing the worker of weaving and spinning sections of the enterprise it was found that prevalence of COPD among the worker of spinning and weaving sections (67.0% and 70.0% respectively) while chronic bronchitis was less in the former section (3.4%). The reason for high prevalence of chronic bronchitis among weaving worker might be due to dyed staff of fabric which contains dyes and other chemicals affecting lungs capacity. Some of the subjects reported about asthma (5%) during their childhood and we could not find a subject of asthma in the workplace (cf. Tanzil and Nafees (2015) Nafees et al. (2013)).

The strength of this study is that we used modified NIOSH questionnaire which is a normal, well known source of data collection used in a lot of research studies on different sectors of economy around the globe. Moreover, ATS criteria were adopted to perform pulmonary function of the subjects. Textile is backbone of Pakistan earning main chunk of revenue from foreign, this study will show a glimpse of respiratory symptoms among textile worker in Punjab.

There are some limitations to this study which would be considered. This study is cross sectional in nature based on single unit and it was not possible for the researchers to generalize their finding of the respiratory burden in textile sector in the Punjab. As it is discussed earlier, this study could not prove smoking as predictor of lung function and COPD independent of duration of employment. Furthermore, longitudinal research work and large sample size are required to identify respiratory impairment among large textile sector in Pakistan (cf. Eastman et al. (2013)). We tried to perform work environment total dust and $PM_{2.5}$ measurements but the sample size was not large enough to explain the effect of exposure on the pulmonary function of the subjects, so to document qualitative effect of the type and the level of on COPD is underestimated. Healthy workers effect (HWE) has significant effect on pulmonary function in any cross-sectional study. It is common selection bias in workplace exposure studies and its exclusion may hamper the results(cf. Minov et al. (2014)). During the trial, it was noted that the workers were operating without any personal protection which reflect the sluggishness of company management commitment in implementing safety measures.

Conclusion:-

The study designed allowed the researcher for recognition of workers which were exposed to cotton dust and $PM_{2.5}$. This cross sectional study has shown reduced lung function associated with workplace exposure to cotton dust and $PM_{2.5}$. To evaluate the prevalence with regard to cotton dust and $PM_{2.5}$ analysis of variance (ANOVA) is applied. In this study correlation analysis is also used to determine the degree of linear association among different factors affecting lungs functions. Subjects with cough, phlegm, chronic bronchitis and occupation related wheeze had significantly impaired pulmonary function and regression analysis was applied to identify the significant factor affecting the pulmonary function.

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