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Comparing lung function of textile workers with the healthy Pakistani population.

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ORIGINAL ARTICLE

COMPARING LUNG FUNCTION OF TEXTILE WORKERS WITH THE HEALTHY PAKISTANI POPULATION

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Background: The purpose of this study was to compare lung function of textile workers with healthy Pakistani population, compare predicted values based on the European Respiratory Society (ERS) equations with those based on the Pakistani equations, and to develop predictor equations for textile workers in Pakistan. **Methods:** This was a secondary analysis of data from two previous surveys where lung function of textile workers was compared with healthy Pakistani men. Spirometry was performed according to the American Thoracic Society guidelines. Independent sample t-test was used to compare the lung function parameters and multivariate linear regression was used to develop predictor equations. **Results:** There were significant differences in lung function of textile workers (FVC: 4.1 L, FEV_1: 3.3 L and FEV_1/FVC: 0.8) compared to healthy Pakistani men (FVC: 3.9 L, FEV_1: 4.1 L and FEV_1/FVC: 1.04). ERS reference equations tended to under-diagnose abnormal lung function, 16.9 % versus 25.3% ($p<0.01$). Predictor equations for Pakistani textile workers were also developed. **Conclusion:** Lung function of textile workers was significantly reduced compared to healthy population. Use of ERS reference equations for Pakistani textile workers may not provide appropriate interpretation.

Keywords: Textile Industry workers; Spirometry; Lung function prediction equations; European Respiratory Society (ERS) prediction equations; Pakistan

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INTRODUCTION

Spirometry is imperative for assessment of lung function both in clinical and occupational settings. In occupational medicine it is indicated at all the levels of prevention and its uses range from pre-employment assessment or health assessment in surveillance programs to clinical evaluation of symptomatic workers.[1] Though spirometry is important for lung function assessment, quality of test, strict adherence to standardized techniques and correct interpretation of results are prerequisites for its optimal utility, especially in occupational setting.[2]

Interpretation of spirometry results is based on comparison of absolute values of various lung function indices with reference values usually derived from large population surveys.[1,3,4] Some of the important predictors of lung function include; age, sex, height, ethnicity, smoking status, history of respiratory illness and obesity.[5,6] Race and ethnicity are important predictors of lung function and several reference equations are available based on assessment of lung function of different ethnic groups.[7,8] However, where such specific reference values are not available, values derived from other population groups may be used with certain correction factor i.e. 0.88 for non-Caucasian, 0.85 for Africans and 0.94 for Asian Americans when equation for Caucasians is being used.[1,3,9,10] Use of such correction factors may not give accurate interpretation[3,11] and therefore, it is recommended to use reference values derived from the local population.[1,12] The American Thoracic Society recommends reference values derived from the third National Health and Nutrition Examination Survey (NHANES III), 1988–94[13] similarly other set of reference values are used in Europe[14,15]. These reference values are also used for various ethnic groups that includes Asians however, these values are derived from Asian migrants settled in the United States or some European countries which may differ from original Asian residents in terms of socio-economic characteristics, nutritional status, exposure to pollution and other environmental factors[9,16,17]

Occupational safety and health administration (OSHA) guidelines recommend spirometry as part of routine surveillance system for various industries involving hazardous exposures such as; asbestos, cadmium, coke oven emissions, and cotton dust.[18] As is true for the general population, absolute values of workers are also compared with some reference values for interpretation and it is recommended that these reference values should be based on data from the local population in order to ensure correct interpretation. OSHA therefore recommends use of equations derived from NHANES III unless a standard requires use of some other reference equation.[18] For example OSHA cotton dust standard requires use of equations developed by Knudson 1976.[19] It is also recommended to compare a worker's spirometry results consistently with a single set of reference values regardless of type reference values used.[17]

Textile workers, especially in the bale opening, carding, spinning and weaving sections, are exposed to large amount of cotton dust with deleterious effects on their lung function.[20] Textile industry is one of the largest production sectors in Pakistan which contributes to around 8% of the GDP.[21] A large number of workers are employed in various textile mills across the country where there is little protection offered against occupational exposure to cotton dust. Recent studies from Pakistan have shown high burden of respiratory illnesses and lung function impairment among textile workers.[22,23] However, previous studies have used reference equations derived from non-local population. Memon *et al*. developed predictor equations for a representative sample of healthy, non-smoking, urban Pakistani population[24] and these reference equations can be used to interpret lung function of textile workers in Pakistan. To the best of our knowledge, no attempt has been made to compare lung function of textile workers with the predicted values for healthy Pakistani population. Therefore, the purpose of this study was to compare the lung function of the textile workers with the predicted values for healthy Pakistani population; compare predicted values for textile workers based on the European Respiratory Society (ERS) equations with those based on the Pakistani equations; and to develop predictor equations for various lung function parameters of textile workers in Pakistan.

MATERIAL AND METHODS

We used data from a cross sectional survey conducted in textile industries of Karachi in which 372 male textile workers participated.[23] Detailed methods are described elsewhere, however briefly, this study included textile workers from spinning and weaving sections of a total of 15 textile mills, situated in five main industrial areas of Karachi and suburbs. Karachi is the largest city and the economic hub of Pakistan with an estimated population of over 21 million according.[25] The city inhabits various ethnic groups from Pakistan and people from different socio-economic strata. Urdu, which is the national language of Pakistan, is commonly spoken and understood in Karachi. n this survey spirometry was performed by a trained physician using a portable spirometer (Vitalograph New Alpha 6000; Vitalograph Ltd., Buckingham, England) in accordance with the American Thoracic Society standard protocols.[14] Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1) and FEV_1/FVC were recorded in liters as well as predicted percentages based on the ERS equations. Results of three acceptable readings were recorded, and the best of the three readings was used for further analysis.

Interviews were conducted by trained data collectors using the American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A).[26] The questionnaire included section on respiratory symptoms with questions regarding cough, phlegm, wheezing, shortness of breath, other chest and past illnesses and family history. Questions pertaining to chest tightness were added from the respiratory questionnaire of WHO Technical Report Series 684.[27] The questionnaire also included sections on socio-demographic information, smoking and occupational history. Wheezing: whistling sounds from chest (with or without cold)

Shortness of breath grade 1: troubled by shortness of breath, when hurrying on the level or walking up a slight hill (based on ATS guidelines and MRC dyspnea scale).[26,28]

Shortness of breath grade 2: walking slower than persons of the same age, at an ordinary pace on level ground, because of breathlessness (based on ATS guidelines and MRC dyspnea scale).[26,28]

Smoking status: ever smoker implies more than 20 packs of cigarettes in a lifetime or more than 1 cigarette a day for 1 year.

Pack-years of smoking: was calculated using the formula: pack-years of smoking=(cigarettes per day×years of smoking)/20.

Socio-economic Status (SES): calculated as proxy indicator by dividing the monthly household income in Pakistani rupees (Rs) (US$1=90 Rs) by number of household members. The continuous variable was later categorized into quartiles based on monthly household income per household member, where high >Rs: 2553, low=Rs: 1714–2553, lower=Rs: 1157–1714, and least <Rs: 1157.

Abnormal spirometry results: If values of FEV_1, FVC and FEV_1/FVC were <80% of predicted

Analyses were performed on SPSS version 19.0. Student's *t*-test was used to compare absolute values in liters of lung function parameters including, FVC, FEV_1 and FEV_1/FVC ratio, to the predicted values in litters, derived from equation developed for healthy Pakistani men by Memon *et al*.[24] Memon *et al*. developed reference equations from data of 601 male and female participants, who were healthy and non-smoking, belonging to different occupations. In our analysis, values for predicted percentages of lung function parameters based on reference equations of European Respiratory Society (ERS) were compared with values based on the Pakistani reference equations. Predictor equations for lung function parameters were derived through multivariate linear regression after adjusting for age, height, weight, smoking history, duration of work (in years), socioeconomic status and various symptoms as independent variables. A variable was added to the model if its p-value was less than 0.25 in univariate analysis. We developed two types of reference equations; one included variables such as socio-demographic factors, occupation and smoking history, while the other equation included respiratory symptoms in addition to these variables.

RESULTS

There were significant differences in the lung function parameters of textile workers compared to reference values based on equations for healthy Pakistani population where FVC was found to be higher among textile workers, 4.1 L compared to 3.9 L ($p<0.001$). Values for FEV_1 and FEV_1/FVC ratio were found to be significantly lower among textile workers compared to predicted values for Pakistani men, i.e., FEV_1: 3.3 L compared to 4.1 L ($p<0.001$); and FEV_1/FVC ratio: 0.8 compared to 1.04 ($p<0.001$) (Table-1). Predicted percentages of values of FVC, FEV_1 and FEV_1/FVC derived from spirometric reference values based on ERS equations and reference values from predictor equations for healthy Pakistani population were also found to be significantly different (Table 2). Predicted percentages from spirometric reference values were lower for FVC and FEV_1/FVC, while for FEV_1 these were higher compared to values derived from Pakistani reference equations. There was discordance in diagnostic categorization of individuals as proportion of workers found to be having compromised lung function using ERS reference equations were different from the proportion found through Pakistani reference equations for FEV_1 and FEV_1/FVC although difference in proportions was not found to be statistically significant for FVC. Similarly when we defined abnormal lung function as abnormality in any of the parameter and compared two reference values, significant difference were found in diagnosis categories. Spirometric reference values based on ERS equations categorized approximately 17% workers as having abnormal spirometry while values based on the Pakistani equation categorized 25% as having abnormal spirometry ($p<0.01$) (Table 3). Figure 1 shows comparison of predicted values for the textile workers based on ERS equations with those based on Pakistani equations for FVC and FEV_1 with respect to age and height. The predicted values based on Pakistani equations were lower than those based on the ERS equations, although the trend of change for these parameters was similar for values derived from these two sets of equations.

Linear regression analysis found positive correlation of all the lung function parameters with height, while negative correlation was found between age, duration of work and smoking. Table 4 and 5 show two sets of regression equations for FVC, FEV_1 and FEV_1/FVC. Adding respiratory symptoms in the model had greater predictive power than without symptoms. Values of R^2 for predictor equations without symptoms for FVC, FEV_1 and FEV_1/FVC were 0.27, 0.32 and 0.24 respectively compared to 0.42, 0.46 and 0.47 for the equations with symptoms.

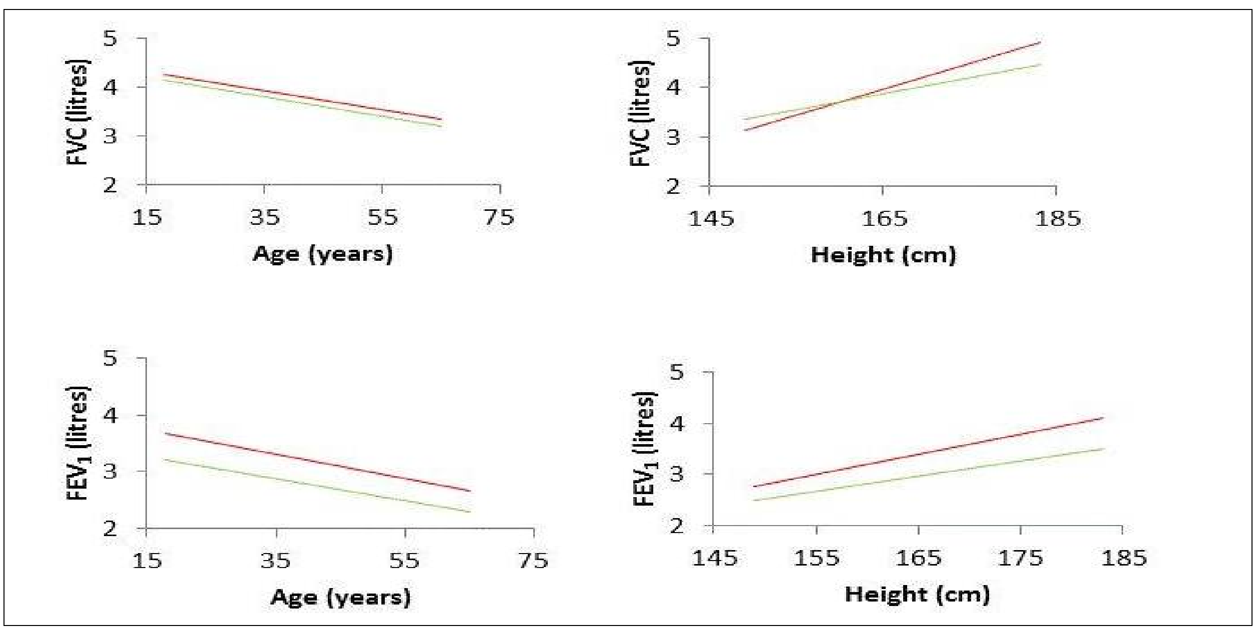

Figure-1: Predicted values of FVC and FEV_1 for age

Table-1: Comparison of lung function parameters of textile workers (n=372) with healthy Pakistani men and height of textile workers using ERS and Pakistani reference equations, Red=ERS reference values and Green=Pakistan reference values

Lung Function Parameters*	Values recorded for textile workers Mean (SD)	Predicted values for healthy Pakistani men[25] Mean (SD)	*p*-value
FVC	4.1 (0.77)	3.9 (0.28)	0.001
FEV_1	3.3 (0.70)	4.1 (0.25)	<0.001
FEV_1/FVC	0.8 (0.09)	1.04 (0.1)	<0.001

*Absolute values in liters. FVC: Forced Vital Capacity, FEV_1 Forced Expiratory Volume in one second.

Table-2: Comparison of percentage predicted values of lung function parameters for textile workers (n=372) based on European Respiratory Society (ERS) reference equations with those based on Pakistani reference equations

Lung function parameter	Percentage predicted values based on ERS reference equations Mean (SD)	Percentage predicted values based on Pakistani reference equations Mean (SD)	*p*-value
FVC	100.48 (±17.5)	103.50 (±18.2)	0.022
FEV_1	94.33(±17.9)	79.92(±17.7)	<0.001
FEV_1/FVC	97.40(±10.4)	104.5(±9.6)	<0.001

Table-3: Comparison of proportion of textile workers (n=372) having compromised* lung function based on values derived through European Respiratory Society (ERS) reference equations with those based on Pakistani reference equations

Individual parameter	Based on ERS reference values %(n)	Based on Pakistani reference values %(n)	*p*-value
FVC	11 (41)	8.3 (31)	0.215
FEV_1	8.1 (30)	24.5 (91)	<0.001
FEV_1/FVC %	7 (26)	0	<0.001
Combined lung function†	16.9 (63)	25.3 (94)	<0.01

*Compromised: FVC and FEV1 <80% and FEV1/FVC <80% of predicted values, †Combined lung function: If any of the parameters; FVC, FEV_1 <80% and FEV_1/FVC is <80% of predicted values

Table-4: Prediction equations for lung function of textile workers

Lung Function Parameter	**Equation**	**R^2 change**	**Standard error**
FVC	[-4.058+(-0.0092x age)+(0.052xheight)+(-0.022x DoW)+(-0.039 x SES)+(-0.008x smoking)]	0.27	0.69
FEV_1	[-2.138+(-0.022x age)+(0.037xheight)+(-0.018x DoW)+(-0.056 x SES)+(-0.001 x smoking)]	0.32	0.61
FEV_1/FVC	[1.063+(-0.004xage)+(-0.001xheight)+(-0.001xDoW)+(-0.007xSES)+(-0.002xsmoking)	0.24	0.08

Height in centimeters, DoW=duration of work, S.E.S=socio-economic status quartiles, Smoking=pack years of smoking=(cigarettes per day×years of smoking)/20.

Table-5: Prediction equations for lung function of textile workers inclusive of respiratory symptoms

Lung Function Parameter	Equation	R^2 change	Standard error
FVC	[-5.93+(-0.031xage)+(0.058xheight)+(-0.012xDoW) +(0.088xS.E.S)+(-0.007xsmoking)+(0.542xSoB)+(-022xwheezing)]	0.42	0.72
FEV_1	[-2.751+(-0.065xage) +(0.043xheight)+(-0.004x DoW)+(-0.01xSES)+(-0.012x smoking)+(-0.35 x SoB)+(-0.038x wheezing)	0.46	0.67
FEV_1/FVC	[0.726+(-0.012xage)+(0.001xheight)+(-0.001xDoW)+(-0.025xSES)+(-0.002 x smoking)+ (-0.029xSoB)+-0.007x wheezing)]	0.47	0.09

Height in centimeters, DoW= duration of work, S.E.S= socio-economic quartiles, Smoking =pack years of smoking = (cigarettes per day×years of smoking)/20.,SoB= Walking slower than persons of the same age, at an ordinary pace on level ground, because of breathlessness. Wheezing= whistling sounds from chest (with or without cold)

DISCUSSION

This study from compared the lung function of textile workers with the general population. We found that the lung function of textile workers was significantly different from the predicted values for healthy Pakistani adult males. Another important finding of our study was discrepancies in interpretation of lung function parameters when using reference values based on ERS equations and reference values based on equations for healthy Pakistani men.

Workers in textile industry are exposed to cotton dust, which is known to be associated with effects on respiratory system such as nasal irritation, sneezing, cough, wheezing and breathlessness, and altered lung function.[29–31] Our study found significant differences in predicted values of FVC, FEV_1 and FEV_1/FVC ratio for textile workers compared to the healthy Pakistani men where textile workers were found to have decreased values for FEV_1 and FEV_1/FVC ratio. This finding is similar to the study conducted on cotton ginners in Pakistan.[22] They found that there was significant decline in FEV_1/FVC ratio in all age groups of cotton ginners ($p<0.05$) compared to healthy individuals. Aminian *et al.* in their study found that respiratory symptoms were higher among the textile workers as compared office workers and there was significant reduction in FEV_1/FVC ratio 80.97 versus 84.05 ($p<0.05$). A study from Nigeria[30] found significant decrements in lung function of workers exposed to cotton dust compared to control group, a finding similar to that of our study. It is postulated that this decline in lung functions is due to inflammation and fibrosis resulting from long term exposure to cotton dust.[32] Interpretation of pulmonary function test may be inappropriate due to the fact that the reference values used for comparison are frequently derived from various studies conducted on different populations, which differ in biological and environmental factors.[4,6,33] Therefore, using equation derived from one population may not be appropriate for another population even after applying correction factors.[3,11] Our study also found discordance in the lung function parameters as percentage of spirometric reference values and values derived from reference equation for local population. This implies that the reference values built in spirometers based on the ERS equation may not be appropriate for our population, especially in occupational settings where a more strict criteria is required than the general population.[34] Another study from Pakistan[35] also found that the values for FEV_1 and FVC were lower by about 13% and 18% in females and 10% and 12% in males, respectively, when compared with those given for Caucasians, a finding similar to our study. We found that interpretation of lung function using reference values from spirometer based on ERS equations and those based on local population differed in terms of the proportion of workers categorized as having abnormal spirometry. Previous studies also found that applying different equations on same population resulted in discordance in the diagnosis.[7,8] A study from India reported that reference equations from different regions of India did not give equivalent results for spirometric interpretation.[11] They compared spirometry records of 27383 patients aged 16–65 years with spirometric values for FVC, FEV_1 and FEV_1/FVC values derived from North, West and South Indian reference equations and found that North and West Indian equations was discordant in 22.1% instances, and the North and South Indian equations in 12.9% instances, with kappa estimates of agreement being 0.626 and 0.781, respectively.[11] Aggarwal *et al*. found that among 6814 subjects reported to have normal spirometry according to Indian references, 53%, 40%, 14%, and 10% of these subjects were identified as having abnormal spirometry according to NHANES III, European standards, Crapo and Knudson equations respectively.[36] A finding which shows wide variations in spirometric interpretation based on local versus international reference values.

We developed spirometric reference equations for textile workers aged 18 and above. Although attempts have been made to develop reference equations for Pakistani population[35,37,38] however, no reference equation has been developed for specific occupational groups. Using reference equation derived from general population may not be appropriate in occupational settings because evaluation of lung function in the occupational setting requires a more sensitive criteria than that for population of patients with respiratory disease as majority of the workers may experience no or little impairment of lung function[34], therefore various equations have been published for different type of workers[39–41]. Variables included in these published studies show great deal of variation. Age and height are used in all the equations, while few included weight as well.[41] Another study also included smoking status, pack years of smoking and symptoms like cough, chest tightness and breathlessness but none of the studies included socio-economic status in the predictor equations.

This study presents two sets of predictor equations for lung functions of textile workers in which respiratory symptoms were also included, giving it a greater predictive power. However, there are certain limitations of our study which need to be considered. First, this analysis was based on a cross sectional survey therefore, changes over time could not be captured and healthy workers present at the time of study may have been more likely to be included which may give higher predicted values for lung function. Healthy worker bias may have led to underestimation of abnormal lung function in our study. Secondly, we included only male participants, while in many textile industries female workers constitute a major proportion of workforce, which limits application of these equations for female workers and calls for extended studies with inclusion of female workers as well. Workers in informal sector were not included, where there may be higher exposures. Since informal sector does not provide health protection and other benefits to the workers therefore, there may be high turnover of the staff and replacement of affected employees. Finally, since this was a secondary data analysis there may be certain biases inherent in the conduct of the primary research which could not be controlled in our work. However, we believe that both the surveys were fairly representative of the given population and convey reliable information regarding the lung function among textile workers and healthy Pakistani population.

CONCLUSION

We found significant decrements in the lung function of textile workers compared to healthy Pakistani adults. Further studies are required for determining causal inferences and accurate measurement of effects on lung function parameters among textile workers compared to the general population. Moreover, there are differences in the interpretation of spirometry results when spirometry results are compared with ERS reference values. Correct interpretation of spirometry results require comparison with appropriate reference value which is derived from local population. Use of ERS reference equations for Pakistani textile workers may not provide appropriate spirometric interpretation as we found discordance in the interpretation based on the two equations. We developed lung function predictor equations for Pakistani textile workers with good predictive power which may be used for further studies in this occupational group.

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