It is considered that acute response is reversible after short-term exposure, but chronic effects may result from prolonged exposure.\[^{[3-5]}\]

Noninvasive methods such as pulmonary function tests (PFTs) can be used for the assessment of respiratory disorders due to cotton dust exposure, but there is no consensus on the use of other methods such as high-resolution computed tomography (HRCT) in the assessment of respiratory problems, however, the long-term effects of exposure to cotton dust using an accurate objective measurement is not well-understood.
According to our knowledge, studies to date have not evaluated the changes in other objective measurements such as chest radiography and computed tomography in relation to chronic function loss in cotton textile workers. To provide the additional understanding of the chronic respiratory effects of exposure to cotton dust; we have conducted this study to determine the frequency of respiratory symptoms, changes in PFTs, and chronic respiratory impairment among cotton textile workers.

MATERIALS AND METHODS

This cross-sectional study for the assessment of respiratory disease among cotton textile workers was established in 2013. The study population consisted of 100 cotton textile workers who were exposed to airborne cotton dust and employed more than 3 years in cotton textile mills in Kermanshah, Iran and 100 unexposed subjects who were relatives of workers, matched for age and sex involved in this study as the control group. Subjects were excluded from the study if they were current or ex-smokers or had a history of respiratory diseases such as asthma, bronchitis, emphysema, bronchiectasis, lung cancer, or any other chronic condition in the preemployment assessment. The study was approved by the Ethics Committee of the Kermanshah University of Medical Sciences. The participants gave written informed consent before the study.

A modified version of the American Thoracic Society (ATS), respiratory symptoms questionnaire was completed for each worker. All workers were interviewed and examined by the pulmonologist.

PFTs and chest radiography were conducted for all subjects on Thursday morning at the end of working week. PFT were carried out by a trained technician using a calibrated spirometer (Jaeger). The highest values for FEV₁ and forced vital capacity (FVC) after three acceptable maneuvers according to ATS criteria were used in subsequent analysis.

According to ATS criteria in the cases with obstructive pattern, changes in FEV₁ and FVC were measured before and 20 min after the separate inhalation of four puffs of 250 µg salbutamol from a metered dose inhaler, administered through a 750 ml spacer device. Patients rested 20 min after the first measurement.

Postbronchodilator test and HRCT scan were performed for those with abnormal PFTs or chest radiography. The HRCT scans were all performed using a 16-slice HRCT scanner (Toshiba Aquilion scanner; Toshiba Medical Systems, Tokyo, Japan) and assessed by one experienced radiologist.

Data were analyzed by SPSS version 16.0 program for Windows (SPSS Inc., Chicago, IL, USA). Quantitative and qualitative variables were measured. Chi-square test was used for the determination of association between two qualitative variables while independent sample t-test was used for evaluation difference between quantitative variables both in exposed and nonexposed groups. \( P < 0.050 \) has been considered as a significant association.

RESULTS

All 100 exposed (cotton workers) and 100 unexposed groups underwent an interview, physical examination, assessment of PFTs, and radiographic results by a pulmonologist.

A total of 51% and 31% of the cotton textile workers had one or more respiratory symptoms and respiratory signs, respectively.

Table 1 summarizes the prevalence of respiratory complaints and PFTs of both groups. The prevalence of cough, sputum, and chest tightness were statistically significant (\( <0.001 \)) between two groups.

PFTs was performed for all subjects. Statistically significant (\( <0.001 \)) decrease in FEV₁, FVC, and FEV₁/FVC were noted in cotton workers when compared with the control group [Table 1]. Twenty-eight percentage of subjects in the exposed group and 5% of subjects in the unexposed group had an obstructive pattern. Overall 25% (7/28) of exposed group with airway obstructive pattern on PFT showed reversibility after postbronchodilator test.

The most prevalent findings in chest radiography were bronchial wall thickening (31%), and air filled lungs (20%), which was statistically significant between groups [Table 2].

Computed tomography was performed in 44 subjects of exposed group and five subjects of the control group who had abnormal chest radiography or PFTs. The most common finding was air trapping (63%, 12/44) [Table 2].

A significant correlation was observed between air trapping and PFT in cotton workers. The results of PFT showed the

Table 1: Demographic and clinical data of the study population

|                          | Cotton workers (case) | Office workers (control) | \( P \) |
|--------------------------|-----------------------|--------------------------|--------|
| Age                      | 36.75±7.35            | 36.94±7.27               | 0.85   |
| Years worked             | 9.24±3.68             | -                        | -      |
| Respiratory symptoms (%) |                       |                          |        |
| Cough                    | 47                    | 10                       | <0.001 |
| Dyspnea                  | 15                    | 9                        | 0.19   |
| Sputum                   | 41                    | 5                        | <0.001 |
| Chest pain               | 12                    | 7                        | 0.23   |
| Chest tightness          | 26                    | 9                        | 0.002  |
| Respiratory signs (%)    |                       |                          |        |
| Wheeze                   | 20                    | 4                        | <0.001 |
| Rhonchus                 | 13                    | -                        | -      |
| Crackles                 | -                     | -                        | -      |
| Pulmonary function test  |                       |                          |        |
| FEV₁                     | 3.12±0.66             | 3.45±0.53                | <0.001 |
| FVC                      | 3.89±0.59             | 4.22±0.50                | <0.001 |
| FEV₁/FVC                 | 0.77±0.07             | 0.81±0.04                | <0.001 |

FVC: Forced vital capacity, FEV₁: Forced expiratory volume in 1 s
decrease in FEV$_1$ and FVC in subjects with air trapping compared with workers without air trapping [Table 3].

Table 4 shows a significant correlation between the presence of respiratory symptoms, respiratory signs, abnormal findings in PFTs, chest radiography, HRCT and length of exposure (years worked in cotton textile), and age.

**DISCUSSION**

The high prevalence of respiratory symptoms in cotton workers is similar to that reported by other studies. The characteristic respiratory symptoms such as chest tightness and cough have been standardized by Schilling. In our study the most common respiratory symptoms were cough and sputum production, these symptoms probably represent variants of the airway irritation because of dust inhalation.

Our study showed that cotton workers had significantly more decrements in their FEV$_1$ and FVC when compared with subjects without exposure, which agrees with the findings of previous studies. Accelerated decline in FEV$_1$ has been observed in cotton workers vs. controls, even in nonsmokers and after retirement. Overall the physiologic picture suggests airways obstruction pattern that was 28% in our study, also a restrictive or mixed pattern may be seen in some workers.

Bronchial wall thickening and air filled lungs which were the most findings in chest radiography which can lead to airflow limitation and respiratory complaints.

Recently, HRCT has been known as an extremely diagnostic method to evaluate pulmonary involvement in patients with respiratory complaints, although prone and end-expiratory HRCT scans allow better recognition of air trapping found in airways disease. According to our data, no study has been performed to determine the HRCT findings of cotton workers. The evaluation of HRCT findings in patients with abnormal chest radiography or PFT showed air trapping. This indicates that this method as a sensitive tool for the assessment of pathologic changes, confirms the expected pathophysiology of airway obstruction in cotton workers.

There was a significant relationship between air trapping which was the most common abnormalities found on HRCT and the decrease in FEV$_1$ and FVC. Lung volumes are also routinely assessed in PFT. Limitation of airflow is due mainly to bronchoconstriction, this results in a reduction in FEV$_1$ and FEV$_1$/FVC ratio, as well as an increase in airway resistance. Early closure of peripheral airway resulted in lung hyperinflation or air trapping and increased residual volume. Some studies found a good correlation between FEV$_1$ and air trapping,[19] also a significant correlation between the extent of air trapping and FEV$_1$/FVC was seen in another study.[20] This study also shows that there is a good correlation between FEV$_1$ and the extent of air trapping. It seems that HRCT images are helpful for showing air trapping in patients with obstructive lung diseases. The presence of this finding in HRCT of cotton workers could be explained by chronic effect of long-term exposure to cotton dust.

Cotton workers worked for 9 years, on average with the range of 3–18 years and more than 44% had worked >10 years. It is concluded on the basis of the significant correlation of findings in Table 4 that respiratory complaints and abnormal findings on objective measurements occur more in those workers who are exposed to cotton dust for a longer period, which is inconsistent with other studies.
CONCLUSION

To the current authors' knowledge, this is the only study, to date, in cotton workers using objective methods rather than PFT. Smoking as a major confounding factor can affect the results of studies on respiratory disorders, many studies did not adequately control for smoking, to control smoking effect; we exclude current or ex-smokers from the study. The identical standardized instrument, HRCT as a sensitive objective measurement and the same technician used in this study. The case and control group were similar in respect to socioeconomics. The main limitation of our study was the lack of quantitative exposure assessment to cotton dust; second, the healthy workers' effect could have affected the current results.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Keane J, Te Velde DW. The Role of Textile and Clothing Industries in Growth and Development Strategies. Investment and Growth Program, Overseas Development Institute; 2008. p. 1-71. Available from: http://www.odi.org/resources/docs/3361.pdf.
2. Wang XR, Zhang HX, Sun BX, Dai HL, Hang JQ, Eisen EA, et al. A 20-year follow-up study on chronic respiratory effects of exposure to cotton dust. Eur Respir J 2005;26:681-6.
3. Wang XR, Pan LD, Zhang HX, Sun BX, Dai HL, Christiani DC. Follow-up study of respiratory health of newly-hired female cotton textile workers. Am J Ind Med 2002;41:111-8.
4. Thind GS. Acute pulmonary alveolar proteinosis due to exposure to cotton dust. Lung India 2009;26:152-4.
5. Wang XR, Pan LD, Zhang HX, Sun BX, Dai HL, Christiani DC. A longitudinal observation of early pulmonary responses to cotton dust. Occup Environ Med 2003;60:115-21.
6. Ferris BG. Epidemiology standardization project (American thoracic Society). Am Rev Respir Dis 1978;118:1-120.
7. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. Eur Respir J 2005;26:948-68.
8. Wang XR, Eisen EA, Zhang HX, Sun BX, Dai HL, Pan LD, et al. Respiratory symptoms and cotton dust exposure; results of a 15 year follow up observation. Occup Environ Med 2003;60:933-41.
9. Altin R, Ozkurt S, Fisekci F, Cimrin AH, Zencir M, Sevinc C. Prevalence of byssinosis and respiratory symptoms among cotton mill workers. Respiration 2002;69:52-6.
10. Bünger J, Schappler-Scheele B, Hilgers R, Hallier E. A 5-year follow-up study on respiratory disorders and lung function in workers exposed to organic dust from composting plants. Int Arch Occup Environ Health 2007;80:306-12.
11. Christiani DC, Wang XR. Respiratory effects of long-term exposure to cotton dust. Curr Opin Pulm Med 2003;9:151-5.
12. Bäkirci N, Kalaca S, Francis H, Fletcher AM, Pickering CA, Tumerdem N, et al. Natural history and risk factors of early respiratory responses to exposure to cotton dust in newly exposed workers. J Occup Environ Med 2007;49:853-61.
13. Schilling RS. Byssinosis in cotton and other textile workers. Lancet 1956;271:319-24.
14. Wang X, Zhang HX, Sun BX, Dai HL, Hang JQ, Eisen E, et al. Cross-shift airway responses and long-term decline in FEV1 in cotton textile workers. Am J Respir Crit Care Med 2008;177:316-20.
15. Lai PS, Fresco JM, Pinilla MA, Macias AA, Brown RD, Englert JA, et al. Chronic endotoxin exposure produces airflow obstruction and lung dendritic cell expansion. Am J Respir Cell Mol Biol 2012;47:209-17.
16. Lai PS, Christiani DC. Long-term respiratory health effects in textile workers. Curr Opin Pulm Med 2013;19:152-7.
17. Aminian O, Mozafari AR, Sadeghniahi Haghighi K, Chavoshi F, Saraie M, Izadi N. Study of respiratory symptoms and pulmonary function in cotton textile workers. J Basic Appl Sci Res 2013;3:33-6.
18. Kobayashi H, Kanoh S, Motoyoshi K, Aida S. Diffuse lung disease caused by cotton fibre inhalation but distinct from byssinosis. Thorax 2004;59:1095-7.
19. Chung MH, Edinburgh KJ, Webb EM, McCowin M, Webb WR. Mixed infiltrative and obstructive disease on high-resolution CT: Differential diagnosis and functional correlates in a consecutive series. J Thorac Imaging 2001;16:69-75.
20. Tanaka N, Matsumoto T, Miura G, Emoto T, Matsuura N, Ueda K, et al. Air trapping at CT: High prevalence in asymptomatic subjects with normal pulmonary function. Radiology 2003;227:776-85.
21. Shi J, Mehta AJ, Hang JQ, Zhang H, Dai H, Su L, et al. Chronic lung function decline in cotton textile workers: Roles of historical and recent exposures to endotoxin. Environ Health Perspect 2010;118:1620-4.
22. Chattopadhyay BP, Saiyed HN, Mukherjee AK. Byssinosis among jute mill workers. Ind Health 2003;41:265-72.