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Original Article

Relationship between metabolic syndrome and pulmonary function in workers with respiratory dust exposure in Iran

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ABSTRACT

Aims: we designed a study to investigate the relationship between metabolic syndrome (MetS) and lung function in workers with dust exposure based on five years of longitudinal study data.
Methods: In this historical cohort study that conducted in iron ore mine, non-smoker male workers who exposed to dust, were enrolled. MetS was determined according to the National Cholesterol Education Program Adult Treatment Panel III. New spirometry parameters and spirometry from 5 years ago, were compared.
Results: In this study 192 workers were identified without MetS and 77 with MetS. The mean of all lung parameters was lower in subjects with MetS, but it was not statistically significant. The median decline in FEV1 and FVC in 5 years was greater in subjects with MetS but were only significant for a decline in FEV1 (P-Value = 0.04). Linear regression analysis showed a significant relationship between a decline in FEV1 and waist circumference (P-Value = 0.001) when adjusted for age, BMI, physical activity level.
Conclusion: In this study, a significant association between mean decline in FEV1 in 5 years and MetS in dust-exposed workers was demonstrated. Decline in FEV1 in 5 years was significantly associated with a Waist circumference as one of the components of MetS.

1. Introduction

As obesity increases worldwide, the incidence of metabolic syndrome (MetS) is on the rise [1]. Economic and social growth has changed the way of life and the use of high-calorie foods and a sedentary lifestyle, which has ultimately led to MetS increase [2].

Several recent studies have reported that pulmonary function worsens with high blood pressure, type 2 diabetes, LDL cholesterol, abdominal obesity and obesity, and insulin resistance.

Witch blood pressure, type 2 diabetes, and abdominal obesity are some of the crystals of MetS. Therefore, it is concluded that there is a significant relationship between MetS and pulmonary function [1,3].

Numerous environmental factors such as cigarette smoke, chronic smoke from fuel, air pollution, and many occupational exposures can also accelerate the decline of FEV1; however, there is a significant difference in a person's sensitivity to it. The presence of MetS predicts a faster decrease in FEV1 over time [4]. A longitudinal study showed that lower base FEV1 is an independent predictor of MetS [5]. Recent cross-sectional studies in China and France have shown that central obesity, a component of MetS, is associated with impaired pulmonary function [6].

Previous studies in Asian and European people have shown an association between MetS and decreased lung function. However, the diagnostic criteria and clinical manifestations of MetS vary according to race [7]. Many studies have been performed on the relationship between metabolic syndrome and lung function, as well as between exposure to respiratory pollutants such as dust on lung function, but limited studies have been performed on the combined effect of metabolic syndrome and dust exposure on lung function. Therefore, we designed a study to investigate the relationship between MetS and pulmonary function in male non-smoker workers with dust exposure based on longitudinal study data.

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Table 1
Comparison of the studied features at visit 1 (2012) and visits 2 (2017).

	Visit 1	Visit 2	P-value
Age (year)	30.33 ± 5.9	35.8 ± 5.92	<0.0001
BMI (kg/m^2)	26.48 ± 4.48	27.59 ± 4.29	<0.0001
Waist circumference (cm)	–	99.54 ± 11.12	<0.0001
FVC (% predicted)	101.08 ± 10.37	87.82 ± 9.78	<0.0001
FEV1 (% predicted)	95.8 ± 10.28	91.04 ± 11.05	<0.0001
FEV1/FVC%	86.28 ± 6.27	79.51 ± 5.17	<0.0001
FEV1/FVC < 70% N (%)	7 (2.6)	10 (3.72)	<0.0001

2. Materials and methods

This historical cohort study was performed on workers who went for a periodic health examination at the Bafgh Iron Ore Mine from August to November 2017. The inclusion criteria were: 1. A male worker, 2. Age over 30 years, 3. Minimum 5 years working experience, 4.Exposure to impermisible amounts of respirable dust in the workplace (Less than 3 mg/m^3 according to ACGIH criteria) [8], (the rate of exposure to respiratory pollutants is based on the results of dust measurements routinely performed by industrial hygiene professionals for industrial monitoring in this mine). Workers who were smokers/ex-smoker or had a history of cardiovascular disease and pulmonary disease or cancer were excluded from the study. Finally, after considering the above criteria, 269 workers entered the study.

After obtaining written permission from the study subjects, data such as age, work experience, smoking, previous medical history, medication history, level of physical activity, and the use of respiratory protective equipment were extracted from their medical records or by completing a questionnaire.

Weight was measured while wearing light clothing, and height was taken without shoes. The waist circumference was measured by standing posture at the navel level [9] with a transcript. BMI was calculated by the weight (kg)/height (m) square method. Blood pressure was measured using a digital sphygmomanometer after 5 min of rest. During the periodic examination, workers' blood samples were taken to measure fasting blood sugar levels, triglycerides, and HDL.

Pulmonary function was measured in a sitting position using a spirometer (spirolab III, Mir, Italy). All tests were performed according to the guidelines recommended by the American Thoracic Society/European Respiratory Society (ATS/ERS) task force [10]. At both times, one trained technician performed between 8 a.m. and 2 pm. The following spirometric parameters were recorded: Forced vital capacity (FVC), FVC %predicted, Forced expiratory volume in 1 s (FEV1), FEV1 %predicted, FEV1/FVC% ratio. Acceptable spirometry taken over the past five years has been extracted from a person's medical record, and lung parameters related to 5 years ago have been compared with recent spirometry. FVC and FEV1 decline (ΔFVC and ΔFEV1) in these five years were calculated as follows: [(% predicted value at visit 2 - % predicted value at visit1)/% predicted value at visit 1] × 100/5 years [6].

According to National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria (NCEP/ATP III, 2005 revision) [11], the criterion for diagnosing MetS in men is having three or more of the following risk factors: waist circumference ≥102 cm; elevated blood pressure (≥130 mm Hg systolic blood pressure or ≥85 mm Hg diastolic blood pressure or on antihypertensive drug treatment in a patient with a history of hypertension; serum TG level ≥150 mg/dL or on drug treatment for elevated triglycerides; Reduced HDL-C < 40 mg/dL or on drug treatment for reduced HDL-C; elevated fasting glucose with a FBS level ≥100 mg/dL or on drug treatment for elevated glucose.

Table 2
Comparison of two groups with and without metabolic syndrome (MetS) at second visit.

	MetS − (n = 192)	MetS + (n = 77)	P-value
Age (year)[a]	36.3 ± 6.13	34.8 ± 5.67	0.23
Work experience[a] **(year)**	11.16 ± 5.02	10.14 ± 4.8	<0.0001
BMI (kg/m^2)[a]	30.38 ± 4.56	28.38 ± 4.56	<0.0001
Waist circumference (cm)[a]	96.52 ± 9.83	105.51 ± 11.22	<0.0001
SBP (mmHg)[b]	120 (110–120)	130 (122–140)	<0.0001
DBP (mmHg)[b]	75 (70–80)	90 (80–90)	<0.0001
TG (mg/dl)[b]	141 (107–192)	208 (171–267)	<0.0001
HDL (mg/dl)[b]	43 (37–47)	37 (35–40)	<0.0001
FBS (mg/dl)[b]	85 (76–91)	92 (80–108)	<0.0001

[a] Mean ± SD.
[b] Median (IQR).

Table 3
Comparison of the latest lung parameters and changes in subjects with and without metabolic syndrome (MetS).

	MetS − (n = 192)	MetS + (n = 77)	P-value
FVC (%predicted)[a]	88.01 ± 10.27	87.39 ± 9.27	0.69
FEV1 (%predicted)[a]	91.47 ± 11.75	89.92 ± 10.10	0.38
FEV1/FVC%[a]	80.27 ± 4.69	79.14 ± 5.46	0.10
ΔFVC (%)[b]	−1.99 (−3.08, −1.44)	−2.02 (−2.76, −1.33)	0.45
ΔFEV1(%)[b]	−0.45 (−1.40, 0.44)	−0.97 (−2.07, 0.00)	0.04

[a] Mean ± SD.
[b] Median (IQR).

Data were analyzed using SPSS ver.20 (IBM SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov test was used to verify the distribution of the data. The student's t-test for parametric data and Mann-Whitney *U* test for non-parametric data were used to compare between groups. Prevalence of using respirators at the workplace and physical activity level were compared between groups by the chi-square test. By using linear regression, we assessed the relationship between a decline in FVC and FEV1 in 5 years with the presence of MetS and its components. A P-value of less than 0.05 was considered statistically significant.

The study was the result of a residency thesis in occupational medicine. The medical ethics committee approved the protocol of Shahid Sadoughi University of Medical Sciences (IR.SSU.MEDICINE.REC.1395.361).

3. Results

In this study, overall, 269 workers were surveyed, of which 192 workers without MetS and 77 with MetS. The prevalence of MetS based on NCEP/ATP III criteria in people studied in this industry was 28.7%. The prevalence of regular use of respirators in the workplace in two groups with and without MetS was 37% and 26%, respectively, which did not differ significantly (P-value = 0.17). There was no significant difference in the level of physical activity between the two groups with or without MetS (P-value = 0.24). The characteristics of subjects in the first and second visits are shown in Table 1.

Lung parameters were lower after five years on the second visit, but BMI had increased. Table 2 shows the characteristics of the two groups with MetS and without MetS.

The mean age of work experience and HDL level was lower in a group with MetS. Waist circumference, BMI, SBP, DBP, FBS, and TG were higher in a group with MetS, the difference between other variables in the two groups was significant except that the average

Table 4
Linear regression coefficient[a] of the metabolic syndrome and its components according to a decline in FEV1 and FVC in 5 years (n = 269).

	A decline in FEV1 (ΔFEV1)		A decline in FVC (ΔFVC)	
	B (95% CI)	P-Value	B (95% CI)	P-Value
Metabolic Syndrome	0.72 (0.19, 1.25)	0.008	0.37 (−0.09, 0.83)	0.12
Waist circumference	0.11 (0.04, 0.18)	0.001	0.05 (−0.01, 0.11)	0.11
High TG	−0.01 (−0.002, 0.002)	0.85	0.04 (−0.002, 0.001)	0.52
High BP	−0.04 (−0.03, 0.02)	0.55	0.01 (−0.02, 0.02)	0.85
Low HDL	−0.07 (−0.04, 0.01)	0.27	−0.04 (−0.03, 0.02)	0.55
High FBS	−0.007 (−0.01, 0.002)	0.12	−0.11 (−0.01, 0.001)	0.08

[a] Adjusted for age, BMI, physical activity.

age.

As shown in Table 3 In subjects with MetS, the mean of all lung parameters was lower than in subjects without MetS, but it was not statistically significant. The median decline in FEV1 and FVC (ΔFEV1 and ΔFVC) were greater in subjects with MetS but were only significant for ΔFEV1.

In the group without MetS, by comparing the FEV1 and FVC parameters between the first and second visits, it was found that both parameters in the second visit were significantly reduced in this group (P-value < 0.0001).

Table 4 Linear regression coefficient of the metabolic syndrome and its components according to a decline in FEV1 and FVC in 5 years (n = 269).

Linear regression analysis showed a significant relationship between a decline in FEV1 and the presence of MetS (P-Value = 0.008) and waist circumference (P-Value = 0.001) when adjusted for age, BMI, physical activity level (Table 4). No such association was seen for other lung parameters (FVC %predicted, FEV1 %predicted, FEV1/FVC, and a decline in FVC with MetS.

4. Discussion

In this longitudinal study, the relationship between pulmonary function and MetS was investigated in non-smoking male miners. They had unauthorized dust exposure in the workplace. The prevalence of MetS based on NCEP/ATP III criteria in subjects studied in this industry was 28.7%. The overall estimation of MetS prevalence in the Iranian male population using a random-effect meta-analysis of data from population-based studies was 27.7% (95% CI: 21.8−33.6%) according to ATP III criteria [12]). The prevalence of MetS in male workers in this industry seems similar to that of the general Iranian population.

In this study, a significant relationship between the mean decline in FEV1 in 5 years, and MetS was demonstrated. On the other hand, the mean decline in FVC tended more reduced in subjects with MetS but with no significant association. Also, linear regression analysis showed that a decline in FEV1 was associated with waist circumference, adjusted for age, BMI, and physical activity level.

In our study, both groups with and without MetS, exposed to respiratory dust and pulmonary values showed a significant decline after 5 years, but the decline, especially in the FEV1, was greater in the MetS group, so maybe the presence of MetS predicts a faster decrease in FEV1 over time. Various studies have reported a correlation between lung function and MetS in men. However, the primary mechanism is not well known. There are studies wherein FVC was associated with the MetS level [13], some with both indicators FVC and FEV1 [1,2,14], and others manifest as an obstructive pattern [6,15−17]. A historical cohort study after a median four years of follow-up showed that a decrease in FEV1% and FEV1/FVC ratio was associated with the progression to metabolically abnormal phenotype in subjects with metabolically healthy non-overweight and with mean age 43.5 years [15]. Like our study, in a study conducted on 147 men over 40 years, in individuals with MetS, the FEV1 decline was more than those without [6]. The reduction of FEV1 can be explained by bronchial hyper-responsiveness due to systemic inflammation that obesity triggers [14].

Although previous studies have examined the relationship between MetS components and lung function, the effect of each component of MetS on lung function varies according to racial differences [7]. Our study, which was conducted in an Iranian population, showed that waist circumference as an indicator of abdominal obesity is significantly associated with a decline in FEV1 over five years. Various studies have shown that lung function is lower in obese people [1,3,18,19]. In a longitudinal study, obesity was associated with the FEV1 parameter, and with weight increase, there was a more significant reduction in FEV1 [20]. Possible explanations are the increase in visceral fat and change the compliance of the diaphragm and chest wall diaphragm movement in obese people [6,21].

Our study had several limitations. Gender differences in the association between lung function and MetS were recognized [1,22]. However, the subjects we studied were male workers in the industry, and it was not possible to study women. Waist circumference was not measured on a first visit, so it was impossible to compare the prevalence of MetS during these five years. This study was one of the few studies that examine the association of MetS with lung function in the working population that exposed to respiratory dust. Given that studies on the relationship between metabolic syndrome and pulmonary function in dust-exposed workers are limited, it is suggested that studies be designed to compare the association of MetS with lung function in the workers with and without respiratory dust exposure to investigate the possible synergistic effect of metabolic syndrome along with dust exposure on reduction of lung function.

In this retrospective study, a significant association between mean decline in FEV1 in 5 years and MetS in male workers was demonstrated. Waist circumference as one of the components of MetS was significantly associated with a decline in FEV1 in 5 years.

Declaration of competing interest

This article summarizes a residency thesis in Shahid Sadoughi University of Medical Sciences. This study was supported by Research Deputy of Shahid Sadoughi University of Medical Sciences. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors and there is no conflict of interest relevant to this study.

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The study was the result of a residency thesis in occupational medicine, and the medical ethics committee approved the protocol

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