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Metabolic Syndrome Impact on Ventilatory Pulmonary Functions

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Abstract

Background: A relation between metabolic syndrome (MS) and lung diseases has been observed in several cross-sectional and longitudinal studies. This syndrome has been identified as an independent risk factor for worsening respiratory symptoms and much more lung function impairment.

Aim: was to study the effect of metabolic syndrome on ventilatory pulmonary functions.

Subjects and methods: This study included 60 subjects. They were further divided to two groups, group (A) included 45 patients with metabolic syndrome and group (B) included 15 apparently healthy subjects as a control group. All were subjected to the followings: History taking and physical examination (Blood pressure, BMI and waist circumference), laboratory investigations as FBG, lipid profiles (TG and HDL), CRP and HbA1C and spirometry (FVC, FEV1and FEV1/FVC).

Results: Among metabolic syndrome subjects (n=45), 28 (63%) had restrictive ventilatory pattern, 3 (6%) had obstructive pattern, 9 (20%) were normal, while 5 (11%) had mixed pattern. Pulmonary functions were impaired more among metabolic syndrome cases. FVC% predicted of group (A) was 61.49 %±17.56 while for group (B) was 85.73%±5.24. FEV1% predicted of group (A) was 66.22%±18.7 while for group (B) was 87.73%±7.98 and differences were statistically highly significant. Pulmonary functions impairment was more prominent among males than females. After examining the association between metabolic components and both FVC % predicted and FEV1 % predicted, results revealed that there was a strong linear decrease in FVC % predicted and FEV1 % predicted as the number of components of metabolic syndrome increased. The β coefficients of FVC % predicted for those with 1, 2, 3, 4 and 5 features of metabolic syndrome were 0.011,-0.018, -0.023, -0.035 and -0.048 in men and 0.020, -0.029, -0.035, -0.047 and -0.068 in women respectively. The β coefficients of FEV1 % predicted for those with 1, 2, 3, 4 and 5 features of metabolic syndrome were 0.009, -0.015, -0.026, -0.041and -0.051 in males and 0.004, -0.009, -0.017, -0.029 and- 0.038 in females, respectively.

Conclusion: Pulmonary function impairment (mainly restrictive pattern) is commonly associated with metabolic syndrome. Forced vital capacity and forced expiratory volume in the first second are associated inversely with the accumulation of elements of the metabolic syndrome and is also associated independently with each element of the metabolic syndrome especially waist circumference.

Keywords: MS; metabolic syndrome, WC; waist circumference, spirometry (FVC: forced vital capacity, FEV1: forced expiratory volume in first second)

Introduction:

Metabolic syndrome (MS) is a complex disorder with high socioeconomic cost that is defined by a cluster of interconnected factors that directly increase the risk of coronary heart disease, other forms of cardiovascular atherosclerotic diseases, and diabetes mellitus type 2 (DMT2) (1).

Its main components are dyslipidemia (elevated triglycerides and apolipoprotein B (apoB)-containing lipoproteins, and low high-density lipoproteins (HDL)), elevation of arterial blood pressure and dysregulated glucose homeostasis, while abdominal obesity and/or insulin resistance (IR) have gained increasing attention as the core manifestations of the syndrome (1).

In a number of recent studies, it was reported that among the changes in pulmonary function, pulmonary function deterioration is related to hypertension, type 2 diabetes, low- density lipoprotein cholesterol, overall obesity, abdominal obesity and insulin resistance (2). Among the above listed factors, hypertension, diabetes, and abdominal obesity are included as diagnostic criteria for metabolic syndrome, hence it can be inferred that identifying the relationship between metabolic syndrome and pulmonary function deterioration is meaningful.

The presence of obstructive or restrictive lung diseases as assessed by spirometry is associated with a higher risk of death (3). In addition, lung function impairment is also associated with insulin resistance (4), type 2 diabetes (5), and cardiovascular diseases (6). Therefore, lung function test may be commonly used as a tool in general health assessment.

Aim of the work:

It was to study the effect of metabolic syndrome on ventilatory pulmonary function.

Subjects and methods:

This cross sectional study included 60 subjects admitted to chest and internal medicine departments in Benha university hospitals from August 2014 to November 2015. They were classified into two groups:

1. **Group [A]:** included (45) patients with metabolic syndrome.
2. **Group [B]:** included (15) apparently healthy subjects.

All subjects were subjected to the followings: History taking and physical examination (Blood pressure and waist circumference), laboratory investigations as FBG, lipid profiles (TG and HDL), CRP and HbA1C and spirometry (FVC, FEV1and FEV1/FVC).

Metabolic syndrome

Metabolic syndrome was defined according to the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) (7)**.** This definition is satisfied if at least three of the five following criteria are met:

- Large waist circumference (>102cm in men and >88cm in women,
- High triglycerides(>150mg/dL) or lipid-specific treatment،
- Low high-density lipoprotein (HDL) cholesterol (men <40 and women <50 mg/dL) or lipid-specific treatment،
- High fasting glucose (>100 mg/dL) or diabetes treatment, and
- High systolic blood pressure (>130 mm Hg) or diastolic blood pressure (>85 mm Hg) or use of antihypertensive therapy.

Pulmonary functions:

Lung function test was performed in all participants by using an automated flow-sensing spirometer (spirolab III Ver 4.3 SN 311860 (Italy)) based on American Thoracic Society/European Respiratory Society, 2005 recommendations (ATS/ERS) (8). If at all possible, at least three forced expiratory maneuvers were performed in an effort to meet the American Thoracic Society standards. The predicted value, actual value and the percentage predicted value for the individuals were measured and these values were based on height, age, gender, and ethnicity of the subjects. The recoded data included FVC, FEV1 and FEV1/FVC ratio.

Lung function impairment

It was defined as FEV1 or FVC less than lower limit of the normal (LLN). With reference to the American Thoracic society/European Respiratory society guidelines (9);

- Obstructive lung impairment was defined as an FEV1-to-FVC ratio< 70% and an FVC> 80% of the predicted value.
- Restrictive lung impairment was defined as an FVC < 80% of the predicted value and an FEV1-to-FVC ratio > 70%.
- Mixed lung impairment was defined as a FEV 1-to-FVC ratio <70% and FVC < 80% of the predicted value. The other was defined as normal lung function (10).

Data management

The clinical data were recorded on a report form. These data were tabulated and analyzed using the computer program SPSS (Statistical package for social science) version 16 to obtain:

Descriptive data

Descriptive statistics were calculated for the data in the form of:

1. Mean and standard deviation $(\pm SD)$, for quantitative data.
2. Frequency and distribution for qualitative data.

Analytical statistics

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:-

1-Student's *t*-test: - Used to compare mean of two groups of quantitative data.

$$t = \frac{\bar{x}_{1-}\bar{x}_{2}}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}}$$

2- Inter-group comparison of categorical data was performed by using chi square test (X^2-value).

$$x^2 = \frac{\sum(observed - \exp ected)^2}{Expected}$$

$$Expected = \frac{col.total\ x\ row total}{Grand\ total}$$

3-Regression coefficient: - to evaluate linear association between variables.

A *P* value <0.05 was considered statistically significant (S) while >0.05 statistically insignificant P value <0.005 was considered highly significant (HS) in all analyses.

Results

In this study, group (A) included (16) males and (29) females with average age was 54.29±7.61 years old and group (B) included (4) males and (11) females with average age 53.3±6.62 years old. As for BMI, the mean value of group (A) was 45.62±4.85 and for group (B) was 28.4±4.58. Gender distribution of metabolic syndrome was 64.4% female and 35.6% male (Table 1). Among metabolic syndrome patients (n=45), 28 (63%) had restrictive ventilatory pattern, 3 (6%) had obstructive pattern, 9 (20%) were normal, while 5 (11%) had mixed pattern. (Table 2)

Pulmonary functions were impaired more among metabolic syndrome cases. FVC% of group (A) was 61.49 %±17.56 while for group (B) was 85.73%±5.24. FEV1of group (A) was 66.22±18.7 while for group (B) was 87.73±7.98 and differences were statistically highly significant. (Table 3)

Among group (A), results revealed that pulmonary functions impairment was more prominent among males than females, as FVC% of males was 61.44±17.7 while for females was 61.52±18.12 with range was (22-93). FEV1% for males was 64.38±17.9 while for females' was 67.24±19.36 .All these differences were statistically not significant. (Table 4)

Regarding comparison of metabolic components between the sub groups of ventilatory patterns (normal, restrictive, obstructive and mixed), there were significant differences in the waist circumference as it was larger in restrictive pattern subgroup while no statistically significant differences were noticed in fasting blood glucose, blood pressure, triglycerides and HDL-C between four subgroups. (Table 5)

After examining the association between metabolic components and FVC percent predicted values, results revealed that there was a strong linear decrease in FVC percent predicted as the number of components of metabolic syndrome increased. The β coefficients of FVC percent predicted (%) for those with 1, 2, 3, 4 and 5 features of metabolic syndrome were 0.011,-0.018, -0.023, -0.035 and -0.048 in men and 0.020, -0.029, -0.035, -0.047 and -0.068 in women, respectively (p for trend< ,0.005). In males and females, abdominal obesity, elevated blood pressure, high triglycerides, FBG, and low HDL-C were significantly associated with lower FVC percent predicted in fully adjusted model (most of the parameters, $p < 0.005$). (Table 6)

On examining the association between metabolic components and FEV1 percent predicted, results revealed that there was a significant adverse relationship between the number of components present and pulmonary function. The β coefficients of FEV1 percent predicted for those with 1, 2, 3, 4 and 5 features of metabolic syndrome were 0.009, -0.015, -0.026, -0.041and -0.051 in males and 0.004, -0.009, -0.017, -0.029 and- 0.038 in females, respectively (p for trend < 0.001). In both men and women, abdominal obesity, high blood pressure, increased triglycerides, and low HDL-C were significantly associated with lower FEV1 percent predicted in fully adjusted model (most of the parameters, p< ,0.005). (Table 7)

Table (1): Comparison between group (A) and group (B) regarding age, sex and BMI

groups / Variables		Group (A) (n=45) Mean ±SD	Group (B) (n=15) Mean ±SD	St t test	P value
Age /y		54.29±7.61	53.3±6.62	0.434	>0.05
Sex	Male	16(35.6)	4(26.7)	X^2 =0.40	>0.05
	Female	29(64.4)	11(73.3)		
BMI (kg/m²)		45.62±4.85	28.4±4.58	12.07	<0.005

BMI: body mass index

Table (2): Prevalence of ventilatory pattern among group (A)

Ventilatory patterns	No (45)	%
Normal	9	20
Restrictive	28	63
Obstructive	3	6
Mixed	5	11

Table (3): Comparison between group (A) and group (B) regarding pulmonary functions:

Groups / PFT	Group (A) Mean ±SD	Group (B) Mean ±SD	St t test	P value
FVC%	61.49±17.56	85.73±5.24	5.24	<0.005
FEV1%	66.22±18.7	87.73±7.98	4.31	<0.005

FEV1/FVC	91.53±9.87	84.67±5.79	2.54	<0.05

PFT: pulmonary function test FVC: forced vital capacity FEV1: forced expiratory volume in first second

Table (4): Differences between males and females regarding pulmonary functions in group (A):

Groups / PFT	Male group (n=16) Mean ±SD	Female group (n=29) Mean ±SD	St t test	P value
FVC%	61.44±17.07	61.52±18.12	0.014	>0.05
FEV1%	64.38±17.9	67.24±19.36	0.488	>0.05
FEV1/FVC	89.87±11.23	92.44±9.11	0.834	>0.05

PFT: pulmonary function test FVC: forced vital capacity FEV1: forced expiratory volume in first second

Table (5): Comparison of components of Metabolic Syndrome among ventilatory pattern subgroups

Patterns / Variables	Normal	Restrictive	Obstructive	Mixed	F test	P value
BMI (kg/m²)	44.56±1.25	46.93±3.63	45.5±5.58	44.83±3.39	0.28	<0.005
WC (cm)	96.38±2.77	98.1±4.55	92.67±3.51	95.0±6.71	3.74	<0.005
SBP(mmHg)	133.75±11.9	137.24±12.8	140.0±10.0	134.0±11.4	0.314	>0.05
DBP (mmHg)	83.75±7.44	87.59±9.12	90.0±0.0	82.0±4.47	1.14	>0.05
FBS (mg/dl)	186.25±29.9	227.55±66.3	244.0±69.2	219.2±37.1	2.18	>0.05
TG (mg/dl)	198.62±36.6	198.38±29.0	180.0±20.0	181.0±33.2	0.749	>0.05
HDL (mg/dl)	43.0±9.17	39.41±8.41	40.33±9.5	42.6±8.14	0.482	>0.05

WC; waist circumference TG; triglycerides HDL; high density lipoprotein FBS; fasting blood sugar
SBP; systolic blood pressure DBP; diastolic blood pressure FVC: forced vital capacity FEV1: forced expiratory volume in first second

Table (6): Regression coefficients of components of metabolic syndrome for FVC percent predicted.

Groups / Variables	Male			Female		
	B	P value	95% CI	B	P value	95% CI
Presence of MS	-0.028	<0.005	-0.040, -0.017	-0.028	<0.005	-0.042, -0.018
N0. of MS components						
1	0.011	>0.05	-0.013, 0.022	0.020	>0.05	-0.031, 0.017
2	-0.018	>0.05	-0.029, 0.016	-0.029	>0.05	-0.044, 0.019
3	-0.023	<0.05	-0.038, 0.009	-0.035	<0.005	-0.050, -0.025
4	-0.035	<0.05	-0.048, -0.020	-0.047	<0.005	-0.064, -0.023
5	-0.048	<0.005	-0.063, -0.032	-0.068	<0.005	-0.085, -0.036
BMI(kg/m²)	-0.036	<0.005	-0.044, -0.027	-0.032	<0.005	-0.041, -0.029
WC (cm)	-0.042	<0.005	-0.051, -0.038	-0.026	<0.005	-0.037, -0.020
SBP (mmHg)	-0.026	<0.005	-0.037, -0.042	-0.028	<0.005	-0.035, -0.022
DBP (mmHg)	-0.021	<0.05	-0.029, -0.014	-0.022	<0.05	-0.031, -0.019

FBS (mg/dl)	-0.015	<0.005	-0.025, -0.009	-0.038	<0.005	-0.044, -0.029
TG (mg/dl)	-0.023	<0.05	-0.027, -0.014	-0.017	<0.005	-0.026, -0.009
HDL (mg/dl)	-0.018	<0.005	-0.028, -0.010	-0.018	<0.05	-0.028, -0.011

MS; metabolic syndrome WC; waist circumference TG; triglycerides HDL; high density lipoprotein FBS; fasting blood sugar
SBP; systolic blood pressure DBP; diastolic blood pressure FVC: forced vital capacity FEV1: forced expiratory volume in first second

Table (7): Regression coefficients of components of metabolic syndrome for FEV1 percent predicted

Groups / Variables	Male			Female		
	B	P value	95% CI	B	P value	95% CI
Presence of MS	-0.024	<0.005	-0.039, -0.014	-0.033	<0.005	-0.049, -0.021
N0. of MS components						
1	0.009	>0.05	-0.023, 0.020	0.004	>0.05	-0.027, 0.020
2	-0.015	>0.05	-0.030, 0.014	-0.009	>0.05	-0.038, 0.024
3	-0.026	<0.05	-0.035, -0.012	-0.017	>0.05	-0.047, 0.014
4	-0.041	<0.005	-0.058, -0.019	-0.029	<0.05	-0.048, -0.019
5	-0.051	<0.005	-0.076, -0.028	-0.038	<0.005	-0.065, -0.010
BMI(kg/m²)	-0.046	<0.005	-0.055, -0.038	-0.037	<0.005	-0.045, -0.027
WC (cm)	-0.031	<0.005	-0.043, -0.027	-0.031	<0.005	-0.040, 0.022
SBP (mmHg)	-0.025	<0.005	-0.035, -0.015	-0.026	<0.005	-0.036, -0.018
DBP (mmHg)	-0.023	<0.05	-0.033, -0.017	-0.018	<0.005	-0.028, -0.008
FBS (mg/dl)	-0.028	<0.05	-0036, -0.019	-0.023	<0.05	-0.029, -0.017
TG (mg/dl)	-0.015	<0.005	-0.023, -0.009	-0.021	<0.05	-0.031, -0.013
HDL (mg/dl)	-0.019	<0.005	-0.28, -0.012	-0.020	<0.05	-0.027, -0.009

MS; metabolic syndrome WC; waist circumference TG; triglycerides HDL; high density lipoprotein FBS; fasting blood sugar
SBP; systolic blood pressure DBP; diastolic blood pressure FVC: forced vital capacity FEV1: forced expiratory volume in first second

Discussion

Metabolic syndrome (MS) or insulin resistance syndrome predicts diabetes and cardiovascular disease, but the definition and the clinical usefulness of MS are controversial (11).

Metabolic syndrome as a clustering of interrelated metabolic risk factors may evolve through adipose tissue disease (12), and may not only be restricted to a risk factor for diabetes and cardiovascular disease but also related to many other systemic disorders, such as chronic kidney disease (CKD) (13), chronic lung disease (14), and fatty liver disease (15).

Decrease lung function, as measured by forced vital capacity (FVC) or forced expiratory volume in one second (FEV1), is known to be associated with increased prevalence and mortality of cardiovascular diseases (16).

Many studies conclude that pulmonary function drops among obese people (17). Previously, studies have used BMI, waist circumference, waist/hip circumference ratio, abdominal thickness (height) and skin thickness test as the markers that show obesity (18). However, as of recent, studies focus on abdominal obesity as indicator of overall level of obesity. As such, this study tried to examine the waist circumference that demonstrates abdominal obesity as well as the relationship between metabolic syndrome components that are easily found among obese people and effects of these factors on pulmonary function.

In this study results revealed no significant differences between two studied groups as regard age, sex hence both these groups were comparable, but there is statistically significant difference regarding BMI as it was higher in group (A) as obesity is one of parameter of metabolic syndrome.

Gender distribution among metabolic syndrome patients in this study revealed that it was more common in females (64.4%) than males (35.6%). These results were in agreement with Chen et al who

examined the association of MS and lung function in 8602 subjects, 26.85% of them had metabolic syndrome. Most of metabolic syndrome patients were females (61.5%) (19). Similar results were also obtained by Choudhary et al who assessed pulmonary functions in 200 patients with metabolic syndrome and most of them were females (55.5%) (20).

In this study, results revealed that the prevalence of restrictive pattern among metabolic syndrome group was (63%). The results of this study were similar to those reported from Choudhary et al study which observed that the prevalence of ventilatory patterns was 50% and restrictive pattern represented the highest one (66%) (20). Another study done by Lim et al who assessed metabolic syndrome, insulin resistance and systemic inflammation as risk factors for reduced lung function in Korean nonsmoking males and found that metabolic syndrome was more significantly related with restrictive pattern (64.7%) (21).

In the current study, pulmonary function, such as FEV1 % predicted and FVC1 % predicted were significantly decreased among those with metabolic syndrome in comparison with those without the syndrome (p value <0.005) and FEV1/FVC ratio was significantly higher among those with metabolic syndrome compared with those without the syndrome. These results were in agreement with Chen et al study who found that FEV1 % predicted and FVC1 % predicted were significantly lower among those with metabolic syndrome compared with those without the syndrome (all of the parameters, p<0.001) but the FEV1/FVC ratio showed statistically non-significant difference between those with and without metabolic syndrome for both men and women (p=0.588 and p=0.079, respectively) (19). Another study showed that pulmonary function variables such as FVC % predicted and FEV1 . % predicted were significantly lower in subjects with MS than non-metabolic subjects (20). Additionally, another study demonstrated that there was a small but statistically significant difference in FEV1/FVC ratio between metabolic and non-metabolic subjects (22).

Impairment of pulmonary function among those with metabolic syndrome is due to abdominal obesity which is considered the core of the pathophysiology of metabolic syndrome (23). One possible explanation is that increased abdominal obesity directly affects thoracic and diaphragm compliance, which impairs lung function (24).

In the present study, comparison of metabolic components between ventilatory patterns (normal, restrictive, obstructive and mixed) revealed that there were statistically significant differences regarding waist circumference which was higher in restrictive pattern between sub groups of ventilatory patterns (P <0.005) but other components showed no statistically significant differences. In agreement with this observation, a study was conducted on 300 subjects (200 of them had metabolic syndrome) and found that there were significant differences in the body mass index (P < 0.05) waist circumference (P<0.001) between four subgroups (20).

The results of this study revealed that both FVC% and FEV1 % predicted significantly declined when the sum of metabolic syndrome diagnostic factors increased. All diagnostic factors such as abdominal obesity, elevated blood pressure, high FBS, high triglycerides, and low HDL-C were significantly linked with reduced FVC % predicted and FEV1% in males and females

These observations were in agreement with Chen et al who examined the association of MS and lung function in 8602 subjects, 26.85% of them had metabolic syndrome. They showed a significant linear decrease in FVC % and FEV1 predicted as the number of components of metabolic syndrome increased. In both males and females, abdominal obesity, high blood pressure, high triglycerides, and low HDL-C were significantly associated with lower FVC % predicted and FEV1 % predicted in fully adjusted models (all of the parameters, P < 0.05) but high glucose was significantly associated with lower FVC % predicted in both males and females and with lower FEV1 % predicted in females in fully adjusted models. (19)

On Myoung-Sook et al. study, there was reverse-correlation found between diagnostic criteria of metabolic syndrome and pulmonary function. Among males, while there were significant differences in FVC according to whether or not there were any diagnostics components for metabolic syndrome, there were no FVC differences found among females. However, for both males and females, pulmonary function differed significantly according to waist circumference. For males, there was a significant statistical difference in FVC and FEV1/FVC (25).

On a study conducted by Leone et al., both males and females showed reverse-correlation between all diagnostic criteria of metabolic syndrome and pulmonary function. As in this study, abdominal obesity was reported as the most potent predictor of poor pulmonary function (26). Additionally, Chen et al. found out that both males and females showed negative correlation between FEV1/FVC and waist circumference even after age, height, weight, workload, energy consumption, and smoking were factored in. Thus, the larger the waist circumference becomes, the greater its effect on pulmonary function, eventually having partial impact on the movements of diaphragm and chest (19).

In Australia, Lazarus et al. showed that FVC has negative correlation with males' waist circumference. This study included about 2744 men and studied body composition and lung function association in men. (27). Furthermore, Ochs-Balcom et al. (28) study also demonstrated that males' and females' FEV1and FVC showed negative correlation with waist circumference. Moreover, Harik-Khan et al. (29) demonstrated that FVC &FEV1 and waist circumference had negative correlation for men, whereas for women, only FVC had correlation and FEV1 showed no correlation. They explain such gender differences by fat distribution that could affect diaphragm and thoracic movement of women more than men.

The result of this study revealed that low HDL-C was correlated positively with impaired pulmonary function (FEV1% and FVC %). This observation was in agreement with Rogliani et al study that examined 237 patients, and found that serum HDL- C had an inverse relationship with lower FEV1 and FVC (30). Similar results were demonstrated by Chen et al who examined the association of metabolic syndrome and lung function and showed that low HDL-C was in a relation with decreased pulmonary function (19). The pathophysiology underlying this association remains vague. Lower HDL-C levels are linked with the development of coronary heart disease due to the function of HDL-C in reverse cholesterol transport and anti-inflammation. It is tempting to speculate that the serum HDL-C level acts as a predictor for the decline of lung function, mainly due to its pleiotropic properties, including antioxidative function, inhibition of cytokine induced expression of endothelial cell adhesion molecules, and suppression of the chemotactic activity of monocytes and lymphocytes. (31)

There are several explanations for the relationship between reduced lung function and MetS. MetS is a cluster of disease comprised of multiple cardiovascular risk factors such as IR, dyslipidemia, glucose intolerance and hypertension, most of which could stem from one cause, visceral obesity (32).

Obesity has long been shown to be related to cause physiologic impairments in respiratory system (33): airflow limitation with reduction of both FEV1 and FVC; reduction in lung volumes, especially expiratory reserve volume (ERV) and functional residual capacity (FRC), which predispose toward a decrease in peripheral airway diameter; reduction in respiratory system compliance, as well as an increase in oxygen cost of breathing and airway hyper responsiveness (AHR). Taken together, decrease in retractive forces of the lung parenchyma on the airways at low lung volume in obese people, lead to reduce airway caliber and increased AHR, which potentially causing detrimental effect on lung function. The association of obstructive lung function with MetS could be explained by obesity and subsequent systemic inflammation and by the role of adipokines (34)**.**

Conclusion

- Pulmonary function impairment (mainly restrictive pattern) commonly associated with metabolic syndrome.
- Forced vital capacity and forced expiratory volume in the first second are associated inversely with the accumulation of elements of the metabolic syndrome and is also associated independently with each element of the metabolic syndrome especially waist circumference.

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