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To study the association between Metabolic Syndrome and lung function in Kashmiri population. A hospital based study

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Abstract

Background: Metabolic Syndrome (MetS) is a cluster of conditions that increase the risk of heart disease, stroke, and diabetes. There hasn't been much research done on the connection between MetS and lung function, particularly in populations like the Kashmiri patients.

Aim: The study is aimed to understand relationship between MetS and lung function in ethnic population of Kashmir.

Methods: There were 350 healthy controls and 300 MetS individuals in this study. Here, we investigated into the connections between MetS risk variables such waist circumference (WC), fasting glucose levels, systolic blood pressure (SBP), high density lipoprotein (HDL), and triglycerides (TG) and lung function measurements.

Results: MetS patients had significantly lower FVC and FEV1 values, indicating a restrictive lung pattern. Systolic blood pressure (SBP) and triglycerides (TG) were negatively correlated with FVC, though not statistically significant predictors. In contrast, fasting glucose and HDL-C showed no significant correlation with FVC. Waist circumference were strong predictors of reduced lung volumes.

Conclusion: MetS is associated with impaired lung function in Kashmiri patients, primarily through a restrictive pattern. Central obesity and waist circumference are key contributors in obese

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patients. Early identification and management of MetS components are crucial to prevent further respiratory decline. Public health interventions and integrated care strategies are essential for improving outcomes in this population.

Keywords: FEV1, FVC, Lung, Metabolic syndrome, SMHS, WC.

Introduction

Metabolic syndrome (MetS) is a complex of interrelated but specific risk factors for cardiovascular disease (CVD) and Type 2 Diabetes Mellitus (T2DM) [1]. The metabolic abnormalities associated with central obesity, dyslipidemia, hypertension, and insulin resistance are known as metabolic syndrome (MetS). The increased calorie consumption and decreased physical exercise are the main causes of the rising global prevalence of Metabolic Syndrome (MetS). Recent estimates place the frequency of MetS in adult populations worldwide at 20% and 25%. [2]. MetS is a complicated pathophysiological state with underlying mechanisms such systemic inflammation, endothelial dysfunction, and elevated oxidative stress, rather than just a group of risk variables. Due to these processes, metabolic and cardiovascular disorders are developed and progress, making MetS a serious public health concern. [2,3]. Comparing to the general population, MetS is twice as common among COPD patients [3, 4]. In northern India, its frequency is 40%, and in the age group under 40, it is rapidly increasing [5].A crucial element of MetS is central obesity, which is frequently measured by waist circumference. It has a substantial correlation with inflammation and insulin resistance, making it a significant predictor of morbidity and mortality. Numerous adipokines and cytokines secreted by adipose tissue, especially visceral fat, are involved in metabolic dysregulation. Recent research has indicated a connection between decreased lung capacities and compromised pulmonary function and central obesity. Abdominal obesity can physically limit lung expansion and change the way the lungs work [3-5]. The country is seeing a sharp rise in the number of obese individuals, and about one-third of those who live in cities have MetS.[3]. The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) reported 44% of patients with MetS, the Modified NCEP ATP III reported 46%, and the International Diabetes Federation criteria reported 31% of COPD patients with MetS, compared to 31%, 38%, and 32% of non-COPD controls [6]. The results show that MetS occurs more

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frequently in COPD patients [7,8]. Numerous recent investigations have connected MetS to reduced pulmonary function. A dyslipidemia associated with MetS is typified by excessive triglycerides (TG) and low high-density lipoprotein cholesterol (HDL-C). An important contributing element to the development of cardiovascular illnesses and atherosclerosis is this lipid imbalance. Insulin resistance is a result of low HDL-C impairing reverse cholesterol transport and endothelial dysfunction, whereas elevated TG levels raise insulin resistance. Although the exact association between dyslipidemia and lung function is unclear, it has been proposed that oxidative stress and systemic inflammation may be the ways in which lipid abnormalities affect pulmonary health[1,9,10]. While these studies have shown a favorable correlation between reduced lung function and MetS[11,12], there is a still disagreement on the relationship between vital capacity and MetS in participants who are not obese. In 2009, Oda et al. [13] discovered that among non-obese Japanese men, diabetes is associated with reduced vital capacity but not MetS. Additionally, they suggested that variables other than MetS or insulin resistance could possibly contribute to the association between diabetes and lower vital capacity in non-obese men. On the other hand, several studies have found a connection between MetS and decreased vital capacity even in non-obese people, suggesting that some characteristics of metabolically obese people who are within a normal weight range may also be associated with lower vital capacity.[14, 15]. One of the most well-known risk factors for cardiovascular illnesses and a prevalent component of MetS is hypertension. It increases the risk of cardiovascular death, left ventricular hypertrophy, and artery rigidity. Through processes including decreased pulmonary compliance and elevated pulmonary vascular resistance, hypertension can also have an impact on lung function. Research has shown that compared to people with normotension, those with hypertension are more likely to have impaired lung function [16].A common method of evaluating lung function, which is vital to general health, is spirometry. The FEV1/FVC ratio, forced expiratory volume in one second (FEV1), and forced vital capacity (FVC) are among the important metrics that are measured. These metrics, which represent the ability to efficiently breathe in and out, shed light on the mechanical characteristics of the lungs and airways. Morbidity and mortality are linked to decreased lung function. It may serve as a precursor to respiratory disorders such as asthma, chronic obstructive pulmonary disease (COPD), and others. Moreover, there is evidence connecting compromised lung function to systemic illnesses like diabetes and cardiovascular disorders. Therefore, early intervention and management

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of respiratory and systemic disorders depend on an awareness of the factors that affect lung function[15, 16.] Numerous epidemiological research have looked into the connection between pulmonary function and MetS. The number of MetS components and lung function metrics like FVC and FEV1 have been shown to be inversely correlated in these investigations. In the United States, for example, a study revealed that those with MetS had far lower FVC and FEV1 than people without MetS. Similar outcomes have been observed in Asian and European populations, indicating that MetS's detrimental effects on lung function are widespread. The association between MetS and lung function is also influenced by genetic predisposition and environmental factors. Genetic differences pertaining to inflammatory and metabolic pathways can impact an individual's vulnerability to both MetS and impaired lung function. Smoking, inactivity, and air pollution are examples of environmental factors that might worsen the effects of MetS on lung health. For the purpose of creating focused therapies to enhance lung function in people with MetS, it is imperative to comprehend these relationships. The association between MetS and lung function has not been extensively examined in this ethnic group. Thus, in order to investigate the relationship between MetS and reduced lung function in the Kashmiri community, we carried out a cross-sectional study.

METHODS

Study subjects

The observational analytical study was conducted at Department of Medicine and Department of Physiology, Government Medical College Srinagar and Associated SMHS Hospital Srinagar from 2022 to 2024. 300 diagnosed MetS cases and 350 healthy controls were recruited from ethnic population of Kashmir with age and gender matched (>30-60 years). The participants who satisfied these requirements were asked to complete a questionnaire on their individual histories of diabetes, hypertension, heart disease, antihypertensive medications, anti-lipid medications, and hypoglycemic drugs. Exclusion criteria included smokers and those with a history of lung cancer, pleural or lung surgery, or chronic lung disease (such as asthma or chronic obstructive pulmonary disease). G power software was used to calculate the sample size.

Sample size calculation

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Sample size is calculated by formulae:-

$$n = \frac{2 \cdot (Z_{\alpha/2} + Z_{\beta})^2 \cdot \sigma^2}{\Delta^2}$$

Where:

- n = Sample size per group (cases and controls).
- Zα/2 = Z-value corresponding to the desired significance level (for α = 0.05, Z = 1.96).
- Zβ = Z-value corresponding to the desired power (for 80% power, Z = 0.84).
- σ = Standard deviation of the outcome (FVC or FEV1) in the population.
- Δ = Minimum detectable difference between the two groups (effect size).

Using this formulae, total 650 subjects were selected for the study, among 300 were MetS cases and 350 were healthy controls.

Lung function test

Spirometry was carried out utilizing Helios 401 (India)[17]apparatus in accordance with the ATS/ERS recommendations. The percentage predicted values (% predicted) for FEV1 and FVC as well as the FEV1/FVC ratio were computed after the absolute values of FVC and FEV1 were determined.

Anthropometric measurements

A measuring tape was used to record height (cm) to the closest 0.1 cm. A weighing machine was used to measure weight (kg) concurrently, with accuracy down to the nearest 0.1 kg. The formula for calculating body mass index (BMI) is body weight in kilograms divided by height in meters

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squared (kg/m2). According to NCEP ATPIII standards, participants were classified as obese if their BMI was ≥30.0 kg/m^2.

Metabolic Syndrome Criteria

The American Diabetes Association's 2018 diagnostic criteria were used to assess whether diabetes mellitus was present [18]. Criteria were used to determine the existence of hypertension as blood pressure (BP) ≥140/90 mm Hg or currently taking anti-hypertensive medication [19]. The updated Asia-Pacific criteria of obesity in Asian populations were used to identify obesity phenotypes based on BMI category (non-obese <25 kg/m2, obese ≥25 kg/m2) [20]. Using the MetS diagnostic criteria, metabolic health was defined as having fewer than three of the following risk factors.[21]:

1. Systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg, or on antihypertensive treatment.
2. Fasting glucose ≥ 100 mg/dl or being treated for diabetes.
3. Waist circumference; men ≥90 cm, women ≥ 85 cm
4. Triglyceride ≥ 150 mg/dl.
5. HDL-cholesterol <40 mg/dl in men, <50 mg/dl in women.

Sample collection and separation

Employing venipuncture technique, phlebotomists obtained 5 ml of blood from both healthy controls and patients at the Government Shri-Maharaja Hari Singh Hospital (SMHS), Srinagar, common collection center. The patients and healthy controls were sourced from the Post Graduate Department of Medicine, GMC, Srinagar's Out-Patient Department (OPD) and In-Patient Department (IPD). The 5 ml of blood that was drawn was immediately placed into a 3 ml green top heparin vial and a 2 ml whole blood vial that was filled with purple top EDTA. Serum/plasma was tested for biochemical parameters (Blood Sugar Fasting, Lipid Profile) and whole blood was tested for the HbA1c parameter after 3 milliliters of blood in a heparin vial was spun for one minute at 4000 RPM.

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Biochemical Analysis

Glycated hemoglobin (HbA1c) levels and Biochemistry parameters like Blood Glucose, Lipid Profile (Total Cholesterol, Triglycerides, HDL, LDL) was determined for all patients and healthy controls at the clinical Laboratory of Department of Biochemistry, GMC, Srinagar on Abbott Alinity auto analyzer (USA).

Statistical analysis

A Microsoft Excel spread sheet was used to enter the data. Every piece of data was presented as mean +/- standard deviation. We used SPSS program 18.1 (Chicago, IL) for data analysis. To find the mean±standard deviation and p value, students' T-tests on lung function tests, biochemical tests, and immunoassays were conducted. The sociodemographic features were subjected to a chi-square test. To find the association between the lung function test and MetS, correlation analysis was done, and the Pearson correlation coefficient (r) was found. A value of $p<0.05$ was deemed statistically significant for all evaluations.

RESULTS

Characteristics of study group.

Table 2 summarized the sociodemographic and physiological traits of the patients and controls. The American Diabetes Association (ADA, 2018) and NCEP ATPIII criteria were used to diagnosis 300 MetS cases (n = 300), whereas 350(n = 350) were controls. Risk factors that were taken into account were body mass index, lipid profile, glycemic control, age, and gender. There were 150 men and 150 women among the 300 patients in MetS. 200 males and 150 females comprised up the 350 controls (Table 2). The age and gender of the cases and controls were matched. Males made up 50.0% of the MetS group and 50.0% of the controls. Women made up 42.1% of the control group and 578.8% of the MetS group. The BMIs of the groups differed significantly ($p<0.001$), with the obese class II accounting for 82.8% of cases and MetS sufferers having a higher BMI than controls. MetS individuals had greater HbA1c and fasting blood sugar levels than controls ($p\leq0.05$). Triglycerides were higher in MetS sufferers than in controls ($P<0.001$).

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Table 2: Socio-demographic and biochemical characteristics of cases and controls included in the study.

S. No.	Characteristics	MetS (n=300)		Controls (n=350)		p value
		N	%	N	%	
1.	**Gender**					
	Male	150	50.0	200	57.1	0.09
	Female	150	50.0	150	42.8	
2.	**Age in years**					
	≤30	100	33.3	100	28.5	<0.001
	>50	200	66.6	250	71.4	
3.	**Dwelling**					
	Urban	200	66.6	200	57.1	0.88
	Rural	100	33.3	150	42.8	
5.	**Lifestyle**					
	Active	100	28.5	100	33.3	<0.001
	Sedentary	250	71.4	200	66.6	
8.	**Fasting Blood Sugar (mg/dl)**					
	<126	00	0	350	100	<0.001
	≥126	300	100	00	0	
9.	**HbA1c**					
	<6.5	00	0	350	100	
	6.5-9.0 (High glycemic	200	66.6	00	0	≤0.05
	control)	100	33.3	00	0	
	>9 (Low glycemic control)					

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10	**BMI (Kg/m^2)**					
	Normal	00	0	350	100	
	Underweight	00	0	00	0	<0.001
	Pre obese	20	6.6	00	0	
	Obese Class I	40	13.3	00	0	
	Obese Class II	240	80.0	00	0	
11.	**Triglycerides (TG) (mg/dl)**					
	Normal	00	0	350	100	<0.001
	Elevated	300	100	00	0	
12.	**Total Cholesterol (TC)**					
	(mg/dl)	00	0	300	85.7	0.18
	Normal	300	100	50	14.3	
	Elevated					
13.	**LDL-C (mg/dl)**					
	Normal	00	0	342	97.7	>0.05
	Elevated	300	100	08	2.3	
14.	**HDL-C (mg/dl)**					
	Normal	00	0	350	100	<0.001
	Low	300	100	00	00	

BMI; Body mass index, TG; Triglycerides, LDL-C; Low density lipoproteins-cholesterol, HDL-C; High density lipoproteins-cholesterol, BMI: Basal Metabolic Index.

The subjects had a mean weight of 86.1 ± 6.8 cm and a mean BMI of 23.6 ± 3.0 kg/m^2. The average age of the subjects was 52.1 ± 8.4 years. 51.4% and 25.7% of cases, respectively, had diabetes and hypertension. The baseline characteristics and MetS components for individuals with obesity and those without obesity with MetS are shown in Table 3.

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Table 3: Levels of clinical and biochemical parameters in cases and controls.

Variable	MetS N=300	Controls N=350	P-Value
Age, yr	54.4±9.1	51.5 ± 8.4	**<0.001**
BMI, kg/m^2	25.1±3.2	23.4 ± 2.8	**<0.001**
Fasting glucose, mg/dl	115.8±18.8	94.4 ± 10.1	**<0.001**
Waist circumference, cm	89.8±6.8	84.4 ± 6.1	**<0.001**
Systolic blood pressure, mmHg	127.7±14.5	117.4 ± 12.4	**<0.05**
Diastolic blood pressure, mmHg	80.2±9.5	75.2 ± 8.1	**<0.05**
Triglycerides, mg/dl	184.9±95.2	125.7 ± 52.7	**<0.001**
Total cholesterol, mg/dl	199.7±36.5	198.5 ± 31.4	**0.21**
LDL, mg/dl	124.5±30.5	122.8 ± 27.1	**0.44**
HDL, mg/dl	45.5±11.5	53.8 ± 12.3	**<0.001**
HbA1C, %	6.9±1.0	5.3 ± 0.5	**<0.001**
FVC, %	93.0±12.0	97.1 ± 11.4	**<0.001**
FEV$_1$, %	102.5±14.1	106.1 ± 13.5	**<0.001**
FEV$_1$/FVC, ratio	82.5±5.8	81.8 ± 6.0	**0.33**
Anti-hypertensive medication	210	14	**<0.001**
Anti-diabetic medication	110	05	**<0.001**
Diabetes	180 (51.4)	10 (3.3)	**<0.001**
Hypertension	90 (25.7)	15 (5.0)	**<0.001**

***BMI, body mass index; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second.**

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When comparing MetS individuals to non-MetS participants, all MetS components were significantly higher. A significantly greater proportion of people with MetS were seen to take oral hypoglycemic or anti-hypertensive drugs. While there was no discernible difference in the FEV1/FVC ratios between the MetS and non-MetS groups, the MetS group's FVC and FEV1 were significantly lower than those of the non-MetS group's individuals (Table 3). FVC, FEV1, and FEV1/FVC were also evaluated between the groups with and without MetS. While the values of FVC and FEV1 were significantly lower in the MetS individuals than in the controls (93.0 ± 12.0% vs. 97.1 ± 11.4% and 102.5 ± 11.4% vs. 106.1 ± 13.5%, respectively; $P < 0.05$), the FEV1/FVC did not change significantly (82.5 ± 5.8% vs. 81.8 ± 6.0%; $P = 0.33$, NS).

Table 4: Correlations between percentage of forced vital capacity (FVC) and parameters of metabolic disorders

Parameters	**Correlation Coefficient** **FVC, n= 300**	**P-value**
Fasting glucose	0.11	0.110
Triglyceride	-0.08	0.004
HDL-C	0.09	0.141
Systolic blood pressure	- 0.07	<0.001
Waist circumference	-0.9	<0.001
HbA1C	-0.12	<0.001

In table 4, FVC values shows no correlation with MetS components, including fasting serum glucose and HDL. Whereas, FVC shows negative correlation with TG, SBP, and WC, even after controlling for age and height.

Table 5: Baseline characteristics and metabolic risk factors of subjects according to quartile of forced vital capacity (FVC) in the non-obese groups (<25 kg/m2).

Risk factors	**<87%**	**87-96%**	**96-104%**	**≥104%**	**P-Value**
Age (years)	52.1 ± 8.7	50.8 ± 9.3	49.6 ± 10.2	47.5 ± 9.8	0.015
Male (%)	60%	58%	55%	50%	0.320
BMI (kg/m²)	23.4 ± 1.1	23.1 ± 1.2	23.0 ± 1.1	22.8 ± 1.2	0.045

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Waist Circumference (cm)	82.3 ± 6.5	81.7 ± 6.0	80.8 ± 6.2	79.5 ± 5.8	0.042
Central Obesity (%)	25%	22%	18%	15%	0.028
Systolic BP (mmHg)	134 ± 15	132 ± 14	128 ± 13	126 ± 12	0.032
Diastolic BP (mmHg)	85 ± 10	83 ± 9	82 ± 8	80 ± 7	0.038
Fasting Glucose (mg/dL)	102.5 ± 12.1	98.3 ± 10.8	95.7 ± 9.8	93.4 ± 8.9	0.018
Triglycerides (mg/dL)	145.7 ± 22.8	140.3 ± 20.6	135.2 ± 19.4	130.8 ± 18.1	0.023
HDL, mg/dl	45.5±11.5	51.8 ± 12.3	52.8 ± 13.3	53.2 ± 13.3	**<0.001**
HbA1C, %	5.9±1.0	5.6 ± 0.5	5.7 ± 0.8	5.4 ± 0.5	**<0.001**
FVC, %	88.0±5.0	91.1 ± 2.6	98.4 ± 2.6	109.4 ± 4.2	**<0.001**
FEV_1, %	89.1±9.2	102.1 ± 13.5	107.1 ± 7.5	119.1 ± 9.5	**<0.001**
FEV_1/FVC, ratio	84.5±8.8	91.8 ± 6.0	91.1 ± 6.0	101.8 ± 6.0	**0.33**

***BMI, body mass index; HDL-C, high density lipoprotein cholesterol; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second.**

According to Table 5, the mean age significantly decreased between Q1 and Q4 (P=0.015), indicating that younger people often have higher FVC values. From the lowest to the highest FVC quartile, there is a significant drop in both BMI and waist circumference (P=0.045 and P=0.042, respectively). In non-obese people, lower central adiposity is linked to improved lung capacities. In the higher FVC quartiles, there is a significant decrease in the prevalence of central obesity as well as both systolic and diastolic blood pressure (P=0.028, P=0.032, and P=0.038, respectively). This implies that a greater FVC may have a preventive impact against metabolic problems. Between Q1 and Q4, there is a significant increase in HDL-C levels, while fasting glucose and triglyceride levels drop (P=0.018, P=0.023, and P=0.030, respectively). Higher lung capacities are correlated with better metabolic profiles. While BMI was lower in patients in the lowest FVC

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quartile than in those in the highest FVC quartile, fasting blood glucose, WC, HbA1C, SBP, and HDL-C were all substantially higher in non-obese subjects (Table 5). Table 5 indicates a significant deterioration in the group's FVC and FEV1 lung function metrics in relation to MetS.

Table 6: Baseline characteristics and metabolic risk factors of subjects according to quartile of forced vital capacity (FVC) in the obese groups (>25 kg/m2).

Variable	<87%	87-96%	96-104%	≥104%	P-Value
Age (years)	54.2 ± 9.1	52.5 ± 8.7	50.3 ± 9.5	49.0 ± 9.2	0.021
BMI (kg/m²)	31.2 ± 3.8	30.5 ± 3.5	29.8 ± 3.6	28.9 ± 3.7	0.034
Waist Circumference (cm)	100.5 ± 8.2	98.7 ± 7.9	96.3 ± 7.5	94.1 ± 7.2	0.028
Central Obesity (%)	90%	85%	80%	75%	0.025
Systolic BP (mmHg)	140 ± 16	137 ± 15	133 ± 14	130 ± 13	0.037
Diastolic BP (mmHg)	90 ± 11	88 ± 10	85 ± 9	82 ± 8	0.040
Fasting Glucose (mg/dL)	108.7 ± 13.5	105.4 ± 12.8	101.2 ± 11.9	98.3 ± 10.7	0.022
Triglycerides (mg/dL)	180.5 ± 25.6	175.3 ± 24.1	170.1 ± 23.4	165.8 ± 22.9	0.030
HDL-C (mg/dL)	38.2 ± 7.3	39.8 ± 7.1	41.2 ± 6.8	42.7 ± 6.5	0.035
HbA1C, %	5.9±1.0	5.1 ± 0.5	5.5 ± 0.8	5.6 ± 0.5	**<0.001**
FVC, %	83.0±6.0	91.1 ± 2.7	98.3 ± 2.1	109.2 ± 5.5	**<0.001**
FEV_1, %	89.5±8.1	99.7 ± 9.0	108.1 ± 7.7	118.1 ± 10.1	**<0.001**
FEV_1/FVC, ratio	82.5±5.8	81.8 ± 6.0	81.7 ± 5.3	80.8 ± 5.1	**0.33**

***BMI, body mass index; HDL-C, high density lipoprotein cholesterol; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second.**

Table 6 shows a significant mean age decline from Q1 to Q4 (P=0.021), indicating that younger people often have higher FVC values. From the lowest to the highest FVC quartile, there is a significant drop in both BMI and waist circumference (P=0.034 and P=0.028, respectively).

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Even in obese people, lower central adiposity is linked to improved lung capacities. In the higher FVC quartiles, there is a substantial decrease in the prevalence of central adiposity and both diastolic and systolic blood pressure (P=0.025, P=0.037, and P=0.040, respectively). This implies that a greater FVC may have a preventive impact against metabolic problems. Between Q1 and Q4, there is a significant increase in HDL-C levels, while fasting glucose and triglyceride levels drop (P=0.022, P=0.030, and P=0.035, respectively). Higher lung capacities are correlated with better metabolic profiles. When compared to persons in the highest FVC quartile, fasting blood glucose, WC, and HbA1C were significantly greater in obese participants in the lowest FVC quartile (Table 6). Table 6 illustrates a significant deterioration in the group's FVC and FEV1 lung function metrics in relation to MetS.

Table 7: Linear Regression Analysis of FVC with Metabolic Risk Factors

Variable	β Coefficient	Standard Error	t-value	P-value	Correlation (r)
Systolic BP (mmHg)	-0.025	0.015	-1.67	0.095	**-0.210 (Significant)**
Triglycerides (mg/dL)	-0.005	0.003	-1.50	0.135	**-0.190 (Significant)**
Fasting Glucose (mg/dL)	-0.002	0.006	-0.33	0.741	**-0.050 (Not Significant)**
HDL-C (mg/dL)	0.008	0.012	0.67	0.504	**0.060 (Not Significant)**
Waist Circumference (cm)	-0.030	0.010	-3.00	0.003*	**-0.300 (Significant)**

Table-7 summarizes that the, Systolic Blood Pressure (SBP) and Triglycerides (TG) have negative β coefficients, suggesting an inverse relationship with FVC. While not statistically significant (P > 0.05), they are correlated with FVC. Fasting Glucose and HDL-C show no significant correlation with FVC, indicating that changes in these variables do not substantially affect lung function. Waist Circumference are significantly negatively correlated with FVC, suggesting that higher values are associated with reduced lung volumes.

Discussion

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The study was done on the Kashmiri population with the goal of figuring out how lung function and MetS are related. The restricted pattern in lung function seen in patients with Metabolic Syndrome (MetS) from Kashmir is the main focus of this study. Reduced lung volumes, most notably a lower Forced Vital Capacity (FVC), are the hallmark of restrictive lung disorders, which are frequently identified by either a normal or elevated FEV1/FVC ratio. There are several physiological, biochemical, and environmental variables that play a complicated role in the interaction between MetS and restrictive lung patterns. The results of this study advance our knowledge of how elements of the metabolic syndrome (MetS), in particular central obesity and high fasting glucose, affect lung function and result in restrictive pulmonary alterations. The FVC and FEV1 values, but not the FVC/FEV1 ratio, were greater in the non-MetS group of study participants than in the MetS group. Patients with metastatic pulmonary disease (MetS) exhibit reduced spirometric values, exhibiting a little but harmonic decline in FEV1 and FVC while maintaining an unaltered FEV1/FVC ratio. This reflects a ventilatory restrictive rather than an obstructive pattern. In order to determine the kind of pulmonary disease, it is crucial to define the restricted spirometric pattern, which is not entirely sufficient but rather a sign that further lung function testing is needed. In actuality, total lung capacity (TLC) must be evaluated in order to determine restriction precisely. Moreover, most patients who have spirometry restrictions have this verified when TLC is examined. Large studies, however, cannot measure TLC since it is costly, time-consuming, and necessitates specialized facilities and paramedics with specialized training. The confluence of systemic inflammation, oxidative stress on lung tissue, and abdominal obesity limiting diaphragmatic mobility is probably what causes the restrictive lung pattern seen in MetS patients. Additionally, the present investigation showed that the presence of three or more MetS components significantly lowers FVC. Recent research indicates that the pathophysiology of significant weight gain contributes to MetS. [22,23]. Our research indicates an adverse relationship between obesity and FVC and FEV1 [24–26]. Consistent with previous studies, we discovered that WC appears to have a negative correlation with FVC and FEV1 in individuals who are obese or not, but BMI appears to have a favorable correlation with these measures. However, those with a BMI greater than 25 kg/m^2 showed a negative correlation with FVC and FEV1, which is also in line with the results of previous studies [27]. These results supported our hypothesis that a higher

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BMI may be an obesity risk factor. Furthermore, central obesity, as opposed to BMI alone, may be a significant factor in declining lung function, particularly in terms of FVC.

In an apparently healthy group, Nakajima et al.[27] recently established a severity-dependent relationship between MetS and metabolic diseases and reduced restrictive pulmonary function. Many conditions, including muscle weakness, congestive heart failure, interstitial lung disease, diabetes mellitus, and obesity, can be linked to restrictions on spirometry. These conditions are also linked to greater morbidity and limitation. [28-31]. A study by Oda et al. [32] shown that in non-obese participants, a decreased vital capacity is linked to diabetes but not to MetS. Specifically, they found that non-obese Japanese had a lower vital capacity, which was associated with a lower BMI, and that there might be additional mechanisms involved in the association between diabetes and lower vital capacity in non-obese Japanese than just MetS or insulin resistance. However, our findings showed that lower FVC values were associated with MetS and diabetes in non-obese individuals, despite the fact that the BMI in the lowest FVC quartile was lower than in the highest quartile. The prevalence of diabetes, hypertension, and MetS, as well as fasting blood glucose, HbA1C level, SBP, and these outcomes between those in the lowest and highest FVC quartiles, were significantly different within the non-obese group. According to our findings, characteristics of metabolically obese individuals with normal body weight may be associated with a lower FVC. [33,34]. Abdominal obesity was a better indicator of pulmonary function than BMI. This potential association may result from the mechanical effects of abdominal obesity on the compliance of the diaphragm and chest wall. [35]. In our multi-linear regression analysis, MetS parameters appeared to be independently linked with FVC when age, height, and MetS components were included. This results suggests that the relationship between insulin resistance and FVC is unaffected by abdominal obesity, despite the fact that it is a risk factor for the development of insulin resistance and has a mechanical component that may lead to impaired lung function. Additional studies have shown the presence of other established factors, like diabetes and hypertension, all of which have a negative relationship with FVC. However, there may be more than one reason causing the decreased lung function. Previous studies have shown that insulin resistance, diabetes, high blood pressure, and cardiovascular disease can all be predicted by impaired lung function [36, 37]. In contrast to previous research, our study did not discover a link between cardiovascular disease and

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decreased lung function; however, we did deduce that a lower forced vital capacity (FVC) was linked to a higher risk of type 2 diabetes, hypertension, hypertriglyceridemia, and central obesity. The lack of link may be explained by the fact that our study's participants had a low prevalence of cardiovascular disease. Therefore, we recommend that patients exhibiting a restrictive pattern be evaluated for MetS and treated as potentially at-risk. It is also important to screen for respiratory dysfunction in MetS patients. To avoid respiratory difficulties, it is essential to identify MetS and its constituent parts as soon as possible. Timely interventions can be facilitated by routinely screening for MetS in patients experiencing unexplained dyspnea or impaired lung function. Lung function should be improved by MetS management. Reduction of body weight, dietary adjustments, and enhanced glycemic management can lessen the constriction on the lungs. Exercise-based pulmonary rehabilitation programs can help improve the endurance and strength of the breathing muscles. To lower the incidence of MetS, Kashmir's public health programs should emphasize lifestyle changes. Community-wide improvements can be spurred by awareness campaigns regarding the detrimental effects of obesity and inadequate glycemic management on lung health. Longitudinal studies should be the main focus of future research in order to determine the causal links between MetS and restrictive lung patterns.

Conclusion

This study comprehensively evaluates the impact of Metabolic Syndrome (MetS) on lung function in Kashmiri patients, with a focus on the association between metabolic risk factors and restrictive lung patterns. The results reveal that patients with MetS have significantly lower Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and FEV1/FVC ratio compared to controls, indicative of a restrictive lung pattern. Although systolic blood pressure (SBP) and triglycerides (TG) are not statistically significant predictors of FVC, they show a negative correlation, highlighting their potential impact on lung function. Conversely, fasting glucose and HDL-C do not exhibit a significant correlation with FVC, suggesting that these parameters may not directly influence lung function in this population**.** It was also found that increased waist circumference was significantly impacting decreased lung function, underscoring the physiological and mechanical effects of MetS constituents on respiratory health. These findings

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highlight the need for thorough management and early identification of MetS in order to lessen its harmful impact on lung function. It is crucial to implement targeted therapies that emphasize better glycemic control, weight management, and lifestyle changes. Integrated healthcare techniques and public health activities are essential for treating the dual burden of metabolic and respiratory disorders in the Kashmiri population, given their unique genetic makeup and environmental circumstances. For Kashmiri patients with MetS, raising awareness and advocating for preventive actions can greatly improve overall health outcomes.

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