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PULMONARY FUNCTION TEST IN METABOLIC SYNDROME: A CASE CONTROL STUDY.

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ABSTRACT

Background: The increasing incidence of overweight and obesity is a major public health concern worldwide. One of the most significant consequences of the obesity epidemic is the rise of metabolic syndrome, a cluster of interrelated metabolic abnormalities that significantly increases the risk of cardiovascular diseases. Though cardiovascular consequences of metabolic syndrome is well known, its effect on lung functions is not fully understood. This study aims to analyse the effects of metabolic syndrome on lung function tests and compare them with healthy individuals.
Materials and Methods: This was a case control study conducted in the department of physiology of a tertiary care medical institute. 40 patients fulfilling the criteria for metabolic syndrome were included in this study. 40 healthy individuals with normal body mass index (18.5 and 24.9) were included in this study as control group. Lung function paramaters such as Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC) and The ratio of Forced Expiratory Volume in 1 second to Forced Vital Capacity (FEV1/FVC) were determined and compared between both the groups.
Results: Lung function parameters, including FEV1, FVC, and FEV1/FVC ratio, were significantly lower in individuals with metabolic syndrome compared to healthy individuals, with all differences being statistically highly significant ($p < 0.0001$). Respiratory parameters FEV1 and FVC showed negative correlations with systolic and diastolic blood pressure, fasting blood sugar, triglycerides, and waist circumference in individuals with metabolic syndrome, indicating that higher values of these variables were associated with lower lung function. In contrast, HDL cholesterol exhibited a slight positive correlation with FEV1 and FVC, suggesting a beneficial effect on respiratory function.
Conclusion: Individuals with metabolic syndrome exhibit significantly reduced lung functions underscoring the adverse effects of metabolic syndrome on respiratory functions.
Keywords: Metabolic syndrome, Lung function test, Forced Vital Capacity, Central Obesity.

INTRODUCTION

The increasing incidence of overweight and obesity is a major public health concern worldwide. This is causing a substantial rise in various non-communicable diseases including cardiovascular diseases, diabetes and its consequences.[1] According to the World Health Organization (WHO), more than 1.9 billion adults were overweight in 2016 of which over 650 million were obese. The rapid escalation of overweight and obesity can be attributed to multiple factors, including changing dietary patterns, reduced physical activity, and urbanization. Consumption of high-calorie processed foods rich in sugars and fats combined with sedentary behavior have significantly contributed to this growing epidemic. Genetic predisposition, socio-economic factors, and environmental influences also play important roles.[2]

One of the most significant consequences of the obesity epidemic is the rise of metabolic syndrome, a cluster of interrelated metabolic abnormalities that significantly increases the risk of cardiovascular diseases, type 2 diabetes and all-cause mortality. Metabolic syndrome is defined by the presence of at least three of the following five criteria: central obesity, hyperglycemia, hypertension, hypertriglyceridemia, and low levels of high-density lipoprotein (HDL) cholesterol. These risk factors, when present together, act synergistically, compounding the individual's likelihood of developing serious health complications.[3] The primary underlying mechanism behind metabolic syndrome is insulin resistance where the body's cells become less responsive to insulin leading to elevated blood glucose levels. Central obesity plays a central role in the pathogenesis of insulin resistance.[4]

Predisposing factors for metabolic syndrome include an unhealthy diet, physical inactivity, and genetic factors. Other contributors include chronic stress, hormonal imbalances and medical conditions such as polycystic ovary syndrome (PCOS).[5] Age and ethnicity also influence the risk of developing metabolic syndrome with older individuals and certain ethnic groups (such as South Asians) being more susceptible. Lifestyle modifications, including dietary changes, increased physical activity, and weight loss are important for managing metabolic syndrome. Despite these efforts, the prevalence of metabolic syndrome continues to rise globally, with current estimates suggesting that approximately one-third of adults in many developed countries meet the criteria for this condition.[6]

The adverse impact of metabolic syndrome on the cardiovascular system is well-documented, with individuals having a markedly higher risk of developing atherosclerosis, coronary artery disease, stroke, and heart failure. The interrelationship between central obesity, insulin resistance, dyslipidemia, and hypertension promotes the development of endothelial dysfunction, inflammation, and oxidative stress, all of which contribute to cardiovascular complications. However, the effects of metabolic syndrome extend beyond the cardiovascular system, with emerging evidence highlighting its detrimental influence on respiratory health.[7]

Metabolic syndrome has been linked to a range of respiratory disorders, including obstructive sleep apnea (OSA), asthma, and chronic obstructive pulmonary disease (COPD). Central obesity is known to exert mechanical effects on respiratory function by restricting diaphragmatic movement, reducing lung volumes, and increasing airway resistance. Insulin resistance and systemic inflammation have also been implicated in the pathogenesis of respiratory dysfunction. Inflammation within the respiratory tract may contribute to airway hyperreactivity and remodeling. These factors collectively lead to a decline in respiratory function, heightening the risk of respiratory diseases in individuals with metabolic syndrome. Despite the growing body of evidence linking metabolic syndrome to respiratory dysfunction, the precise mechanisms underlying this association remain to be fully understood.[8]

Several studies have demonstrated a significant reduction in FVC and FEV1 in individuals with metabolic syndrome, particularly in those with central obesity. This decline in lung function is believed to result from mechanical constraints imposed by excess abdominal fat, which limits diaphragmatic excursion and reduces lung expansion.[9] Additionally, insulin resistance and systemic inflammation may contribute to airway remodeling and obstruction further compromising respiratory function. Although the majority of research has focused on spirometric parameters, other respiratory function tests, such as DLCO and PEFR, may also be affected in individuals with metabolic syndrome. Despite these findings, there remains considerable variability in the reported effects of metabolic syndrome on respiratory function, necessitating further investigation.[10]

The present study aims to address this knowledge gap by conducting a comparative analysis of respiratory function tests in individuals with and without metabolic syndrome.

MATERIALS AND METHODS

This was a case control study conducted in the department of physiology of a tertiary care medical institute. 40 patients fulfilling the criteria for metabolic syndrome were included in this study. 40 healthy individuals with normal body mass index (18.5 and 24.9) were included in this study as control group. Informed and written consent was obtained from all the partipants. The sample size was determined on the basis of pilot study on the topic of respiratory function tests in metabolic syndrome. Keeping the power to be 90% and confidence interval to be 95% the sample size required was 35 patients therefor we included 40 patients in our study as cases and similar number of healthy individuals were enrolled as control group. Demographic details of all participants including age, gender, history of medications, physical activities, past surgery and eating habits was noted. Height and weight were measures and BMI was calculated in all cases. Fasting blood glucose levels, blood pressure values, lipid profile and and waist circumference was noted in cases as well as control group.

Patients with presence of any 3 of the 5 of following factors were diagnosed to be having metabolic syndrome as per the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria,[11]

1. Fasting glucose ≥100 mg/dL.
2. Blood pressure ≥130/85 mm Hg,
3. Triglycerides ≥150 mg/dL.
4. HDL-C < 40 mg/dL in men or < 50 mg/dL in women

5. Waist circumference ≥102 cm (40 in) in men or ≥88 cm (35 in) in women.

Pulmonary function test was performed in all cases measured using a spirometer (RMS Helios 702 portable spirometer). Pulmonary function test was performed in sitting position. The values measured were Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC) and The ratio of Forced Expiratory Volume in 1 second to Forced Vital Capacity (FEV1/FVC) was determined in all cases. The comparison of these parameters between individuals with metabolic syndrome and healthy individuals was done.

The statistical analysis was done with the help of SPSS version 21.0 software. Quantitative data was presented as mean and standard deviation whereas qualitative data was presented by frequency and percentage tables. Unpaired t-tests were employed for quantitative data, and Chi-square tests were used for qualitative data. P value less than 0.05 was taken as statistically significant.

Inclusion Criteria

1. Patients having metabolic syndrome as per the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria (Cases) and similar number of healthy individuals (Control group).
2. Age above 18 years
3. Those willing to give written and informed consent to be part of study.

Exclusion Criteria

1. Age less than 18 years.
2. Those who refused consent.
3. Patients with pre-existing chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma or interstitial lung disease.
4. History of recent myocardial infarction, stroke, or unstable cardiovascular conditions in the past 6 months.
5. Individuals with history of smoking.
6. Individuals taking medications that can influence respiratory function, such as long-term bronchodilators or corticosteroids.
7. Pregnant women.

RESULTS

The analysis of the gender distribution of the studied cases showed that in Group A (Metabolic Syndrome), there were 24 males, comprising 60% of the group, and 16 females, making up 40%. In Group B (Healthy Individuals) there were 22 males, (55%) and 18 females (45%). Both groups consisted of a total of 40 individuals each. Both the groups were comparable with respect to gender distribution (P= 0.8213). [Table 1]

In Group A (metabolic syndrome) the most common age group among males was Above 50 (32.5%) followed by the 41-50 years (20%). Among females, the Above 50 age group also had the highest number (17.5%), followed by 6 females (15%) in the 41-50 age group. Overall, males constituted 60% of the group, while females made up 40%. The mean age for males was 54.34 ± 9.98, and for females, it was 51.68 ± 8.46. IN group A mean age of males and females was found to be comparable with no statistically significant difference (P=0.386). 10 (25%) males and 9 (22.5%) females were above 50 years followed by 7 males (17.5%) and 6 females (15%) in 41-50 years age group. Males accounted for 55% of Group B, and females made up 45%. The mean age for males and females in this group was 53.87 ± 8.12 and 50.98 ± 7.14 respectively. In group B also mean age of males and females was found to be comparable with no statistically significant difference (P=0.2448). [Table 2]

Systolic blood pressure (SBP) was notably higher in the metabolic syndrome group (150.76 ± 15.89 mmHg) as compared to healthy individuals (139.22 ± 14.98 mmHg) The difference was found to be statistically significant. Similarly diastolic blood pressure (DBP) was also elevated in the metabolic syndrome group (91.34 ± 6.97 mmHg) as compared to the healthy group (84.58 ± 5.99 mmHg). Fasting blood sugar (FBS) was significantly higher in the metabolic syndrome group (119.89 ± 15.67 mg/dl) as compared to healthy individuals (99.23 ± 14.72 mg/dl). Similarly serum triglyceride levels Triglycerides (TG), waste circumference and body mass index were found to be more in metabolic syndrome group as compared to healthy individuals and the difference was statistically highly significant (P<0.0001). HDL cholesterol (HDL C) was lower in the metabolic syndrome group (34.85 ± 3.98 mg/dl) as compared to the healthy group (40.21 ± 3.89 mg/dl) and this difference was statistically significant (p < 0.0001). [Table 3]

The analysis comparing lung function between individuals with metabolic syndrome and healthy individuals showed significant differences across all parameters. Forced Expiratory Volume in 1 second (FEV1) was lower (3.45 ± 0.42 liters) in the metabolic syndrome group at compared to healthy individuals (3.91 ± 0.38 liters in the), with a highly significant P value of less than 0.0001. Similarly, Forced Vital Capacity (FVC) was less in the metabolic syndrome group (3.10 ± 0.45 liters) as compared to healthy individuals (3.90 ± 0.40 liters). Ratio of FEV1 to FVC (FEV1/FVC %) was also lower in individuals with metabolic syndrome (79.20 ± 5.20%) as compared to healthy individuals (84.30 ± 4.90%). The differences observed across these respiratory function parameters were statistically highly significant (P < 0.0001). [Table 4]

Various respiratory parameters such as Forced Expiratory Volume in 1 second (FEV1) and Forced Vital Capacity (FVC)were correlated with variables including systolic and diastolic blood pressure (SBP and DBP), fasting blood sugar (FBS), triglyceride (TG) levels, high-density lipoprotein cholesterol (HDL-C), and waist circumference (WC) in individuals with metabolic syndrome. The analysis revealed negative correlations between systolic blood pressure and FEV1 (-0.14) and FVC (-0.16), indicating that higher SBP values were associated with lower lung function. A similar trend was observed for diastolic blood pressure, with negative correlations for FEV1 (-0.02) and FVC (-0.024). Fasting blood sugar showed a notable negative correlation with FEV1 (-0.22) and FVC (-0.18), suggesting a decline in these respiratory parameters with increasing FBS. Triglyceride levels also displayed negative correlations with FEV1 (-0.040) and FVC (-0.038). HDL exhibited a slight positive correlation with FEV1 (0.05) and FVC (0.06) suggesting a beneficial effect of higher HDL levels on respiratory function. Lastly waist circumference was negatively correlated with FEV1 (-0.210) and FVC (-0.182). [Table 5]

Table 1: Gender Distribution of the studied cases

Gender Distribution	Group A (Metabolic Syndrome)		Group B (Healthy Individuals)	
	Number of individuals	Percentage (%)	Number of individuals	Percentage (%)
Males	24	60%	22	55%
Females	16	40%	18	45%
Total	40	100%	40	100%
P= 0.8213 (Not Significant)				

Table 2: Gender Wise Age Distribution of studied cases

Gender Wise Age distribution		Males		Females		
		Number	Percentage	Number	Percentage	
Group A (Metabolic Syndrome)	18-30	0	0.00%	1	2.50%	P = 0.386 Not significant
	31-40	3	7.50%	2	5.00%	
	41-50	8	20.00%	6	15.00%	
	Above 50	13	32.50%	7	17.50%	
	Total	24	60.00%	16	40.00%	
Mean Age		54.34 ± 9.98		51.68 ± 8.46		
Group B (Healthy Individuals)	18-30	1	2.50%	0	0.00%	P = 0.2448 Not significant
	31-40	4	10.00%	3	7.50%	
	41-50	7	17.50%	6	15.00%	
	Above 50	10	25.00%	9	22.50%	
	Total	22	55.00%	18	45.00%	
Mean Age		53.87 ± 8.12		50.98 ± 7.14		

Table 3: Comparison of variables of metabolic syndrome in both the groups

Variables	Metabolic Syndrome	Healthy Individuals	P value
SBP (mm/Hg)	150.76 ± 15.89	139.22 ± 14.98	P = 0.0013
DBP (mm/Hg)	91.34 ± 6.97	84.58 ± 5.99	P < 0.0001
FBS (mg/dl)	119.89 ± 15.67	99.23 ± 14.72	P < 0.0001
TG (mg/dl)	199.72 ± 29.76	169.45 ± 24.85	P < 0.0001
HDL C (mg/dl)	34.85 ± 3.98	40.21 ± 3.89	P < 0.0001
WC (cm)	105.58 ± 7.82	89.76 ± 6.97	P < 0.0001
BMI (kg/m²)	34.98 ± 3.42	29.76 ± 2.95	P < 0.0001

Table 4: Comparison of FEV1, FVC and FEV1/FVC ratio in both the groups

Variables	Metabolic Syndrome	Healthy Individuals	P value
FEV1 (Liter)	3.45 ± 0.42	3.91 ± 0.38	P < 0.0001
FVC (Liter)	3.10 ± 0.45	3.90 ± 0.40	P < 0.0001
FEV1/FVC %	79.20 ± 5.20	84.30 ± 4.90	P < 0.0001

Table 5: Correlation of variables and pulmonary function test in studied cases

Variables in individuals with metabolic Syndrome	FEV1 (Pearsons's correlation coefficient)	FVC (Pearsons's correlation coefficient)	Inference
SBP (mm/Hg)	-0.14	-0.16	Negative Correlation Higher systolic blood pressure values were found to be associated with decreasing FEV1 and FVC .
DBP (mm/Hg)	-0.02	- 0.024	Negative Correlation Higher Diastolic blood pressure values were found to be associated with decreasing FEV1 and FVC .
FBS (mg/dl)	-0.22	-0.18	Negative Correlation Higher Fasting blood sugar values were found to be associated with decreasing FEV1 and FVC .
TG (mg/dl)	-0.040	-0.038	Negative Correlation Higher triglyceride values were found to be associated with decreasing FEV1 and FVC .
HDL (mg/dl)	0.05	0.06	Positive Correlation

			Lower HDL values were found to be associated with decreasing FEV1 and FVC .
WC (cm)	-0.210	-0. 182	Negative Correlation Higher waist circumference values were found to be associated with decreasing FEV1 and FVC.

DISCUSSION

Adverse cardiovascular consequences of metabolic syndrome are well known. Presence of risk factors seen in metabolic syndrome (central obesity, hypertension, elevated blood sugar, high triglycerides, and low high-density lipoprotein) accelerates the development of atherosclerosis leading to the accelerated atherosclerosis.[12] This increases the likelihood of hypertension and coronary artery disease, both of which heighten the risk of events such as myocardial infarction and embolic stroke. Insulin resistance (hallmark of metabolic syndrome) contributes to endothelial dysfunction and inflammation further exacerbating cardiovascular strain. Individuals with metabolic syndrome are also more prone to developing heart failure and arrhythmias thereby significantlyincreasing the risk of cardiovascular morbidity and mortality.[13]

Relatively less is known about the effects of metabolic syndrome of various lung function parameters such as FEV1, FVC and FEV1/FVC ratio. Though the mechanism by which factors associated with metabolic syndrome affects various lung function parameters is not clearly known however adiposity as well as fat-induced inflammation is thought to have a role in affecting lung functions. In contrast to the well-known association between asthma and obesity, the recognition that MetS affects the lung functions is relatively new. Also uncertainty as to the relative contribution that each metabolic factor has in adversely affecting the respiratory functions.[14]

In this study FEV1was lower in the metabolic syndrome group at compared to healthy individuals. Similarly, FVC and Ratio of FEV1 to FVC was less in the metabolic syndrome group as compared to healthy individuals. The differences observed these was statistically highly significant ($P < 0.0001$). Rafael Molina-Luque et al conducted a cross-sectional study to determine if a higher number of metabolic syndrome (MetS) criteria is linked to increased lung function decline.[15] For this purpose, the authors undertook a study comprising a random sample of 1,980 workers. MetS was diagnosed using harmonized criteria, and spirometric variables were used to assess lung function. The study found that Met S was associated with reduced lung function (mean FEV1 83 vs 89.2; p<.001) and increased prevalence of lung dysfunction (41% vs 21.9%). On the basis of these findings, the authors concluded that an increasing number of MetS risk factors worsened lung function and emphasized the importance of using spirometry for early detection. Similar detrimental effect of components of metabolic syndrome on lung functions was also reported by the authors such as Lee YY et al,[16] and Scarlata S et al.[17]

In this study respiratory parameters, such as FEV1 and FVC negatively correlated with systolic and diastolic blood pressure, fasting blood sugar, triglyceride levels, and waist circumference in individuals with metabolic syndrome. On the other hand HDL cholesterol levels showed a slight positive correlation with lung function. These findings suggest that worsening metabolic syndrome factors are associated with reduced lung function. Ahmed MS et al conducted a prospective, observational study to examine the relationship between metabolic syndrome (MetS) risk factors and lung function.[18] For this purpose, the authors studied 60 patients at a tertiary care hospital using spirometry. Pulmonary function tests, such as FEV1, FVC, and FEV1/FVC ratios, were analyzed along with MetS components like BMI, systolic and diastolic blood pressure, and cholesterol. Significant gender differences were observed across BMI, blood pressure, cholesterol, and other metabolic markers ($p<0.05$). The study found that FEV1 and FVC were inversely related to the number of MetS components. For example, FEV1 was significantly lower in individuals with higher BMI, fasting glucose, and triglyceride levels. Male and female participants showed statistically significant differences in pulmonary function, with males generally exhibiting poorer lung function. On the basis of these findings, the authors concluded that the accumulation of MetS components adversely affects lung function, highlighting the need for early intervention. Similar correlation between components of metabolic syndrome and lung function test was also reported by the authors such as Bae MS,[19] et al and Chen WL et al.[20]

CONCLUSION

Individuals with metabolic syndrome have significantly lower lung function parameters (FEV1, FVC, and FEV1/FVC) compared to healthy individuals. Negative correlations between respiratory parameters and metabolic factors such as blood pressure, fasting blood sugar, triglycerides, and waist circumference highlight the adverse impact of metabolic syndrome on lung functions.

Conflict of Interest: None.

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