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A STUDY OF METABOLIC SYNDROME IN TYPE 2 DIABETES MELLITUS AND NORMAL ADULT INDIVIDUALS

Dr Amita Gandhi- Associate professor[1*], Dr Krunal Talsaniya- Associate professor[1*], Dr Bhavikkumar Prajapati- Associate professor[2*]

1 Department of medicine, GMERS Medical college, Sola, Ahmedabad, Gujarat

2 Department of medicine, Dr M K Shah Medical College and Research Center, Chandkheda, Ahmedabad, Gujarat

Corresponding author: Dr Bhavikkumar Prajapati

Mobile number: 9909961887

Email ID: bhavikap87@yahoo.com

ABSTRACT: INTRODUCTION: Metabolic syndrome is a constellation of metabolic abnormalities that includes central obesity, hypertension, elevated fasting glucose, low high-density lipoprotein (HDL) cholesterol, high triglyceride (National Cholesterol Education Program Adult Treatment Panel III [NCEP ATP III]). It is associated with increased risk of coronary artery disease and stroke. Regardless of the existing controversies in diagnosis and definition, the metabolic syndrome is still considered to be a useful diagnostic tool in primary care prevention. A very few studies have been done in this topic in Gujarat, most of the data are from western population. So, no useful data is available regarding association of various parameters of metabolic syndrome particularly in our setup and area. **AIMS AND OBJECTIVES:** To study clinical profile of metabolic syndrome and its individual components in Type 2 diabetic and non-diabetic subjects**.** We also want to compare the distribution of metabolic syndrome by using the different criteria (ATP-III and IDF)**,** compare the association of hypercholesterolemia and hypertension with type 2 diabetes mellitus and to compare the distribution of metabolic syndrome with hyperglycaemia and establishing its strong association with Type 2 DM by comparing them with non-diabetics. **MATERIALS AND METHODS:** we include the patients with T2DM with age >20 years and should be on treatment. We exclude the patient with T2DM age < 20 years, pregnant women, patient on long term steroid therapy, patient with severe complications, moribund patients and patient refusal. We took Waist Circumference Measurements, Blood Pressure Measurement and biochemical tests. **DISCUSSION:** Present study highlights the prevalence of metabolic syndrome in two different group, diabetic and non-diabetic. It is evident from the study that diabetic patients have higher prevalence of Mets than normal people. It is also concluded that hypertension, hyperlipidemia and central obesity are also closely related with metabolic syndrome. **CONCLUSION:** In this study, we have completed our data in our hospital with limited number of patients. When we are calculating the prevalence, larger sample size is recommended. So, we can apply the same for generalized population. Same like diabetic patients, we can also compare the prevalence of metabolic syndrome in hypertensive and non-hypertensive patients by dividing the study population into both groups.

KEY WORDS: Diabetes mellitus, Hypertension, metabolic syndrome, Dyslipidemia

INTRODUCTION: Metabolic syndrome is a constellation of metabolic abnormalities that includes central obesity, hypertension, elevated fasting glucose, low high-density lipoprotein (HDL) cholesterol, high triglyceride (National Cholesterol Education Program Adult Treatment Panel III [NCEP ATP III]. It is associated with increased risk of coronary artery disease and stroke. In 1988, Reaven proposed the concept of syndrome X. In 1988, WHO proposed a formal definition of metabolic syndrome. Three years later, the NCEP ATP III proposed metabolic syndrome based on clinical parameters. The European Group for the study of Insulin Resistance (EGIR), The World Health Organization (WHO) and International Diabetes Federation (IDF) had also developed their own definition. Regardless of the existing controversies in diagnosis and definition, the metabolic syndrome is still considered to be a useful diagnostic tool in primary care prevention. It gives

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opportunity for early patient identification and education on proper and early health behavioural changes implicated in the development of the deadly cardiovascular diseases like hypertension and diabetes. Patients could be educated early about the connection between their lifestyle, health risks, and medical outcomes. For instance, the (NCEP/ATP III) identifies metabolic syndrome as an indication for vigorous lifestyle intervention. Effective interventions include diet, exercise, and judicious use of pharmacologic agents to address specific risk factors. Weight loss will significantly improve all aspects of metabolic syndrome. Increase in physical activity and decrease in caloric intake by reducing portion sizes have been found to improve metabolic syndrome abnormalities, even in the absence of weight loss. Specific dietary changes that are appropriate for addressing different aspects of the syndrome include reducing saturated fat intake to lower insulin resistance, reducing sodium intake to lower blood pressure, and reducing high-glycaemic-index carbohydrate intake to lower triglyceride levels. A very few studies have been done in this topic in Gujarat most of the data are from western population. So, no useful data is available regarding association of various parameters of metabolic syndrome particularly in our setup and area. Therefore, we are doing this study to gather more data and information that will be of much use in taking better care of our patients by better diagnosis and reducing complication by early detection and elimination. Thus, we find need for such study in our population.

AIMS AND OBJECTIVES:

AIM:

To study clinical profile of metabolic syndrome and its individual components in Type 2 diabetic and non-diabetic subjects

OBJECTIVES:

PRIMARY OBJECTIVE

- To study clinical profile of metabolic syndrome and its individual components in T2 diabetic and non-diabetic subjects.

SECONDARY OBJECTIVE

- To compare the distribution of metabolic syndrome by using the different criteria (ATP-III and IDF)
- To compare the association of hypercholesterolemia and hypertension with type 2 diabetes mellitus.
- To compare the distribution of metabolic syndrome with hyperglycaemia and establishing its strong association with Type 2 DM by comparing them with non-diabetics.

MATERIALS AND METHODS:

Study Area: The study was performed in tertiary care hospital – G.M.E.R.S. Medical College and Hospital, Sola, Ahmedabad

Study Design: Case control study

Study Period: From April 2022 to May 2023

Study Population: Patients of type 2 diabetes mellitus and non-diabetic groups visiting medicine who gave consent to take part in study fulfilling the inclusion criteria.

Inclusion Criteria:

1. Patient with T2DM with age >20 years
2. Patients should be on treatment (taking insulin injections or oral hypoglycaemic drugs)

Exclusion Criteria:

1. Patient with T2DM age < 20 years
2. Pregnant women
3. Patient on Long term steroid therapy

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4. Patient with severe complications (Diabetic ketoacidosis / Hyperosmolar coma)
5. Moribund patients
6. Patient refusal

Family selection was random. For nondiabetic group, matching of the patients are done by age (+/- 5 yrs) and gender.

Methodology: Waist Circumference Measurements: Waist circumference was also taken using a non-stretchable tape measure at level of the uppermost edge of the hip bone on a light clothed abdomen with the tape parallel to the ground and recorded to the nearest centimetres.

Blood Pressure Measurements: Blood pressure was taken from the arm (brachial artery) from all respondents in the first encounter by using digital sphygmomanometer. Blood pressure measurement was done in a sitting position with the arm supported and repeated after 5 minutes; the average of the three measurements was taken as a blood pressure. The systolic pressure of above or equal to130mmHg and diastolic pressure above or equal to 85mmHg was regarded as a high blood pressure. Those who found to have high BP were further evaluated and treated appropriately.

Biochemical Tests: After an overnight fasting, blood samples for high density lipoproteins (good cholesterol), serum triglycerides and blood glucose was collected. Five millilitres of venous blood was taken from the antecubital fossa and placed in empty sterile tubes.

Diagnostic Criteria for the Metabolic Syndrome:

In this study, metabolic syndrome was diagnosed using the ATP III and IDF definitions, as summarized below.

According to ATP III criteria,
The individual must have **three or more** of the following:

1. Waist circumference >102 cm (40.2 in) in men and >88 cm (35.6 in) in women
2. Serum triglycerides ≥150 mg/dl
3. Blood pressure ≥130/85 mmHg
4. HDL cholesterol <40 mg/dl in men and <50 mg/dl in women
5. Fasting plasma glucose >5.6mmol/l (≥100 mg/dl)

According to IDF criteria,
The individual **must** have Central obesity (defined as waist circumference with ethnicity specific values, if BMI is >30kg/m², central obesity can be assumed and waist circumference does not need to be measured)
AND **any two** of the following:

1. Raised triglycerides: >150 mg/dL (1.7 mmol/L), or specific treatment for this Lipid abnormality.
2. Reduced HDL cholesterol: < 40 mg/dL (1.03 mmol/L) in males, < 50 mg/dL (1.29 mmol/L) in females, or specific treatment for lipid abnormality
3. Raised blood pressure: systolic BP >130 or diastolic BP >85 mm Hg, or treatment of previously diagnosed hypertension.
4. Raised fasting plasma glucose :(FPG)>100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes. If FPG >5.6 mmol/L or 100 mg/dL, OGTT Glucose tolerance test is strongly recommended but is not necessary to define presence of the Syndrome.

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RESULTS AND ANLAYSIS: results and analysis are below

Table 1: Gender Distribution

Gender	N	%
Male	91	56.88%
Female	69	43.13%
Total	160	100.00%

Table 2: Mean Age

Gender	Mean Age	SD
Male	53.10	12.92
Female	58.75	11.51
Total	55.54	12.61

Table 3: Study Population

Gender	Diabetic	%	Non Diabetic	%
Male	45	56.25%	46	57.50%
Female	35	43.75%	34	42.50%
Total	80	100.00%	80	100.00%

Table 4: Age Group Distribution

Age Group	Total	%
20-39 Years	13	8.13%
40-59 Years	83	51.88%
> 60 Years	64	40.00%
Total	**160**	**100.00%**

Results according to NCEP ATP III Criteria (Table 5-10):
Table 5: Prevalence of Metabolic Syndrome (NCEP ATP III)

Diabetes		Yes	No	Total	p value
Metabolic Syndrome (Present)	**Male**	28	14	42	**0.000**
	%	49.12%	48.28%	100.00%	
	Female	29	15	44	
	%	50.88%	51.72%	100.00%	
Total		**57**	**29**	**86**	
%		**71.25%**	**36.25%**	**53.75%**	

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Metabolic Syndrome (Absent)	**Male**	17	32	49	
	%	73.91%	62.75%	100.00%	
	Female	6	19	25	
	%	26.09%	37.25%	100.00%	
Total		**23**	**51**	**74**	
%		**28.75%**	**63.75%**	**46.25%**	
p value		**0.05**	0.244	**0.037**	

Table 6: Prevalence of MetS (NCEP ATP III) in Diabetic Group (Age Group Analysis)

Age Group	**Diabetes (Yes)**				**Total**	**%**	**p value**
	MetS (Present)	**%**	**MetS (Absent)**	**%**			
20-39 Years	2	22.22%	7	77.78%	9	100.00%	**0.006**
40-59 Years	29	69.05%	13	30.95%	42	100.00%	
> 60 Years	26	89.66%	3	10.34%	29	100.00%	
Total	57	71.25%	23	28.75%	80	100.00%	

Table 7: Prevalence of MetS (NCEP ATP III) in Non Diabetic Group (Age Group Analysis)

Age Group	**Diabetes (No)**				**Total**	**%**	**p value**
	MetS (Present)	**%**	**MetS (Absent)**	**%**			
20-39 Years	1	25.00%	3	75.00%	4	100.00%	0.755
40-59 Years	15	36.59%	26	63.41%	41	100.00%	
> 60 Years	13	37.14%	22	62.86%	35	100.00%	
Total	29	36.25%	51	63.75%	80	100.00%	

Table 8: Prevalence of MetS (Gender Analysis)

Gender	**MS (Present)**	**%**	**MS (Absent)**	**%**	**Total**	**%**	**p value**
Male	42	46.15%	49	53.85%	91	56.88%	0.025
Female	44	63.77%	25	36.23%	69	43.13%	
Total	86	53.75%	74	46.25%	160	100.00%	

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Table 9: Multiple Logistic Regression of MetS with DM, Age Group, Gender and Obesity

Metabolic Syndrome (NCEP ATP III)				
Variable	**p value***	**Odds Ratio**	**95% C.I.**	
			Lower	**Upper**
Diabetes Mellitus	0.002	0.348	0.181	0.671
Gender	0.025	2.128	1.095	4.135
Age Group	0.029	1.787	1.061	3.008
Obesity	0.000	4.258	2.526	6.897
***Logistic Regression**				

Table 10: MetS and Blood Investigation & Blood Pressure (Mean ± SD)

Blood Parameters	**Metabolic Syndrome (Present)**	**Metabolic Syndrome (Absent)**	**p value**
FBS	172.95±72.07	122.99±52.57	0.000
Total Cholesterol	258.95±56.60	211.32±38.08	0.000
Triglyceride	170.56±31.81	144.20±30.29	0.000
HDL	41.05±9.32	49.46±8.69	0.000
LDL	160.12±22.88	144.99±23.44	0.000
SBP	145.64±20.63	133.77±19.15	0.000
DBP	83.31±9.79	77.01±13.89	0.002

Results according to IDF Criteria (Table 11-16):

Table 11: Prevalence of Metabolic Syndrome (IDF)

Diabetes		**Yes**	**No**	**Total**	**p value**
Metabolic Syndrome (Present)	**Male**	24	11	35	**0.007**
	%	48.00%	40.74%	45.45%	
	Female	26	16	42	
	%	52.00%	59.26%	54.55%	
Total		**50**	**27**	**77**	
%		**62.50%**	**33.75%**	**48.13%**	
Metabolic Syndrome (Absent)	**Male**	21	35	56	
	%	70.00%	66.04%	67.47%	
	Female	9	18	27	
	%	30.00%	33.96%	32.53%	
Total		**30**	**53**	**83**	
%		**37.50%**	**66.25%**	**51.88%**	
p value		**0.065**	**0.035**	**0.006**	

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Table 12: Prevalence of MetS (IDF) in Diabetic Group (Age Group Analysis)

Age Group	Diabetes (Yes)				Total	1 %	p value
	MetS (Present)	%	MetS (Absent)	%			
20-39 Years	3	33.33%	6	66.67%	9	11.25%	0.090
40-59 Years	25	60.98%	16	39.02%	41	51.25%	
> 60 Years	22	73.33%	8	26.67%	30	37.50%	
Total	50	62.50%	30	37.50%	80	100.00%	

Table 13: Prevalence of MetS (IDF) in Non Diabetic Group (Age Group Analysis)

Age Group	Diabetes (No)				Total	%	p value
	MetS (Present)	%	MetS (Absent)	%			
20-39 Years	0	0.00%	4	100.00%	4	5.00%	0.341
40-59 Years	15	35.71%	27	64.29%	42	52.50%	
> 60 Years	12	35.29%	22	64.71%	34	42.50%	
Total	27	33.75%	53	66.25%	80	100.00%	

Table 14: Prevalence of MetS (Gender Analysis)

Gender	MetS (Present)	%	MetS (Absent)	%	Total	%	p value
Male	35	38.50%	56	61.50%	91	56.88%	0.007
Female	42	60.90%	27	39.10%	69	43.13%	
Total	77	48.13%	83	51.88%	160	100.00%	

Table 15: Multiple Logistic Regression of Mets (IDF) with DM, Age Group and Gender

Metabolic Syndrome (IDF)				
Variable	p value*	Odds Ratio	95% C.I.	
			Lower	Upper
Diabetes Mellitus	0.000	0.306	0.160	0.584

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Gender	0.005	0.402	0.211	0.763
Age Group	0.116	1.020	0.995	1.046
***Logistic Regression**				

Table 16: MetS and Blood Investigation & Blood Pressure (Mean ± SD)

Blood Parameters	Metabolic Syndrome (Present)	Metabolic Syndrome (Absent)	p value
FBS	174.26±69.43	127.99±59.23	0.000
Total Cholesterol	263.55±56.48	212.23±38.37	0.000
Triglyceride	169.96±34.05	147.61±31.45	0.000
HDL	42.06±9.62	47.60±9.53	0.000
LDL	161.47±23.49	145.37±24.57	0.000
SBP	144.44±20.37	136.60±20.56	0.017
DBP	83.16±9.66	78.07±13.69	0.007

DISCUSSION: Our results revealed high prevalence rates of metabolic syndrome were found in female compared to male, independently of the criteria used. In our study, 53.75% (N=86) patients were classified as having metabolic syndrome and 46.25% patients were classified as not having metabolic syndrome. Below table shows prevalence of metabolic syndrome found in various other studies. As we have taken 80 diabetic patients in our study, the prevalence in our study is much higher. However, in non-diabetic group, prevalence of Mets is 36.25% which is comparable to other studies.

Table: Prevalence of Metabolic Syndrome in various studies.

Reference	City, country	MS prevalence (%)	Diagnostic criteria
Abdul-Rahim HF, *et al.*, 2001[1]	Palestinian	17%	WHO
Ford ES, 2003[2]	US	ATPIII – 23.9%; WHO – 25.1%	ATPIII & WHO
Al-Lawati JA, *et al.*, 2003[3]	Nizwa City, Oman	17%; 21%	ATPIII
Resnick HE, *et al.*, 2003[4]	Arizona, Oklahoma & Dakota	35%	ATPIII
Azizi F, *et al.*, 2003[5]	Tehran, Iran	30.1%; 33.7%	ATPIII
Tan CE, *et al.*, 2004[6]	Singapore	Asian Indians: 28.8%; Malays: 24.2%, Chinese: 14.8%	ATPIII
Oh J, *et al.*, 2004[7]	Korea	Men: 29%; Women: 16.8%	ATPIII [modified]
Ilanne-Parikka P, *et al.*, 2004[8]	Finland	Men: 38.8%; Women: 22.2%	WHO
Jaber LA, *et al.*, 2004[9]	Michigan, US	ATPIII: 23%; WHO: 28%	ATPIII & WHO

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Reference	City, country	MS prevalence (%)	Diagnostic criteria
Thomas GN, *et al.*, 2005[10]	Hong Kong	21.9%	ATPIII [modified]
Son LNTD, *et al.*, 2005[11]	Ho Chi Minh City, Vietnam	18.5%; 12.0%	ATPIII
Gu D, *et al.*, 2005[12]	China (Inter-ASIA)	Men: 9.8%; Women: 17.8%	ATPIII
Ford ES, 2005[13]	United States.	ATPIII: 34.5%; IDF: 39.0%	ATPIII & IDF
Ko GT, *et al.*, 2005[14]	Hong Kong	WHO: 13.4%; EGIR: 8.9%; ATPIII: 9.6%	WHO, EGIR & ATPIII [modified]
Adams RJ, *et al.*, 2005[15]	South Australia	IDF: 22.8%; ATPIII:15%	IDF & ATPIII
Guerrero-Romero F, *et al.*, 2005[16]	Northern Mexico (Durango City)	IDF:22.3%; ATPIII:22.6%; WHO: 15.4%	IDF, ATPIII & WHO
Shiwaku K, *et al.*, 2005[17]	Japan, Korea and Mongolia	Japanese: 12%; Koreans: 13%; Mongolians: 16%	ATPIII [modified: BMI ≥ 25]
Scuteri A, *et al.*, 2005[18]	Cardiovascular Health Study (CHS)	ATPIII: 28.1%; WHO: 21%	ATPIII & WHO
Bo S,*et al.*, 2005[19]	North-western Italy	23.1%	ATPIII
Mohan V, *et al.*, 2001[20]	Chennai, India	11.2%	EGIR
Ramachandran A, *et al.*, 2003[21]	Chennai, India	41.1%	ATPIII [modified]
Gupta R, *et al.*, 2004[22]	Jaipur, India	31.6%; 24.9%	ATPIII
Deepa M *et al.*, 2004[23]	Chennai, India	WHO: 23.2%; ATPIII: 18.3%; IDF: 25.8%	WHO, ATPIII & IDF

In contrast to the study of Felix-Val *et al.*, [24] the present study, apart from assessing the prevalence of MetS in type 2 diabetic patients, also used logistic regression analysis to determine the most critical risk factors that need to be monitored in order to control, prevent and treat diabetes. The main finding of this study was a high prevalence (71.25%) by NCEP ATP III criteria, 62.50% by IDF criteria) of MetS in type 2 diabetics which was consistent with previous study by Nsiah K et al [25], 58.00% prevalence of MeTs in type 2 diabetics. Females showed higher prevalence of MetS (63.77%) as they had more of the risk factors contributing to MetS, compared to males (46.15%), which was consistent with a previous study by Felix-Val *et al.* [24] and Ford *et al.* [26] From the logistic regression analysis, females were 2 times more likely to have MetS than males. There was a high prevalence of obesity, contributing to 56.25% of the entire diabetes study population. Obese persons were 4 times more likely to have MetS, compared to normal weight persons. Obesity worsens insulin resistance which then leads to increased hepatic production of very low-density lipoprotein and the consequent release

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of high levels of TG in the bloodstream leading to more prevalence of Metabolic syndrome. Persons with impaired glucose tolerance and type 2 diabetes, have hypertriglyceridemia as well as increased HDL catabolism, leading to lowered HDL levels. [27] A number of potential mechanisms could explain the inverse relationship between the hypertriglyceridemia of insulin resistant states and increased HDL catabolism, leading to low plasma HDL concentrations. One possibility is a reduction in lipoprotein lipase (LPL) activity, which would have the effect of impairing the maturation of HDL particles. The normal insulin-mediated stimulation of LPL activity has been shown to be blunted in insulin resistance. In type 2 diabetes, particularly when glycemic control is poor and in patients who are relatively insulin deficient, LPL activity is reduced. Thus, obesity is a major risk factor that really needs to be controlled in order to prevent type 2 diabetes mellitus or to stop or slow down the development of some complications. In the present study, hypertension was found to be the commonest component in the entire type 2 diabetes study population, followed by central obesity and lowered HDL-C. In the both males and females, the most prevalent component was hypertension, followed by hypertriglyceridemia and then lowered HDL. This result is in fair agreement with Felix-Val *et al*. in 2008, [24] who, using the NCEP/ATP III, found hypertension to be the commonest in males, followed by hypertriglyceridemia. Hypertensive diabetic patients have a greater risk of micro and macrovascular complications than normotensive patients. Prevalence of Metabolic syndrome in the 40–49 age group is 69.05% (according to NCEP/ATP III criteria) / 60.98% (according to IDF criteria) and in the >60 age group is 89.66% (according to NCEP/ATP III criteria) / 70.33% (according to IDF criteria). This indicates that in the diabetic group, as the age increases, people are likely to have a high prevalence of the MetS components, irrespective of sex. Thus, serious preventive and control measures should be taken as one nears these age groups since the prevalence of MetS increases with age. Individuals should be advised to exercise more, watch their diet by eating food containing little amounts of saturated fats and cholesterol, and foods containing refined sugars and rather take in more fiber-rich foods. These findings are also consistent with previous studies. High fiber diets have been shown to have good glycemic index, having the potential to lower fasting plasma glucose, total cholesterol and triglyceride, plasma concentrations. They simply decrease gastrointestinal absorption of cholesterol and carbohydrates.

RECOMMENDATION:

1. In this study, we have completed our data in our hospital with limited number of patients (160). When we are calculating the prevalence, larger sample size is recommended. So, we can apply the same for generalized population.
2. Same like diabetic patients, we can also compare the prevalence of metabolic syndrome in hypertensive and non-hypertensive patients by dividing the study population into both group

LIMITATIONS:

1. There are three different international criteria to define the Metabolic syndrome. We have obtained our result-prevalence of Mets by using NCEP ATP III and IDF criteria. For WHO criteria, insulin resistance is must which is unpredictable in every patients and difficult to measure.
2. Sample size of this study is very small. Large multi-centric trial with large sample is required to validate the study data

CONCLUSION:

1. Present study highlights the prevalence of metabolic syndrome in two different group, diabetic and non-diabetic.
2. Prevalence of Mets in diabetic patients,
   71.25% (NCEP ATP III criteria)
   62.50% (IDF criteria)
3. Prevalence of Mets in non-diabetic patients,
   36.25% (NCEP ATP III criteria)
   33.75% (IDF criteria)

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4. It is evident from the study that diabetic patients have higher prevalence of Mets than normal people.
5. It is also concluded that hypertensive patients (>130/85) are more associated with metabolic syndrome.
6. Hyperlipidemia and central obesity are also closely related with metabolic syndrome.

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