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RESEARCH ARTICLES

Frequency of Metabolic Syndrome in Type 2 Diabetes Mellitus in a Tertiary Care Hospital of Bangladesh

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ABSTRACT

Background: As a well-established risk factor for coronary heart disease, Metabolic Syndrome was already encountered. But the relationship between Metabolic Syndrome and Type 2 Diabetes Mellitus and the independent contribution of Metabolic Syndrome remained unclear. To evaluate the status of metabolic syndrome in the Type 2 diabetic population and for their ability to predict Type 2 Diabetes Mellitus, in parallel with conventional stroke risk factors, this study was planned. **Methods:** A hospital-based descriptive observational study was conducted in 100 patients with Type 2 Diabetes Mellitus who were selected by consecutive random sampling techniques. Patients were diagnosed through proper history, clinical examination, and necessary investigations. The outcome values were measured in anthropometric measurements, blood pressure, dyslipidemia, and blood glucose. **Results:** Among 100 patients with Type 2 Diabetes Mellitus, (64%) were females who were housewives (41%) with significant difference ($p < 0.001$) and Mean± SD was 58±12.24 yrs ranging from 32-85 years. About 30% had a positive family history of Type 2 Diabetes Mellitus and 28% tobacco abuse. Of the total, 31% of patients had high blood pressure, and 28% had low HDL with a significant difference ($p<0.001$), but 46% had high triglyceride levels, which was not significant. More than half (53.12%) females showed central obesity, while only 16.67% had central obesity among males, and it showed a significant difference ($p=0.04$) in both sex. There was a high frequency of Metabolic Syndrome in a patient with Type 2 Diabetes Mellitus (68%) with a significant difference, and 48% were female, and 20 % were male. In patients of Metabolic Syndrome, central obesity was found in 36(52.94%) patients where females were predominantly affected 32(88.89%), hypertension found in 28(4118%) patients where male were predominantly affected 16(57.14%) patients, hypertriglyceridemia found in 44(64.70%) patients where a female was predominantly affected 26(59.09%) patients and low HDL found in 22(32.35%) patients where a female was predominantly affected 16(72.73%). **Conclusion:** The frequency of Metabolic Syndrome was more than double in women (48%). Central obesity and low HDL were significantly more prevalent in women than men, where hypertension was significant in men. So it would be reasonable to conclude that women are more likely to suffer from Metabolic Syndrome from cardiovascular morbidity and mortality.

KEYWORDS: Metabolic syndrome; Central obesity; Waist-Hip Ratio (WHR); Blood pressure, Dyslipidemia.

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INTRODUCTION

Metabolic Syndrome is a major health problem globally, and it increases various cardiovascular disease risk factors like diabetes and pre-diabetes, abdominal obesity, hyperlipidemia, and high blood pressure. People with Metabolic Syndrome have a five-fold greater risk of developing Type 2 Diabetes Mellitus.[1] There are several definitions for Metabolic Syndrome. The definitions of the National Cholesterol Education Program (NCEP/ATP III) and International Diabetes Federation (IDF) are the most widely used.[2] It is now believed that Metabolic Syndrome is driving the twin global epidemics of Type 2 Diabetes and cardiovascular disease. South Asians have a

high prevalence of Metabolic Syndrome [3] and an unusually high tendency to develop Type 2 Diabetes Mellitus and atherosclerotic cardiovascular disease (ASCVD).[4] In order to reduce the medical and economic burdens, it is imperative to identify patients with Metabolic Syndrome and treat them early with lifestyle modification and drugs, where needed.

Obesity, particularly abdominal obesity, is associated with resistance to the effects of insulin on peripheral glucose and fatty acid utilization, often leading to Type 2 Diabetes Mellitus. Insulin resistance, the associated hyperinsulinemia and hyperglycemia, and adipocyte cytokines (adipokines) may also lead to vascular endothelial dysfunction, an abnormal lipid profile, hypertension, and vascular inflammation, all of which promote the development of atherosclerotic cardiovascular disease (ASCVD). [5] A similar profile can be seen in individuals with abdominal obesity who do not have an excess of total body weight. [6]

Obesity is strongly associated with reduced longevity and stroke, diabetes, thrombosis, and the development of coronary artery disease. Obesity contributes to atherosclerosis and the transition to acute ischemic stroke.[7] Obesity leads to insulin resistance that, in turn, leads to a cluster of traditional risk factors, known as metabolic syndrome, which facilitates atherogenesis. [8] Increased intra-abdominal fat causes 'central' ('abdominal,' 'visceral,' 'android' or 'apple-shaped') obesity, which contrasts with subcutaneous fat accumulation causing 'generalized' ('gynoid' or 'pear-shaped') obesity; the former is more common in men and is more closely associated with Type 2 Diabetes, the Metabolic Syndrome and cardiovascular disease and ischemic stroke as well. Abdominal obesity is an independent, potent risk factor for ischemic stroke in all race & ethnic groups. It is a stronger risk factor than BMI and has a greater effect on younger persons. [9]

In insulin-resistant individuals, the adipose tissues have a diminished capacity to take up free fatty acids. These free fatty acids are available to the liver that, as a result, secretes an increased amount of very-low-density lipoprotein (VLDL).[10] VLDL delivers cholesterol to the vessel wall facilitating atherogenesis. Also, high-density lipoprotein (HDL) cholesterol concentration in insulin-resistant individuals is reduced, and dense low-density lipoprotein (LDL) cholesterol particles are generated. [9]

Body mass index (BMI) is altered by parameters other than body fat, such as muscle mass and fluid status. Abdominal obesity, measured by waist circumference (WC) or waist-hip ratio (WHR), has been suggested as a better predictor of cardiovascular and stroke events.[11] Obesity can be measured by BMI, waist circumference (WC), and waist-hip ratio (WHR). WHR may be the preferred measure of the ischemic stroke risk associated with obesity. In contrast with BMI, WHR specifically addresses abdominal obesity and correlates better with overall atherosclerotic disease prevalence. WHR is obtained by dividing the mean waist circumference (measured between the lower border of the ribs and the iliac crest in a horizontal plane) by the mean hip-circumference (measured at the widest point over the buttocks). Abdominal obesity, measured by waist circumference or WHR, has been suggested as a better predictor of cardiovascular risk.[12]

People with metabolic syndrome are twice as likely to die from and three times as likely to have a heart attack compared with people without the syndrome. Studies have shown that Asians have a higher percentage of adiposity at lower BMI than Caucasians and are more prone to develop Metabolic Syndrome. Obesity, particularly abdominal obesity, is associated with resistance to the effects of insulin on peripheral glucose and fatty acid utilization, often leading to Type 2 Diabetes Mellitus, and type-2 diabetes mellitus patients are more prone to develop Metabolic Syndrome. But there is no data available regarding the actual number of people affected in Bangladesh. So the present study aimed to observe the status of Metabolic Syndrome in Type 2 Diabetes Mellitus patients, describe patients of metabolic syndrome, observe the clustering of cardiovascular risk factors in Type 2 Diabetes Mellitus, and observe the demographic profile.

MATERIALS AND METHODS

This hospital-based descriptive observational study was carried out at Dhaka Medical College and Hospital (DMCH, Dhaka, Bangladesh, October 2012 to April 2013 after getting ethical clearance from ERC (Ethical Review Committee) of DMCH. The purposive sampling technique selected the sample. However, the calculated sample size was 96, but 100 samples were taken in the study.

Inclusion criteria

1. Patients of diagnosed type 2 diabetes mellitus.
2. Age- more than 30 years.

Exclusion criteria

1. Patients with acute illness. (e.g. Stroke, myocardial infarction)
2. Patients with other co-morbidity. (e.g., genetic or congenital defect in height and weight, ascites, pregnancy)
3. Patients on regular anti-dyslipidemic drugs, diuretics, and beta-blockers.

Data collection procedure

After the arrival of a patient with known Type2 Diabetes Mellitus, immediately attend the patient and examine thoroughly to measure weight (kg), height, and waist circumference (centimeters), and then BMI was calculated. Pulse and BP were recorded. The CRF was filled by the study physician herself by direct face-to-face interview method. Then about 5 ml of blood was collected to estimate FBS and fasting lipid profile (total cholesterol, LDL, HDL, TG.). Spot collection of the sample outdoors and sample collection was done within 24 hrs for indoor patients. Those patients who were not in the fasting state were asked to come to the fasting state the next morning. The sample was sent to the pathology department of DMCH, and these were analyzed by automated analyzer machine Biolis24i machine. After being briefed about the objectives, risks, benefits, freedom for participating in the study, and confidentiality, patients were enrolled in the study. Informed consent was obtained accordingly. The study physician himself filled up the pre-structured CRF.

Diagnostic tools

A. Diagnostic criteria of Diabetes Mellitus

A diagnosis of diabetes, as defined by the American Diabetes Association (ADA), requires one of the following four criteria to be met:

1. Fasting plasma glucose (FPG): 126mg/l (7.0 mmol/L) after a minimum of eight hours with no caloric intake,
2. Symptoms of hyperglycemia and a casual (random) plasma glucose: 200 mg/dL (11.1 mmol/L),

3. Two hours plasma glucose: 200 mg/dl (11.1 mmol/L) during a 75-gram oral glucose tolerance test (OGTT), or
4. Glycated hemoglobin A1c (HbA1c): 6.5% using a method that is National Glycohemoglobin Standardization Program (NGSP) certified and standardized to the Diabetes Control and Complications Trial (DCCT) assay.[13]

B. Anthropometry

The data on anthropometry includes Waist Circumference (WC) and Waist Hip Ratio (WHR). By using standard non-elastic tape, WHR is obtained by dividing the mean waist circumference (measured between the lower border of the ribs and the iliac crest in a horizontal plane) by the mean hip-circumference (measured at the widest point over the buttocks). WC was measured midway between the iliac crest and costal margins after removing folds of clothing. Standard landmarks and methodology were followed in recording the anthropometric measurements.[14]

Operational definitions

a. Hypertension: BP>140/90mmHg or patients on antihypertensive medication. (JNC- 7, 2004) [3]

b. Diabetes Mellitus: Symptoms of diabetes plus casual plasma glucose concentration 200mg/dl (11.1mmol/l) or Fasting plasma glucose.126mg/dl (7mmol/l). Type2 Diabetes Mellitus was defined as diabetes mellitus develop after the age of 30 years.[4]

c. Body mass index: BMI is calculated in (kg/m2). Classification of overweight and obesity by BMI:
Classification BMI kg/m2
Healthy weight
18.5-24.977

d. Obesity: The recommended BMI cut-off value for Asians for overweight is 23-25 kg/m². [15]

e. Metabolic Syndrome: Diagnostic criteria for metabolic syndrome include three or more of the following: [16]

S. N	Risk factor	Standard level	
1.	Abdominal obesity		Waist circumference
		Men	≥102cm (40 in)
		Women	≥88cm (35in)
2.	Triglyceride (TG)		≥150mg/dl
3.	HDL cholesterol		
		Men	≤40mg/ dl
		Women	≤50 mg/dl
4.	Fasting glucose(FBS)		≥110 mg/dl
5.	Blood pressure		130/80mmHg

f. Waist circumference is considered the intermediate abdominal area, perimeter between the last costal arch and the iliac crest measured. During measurement, the tape must be kept horizontal. [15]

Data analysis

Data were analyzed using computer-based software, statistical package for social science (SPSS) version 15. Categorical variables like gender, history of hypertension, diabetes mellitus, smoking, dyslipidemia were presented in frequencies and percentages. Continuous variables like age, waist circumference, WHR were calculated as mean, standard deviation. Cross tabulation was performed to get the relation between males and females.

RESULTS

One hundred patients diagnosed with Type 2 Diabetes Mellitus were studied in Dhaka Medical College Hospital, Dhaka, from July to December 2012. Table I shows that most patients were female and the Mean±SD of male and female patients. It was found that about one-third of patients with a positive family history of Type 2 Diabetes Mellitus and tobacco abuse. The maximum number of Type 2 Diabetes Mellitus patients (about 94%) was above 40 years of age, and the maximum frequency was found in between 60-69 years (about 29%). (Table II)

Table I General characteristics of patients

Variable	Value
Age	Mean (58.04years) ± SD12.24
Sex **Male** **Female**	 36% 64%
Family history of Type 2 Diabetes Mellitus	30%
Tobacco abuse	28%

Table II: Age distribution of patients

Age range (year)	No. of patient	Frequency
30-39	6	6.0
40-49	24	24.0
50-59	25	25.0
60-69	29	29.0
> 70	16	16.0
Total	100	100.0
Mean±SD **Range**	58.04±12.24 32-85	

Figure 1: shows that most of the patients were housewives (41%), followed by a businessman (22%) and then a service holder (20%).

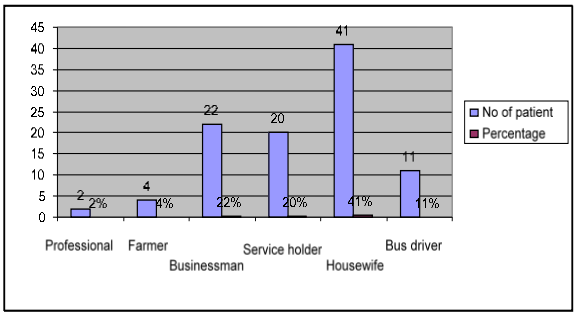

Fig 1 Occupational distribution of patients (n=100)

Table III shows that the majority of the patients belong to 40 years and above (94%) with a female predominance of 64(64%).

Table III Association between age group and sex of patients (n=100)

Age group	Sex		Total
	Male (n=36)	Female (n=64)	
30-39	3	3	6

	8.3%	4.7%	6.0%
40-49	8	16	24
	22.2%	25.0%	24.0%
50-59	7	18	25
	19.4%	28.1%	25.0%
60-69	13	16	29
	36.1%	25.0%	29.0%
> 70	5	11	16
	13.9%	17.2%	16.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test χ^2 =2.416 df = 4 p=0.67

Table VI shows the frequency of Metabolic Syndrome with sex. In this study, 68% of Type 2 Diabetes Mellitus patients showed a female predominance (75%) with a significant difference.

Table IV Association between sex and Metabolic Syndrome (n=100)

Metabolic syndrome	Sex		Total
	Male (n=36)	Female (n=64)	
Absent	16	16	32
	44.4%	25.0%	32.0%
Present	20	48	68
	55.6%	75.0%	68.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test $\chi2$ =4.03 df = 1 p=0.04 (significant)

Central obesity was present in 40% of Type 2 Diabetes Mellitus patients with a female predominance (53.1%), which showed a significant difference. (Table V)

Table V Association between sex and central obesity (n=100)

Central obesity	Sex		Total
	Male (n=36)	Female (n=64)	
Present	6	34	40
	16.7%	53.1%	40.0%
Absent	30	30	60
	83.3%	46.9%	60.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test $\chi2$ =12.76, df = 1, p < 0.001 (significant)

Table VII shows that hypertension is present in 31% of patients with Type 2 Diabetes Mellitus with a male predominance (55.6%) and significant difference.

Table VI Association between sex and hypertension (n=100)

Hypertension	Sex		Total
	Male (n=36)	Female (n=64)	
Present	20	11	31
	55.6%	17.2%	31.0%
Absent	16	53	69
	44.4%	82.8%	69.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test $\chi2$ =15.86 df = 1 p < 0.001 (significant)

A higher triglyceride (TG) was present in 54% of patients with Type 2 Diabetes Mellitus with a female predominance (59.4%). (Table VII)

Table VII Association between sex and TG (n=100)

TG	Sex		Total
	Male (n=36)	Female (n=64)	
High	16	38	54
	44.4%	59.4%	54.0%
Normal	20	26	46
	55.6%	40.6%	46.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test $\chi2$ =2.06 df = 1 p = 0.15

Table VIII shows a low HDL level present in 28.0% of patients with Type 2 Diabetes Mellitus with a female predominance (29.7%).

Table VIII Association between sex and HDL (n=100)

HDL	Sex		Total
	Male (n=36)	Female (n=64)	
Low	9	19	28
	25.0%	29.7%	28.0%
Normal	27	45	72
	75.0%	70.3%	72.0%
Total	36	64	100
	100.0%	100.0%	100.0%

Chi-square test $\chi2$ =0.251, df = 1, p = 0.62

In patients of Metabolic Syndrome, central obesity was found in 36(52.94%) patients where females were predominantly affected 32(88.89%), hypertension found in 28(4118%) patients where male were predominantly affected 16(57.14%) patients, hypertriglyceridemia found in 44(64.70%) patients where a female was predominantly affected 26(59.09%) patients and low HDL found in 22(32.35%) patients where a female was predominantly affected 16(72.73%). (Table IX)

Table IX Frequencies of central obesity, hypertension, hyper-triglyceridemia and low HDL level in patients with Metabolic Syndrome.

Variable	Metabolic Syndrome(n=68)		Frequency
	Male	Female	
Central obesity	4	32	36
	11.11%	88.89%	52.94%
	16	12	28

Hypertension	57.14%	42.86%	41.18%
Hyper triglyceridemia	18	26	44
	40.90%	59.09%	64.70%
Low HDL	6	16	22
	27.27%	72.73%	32.35%

DISCUSSION

This descriptive observational study was done among 100 Type 2 Diabetes Mellitus patients at Dhaka Medical College Hospital. The frequency of Metabolic Syndrome in this study is 68% among Type 2 Diabetes Mellitus patients with a female predominance (75%), consistent with a prior study done in the Diabetes Clinic of Nishtar Medical College and Hospital Multan. In their study involving a total of 187 Type 2 Diabetic patients, the frequency of Metabolic Syndrome was 65.2%, with a female predominance (43.3%). [17] This finding is also nearer to the study done in Liaquat National Hospital, Karachi, among 233 patients with Type 2 Diabetes Mellitus, which showed a frequency of Metabolic Syndrome was 79.7% with female predominance (45.5%) by applying NCEPATP III criteria and 68.1% Metabolic Syndrome with a female predominance(43.7%) by applying IDF criteria. [18] But these findings are not consistent with a cross-sectional study at OPD BIRDEM hospital among 100 DM and 44 IGT subjects in which 39.6% Metabolic Syndrome have present. [19]

The main reason for female predominance in Metabolic Syndrome is possibly the high rate of central obesity in females. The frequency of central obesity among patients with Metabolic Syndrome was 32 (88.89%). This may be related to the sedentary lifestyle of women and also due to religious and social barriers. [20] In this study, most patients are housewives (41%) followed by a businessman (22%) who also lead a sedentary lifestyle. Moreover, abdominal obesity is common in south Asians and is evident in non-obese people having a high percentage of body fat, thick subcutaneous adipose tissue, low muscle mass, insulin resistance, and hyperinsulinemia. This body composition is conducive to the development of Metabolic Syndrome. [21]

In American blacks, Mexican Americans, Korea, Iran, India, Oman, and Kinmen, women had a higher prevalence of metabolic syndrome than men. [22] This finding is not consistent with the study of Mohsin et al. conducted in PIMS, Islamabad. 106 patients showed a very high frequency of Metabolic Syndrome, 91 (85.8%) females (95%) were highly affected. Another factor of female predominance in Metabolic Syndrome is related to the higher frequency of hyper-triglyceridemia and low LDH.[19]

Hyper-triglyceridemia has been found in 44(64.70%) patients with Metabolic Syndrome, where females are predominantly affected (59.09%). That finding is also consistent with the study done in the Diabetes Clinic Of Nishtar Medical College and Hospital, Multan was a descriptive cross-sectional study involving a total of 187 Type 2 Diabetic patients that showed 68.4% hyper-triglyceridemia with female predominance 42.2%. [17] Mohsin et al. conducted a study in PIMS, Islamabad, and among 106 patients, about 78% of females showed hypertriglyceridemia.[23]

In this study, the low-frequency LDH is 22(32.35%) with a female predominance of 16 (72.73%), whereas the study of Mohsin et al. conducted a study in PIMS, Islamabad. 106 patients showed low LDH levels were present in all female patients.[23] The number of hypertensive patients among the patients with Metabolic Syndrome is 28(41.18%) with a male predominance of 16 (57.14%), which is also consistent with Mohsin et al. conducted a study in PIMS, Islamabad. There were 106 patients showed 73% of the male was hypertensive. [23] The mean age of the study population was 58 years ± SD 12.24, ranging from 32-85 years. The majority of the patients in this study were above 40 years (94%). Six (6) cases were found below 40 years. This study showed that 24% of patients were in the 4th decade, 25% were in the 5th decade, and 29 % were in the 6th decade. Thirty percent of the study population had a positive family history of type 2 diabetes mellitus, and 28% had a history of tobacco abuse. In individuals with diabetes, the coexistence of other metabolic syndrome factors denotes a higher risk for future development of atherosclerotic cardiovascular disease. [24]

The predominant underlying risk factors for the syndrome seem to be abdominal obesity and insulin resistance [25], supported by our study. Other associated conditions can be physical inactivity, aging, hormonal imbalance, and an atherogenic diet (e.g., diet rich in saturated fat and cholesterol). The aim of clinical management in individuals with Metabolic Syndrome was to reduce the risk for clinical atherosclerotic cardiovascular disease (ASCVD). Even in people with Metabolic Syndrome, first-line therapy is directed toward the major risk factors: LDL-Cholesterol above goal, hypertension, and diabetes.[25]

LIMITATIONS

- Single-center study with a smaller sample size which may not reflect the exact situation of the disease in the community
- A prospective longitudinal study should be done on a large scale on type 2 diabetes mellitus patients and followed up for a long time till to develop metabolic syndrome to get more scientific conclusions in this regard.
- As it was an observational study so, it explored the frequencies and percentages of Metabolic Syndrome and its relationship between Type II Diabetes Mellitus but confounding variables like hypertension, diabetes mellitus, smoking, dyslipidemia were not controlled.
- Logistic regression analysis will be required to get the accurate association and is the major limitation of the study.

CONCLUSION

A higher frequency of metabolic syndrome (68%) in 100 Type 2 Diabetes Mellitus patients was found. The frequency of metabolic syndrome is more than double in women (48%) compared to men (20%). Central obesity and low HDL were significantly more prevalent in women than in men, where hypertension was significantly prevalent in men compared to women. So it would be reasonable to conclude that women are more likely to suffer from a metabolic syndrome that is at the risk of cardiovascular morbidity and mortality. The following measures should be taken to overcome weight reduction measures control blood pressure and dyslipidemia.

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AUTHORS' CONTRIBUTIONS

The participation of each author corresponds to the criteria of authorship and contributorship emphasized in the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals of the International Committee of Medical Journal Editors. Indeed, all the authors have actively participated in the redaction, the revision of the manuscript, and provided approval for this final revised version.

COMPETING INTERESTS

The authors declare no competing interests with this case.

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REFERENCES

[1] Stern MP, Williams K, Gonzalez-Villalpando C, Hunt KJ, Haffner SM. Does the metabolic syndrome improve identification of individuals at risk of type 2 diabetes and/or cardiovascular disease? Diabetes Care. 2004; 27(11):2676-81. DOI: 10.2337/diacare.27.11.2676

[2] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation. 2005; 112(17):2735–52. DOI:10.1161/circulationaha.105.169404

[3] Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Metabolic syndrome in urban Asian Indian adults – a population study using modified ATP III criteria. Diabetes Res Clin Pract. 2003;60(3):199-204. DOI: 10.1016/s0168-8227(03)00060-3

[4] Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation. 1998; 97(6): 596-601. DOI: 10.1161/01.cir.97.6.596

[5] DeFronzo RA, Ferrannini E. Insulin resistance. A multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease. Diabetes Care. 1991;14(3):173-94. DOI: 10.2337/diacare.14.3.173

[6] Conus F, Allison DB, Rabasa-Lhoret R, St-Onge M, St-Pierre DH, Tremblay-Lebeau A, et al. Metabolic and behavioral characteristics of metabolically obese but normal-weight women. J Clin Endocrinol Metab. 2004; 89(10):5013–20. DOI: 10.1210/jc.2004-0265

[7] Joshi P, Islam S, Pais P, Reddy S, Dorairaj P, Kazmi K, et al. Risk Factors for Early Myocardial Infarction in South Asians Compared With Individuals in Other Countries. JAMA. 2007; 297 (3):286-94. DOI: 10.1001/jama.297.3.286

[8] Haffner S, Taegtmeyer H. Epidemic obesity and the metabolic syndrome. Circulation. 2003; 108(13):1541-5. DOI: 10.1161/01.cir.0000088845.17586.ec

[9] Suk SH, Sacco RL, Boden-Albala B, Cheun JF, Pittman JG, Elkind MS, at al. Abdominal obesity and risk of ischemic stroke: The Northern Manhattan Stroke Study. Stroke. 2003; 34(7):1586-92. DOI: 10.1161/01.str.0000075294.98582.2f

[10] Ginsberg HN. Insulin resistance and cardiovascular disease. J Clin Invest. 2000; 106(4):453-8. DOI: 10.1172/jci10762

[11] Suk SH, Sacco RL, Boden-Albala B, Cheun JF, Pittman JG, Elkind MS, at al. Abdominal obesity and risk of ischemic stroke: The Northern Manhattan Stroke Study. Stroke. 2003; 34(7):1587-92. DOI: 10.1161/01.str.0000075294.98582.2f

[12] Rexrode KM, Carey VJ, Hennekens CH, Walters EE, Colditz GA, Stampfer MJ, et al. Abdominal adiposity and coronary heart disease in women. JAMA. 1998; 280(21):1843-48. DOI: 10.1001/jama.280.21.1843

[13] American Diabetes Association. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care. 2011;34(Supplement 1):S62-S69. DOI: 10.2337/dc11-s062

[14] Lohman TG, Roche AF, Martorell R. Anthropometric Standardisation Reference Manual. Champaign: Human Kinetics Books; 1988.

[15] Clinical Guidlines on the identification, Evaluation and treatment of overweight and obesity in adults .National institute of health; National heart, lung and blood institute; US. department of Health and human services: public health services;1998.

[16] Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C; American Heart Association, et al. Definition of metabolic syndrome: report of the National, Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation. 2004; 109(3):433-438. DOI: 10.1161/01.CIR.0000111245.75752.C6

[17] Tanweer S, Illahi Y, Amatya B, Naeem A, Zia Tareen F. Frequency of the Metabolic Syndrome In Type 2 Diabetic Subjects Attending The Diabetes Clinic Of Nishtar Medical College And Hospital. Ann Punjab Med college. 2011; 5(1): 53-58. DOI: 10.29054/apmc/2011.533

[18] Imam SK, Shahid SK, Hassan A, Alvi Z. Frequency of the metabolic syndrome in type2 diabetic subjects attending the diabetes clinic of tertiary care hospital. J Pak Med Assoc. 2007;57(5):239-42. [Accessed 2022 Feb 23]. Available from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.506.4277&rep=rep1&type=pdf

[19] Khan UK, Dipta TF, Faruque MO, Sarder K, Sultana S, Nahar Q. Prevalence of Metabolic Syndrome in Diabetic Patient. J Banglad College Physic Surg. 2012; 30(2)-85-90. DOI:10.3329/jbcps.v30i2.11409

[20] Barbaro G, Barbarini G. Highly active antiretroviral therapy-associated metabolic syndrome and cardiovascular risk. Chemotherapy. 2006; 52(4):161-5. DOI:10.1159/000093034

[21] Agrawal V, Bansal M, Mehrotra R, Hansa G, Kasliwal RR. Prevalence of Metabolic Syndrome and its Individual Components in an Asymptomatic Urban North Indian Population. Indian Heart J. 2003; 5.

[22] Chuang SY, Chen CH, Tsai ST, Chou P. Clinical identification of the metabolic syndrome in Kinmen. Acta Cardiol Sin. 2002; 18:16-23.

[23] Mohsin A, Zafar J, Nisar Y, Imran SM, Zaheer K, Khizar B, et al. Frequency of the metabolic syndrome in adult type2 diabetics presenting to Pakistan Institute of Medical Sciences. J pak Med Assoc. 2007: 57(5):235-9. [Accessed 2022 Feb 23]. Available from: https://web.archive.org/web/20170809030224id_/http://jpma.org.pk/PdfDownload/1089.pdf

[24] Grundy SM, Brewer Jr HB, Cleeman JI, Smith Jr SC, Lenfant C. Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation. 2004;109(3):433-8. DOI:10.1161/01.cir.0000111245.75752.c6

[25] Gavrilova O, Marcus-Samuels B, Graham D, Kim JK, Shulman GI, Castle AL et al. Surgical implantation of adipose tissue reverses diabetes in lipoatrophic mice. J Clin Invest. 2000; 105(3):271-8. DOI: 10.1172/jci7901