A Cross-sectional Study to Evaluate Metabolic Syndrome in Individuals with Type 2 Diabetes Mellitus at Tertiary Care Hospital in Central India

[1]Dayashankar Parauha, [2]Sarita Jalodiya, [3]Pawan Kumar Maurya and [4]Arun Kumar Pargi
[1]Rewa, Madhya Pradesh, Indian
[2]Khandwa, Madhya Pradesh, Indian
[3]Department of Pharmacology, MGM Medical College, Indore, Madhya Pradesh, India
[4]Department of Surgery, N.S.C. Government Medical College, Khandwa, Madhya Pradesh, India

OPEN ACCESS

ABSTRACT
The diabetic condition is influenced by several factors, some of which can accelerate the disease's progression to various complications that aggravate the morbidity. This study aimed at determining the prevalence of metabolic syndrome (MetS) and its individual components and the most critical predictive risk factors of MetS in type 2 diabetic patients. The present study was a cross-sectional study that included a sample of 140 individuals diagnosed with type 2 diabetes mellitus. The study was carried out at a tertiary care institute located in Central India. The research utilized a questionnaire to gather data on individuals with diabetes, conducted anthropometric measurements and collected blood samples to measure specific biochemical parameters, including fasting blood glucose and lipid profile. Metabolic syndrome (MetS) was established based on the criteria outlined by the National Cholesterol Education Program/Adult Treatment Panel III. The study population comprised 100 type 2 diabetes mellitus patients, made up of 33 males (33%) and 67 females (67%). The overall mean age of the population was 51.31 (SEM = 0.97) years The prevalence of MetS was 58% in the studied population. For the overall population, hypertension was the commonest component (60%) of the MetS, followed by high waist circumference, or central obesity. Female type 2 diabetics had a higher prevalence of MetS and carried more components than their male counterparts. With hypertension being the commonest component, future cardiovascular disease prevention strategies should focus attention on its management and prevention, through education.

INTRODUCTION

Diabetic individuals are susceptible to the development of various complications due to their hyperglycemic state, which significantly contributes to their overall morbidity. The propensity of individuals with diabetes to experience complications is influenced by a combination of risk factors that can be modified and those that cannot be modified. Presently, there exists a heightened level of interest in a group of risk factors known as metabolic syndrome (MetS), which serves as a predictive indicator for cardiovascular disease and type 2 diabetes mellitus[1]. The major characteristics that it encompasses are as follows: The individual exhibits hypertriglyceridemia, diminished levels of high-density lipoprotein-cholesterol (HDL-C), abdominal obesity, hypertension and concurrent insulin resistance/glucose intolerance (hyperinsulinemia)[2]. The condition is linked to a three to five times higher likelihood of developing type 2 diabetes mellitus, a disease that has become highly prevalent in numerous nations[3,4]. According to existing research, the global occurrence of Metabolic Syndrome (MetS) ranges from 7.9-43% in males and 7-56% in females. According to existing data, it is widely accepted that the estimated global prevalence of diabetes mellitus among adults is approximately 4%[5]. According to the Guidelines of the National Cholesterol Education Program/Adult Treatment Panel (NCEP/ATP III), the prevalence of Metabolic Syndrome (MetS) in urban Ghana ranges from 23-38%[6]. Additionally, type 2 diabetes mellitus affects a minimum of 6% of the adult population in urban Ghana. According to a study conducted in 2008, it was determined that the prevalence of Metabolic Syndrome (MetS) among patients diagnosed with type 2 diabetes at the Komfo Anokye Teaching Hospital was 55.9%[7]. The syndrome has the potential to advance into type 2 diabetes, a condition that is also experiencing a rise in prevalence.

Metabolic syndrome (MetS) is commonly attributed to insulin resistance or obesity associated with insulin resistance, a state in which the body's cells are unable to effectively uptake glucose from the bloodstream. Obesity associated with insulin resistance is attributed to suboptimal dietary habits and insufficient engagement in regular physical activity. Various genetic and lifestyle risk factors, as well as predictor variables, contribute equally to the development of metabolic syndrome (MetS). Several factors contribute to the development of type 2 diabetes, including advancing age (specifically, individuals over the age of 40), cigarette smoking, alcohol consumption, being overweight, leading a sedentary lifestyle and having a family history of the disease[8].

In recent times, there has been a notable rise in mortality rates associated with type 2 diabetes mellitus. However, there is a scarcity of local information regarding the causes of Metabolic Syndrome (MetS) due to a limited availability of published data on the prevalence of MetS and its correlation with type 2 diabetes mellitus. The objective of this study is to identify the primary risk factors associated with Metabolic Syndrome (MetS) that contribute to the development of prediabetes and type 2 diabetes mellitus within specific populations.

MATERIALS AND METHODS

The current study comprised a cross-sectional design, encompassing a cohort of 140 individuals who had received a diagnosis of type 2 diabetes mellitus. The research was conducted at a tertiary care institution situated in Central India. Diabetes is commonly characterized by a glycated hemoglobin (HbA1c) level equal to or exceeding 6.5%. All patients will receive a comprehensive explanation of the study's procedures and rationale and informed written consent will be obtained whenever feasible, using the patients' local language. Socio-demographic data and clinical information will be gathered using a semi-structured Performa. A total of 140 participants, consisting of 46 males and 94 females, were included in the study from the Diabetic Centre of the Medical College Teaching Hospital. The age range of the study participants spanned from 20-86 years. The participants refrained from consuming any food or beverages for the duration of the night prior to the blood sampling procedure. The study excluded individuals diagnosed with type 1 diabetes and pregnant women. All participants provided informed consent to participate in the study following a comprehensive explanation of the study's objectives. Demographic and clinical factors, including age, gender, age of diabetes onset and familial history of diabetes, were obtained through the utilization of a questionnaire and examination of patients' medical records. The measurement of blood pressure was conducted utilizing a sphygmomanometer. Blood pressure was measured in the right arm while the participant was in a seated position. Two blood pressure measurements were obtained with a time interval of 5 minutes between them and the average of the two readings was utilized. The measurement of height was conducted with a stadiometer, without the presence of shoes and rounded to the nearest 0.1 cm. Similarly, weight was measured using a bathroom scale, with individuals wearing light clothing and rounded to the nearest 0.1 kg. The calculation of body mass index (BMI) involved the division of weight (expressed in kilograms) by the square of height

(expressed in square meters). The measurement of waist circumference was conducted with precision to the nearest 0.1 cm, employing a measuring tape positioned at the midpoint between the inferior angle of the ribs and the suprailiac crest.

RESULTS

The study sample consisted of 140 individuals diagnosed with type 2 diabetes mellitus, with 46 being male (33%) and 94 being female (67%). The population's average age was found to be 51.31 years, with a standard error of measurement (SEM) of 0.97. When examining the data by gender, it was observed that males had an average age of 52.86 years (SEM = 1.56), while females had an average age of 50.54 years (SEM = 1.22) (Table 1). The average BMI value was found to be 26.43 kg m^{-2}. Notably, the average BMI of females was significantly greater (p<0.0244) compared to that of males. Although the waist circumference of females was observed to be greater, no statistically significant difference was found. All of the participants in the study were non-smokers and had no history of smoking. Overall, the data indicates that 47% of the participants reported engaging in regular exercise. Of this group, 56% were male and 41% were female. Additionally, it was found that 12% of the participants continued to consume fast food. Regarding the biochemical parameters, there were no statistically significant differences observed between males and females.

Table 2 displays the overall percentage prevalence of Metabolic Syndrome (MetS) as 58%. The prevalence of males was found to be 23%, while females exhibited a higher prevalence of 77%.

Hypertension emerged as the most prevalent constituent (60%) of the Metabolic Syndrome (MetS) within the general population, with high waist circumference, or central obesity, ranking second. Among females, central obesity was found to be the predominant component, with a prevalence rate of 87%. This was closely followed by lowered high-density lipoprotein (HDL) levels, which exhibited a prevalence rate of 77%. Among males, hypertension was found to be the most prevalent component, accounting for 31% of cases, while hypertriglyceridemia followed closely behind at 25%. The sole components that exhibited a statistically significant difference between males and females were central obesity and low HDL.

According to the data presented in Table 3, individuals who possessed three or more of the identified risk factors were classified as having Metabolic Syndrome (MetS). In terms of age, individuals falling within the age range of 50-59 exhibited the highest prevalence of Metabolic Syndrome (MetS) at 39%, while those aged 70 years and above had the lowest prevalence at 5%. The incidence of Metabolic Syndrome (MetS) among females was approximately threefold greater (77%) in comparison to males. Individuals classified as obese exhibited a higher prevalence of metabolic components (40%) in comparison to those classified as having a normal weight (22%). The prevalence of Metabolic Syndrome (MetS) was found to be highest among junior high school or form four leavers, with a majority of 55%. Variables such as sex, BMI and educational status exhibited statistically significant differences, in contrast to the remaining independent variables.

Table 1: General characteristics of the studied population

Parameter	Total (n = 140) (%)	Male (n = 46) (%)	Female (n = 94) (%)	p-value
Age	51.31±0.97	52.86±1.56	50.54±1.22	0.2588
Anthropometry and BP				
WC	91.58±1.22	89.73±1.81	92.51±1.59	0.2838
BP (systolic)	135.90±1.53	134.50±2.72	136.60±1.84	0.5101
BP (diastolic)	79.11±1.01	78.00±2.12	79.67±1.09	0.4394
BMI	26.43±0.42	25.10±0.66	27.09±0.52	0.0244
Sociodemographic				
Smoking				
Ever drank	0 (0)	0 (0)	0 (0)	
Alcohol				
Ever drank	66(47)	35(76)	31(33)	0.3542
Never drank	74(53)	11(24)	63(67)	
Exercise				
Do Exercise	66 (47)	26 (56)	39(41)	0.1253
Do Not Exercise	74 (53)	20(44)	55 (59)	
Fast Foods				
Still Taking	17 (12)	6(14)	10(11)	0.7236
Stopped Taking	123(88)	40 (86)	84(89)	
Biochemical Indices				
FBS	9.77±0.36	9.76±0.64	9.78±0.44	0.9782
TG	1.54±0.08	1.49±0.15	1.57±0.08	0.6291
HDL	1.32±0.05	1.27±0.06	1.35±0.06	0.4445

Table 2: Prevalence of the individual components of MetS

Parameter	Male (n = 46) (%)	Female (n = 94) (%)	Total (n = 140) (%)	p-value
High WC	6(12)	82 (87)	69 (49)	0.001***
Elevated FBS	15 (33)	63 (67)	140 (100)	0.691
Elevated TG	12(25)	70 (75)	46 (33)	0.110
Lowered HDL	10 (23)	72(77)	57 (41)	0.019*
Elevated systolic BP	14(31)	65(69)	84 (60)	0.480
MetS	10 (23)	72(77)	81 (58)	

Table 3: A comparative analysis of the influence of the risk factors on MetS

Risk factors	MetS components (%) 3 or more (n = 81)	2 or less (n = 59)	p-value
Age			
20-39	6 (8)	13(22)	0.083
40-49	25 (31)	14 (24)	
50-59	32(39)	16 (27)	
60-69	14(17)	11 (19)	
70+	4 (5)	5(8)	
Sex			
Male	19 (23)	28 (47)	0.001***
Female	62(77)	31(53)	
BMI			
Under weight	4 (5)	3 (5)	0.001***
Normal weight	18(22)	35(60)	
Over weight	27 (33)	17 (28)	
Obese	32 (40)	4 (7)	
Exercise			
Yes	38 (47)	26 (45)	0.745
No	43 (53)	33 (55)	
Family history			
Yes	64(79)	52 (88)	0.422
No	10 (12)	4 (7)	
I do not know	7 (9)	3 (5)	
Fast food			
Yes	11 (13)	6(11)	0.756
No	70 (87)	53(89)	
Ever taken soft drinks			
Yes	2 (2)	1 (2)	0.978
No	79 (98)	58(98)	
Education			
Uneducated	11 (13)	8 (13)	0.044*
Primary	12 (15)	2 (3)	
JHS/form 4	45 (55)	35 (60)	
SHS	3 (4)	8 (13)	
Tertiary	10 (13)	6 (10)	
Ever drank alcohol			
Yes	36 (45)	34 (57)	0.470
No	45 (55)	25 (43)	

DISCUSSION

The incidence of noncommunicable diseases, such as type 2 diabetes mellitus and cardiovascular diseases, has exhibited a proportional rise owing to the escalation of metabolic syndrome. In contrast to the findings of Felix-Val et al.[7], the present study revealed a notable prevalence (58%) of Metabolic Syndrome (MetS) among individuals diagnosed with type 2 diabetes. Consistent with previous studies conducted by FelixVal et al.[7] and Ford et al.[8], it was observed that females exhibited a greater prevalence of Metabolic Syndrome (MetS) at 77% and displayed a higher number of associated risk factors compared to males, which stood at 23%[9]. The prevalence of women engaged in trading or experiencing unemployment in this particular geographical area may be attributed to factors such as their predominantly sedentary lifestyles or potentially genetic influences.

The prevalence of obesity was observed to be significant, constituting 40% of the total sample population in the diabetic study. The presence of obesity amplifies the manifestation of insulin resistance, consequently stimulating the liver to increase the production of very low density lipoprotein (VLDL), leading to an excessive release of triglycerides (TG) into the bloodstream.

Individuals with type 2 diabetes and impaired glucose tolerance exhibit hypertriglyceridemia and increased HDL catabolism, resulting in decreased levels of HDL[10]. The potential mechanisms underlying the inverse association between hypertriglyceridemia in insulin resistant states and increased HDL catabolism, leading to reduced plasma HDL levels, are multifaceted and diverse. One potential factor that could impact the maturation of HDL particles is a reduction in the activity of lipoprotein lipase (LPL). Individuals who exhibit insulin resistance have been found to experience a diminished response in LPL activity, which is typically stimulated by insulin[11]. The activity of lipoprotein lipase (LPL) is reduced in individuals with type 2 diabetes, particularly in those with suboptimal glycemic control and mild insulin deficiency[12]. The management of obesity is imperative in mitigating the risk of developing or exacerbating type 2 diabetes mellitus and associated complications.

In line with a study conducted by Moebus et al.[11], it was observed that individuals with diabetes and lower levels of education exhibited a significantly higher incidence of Metabolic Syndrome (MetS). According to the data provided in reference, individuals with elementary school education (15%) and those who completed junior high school or form four (56%) exhibited a higher prevalence of diabetes compared to individuals with senior high school education (4%) and those with tertiary level education (13%). This phenomenon may arise due to individuals' limited understanding of healthy dietary practices, such as the consumption of excessive quantities of saturated fats and high-carbohydrate diets, coupled with irregular physical activity and sedentary lifestyles. The study sample did not find a significant association between the consumption of fast food (13%) and soft drinks (2%) and the development of Metabolic Syndrome (MetS). It was observed that the majority of individuals with diabetes, both before and after being diagnosed, tended to avoid these food and beverage choices.

There has been a proposition positing that a familial history might expedite the development of Metabolic Syndrome (MetS)[13]. The findings of this study indicate that individuals who have a familial predisposition to diabetes have a significantly higher

likelihood, specifically 79% more likely, of exhibiting three or more components of Metabolic Syndrome (MetS).

Hypertension was identified as the predominant factor within the study population of type 2 diabetes, as indicated by the findings of the present study. The next most prevalent factors were central obesity and a reduced level of high-density lipoprotein cholesterol (HDL-C). Hypertension emerged as the predominant factor among males, succeeded by hypertriglyceridemia and reduced HDL levels, as indicated in Table 2. This finding is in line with the findings of Felix-Val *et al*.[7], who utilized the NCEP/ATP III and identified hypertension and hypertriglyceridemia as the two most prevalent conditions among males. Before being diagnosed with diabetes, a substantial proportion of the male participants (76%) were found to engage in considerable alcohol consumption, as indicated in Table 1. It is widely recognized that alcohol consumption is associated with the development of hypertension[14]. Individuals diagnosed with hypertension and diabetes mellitus are at an increased risk of developing both microvascular and macrovascular complications. The predominant factor observed in females was central obesity, which was subsequently followed by low HDL, high triglycerides and hypertension (Table 2). The potential factors contributing to this phenomenon include women's lower frequency of physical activity, sedentary lifestyle possibly associated with their trading activities and regular consumption of starchy foods, refined carbohydrates and late-night snacking. Moreover, it has been observed that the incidence of central obesity and low levels of high-density lipoprotein cholesterol (HDL-C) is significantly greater in females compared to males. It is widely recognized that individuals with lower levels of high-density lipoprotein cholesterol (HDL-C) are at an increased risk of developing cardiovascular or coronary disorders[15].

Based on the data presented in Table 3, it can be observed that 39% of individuals belonging to the age group of 50-59 and 31% of individuals belonging to the age group of 40-49 exhibited three or more components of Metabolic Syndrome (MetS). This observation implies that individuals within the age range of 40-59 exhibit a greater likelihood of experiencing a high prevalence of the components associated with Metabolic Syndrome, irrespective of their gender. Given the correlation between age and the incidence of Metabolic Syndrome (MetS), it is imperative to implement effective preventive and control strategies as individuals enter these specific age cohorts[16]. It is advisable to promote increased physical activity among individuals, alongside the adoption of dietary practices that involve the consumption of meals low in saturated fats, cholesterol and refined sugars, while prioritizing the intake of foods rich in dietary fiber. Research studies have demonstrated that diets rich in dietary fiber exhibit a diminished glycemic index and possess the capacity to decrease levels of triglycerides, total cholesterol and fasting plasma glucose in the bloodstream. They simply reduce the absorption of carbohydrates and cholesterol in the intestines[17]. Overall, the prevalence of metabolic syndrome (MetS) was found to be high among the individuals with type 2 diabetes who were included in the study, which aligns with the findings reported by Felix-Val *et al*.[7].

CONCLUSION

This study has provided evidence of a heightened occurrence of Metabolic Syndrome (MetS) at a rate of 58%. The majority of the specific risk factors were found to be more prevalent among women in comparison to men, with women exhibiting a threefold higher likelihood of having MetS. The prevalence of hypertension was found to be the highest among the studied components, followed by central obesity, low HDLC levels and hypertriglyceridemia. Both obesity and low educational status have been identified as significant predictors of metabolic syndrome (MetS) in individuals with type 2 diabetes.

REFERENCES

1. Lorenzo, C., M. Okoloise, K. Williams, M.P. Stern and S.M. Haffner, 2003. The metabolic syndrome as predictor of type 2 diabetes. Diabetes Care, 26: 3153-3159.

2. Alberti, K.G. and P.Z. Zimmet, 1998. Definition, diagnosis and classification of diabetes mellitus and its complications. part 1: Diagnosis and classification of diabetes mellitus provisional report of a who consultation. Diabet Med., 15: 539-553.

3. Wilson, P.W.F., R.B. D'Agostino, H. Parise, L. Sullivan and J.B. Meigs, 2005. Metabolic syndrome as a precursor of cardiovascular disease and type 2 diabetes mellitus. Circulation, 112: 3066-3072.

4. Ford, E.S., 2005. Risks for all-cause mortality, cardiovascular disease and diabetes associated with the metabolic syndrome. Diabetes Care, 28: 1769-1778.

5. Danquah, I., G. Bedu-Addo, K.J. Terpe, F. Micah and Y.A. Amoako *et al*., 2012. Diabetes mellitus type 2 in urban Ghana: Characteristics and associated factors. BMC Public Health, Vol. 12, No. 210 .10.1186/1471-2458-12-210.

6. Nyarko, K. Adubofour, F. Ofei, J. Kpodonu and S. Owusu, 1997. Serum lipid and lipoprotein levels in Ghanaians with diabetes mellitus and hypertension. J. Natl. Med. Assoc., 89: 191-196.

7. Titty, F.V.K., W.K.B.A. Owire and M.T. Agyei-F, 2008. Prevalence of metabolic syndrome and its individual components among diabetic patients in Ghana. J. Bio. Sci., 8: 1057-1061.

8. Ferrannini, E., 1995. Physiological and metabolic consequences of obesity. Metabolism, 44: 15-17.

9. Ford, E.S., W.H. Giles and W.H. Dietz, 2002. Prevalence of the metabolic syndrome among us adults. JAMA, 287: 356-359.

10. Pietzsch, J., U. Julius, S. Nitzsche and M. Hanefeld, 1998. *In vivo* evidence for increased apolipoprotein A-I catabolism in subjects with impaired glucose tolerance. Diabetes, 47: 1928-1934.

11. Moebus, S., J. Hanisch, P. Aidelsburger, P. Bramlage, J. Wasem and K.H. Jöckel, 2007. Impact of 4 different definitions used for the assessment of the prevalence of the metabolic syndrome in primary healthcare: The german metabolic and cardiovascular risk project (GEMCAS). Cardiovasc. Diabetol., Vol. 6, No. 22. 10.1186/1475-2840-6-22

12. Grundy, S.M., J.I. Cleeman, S.R. Daniels, K.A. Donato and R.H. Eckel *et al.*, 2005. Diagnosis and management of the metabolic syndrome. Circulation, 112: 2735-2752.

13. Lewis, G.F. and D.J. Rader, 2005. New insights into the regulation of hdl metabolism and reverse cholesterol transport. Circ. Res., 96: 1221-1232.

14. Zimmet, P., K.G.M.M. Alberti and J. Shaw, 2001. Global and societal implications of the diabetes epidemic. Nature, 414: 782-787.

15. Chandalia, M., A. Garg, D. Lutjohann, K. von Bergmann, S.M. Grundy and L.J. Brinkley, 2000. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. Engl. J. Med., 342: 1392-1398.

16. Eckel, R.H., T.J. Yost and D.R. Jensen, 1995. Alterations in lipoprotein lipase in insulin resistance. Int. J. Obes. Relat. Metab. Disord., 19: 16-21.

17. Yost, T.J., K.K. Froyd, D.R. Jensen and R.H. Eckel, 1995. Change in skeletal muscle lipoprotein lipase activity in response to insulin/glucose in non-insulin-dependent diabetes mellitus. Metabolism, 44: 786-790.