Original Article

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Physiology Section

Type 2 Diabetes Mellitus- Better Associated with BMI, Abdominal Obesity or Insulin Resistance?

SREELAKSHMI MOHANAN[1], GEETHA NAIR[2], JEAN MALIEKKAL[3]

ABSTRACT

Introduction: Type 2 Diabetes Mellitus (T2DM) has emerged as a major public health concern globally and it is associated with a multitude of complications leading to mortality and morbidity. A close association has been observed with T2DM and obesity in various studies, which has been closely associated with intra-abdominal or central obesity rather than to overall adiposity.

Aim: To evaluate the association of T2DM with anthropometric parameters, abdominal obesity parameters and Insulin Resistance (IR).

Materials and Methods: A case-control study was conducted amongst 64 normal healthy individuals and 64 diabetic patients attending the diabetic clinic of a tertiary care centre over a period of one year. Participants aged between 30 to 75 years were recruited. The abdominal obesity anthropometric parameters which included Body Mass Index (BMI), Waist Circumference (WC), Waist Hip Ratio (WHR), Waist Height Ratio (WHtR) were recorded. IR was estimated using Homeostasis Model Assessment (HOMA)-IR method. Data was entered in Microsoft Excel software and data was analysed using Statistical Package for the Social Sciences (SPSS) software version 16.0.

Results: A 64 T2DM patients and 64 normal healthy controls were included in the study. The mean BMI was 23.1±2.3 and 21.3±1.2 for cases and controls, respectively (p-value <0.001). The mean WC was 84.0±4.8 and 80.5±2.8 (p-value=0.003), and mean WHR was 0.9±0.3 and 0.8±0.02 (p-value <0.001) for cases and controls, respectively. The mean WHtR was 0.5±0.1 and 0.5±0.03 (p-value=0.330), and mean IR was 3.8±1.1 and 1.3±0.2 (p-value <0.001) for cases and controls, respectively. A statistically significant positive correlation was observed between IR and WC of T2DM patients (p-value=0.025). A statistically insignificant positive correlation was observed between IR and BMI (p-value=0.105).

Conclusion: Body Mass Index (BMI), abdominal obesity parameters and IR values were elevated in T2DM. Among the anthropometric parameters studied, WHtR was observed to be a better parameter and it can be used routinely in a clinical setting as it has a constant parameter (height).

Keywords: Body mass index, Insulin resistance, Waist circumference, Waist height ratio, Waist hip ratio

INTRODUCTION

Diabetes has risen to epidemic proportions globally. The data from the World Health Organisation (WHO) reveals that approximately 422 million people worldwide have diabetes and this metabolic disease causes about 1.6 million deaths each year. T2DM can lead to an array of macro and microvascular complications such as cerebrovascular and cardiovascular diseases, diabetic retinopathy and diabetic nephropathy. These complications are further associated with increased disability and reduced quality of life and lowered life expectancy [1]. With globalisation and sedentary lifestyle, there is an overwhelming rise in the overweight and obese individuals. It is estimated that, globally about 1.9 billion adults are overweight and about 650 million people come under the obese category [2]. In India, more than 135 million people are obese and in urban India more than a third of the adults are estimated to be overweight or obese [3]. The prevalence of obesity varies from 11.8% to 31.3% while central obesity varies from 16.9% to 36.3% [4]. It has been observed that increased BMI was associated with increased prevalence of T2DM [5].

South Asians have lower obesity rates as defined by the BMI values but however they have larger waist measurements WC and waist-to-hip ratios (WHR), indicating greater levels of central obesity [6]. WC is often used clinically as an indicator of abdominal fat as it correlates with the total abdominal fat mass measured by computed tomography and it is also difficult to measure the abdominal fat mass directly in a clinical setup [7]. Abdominal fat mass is of particular significance not only in the development of T2DM, but it is also implicated in other chronic diseases, such as hypertension, dyslipidemia and cancer. Recently, WHtR has been identified to be better than WC or BMI for screening adults with metabolic risk factors [8]. IR and inadequate functioning of β-cells are the major pathophysiologic agents causing T2DM however, these features occur with very different time courses. IR is the earliest abnormality that can be detected in T2DM [9].

In the routine clinical practice though the various anthropometric parameters are analysed in the assessment of obesity and its possible relationship with diabetes, it is not given due importance. There always exist issues among clinicians regarding which parameter holds the best in the busy clinical practice which can be utilised for the efficient detection and management of obesity among diabetics. In view of this, a case control study was done in the northern part of Kerala, which has not been done in this part of the world, though similar studies were done elsewhere. The present study was aimed at evaluating the association of T2DM with abdominal obesity parameters and Insulin Resistance (IR).

MATERIALS AND METHODS

A case-control study was conducted amongst diabetic patients attending the Outpatient Department (OPD) of the diabetic clinic in the Government Medical College, Calicut, Kerala, India. This study was conducted over a period of one year from August 2015 to July 2016. The study was approved by the Institutional Ethics Committee with the approval number ECR/395/Inst./KL/2013. All participants were included in the study only after receiving their written informed consent.

Inclusion criteria: Diabetic patients of both genders aged between 30 to 75 years were included in the study.

Exclusion criteria: Patients with impaired glucose tolerance and other endocrine disorders, renal disease, pregnancy and lactation were excluded from the study.

Sample size was calculated accepting the power of 80% using computerised methods. A total of 64 patients with T2DM and 64 normal healthy individuals were included in the study as per inclusion and exclusion criteria. The matching controls were normal healthy individuals recruited randomly amongst the hospital staff and patient's relatives.

Subjects were examined and their anthropometric measurements including height, weight, WC and Hip Circumference (HC) were measured using a structured and specially designed proforma.

Anthropometric Assessments

Height was assessed with measuring tape and weight was measured using weighing scale with the participants wearing light thin clothing and no shoes. WC was measured midway between the lower border of the rib cage and the ileac crest. Ethnic specific normal values for WC include men ≤90 cm (35 inches) and women ≤80 cm (31.5 inches). HC was measured at the point of maximum circumference of the buttocks with the subject wearing thin clothing. WHR is calculated as WC(cm)/HC(cm). WHR >1 in men and >0.85 in women indicates abdominal obesity. WHtR is estimated as WC(cm)/height(cm). BMI is measured by Weight(kg)/Height (m^2). The BMI values for Indians proposed by the Health Ministry of India [10] which includes; Underweight is <18.4 kg/m^2; Normal weight is 18.5-22.9 kg/m^2; Overweight is 23 to 24.9 kg/m^2; Obese is 25 kg/m^2.

The blood sugar levels were estimated by the Glucose oxidase-peroxidase method and Serum insulin was estimated by Enzyme Linked Immunosorbent Assay (ELISA). IR was calculated from the fasting serum insulin and plasma glucose values by Homeostasis Model Assessment (HOMA) using Oxford HOMA calculator [11].

STATISTICAL ANALYSIS

The data analysis was done using Microsoft Excel and SPSS software version 16.0. The mean and standard deviation of each parameter- BMI, WC, WHR, WHtR and IR values were calculated. The significance of the difference of mean of each parameter among the cases and controls were analysed using the Analysis of Variance (ANOVA) test. The p-value of <0.05 was taken as statistically significant. Pearson's correlation coefficient was used to find the correlation between the obesity parameters BMI and WC with IR in patients with T2DM.

RESULTS

A total of 64 patients with T2DM and 64 normal healthy individuals were included in the study. Among the cases out of 64 subjects, 39 (60.94%) were males and 25 (39.06%) were females. Participants aged between 30 to 75 years have been included in the study. The baseline demographic data of the subjects is given in [Table/Fig-1]. No statistically significant difference was observed between the cases and controls.

Variable		Cases	Controls	Chi-square	p-value
Age (years)	31 to 45	6 (9.38%)	10 (15.63%)	1.44	0.22
	46 to 60	32 (50%)	33 (51.56%)		
	61 to 75	26 (40.62%)	21 (32.81%)		
Gender	Male	39 (60.94%)	28 (43.75%)	3.75	0.0525
	Female	25 (39.06%)	36 (56.25%)		
Occupation	Professionals	15 (23.43%)	21 (32.81%)	0.88	0.346
	Manual labourers	23 (35.93%)	19 (29.68%)		
	Homemakers	9 (14.06%)	11 (17.18%)		
	Not working	17 (26.56%)	13 (20.31%)		

[Table/Fig-1]: Baseline demographic characteristics.
p-value <0.05 was considered statistically significant

The mean BMI was 23.1±2.3 and 21.3±1.2 for cases and controls, respectively (p-value <0.001). The mean WC was 84.0±4.8 and 80.5±2.8 (p-value=0.003), and mean WHR was 0.9±0.3 and 0.8±0.02 (p-value <0.001) for cases and controls respectively. The mean of WHtR was 0.5±0.1 and 0.5±0.03 (p-value=0.330), and mean IR was 3.8±1.1 and 1.3±0.2 (p-value <0.001) for cases and controls respectively [Table/Fig-2]. A positive correlation was observed between IR and BMI in patients with diabetes. It was however not significant (p-value=0.105). A statistically significant positive correlation was observed between IR and WC of diabetic patients (p-value=0.025) [Table/Fig-3].

Anthropometric obesity parameter	Cases	Controls	p-value
BMI (Kg/m^2)	23.1±2.3	21.3±1.2	<0.001*
WC (cm)	84.0±4.8	80.5±2.8	0.003*
WHR	0.9±0.3	0.8±0.02	<0.001*
WHtR	0.5±0.1	0.5±0.03	0.330
IR	3.8±1.1	1.3±0.2	<0.001*

[Table/Fig-2]: Obesity parameters in diabetics and controls.
*p-value <0.05 was considered statistically significant; BMI: Body mass index; WC: Waist circumference; WHR: Waist hip ratio; WHtR: Waist height ratio; IR: Insulin resistance

Group	Insulin resistance	BMI	WC	WHR	WHtR
Cases	r-value	0.204	0.281*	0.039	0.296*
	p-value	0.105	0.025	0.760	0.017
Controls	r-value	0.075	-0.053	-0.200	0.103
	p-value	0.557	0.679	0.113	0.417

[Table/Fig-3]: Correlation of Insulin Resistance (IR) with Body Mass Index (BMI), Waist circumference (WC), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) using Pearson correlation significance (2-tailed).
*p-value <0.05 was considered statistically significant

DISCUSSION

In the present study, the mean BMI values were higher in T2DM when compared to the healthy controls. BMI is the parameter that is commonly used in the clinical practice to grade the severity of obesity. Studies have observed a close association of high BMI with lifestyle disorders especially T2DM [12]. Study to Help Improve Early evaluation and management of risk factors Leading to Diabetes (SHIELD) 2004 screening questionnaire survey and the National Health and Nutrition Examination Surveys (NHANES) are two large databases which reflected and supported the clinical observation that persons with higher BMI are at greater risk for developing T2DM. In addition, it was observed that 59% of the adults in SHIELD survey and 51% in NHANES study with T2DM were obese. The survey added that the converse also holds true i.e., most of these patients with metabolic diseases are either overweight or obese [5]. Similarly, in a study conducted in United States, amongst the overweight persons, men had 30% and women had 10% greater risk for the development of T2DM.

In the obese category there was 100% greater risk of T2DM in both males and females when compared to their counterparts with normal BMI. Besides, BMI ≥40 kg/m^2 increases the risk of developing T2DM by as much as 180% for men and 150% for women [13]. These observations point to the fact that even a slightly elevated BMI is associated with a high risk of developing T2DM. Akin to the western data, the results from the present study also showed a direct relation of T2DM with BMI, though the cut-offs are lower than World Health Organisation (WHO) criteria due to risk factors and morbidities specific for Asians on the basis of ethnicity. However, with BMI it is not possible to distinguish between a person with excessive fat accumulation and a person with high muscle mass. Because of this limitation, abdominal obesity parameters such as WC and WHR, which better reflect central obesity, has been gaining popularity for assessing the relative visceral fat distribution.

In the present study, WC values were higher in T2DM when compared to controls. In a similar study conducted by Joshi B and Shrestha L the mean WC of the diabetic patients were higher than that of the control group and the difference was statistically significant (p-value <0.001) [14]. Though WC is a simple measurement of abdominal obesity it better reflects the accumulation of intra-abdominal fat [15]. Visceral adipose tissue accumulation and hypertrophy of adipocytes combined with a sedentary lifestyle in environmentally and genetically susceptible patients is an important cause for the development of metabolic diseases such as T2DM [16]. Visceral fat is the main source of inflammatory cytokines and free fatty acids and its accumulation leads to the development of IR. This explains the importance of measuring WC in a diabetic patient where BMI cannot be utilised as a reliable parameter. Therefore, even when the BMI is not high, the WC should be assessed carefully [17]. However, as WC does not account for the differences in height, individuals with the same WC but different heights are not likely to have the same cardio metabolic risk [18].

In the present study, the mean WHR of the diabetic patients were higher than that of the control group and the difference was statistically significant (p-value <0.001). Increased WHR in diabetics indicates the importance of abdominal obesity [14]. Intra-abdominal adipocytes release glycerol as a result of lipolysis and it cannot be reincorporated into triglyceride because adipose tissue lacks glycerokinase [19]. The resultant increased availability of glycerol would augment gluconeogenesis. However, in individuals who have lost weight, WHR might not be accurate because both WC and HC can decrease proportionately and thus there are very little changes in the WHR.

In the current study, the WHtR values were significantly higher than the control group. Similar results were observed by Guasch-Ferre M et al., [20]. There is a strong association between WHtR with T2DM. This is an indicator of the importance of abdominal adiposity [20]. WHtR has height as a constant measure and therefore will change only when there is a change in the waist measurement, while other indices, like WHR are much more sensitive to alterations in body size, and both hip as well as waist could increase or decrease proportionately [20]. This obesity parameter is also easier and cheaper to measure than BMI. In a study by Son YJ et al., amongst 2,900 non diabetic participants, it was observed that those with increased baseline WHtR and WC developed diabetes after four years [18].

The authors noted that the IR values were significantly higher in T2DM patients. Similar results were obtained by Reaven GM, diabetes develops when the pancreatic β-cells are unable to maintain the level of compensatory hyperinsulinemia required to prevent hyperglycaemia [21]. For more than half a century, the link between IR and T2DM has been recognised. IR is not only the most powerful predictor for the future development of T2DM but it is also a therapeutic target once hyperglycaemia occurs. By monitoring the levels of IR, T2DM can be controlled and ultimately the overall health of the individual is improved.

In the present study, a positive correlation was obtained between IR and BMI in patients with T2DM. It was however not significant with a p-value of 0.105. Similar results were observed by Chang SA et al., [22]. BMI is an important determinant of IR in patients with T2DM. A higher BMI is associated with decreased insulin sensitivity in patient with T2DM [22]. Increasing BMI probably contributes to further deterioration of exocrine pancreatic cell function with associated increase in IR.

The authors noted a significant positive correlation was obtained between IR and WC inpatients with T2DM (p-value=0.025). Similar results were observed by Mirarefin M and Sharifi F [23]. WC is one of the most commonly used indices of truncal obesity and accumulation of visceral fat. Studies have shown that when adipose tissue gets accumulated in the viscera there is an increase in the release of free fatty acids and inflammatory cytokines and decrease in the secretion of adiponectin. These changes in the mediators could decrease the sensitivity of insulin in muscle tissues and thus decrease the glucose uptake mediated by insulin [24]. In obese individuals, resistance develops to the cellular actions of insulin and it is characterised by the decreased ability of insulin to inhibit output of glucose from the liver and also there is decreased ability to promote the uptake of glucose in fat and muscle [25]. IR is thus a key aetiological factor for the development of T2DM.

The present study was an effort to identify the best obesity parameter amongst the various anthropometric measures that are associated with T2DM. According to the study, WHtR is the best parameter as unlike BMI it considers central adiposity and is also cheaper to assess and unlike WC and WHR it has a constant parameter (height) and therefore can be used to assess the control of obesity and therefore T2DM. Inspite of the small sample size, WHtR can be endorsed as the most feasible and convenient measure that can be used as it is significantly associated with T2DM.

Limitation(s)

The present study has got some limitations. It is a single centre study and the sample size is relatively small. Patients could have been segregated on the basis of gender so that a better understanding of the sex difference on the anthropometric parameters could have been obtained.

CONCLUSION(S)

One unique feature of the present study is that this study was conducted in a tertiary care centre in the Northern part of Kerala where a large number of patients attend the diabetic clinic so that the present study can be considered as a representative of the Northern part of Kerala. Thus to conclude, WHtR is the best parameter as unlike BMI it considers central adiposity and is also cheaper to assess and unlike WC and WHR it has a constant parameter (height) and therefore can be used to assess the control of obesity and therefore T2DM. Hence it can be used routinely in a clinical setting. Obesity should be considered a disease by the physician and early identification and treatment of obesity will help to prevent or atleast delay the development and progression of obesity related complications particularly T2DM. Lifestyle modifications especially weight management by adopting a healthy diet and exercise is crucial and should be promptly suggested even when these individuals are otherwise healthy in order to prevent the onset of obesity related complications.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Physiology, Kunhitharuvai Memorial Charitable Trust Medical College, Calicut, Kerala, India.
2. Professor and Head, Department of Physiology, Government Medical College, Calicut, Kerala, India.
3. Professor and Head, Department of Physiology, Government Medical College, Calicut, Kerala, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sreelakshmi Mohanan,
Department of Physiology, KMCT Medical College, Calicut, Kerala, India.
E-mail: sreelakshmiarun2018@gmail.com

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