Original Research Paper

International Physiology 6(2), May - August 2018

DOI: https://dx.doi.org/10.21088/ip.2347.1506.6218.19

Study of Anthropometric Parameters as Predictors of Diabetes Mellitus

Vandali Jyothi[1], Mohd. Noorjahan Begum[2]

Author's Affiliations:
[1,2]Assistant Professor, Department of Physiology Malla Reddy Medical College for Women, Qutubullapur, Hyderabad, Telangana 500055, India.

Corresponding Author:
Mohd. Noorjahan Begum,
Assistant Professor, Department of Physiology, Malla Reddy Medical College for Women, Suraram, Qutubullapur, Hyderabad, Telangana 500055, India.
E-mail: dr.noorie@gmail.com

Received on: May 21, 2018
Accepted on: June 09, 2018

Abstract

Introduction: Diabetes is a group of metabolic disorders in which there is high blood sugar level over a prolonged period and which leads to many complications such as cardiovascular disease, neuropathy, nephropathy, retinopathy etc. Causes of diabetes vary depending on genetic makeup, family history, ethnicity, health and environmental factors. There is alarming increase in the incidence and prevalence of diabetes mellitus in Asian Indians. Obesity and fat distribution are well established risk factors for Non Insulin Dependent Diabetes Mellitus. Anthropometry is the technique used to express the form and dimensions of the body. Obesity is the main cause of alteration in the anthropometric measurements. *Materials and Methods:* In our study we measured anthropometric parameters such as body mass index, waist circumference, hip circumference, waist to hip ratio in normal and diabetic subjects. *Results:* We observed that BMI has a risk factor of 4.5 and 14.5 in male and female respectively. WC has risk factor of 8.38 and 12.86 in males and females respectively. HC has a risk factor of 11.32 and12.28 in males and females respectively with $p<0.05$, where as WHR has a risk factor of 16.5 and 18.1 in males and females. *Conclusion:* Irrespective of age or measure used, women always had higher prevalence of overweight and obesity than men. BMI with WHR and WC can be used as extremely useful predictor of Diabetes Mellitus.

Keywords: Diabetes Mellitus; Body Mass Index; Waist Circumference; Hip Circumference; Waist to Hip Ratio.

Anthropometry is a technique used to express the form and dimensions of the body such as height, weight, breadth, girth and distance between anatomical points, which vary with ethnicity, sex, age, diet, physical activity and habits of an individual [1]

Obesity is a chronic metabolic change characterized by excess of body fat and which is the main cause of alteration in the anthropometric measurements [2,3]. Obesity is associated with cardiovascular abnormalities, pulmonary dysfunctions, gastrointestinal diseases, Genitourinary diseases, musculoskeletal diseases, cancer, endocrine and metabolic diseases [2]. Insulin resistance and hyper insulinemia are characteristic features of human obesity [3].

Diabetes mellitus is a syndrome of impaired carbohydrate, fat and protein metabolism [4]. It is a clinical condition characterized by increased blood glucose level (hyperglycemia) due to insufficient or inefficient (incompetent) insulin [5].

There is alarming increase in incidence and prevalence of diabetes mellitus in Asian Indians [6]. Obesity is the predisposing factor for 80% of Non insulin dependent diabetes mellitus (NIDDM) [7]. Obesity and fat distribution are well established risk factors for type II diabetes [8]. The evidence linking obesity and central adiposity with diabetes mellitus is strong and consistent [9-12].

BMI is recommended by WHO as the most useful measure of obesity [13]. It is however a crude index that does not take into account, the distribution of body fat, resulting in variability in different individuals and populations [14]. Several simple anthropometric indices of body compositions such as waist circumference, waist to hip ratio (WHR), waist to height ratio (WHTR) predict the incidence of disease. Risk thresholds for their measures have been

proposed, but these have been derived mainly in European or North American populations [15,16]. It is not clear whether these thresholds are applicable in developing countries where the burden from obesity and diabetes is high.

The aim of the present study was to compare the anthropometric parameters as predictors of incidence of diabetes mellitus. India is a developing country with 55% overall prevalence of obesity among woman between 25–64 yrs of age. The prevalence of diabetes and its adverse health effects has risen most rapidly in South India, which is becoming the "diabetes capital" having a higher number of people with diabetes than any other part of the country with estimates ranging from 19.4 million in 1995 to 32.7 millions in 2000. This number is expected to rise to reach 57.2 millions by 2025 [6]. The prevalence of diabetes mellitus is progressively increasing in India and has been observed that obesity is one of the main reason for diabetes

Materials and Methods

The present study was undertaken to correlate the anthropometry study and the diabetes both in normal and diabetic subjects. We also aimed to determine possible risk thresholds for these indices in population of Karimnagar, Telangana. At the outpatient department (OPD) of medicine, Prathima Institute of Medical Sciences, Karimnagar. 200 patients attending with the history suggestive of diabetes mellitus were selected randomly and considered as study group. Similar number of age and sex matched healthy attendants of non-diabetic patients were randomly selected and taken as controls. Informed written consent was taken for all patients and controls. Participants were divided into five age groups.

21-30 years - Group A, 31- 40 years - Group B, 41-50 years Group C, 51-60 years Group D and 61 and above - Group E.

Baseline Medical Examinations

A. Medical history was obtained.

B. Blood pressure was measured as per WHO guidelines using a standard mercury sphygmomanometer.

C. Anthropometric measurements were recorded.

1. Body weight: Body weight was measured (to the nearest 0.5 Kg) with subject wearing light clothing without shoes, standing motionless on the weighing scale and with the weight distributed equally on both legs.

2. Height: Height was measured in cms (to the nearest 0.5cm) with the subject standing in an erect position against a vertical scale and with the head positioned so that the top of the external auditory meatus was level with the inferior margin of the bony orbit (Frankfurt's plane).

3. Waist Circumference (WC): In standing position, a point midway between highest point of iliac crest and lower margin of the ribs is marked on both lateral sides. After exhaling, using a flexible, non-elastic measuring tape, waist circumference in cms is measured at the marked point level.

4. Hip Circumference (HC): HC was measured at the level of greater trochanter, by measuring to nearest mm, at the point where buttocks extended maximum, when viewed from the side in standing position using a flexible non-elastic tape.

5. Waist to Hip Ratio (WHR): WHR was calculated to the nearest 0.1 cm.

$$\text{WHR} = \frac{\text{Waist Circumfere nce}}{\text{Hip Circumfere nce}}$$

6. Body Mass Index (BMI):

$$\text{BMI} = \frac{\text{Weight in kilograms}}{\text{Height in meters X Height in meters}}$$

D. Blood sugar estimation: Blood samples were obtained after 12 hours overnight fast and 2 hours after a 74g oral glucose load.

Results

Higher % incidence of DM in both males (29.2%) and females (28.6%) observed in age group D (Table 1).

26.5% diabetic subjects had BMI above normal but 7% NDM also had increased BMI (Table 2a).

In males the values were of significant ($p=0.0013$) in the group of males who had BMI more than 35 kg/m^2, whereas in females it was significant ($p=0.004$, 0.003, 0.001) in group of females who had BMI 26 to more than 35kg/m^2. This indicates that females with higher BMI have more relative risk of developing diabetes mellitus (Table 2b).

Diabetic males of age groups A, B, C had shown significant increase ($p<0.05$) in WC when

compared with diabetic females. Diabetic females of age groups D,E had shown significant increase ($p<0.05$) in WC when compared with diabetic males (Table 3).

As age advances diabetic females had shown significant increase in HC when compared with diabetic males (Table 4).

Diabetic females had significant increase ($p<0.05$) in WHR when compared with diabetic males (Table 5).

Relative risk of diabetes with BMI, WC, HC and WHR is more in females than in males (Table 6).

Statistical Analysis

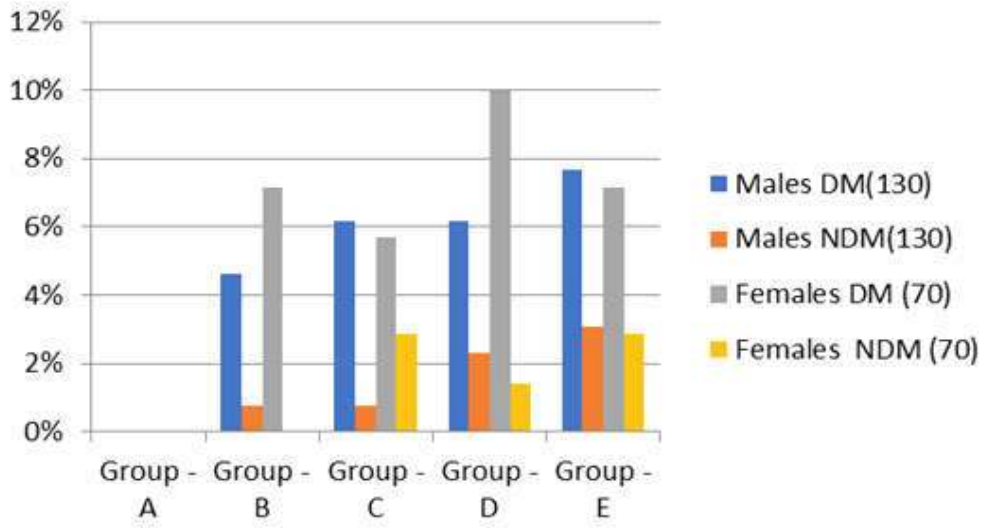
Results were recorded. Percentage, mean, standard deviation were calculated. p value <0.05 was considered as statistically significant. Data were analyzed using SPSS v.23.0.

Table 1: Age, sex wise distribution of diabetic and non-diabetic males and females

Age groups (years)	Males (Total=260)		Females (Total=140)	
	DM (130)	NDM (130)	DM (70)	NDM (70)
21-30 yrs (A)	10 (7.7%)	10 (7.7%)	5 (7.14%)	5 (7.14%)
31-40 yrs (B)	22 (16.92%)	22 (16.92%)	15 (21.42%)	15 (21.42%)
41-50 yrs (C)	30 (23.07%)	30 (23.07%)	15 (21.42%)	15 (21.42%)
51-60 yrs (D)	38 (29.23%)	38 (29.23%)	20 (28.6%)	20 (28.6%)
60 and above (E)	30 (23.07%)	30 (23.07%)	15 (21.42%)	15 (21.42%)
Total	130 (100%)	130 (100%)	70 (100%)	70 (100%)

Table 2a: Diabetic and non-diabetic males and females above normal limit of BMI in different age groups

Age groups	Males		Females		Total	
	DM(130)	NDM(130)	DM (70)	NDM (70)	DM(200)	NDM(200)
Group - A	0(0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0(0.00%)	0 (0.00%)
Group - B	6(4.61%)	1(0.76%)	5 (7.14%)	0 (0.00%)	11(5.5%)	1(0.5%)
Group - C	8(6.15%)	1(0.76%)	4 (5.71%)	2 (2.85%)	12(6%)	3(1.5%)
Group - D	8(6.15%)	3(2.30%)	7 (10%)	1 (1.42%)	15(7.5%)	4(2%)
Group - E	10(7.69%)	4(3.076%)	5 (7.14%)	2 (2.85%)	15(7.5%)	6(3%)
Total	32(24.61%)	9(6.92%)	21 (30%)	5 (7.14%)	53(26.5%)	14(7%)



Graph 1:

Table 2b: Risk of DM associated with BMI increase

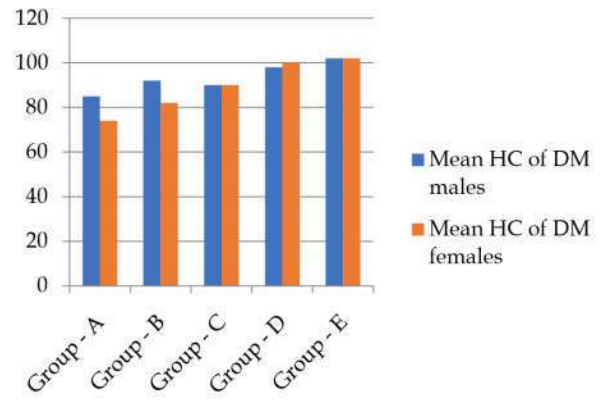
BMI (Kg/m²)	Males - 130			Females - 70		
	No. of DM	Relative risk	p-value	No. of DM	Relative risk	p-value
< 24.99	98(75.38%)	1.0	0.2090	49 (70%)	1.0	0.4207
25-29.99	22(16.92%)	1.29	0.0548	13 (18.6%)	9.14	0.0047
30-34.99	7(5.4%)	3.10	0.0351	7 (10%)	10.36	0.0033
> 35	3(2.31%)	4.50	0.0013	1(1.42%)	14.50	0.0012

Table 3: Comparison of WC of diabetic males and females

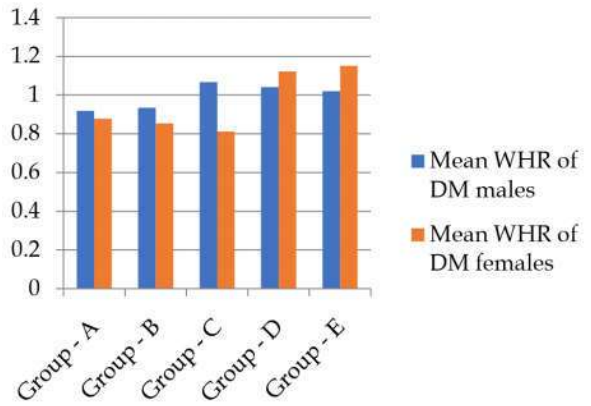
Age groups	Mean, SD, %, WC of DM males	Mean, SD, %, WC of DM females	p-value
Group - A	78±2.66 (40%)	65±2.00 (40%)	<0.0228
Group - B	86±2.61 (45.45%)	70±1.80 (33.33%)	<0.001
Group - C	96±2.59 (59.99%)	72±2.10 (80%)	<0.001
Group - D	102±2.30 (52.63%)	112±9.6 (75%)	<0.001
Group - E	104±2.97 (73.33%)	118±12.82 (93.33%)	<0.001

Table 4: Comparison of HC of DM males and females

Age groups	Mean, SD, %, HC of DM males	Mean, SD, %, HC of DM females	p-value
Group - A	85±0.66(40%)	74±1.1 (40%)	0.0228
Group - B	92±1.30(36.36%)	82±1.30 (46.60%)	<0.080
Group - C	90±0.74(59.99%)	90±1.33 (66%)	<0.500
Group - D	98±1.31(55.26%)	100±1.83 (60%)	<0.001
Group - E	102±2.22(76.66%)	102±2.13 (66.66%)	<0.500



Graph 2:



Graph 3:

Table 5: Comparison of WHR of diabetic males and females

Age groups	Males Mean, SD, %, WHR of DM	Females Mean, SD, %, WHR of DM	p-value
Group - A	0.9176±0.019 (60%)	0.8783 ± 0.0234 (40%)	P<0.022
Group - B	0.9347±0.0162 (54.54%)	0.8536±0.0176 (40%)	P<0.001
Group - C	1.0666±0.0210 (66.66%)	0.8111±0.0124 (86.66%)	P<0.001
Group - D	1.0408±0.0103 (73.68%)	1.1213±0.0847 (65%)	P<0.001
Group - E	1.0198±0.0078 (80%)	1.1514±0.1001 (86.66%)	P<0.001

Table 6: Calculated relative risk of diabetes with BMI, WC, HC, WHR in males and females

Risk factors	Males			Females - 70		
	Mean ± SD	Relative risk	p-value	Mean ± SD	Relative risk	p-value
BMI (Kg/m²)	44±2.00	4.5	0.0013	42±2.330	14.5	0.0012
WC (cms)	93.2±1.47	8.38	< 0.001	87.6±9.900	12.86	0.0139
HC (cms)	93.4±2.46	11.32	0.0047	89.6±1.684	12.28	0.0032
WHR	0.9959±0.2593	16.5	0.002	0.96314±0.0657	18.1	0.0031

Table 7: Comparison of various anthropometric parameters in DM, NDM males and females

Variables	Males		Females	
	Mean ± SD of DM	Mean ± SD of NDM	Mean ± SD of DM	Mean ± SD of NDM
Age (yrs)	56.00±10.90	45.4±16.60	52.00±11.00	42.7±13.70
Height	164.2±6.40	160.0±5.80	154.2±6.53	151.4±6.70
Weight (Kg)	65.8±10.10	60.0±13.0	60.9±10.27	52.7±4.00
BMI(Kg/m^2)	24.5±3.60	22.2±4.0	25.6±4.11	22.04±9.20
WC (cms)	93.2±1.47	80.7±0.32	87.6±1.684	85.0±2.84
HC (cms)	93.4±2.46	8.70±0.32	89.6±1.684	85.0±2.84
WHR	0.9959±0.2593	0.9225±0.1021	0.96314±0.0657	0.7831±0.0431

Discussion

In the comparative study of anthropometric parameters as determinants of diabetes mellitus, we had mean body weight of all subjects. By correlation between the height and weight 28.2% diabetic subjects were over weight and 71.8% had normal weight. (Table 7). In various Indian studies over weight ranges from 1.8% as in Ramachandra et al. [17] 7.4% as in Mukhyaprana et al. study to as high as 28% as in Tripati et al. study [18].

BMI increased (above 25kg/m^2) significantly ($p<0.05$) with advancement of age Table 2a). BMI of diabetic subjects are more positively correlated with age than non-diabetic subjects. Similar observation have been made by Shah et al. [19]. Our observations indicate that the BMI alone is an imperfect indicator of Diabetes Mellitus. In Indian context similar observations are very common [20].

Although BMI is one of the predictor for Diabetes mellitus, the effect of BMI in developing diabetes mellitus was different in males and females, females having greater risk factor than the males as shown above (Table 2b). Studies of diabetes mellitus and BMI in Korea by Eun Ju Sung et al. [21] and Colditz Ga et al. showed that the incidence of diabetes mellitus began to increase when the BMI exceeded 22 Kg/m^2 [12].

Waist circumference highly correlates with abdominal fat and is used as a marker for abdominal obesity and diabetes mellitus [22]. In our study, in females relative risk for WC and BMI were 12.86 and 14.5 respectively (Table 4) and WC is a better predictor of relative risk of diabetes in males than in females. Recent studies have reported that abdominal obesity increases the risk of diabetes between the male and female independently of BMI [22].

The percentage and relative risk factor was slightly higher in females with 12.28 and mean HC if 89.6 ±1.68cm and in males with a relative risk of 11.32 and mean HC if 93.4+2.46cm (Table 4 & 6)

It has been observed central obesity is an important risk factor for development of metabolic syndromes like diabetes mellitus. Though BMI measures the overall obesity with good relationship to fat content, it neglects body fat distribution. The WHR is good parameter to study the central obesity [14]. Therefore it is an important risk factor of diabetes mellitus to be considered even in thin and normal people as per BMI.

Relative risk factor for WHR in males is 16.5 and in females it is 18.1 (Table 6) where as the relative risk factor for WC in males is 8.38 and females it is 12.86. Thus the WHR is a better predictor of obesity and diabetes mellitus. Sayeed et al. [23] reported that prevalence of diabetes increases significantly with increase in BMI and WHR. Welborn TA et al reported WHR as being superior to other indices of obesity in determining risk of diabetes [14].

Summary and Conclusion

The main aim of the present study is to assess which of the anthropometric parameters is the best predictor of Diabetes Mellitus. The parameters considered were BMI, WC, HC, WHR.

Calculated relative risk of diabetes with BMI, WC, HC and WHR is more in females than in males, where as WHR has a risk factor of 16.5 and 18.1 in males and females.

Irrespective of age or measure used, women always had higher prevalence of overweight and obesity than men. It is observed that the WHR is better parameter in assessing the obesity and correlation with diabetes. The present shows that comparison of anthropometric parameters between the diabetic and the healthy controls showed that BMI, WC, HC, and WHR were higher in diabetics than the normal healthy subjects.

To conclude, the BMI with WHR and WC can be used as extremely useful predictor of Diabetes Mellitus.

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