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A Study of Anthropometric Indices in Type-2 Diabetes Mellitus

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Abstract **Original Research Article**

Introduction: Diabetes mellitus is a chronic disease which requires continuing medical care and education to prevent acute complications and to reduce the risk of long-term complications. A higher prevalence of diabetes was found in urban (8.1%) compared with rural populations (2.3%). Age, Sex, and waist-to-hip ratio for men were significant risk factors for both urban and rural subjects following fasting and 2-h post-glucose values adjusted for a number of confounding variables. Over a period of time, anthropometric parameters have evolved into reliable indicators for predicting the incidence of DM. This study examined association between anthropometry and type2 Diabetes mellitus. ***Aim of the study*:** The aim of this study was to know the value of Anthropometric indices in type-2 diabetic patients. ***Methods*:** This was an observational cross-sectional study and was conducted in the Department of Medicine and Endocrine in Dhaka Medical College Hospital (DMCH) and BIRDEM, Dhaka, Bangladesh during the period from July 2012 to December 2012. In total 100 patients both male and female were included in the study. Statistical analysis was done by using SPSS (Statistical Package for Social Science) Version 22 for windows 10 ***Result*:** In this study, 70% patients were found in above 45 years of age group. Of them, male was 58% and female 42%. That is the ratio was 3:2. Among them, 25% patients were businessman, housewife (20%), unemployed (12%), farmer (10%), service holder (10%). 47% were from rich families and 43% were from middle class families. Among anthropometric measurements of the type-2 diabetic patients, a mean WC 92cm for male, 90cm for female and 91cm for both sexes; a mean HC of 100cm for male, 102cm for female, 101cm for both sexes; a mean WHR of 0.92 for male, 0.88 for female, 0.90 for both sexes; a mean TC of 46 for male, 49cm for female, 47.5cm for both sexes; WHtR 0.53 for male, 0.56 for female, 0.54 for both sexes were associated with highest diabetic incidence 18%, 12% & 30% respectively. ***Conclusion:*** Anthropometric indices are valuable tools in assessing obesity and type 2 diabetes due to their simplicity and accuracy. While institutions like ICDDRB and BIRDEM have studied these indices, they often focus on individual parameters.

Keywords: Anthropometric indices, Type 2 diabetes, WC, HC TC, WHR, WHtR.

INTRODUCTION

Diabetes mellitus is a chronic disease which requires continuing medical care and education to prevent acute complications and to reduce the risk of long-term complications. A higher prevalence of diabetes was found in urban (8.1%) compared with rural populations (2.3%). Age, Sex, and waist-to-hip ratio for men were significant risk factors for both urban and rural subjects following fasting and 2-h post-glucose values adjusted for a number of confounding variables [1]. Obesity is known to be a cause of insulin resistance. Insulin resistance will cause hyperinsulinemia and impaired glucose tolerance, eventually causing Type 2 diabetes. Weight reduction of 5 to 9 kg without achieving the optimum weight will be able to control one's diabetic condition. The United Kingdom Prospective Diabetes Study on type 2 diabetes patients found that the level of blood glucose was greatly improved in those who achieved weight reduction [2].

Obesity is associated with a higher prevalence of hypertension, type 2 diabetes mellitus and dyslipidaemia [3]. In a rural population of Bangladesh an increased prevalence of diabetes was found with 6.8% in the present survey compared with 2.3% in earlier survey. Age, BMI and systolic blood pressure were found to be significant risk factors following both for Fasting Blood Glucose (FBG) and for Oral Glucose Tolerance Test

(OGTT). Differences in the indices of obesity that is body mass index (BMI), waist–hip ratio (WHR), and waist girth, may in part explain the increased prevalence, which in turn may explain due to fast expanded urbanization [4]. Obesity anthropometric indexes such as body mass index (BMI), waist circumference (WC), waist–hip ratio (WHR), and waist to height ratio (WHtR), thigh circumference are all useful anthropometric measurements to provide important information. Apart from the association between anthropometric indices in type 2 Diabetes Mellitus patients and cardiovascular risks, it is also important to define the cut off values of an individual index to allow effective screening [5]. In recent years, non-communicable diseases (NCD) like obesity, hypertension (HTN) and Type 2 diabetes are on the increase, especially in the developing nations. Body mass index (BMI), waist-to-hip ratio (WHR) and Waist-to-height ratio (WHtR) are used as indices of obesity to relate Type-2 DM, hypertension and coronary artery disease (CAD) which are the major determinants of morbidity and mortality [6]. Simple anthropometrical measurements have been used as surrogate measurements of obesity and have more practical value in both clinical practice and for large scale epidemiological studies. Body Mass Index which relates weight to height is a simple measure of body size. Waist circumference and waist–hip ratio (WHR) are alternatives to Body Mass Index. Waist circumference is the best simple measure of both intra-abdominal fat mass and total fat [7]. Diabetes is becoming an epidemic disease in Asian countries like Bangladesh. There is an urgent need to evolve methods of primary prevention in these populations to save the community from the burden of diabetes and its sequelae. There is compelling evidence that indicates that maintenance of ideal BMI by lifestyle modifications helps to delay or postpone the onset of diabetes. Therefore, identification of the normal cutoff values for each population is the primary step, since universal criteria do not hold good for all races. Because upper body adiposity is also an important risk indicator for insulin resistance, the cutoff values for Waist Circumference and Waist-Hip Ratio have also been determined. The risk of diabetes was significant at BMI -23 kg/m^2 for urban Indians [8].

Obesity has emerged as a major disorder associated with many metabolic diseases in both developed and developing countries. Although obesity has a genetic etiology, the major precipitating factor is environmental, mostly related to sedentary life style and causing conservation of energy as body fat. A positive association between obesity and the risk of developing type 2 diabetes has been consistently observed in many populations [9]. Central obesity is an independent risk factor for cardiovascular disease, particularly in women. In most developed countries, the prevalence of obesity is increasing steadily, and has reached epidemic proportion in some populations with a resultant increase in cardiovascular disease burden. The fundamental basis of the association between obesity and type 2 Diabetes Mellitus is a subject under intense scrutiny [10]. Individual with type 2 Diabetes Mellitus are at particular risk of the adverse consequence of obesity, and the interaction of both disorders with other component of metabolic syndrome culminate in an increase in macro vascular and micro vascular complication and the associated reduction of in quality of life. Body mass index (BMI), which relates weight to height, is the most widely used and simple measure of body size and it is frequently used to estimate the prevalence of obesity within a population. Body Mass Index does not reflect body fat distribution, whereas the intra-abdominal deposition of adipose tissue is a major contributor to the development of hypertension, insulin resistance, Diabetes Mellitus and dyslipidemia. Thus, other anthropometric indices such as waist circumference (WC), hip circumference (HC), thigh circumference, waist to height ratio (WHtR), and waist to hip ratio (WHR) have been used as alternatives to Body Mass Index. Waist circumference is increasingly being accepted as the best anthropometric indicator of abdominal adiposity and metabolic risk. The muscle mass might may be better reflected by the thigh circumference. The thigh circumference might be a better indicator for the leg muscle mass than the hip circumference because it might be less influenced by the bone (pelvic width) and the gluteal fat [11]. Obesity is a chronic disease that has been increasing significantly worldwide; being one of the main risk factors for the developing of type-2 diabetes. The pattern of distribution of body fat and visceral adipose, when altered, can induce to the emergency of both Diabetes Mellitus and glucose intolerance, being related to ages below 65 years old [12]. The abdominal obesity, translated by the waist circumference in the presence of overweight, is associated to the insulin resistance as well as to metabolic syndrome, being more correlated to metabolic risk factors then to the isolated increasing of Body Mass Index. On the other hand, waist-to-height ratio has been reported to be an effective predictor of metabolic risks and it may be a better measure of relative fat distribution amongst subjects of different age and statures. Bangladeshi data lack in this perspective [13]. The abdominal circumference presented itself as a rate of adiposity better than the other rates, reporting strong risk factor to health, once it is responsible to the accumulation of abdominal fat. This fat distribution in the abdomen seems to be a metabolically active tissue, constantly renewing itself. In addition, in relation to lipolysis, this tissue seems to be more sensitive to catecholamines, which differs from the preservative action of the insulin [14]. For many physically in active people who are overweight, any kind of physical activity appears difficult, and this often prevents people who are obese from initiating and adhering to specific form of physical activity [15]. The study aims to know the value of Anthropometric indices in type-2 diabetic patients.

OBJECTIVES

The main objective was to know the value of Anthropometric indices in type-2 diabetic patients.

METHODOLOGY & MATERIALS

This was an observational cross-sectional study and was conducted in the Department of Medicine and Endocrine in Dhaka Medical College Hospital (DMCH) and Bangladesh Institute of Research and Rehabilitation for Diabeties (BIRDEM), Dhaka, Bangladesh during the period from July 2012 to December 2012.

The study was conducted on 100 adult patients (aged over 25 years) diagnosed with type 2 diabetes mellitus, who were admitted to the Medicine and Endocrine departments of DMCH and BIRDEM. Data collection spanned 180 days, with each participant undergoing an interview lasting up to one hour. The required equipment included a digital weight scale, a wall-mounted stadiometer, a calculator, a measuring tape, a worksheet on a clipboard, and a telephone. Anthropometric measurements were taken with participants barefoot and wearing light clothing. Weight was measured to the nearest 0.1 kg and height to the nearest 0.1 cm. Body Mass Index (BMI) was calculated as weight divided by height squared (kg/m²). Waist circumference was measured midway between the lowest rib and the iliac crest, hip circumference at the widest point of the buttocks, and thigh circumference just below the gluteal fold. Waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) were then calculated. Data collection involved interviews, physical examinations, medical history review, consultation records, and adherence to a structured protocol. Inclusion criteria included adults over 25 years of age with type 2 diabetes who provided informed consent. Patients with co-morbid conditions, those under 25 years, or those unwilling to participate were excluded. Diabetes was defined according to standard clinical criteria, including elevated fasting glucose (≥7.0 mmol/L), postprandial glucose (≥11.1 mmol/L), HbA1c >6.5%, or random plasma glucose ≥200 mg/dL in symptomatic individuals. Patients who were fulfilled the inclusion criteria and willing to enroll in the study were included in the study after receiving the informed written consent.

Statistical Analysis: All data were recorded systematically in preformed data collection form and quantitative data was expressed as mean and standard deviation and qualitative data was expressed as frequency distribution and percentage. Statistical analysis was carried out by using Statistical analysis was done by using SPSS (Statistical Package for Social Science) Version 22 for windows 10. P value <0.05 was considered as statistically significant. Confidentially was strictly maintained.

RESULT

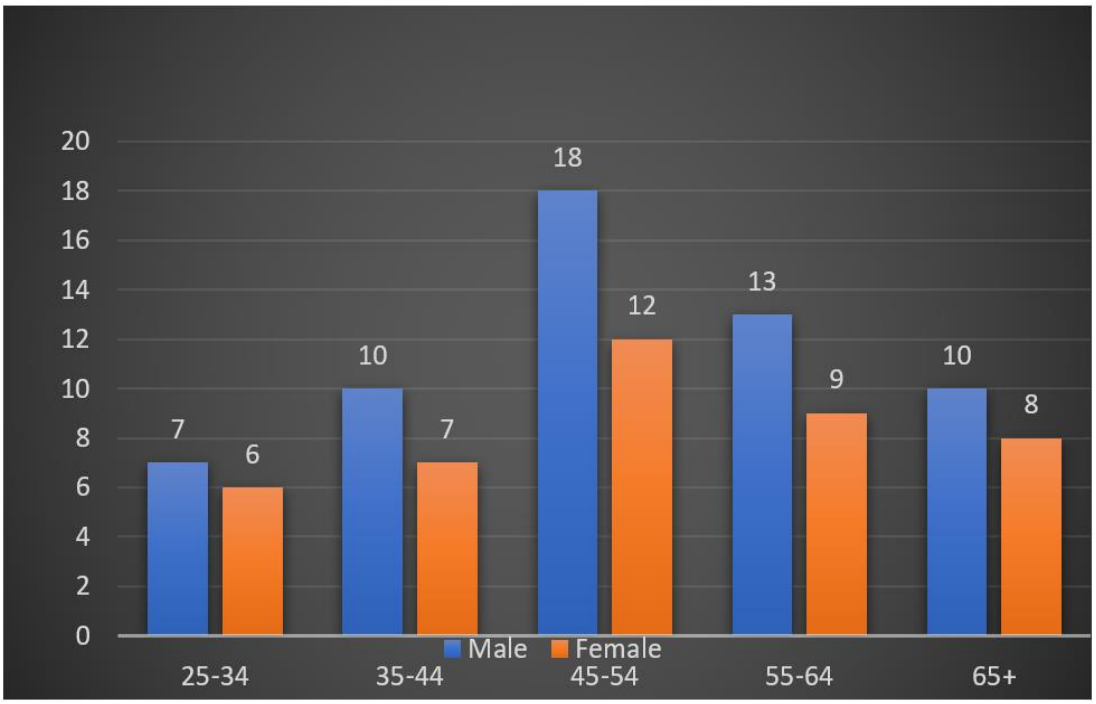

Figure 1: Age distribution of our study subjects (N=100)

Figure 1 showed that the majority of participants were aged 45–54 years (18 males, 12 females), followed by 55–64 years.

Table 1: Baseline characteristics of the study population

Characteristics		Frequency	Percentage (%)
Mean age		45.75 ±12.72	
Gender	Male	58	58
	Female	42	42
Marital Status	Married	70	70
	Unmarried	25	25
	Widow	5	5
Occupation	Farmer	10	10
	Businessmen	25	25
	Teacher	8	8
	Service holder	10	10
	Housewives	20	20
	Student	8	8
	Unemployed	12	12
	Others	7	7
Monthly Income	<10,000	10	10
	10,000-20,000	43	43
	>20,000	47	47
Area	Rural	24	24
	Urban	76	76

In table 1 we showed the baseline characteristics of the respondents. The mean age was 45.75 ±12.72 years. Among the 100 participants, 58% were male and 42% were female. The majority of the participants were married (70%), followed by 25% who were unmarried and 5% who were widowed. In terms of occupation, businessmen made up the largest group (25%), followed by housewives (20%), service holders (10%), and farmers (10%), while students and teachers each represented 8%, the unemployed accounted for 12%, and 7% fell under the category of others. Regarding monthly income, 47% of participants reported earning more than 20,000 BDT, 43% earned between 10,000 and 20,000 BDT, and 10% earned less than 10,000 BDT. The majority of the participants (76%) were from urban areas, while 24% resided in rural regions.

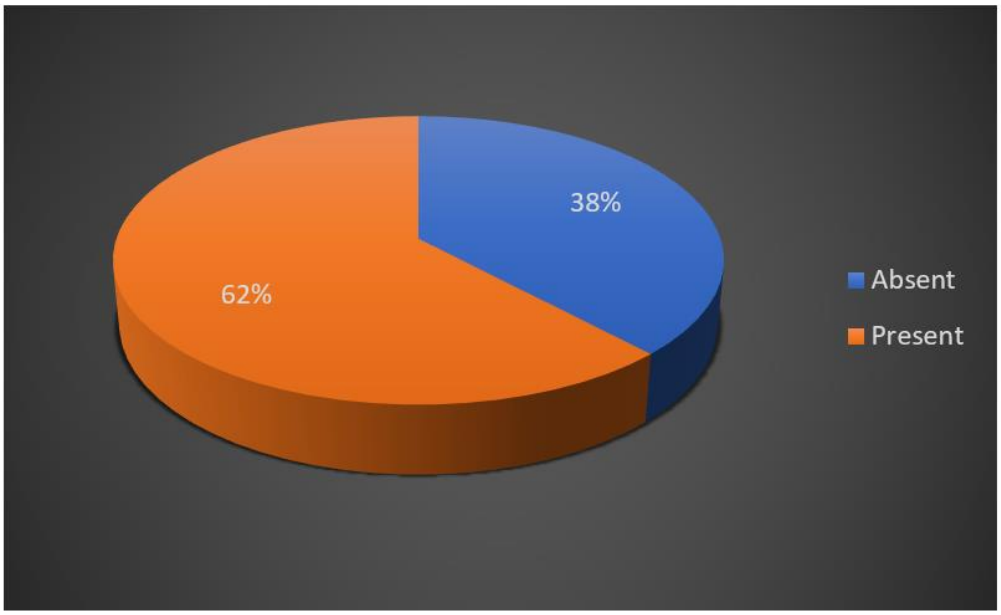

Figure 2: Family history of diabetes among study participants

Figure 2 showed that a majority of the study participants (62%) reported a positive family history of diabetes, while 38% had no such family background.

Table 2: Mean Waist, Hip, Thigh circumference (cm) among the type 2 diabetic patients

Age		WC (cm)	HC (cm)	TC (cm)
25-34	Male	88 (7%)	99 (7%)	44 (7%)
	Female	86 (6%)	101 (6%)	50 (6%)
	Both	87 (13%)	100 (13%)	47 (13%)
35-44	Male	93 (10%)	101 (10%)	45 (10%)
	Female	91 (7%)	103 (7%)	47 (7%)
	Both	92 (17%)	102 (17%)	46 (17%)
45-54	Male	92 (18%)	100 (18%)	46 (18%)
	Female	90 (12%)	102 (12%)	49 (12%)
	Both	91 (30%)	101 (30%)	47.5 (30%)
55-64	Male	95 (13%)	101 (13%)	43 (13%)
	Female	93 (9%)	102 (9%)	47 (9%)
	Both	94 (22%)	101.5 (22%)	45 (22%)
>65	Male	99 (10%)	102 (10%)	42 (10%)
	Female	97 (8%)	104 (8%)	45 (8%)
	Both	98 (18%)	103 (18%)	43.5 (18%)
25-65+	Male	93.4 (58%)	100.6 (58%)	44 (58%)
	Female	91.4 (42%)	102.4 (42%)	47.5 (42%)
	Both	92.4 (100%)	101.5 (100%)	45.8 (100%)
Correlation Coefficient (r)	Male	0.94	0.83	-0.6
	Female	0.51	0.34	-0.32
	Both	0.94	0.78	-0.79

Table 2 shows that type 2 diabetic patients, the highest incidence (30%)—18% in males and 12% in females—was associated with specific mean anthropometric measurements. A mean waist circumference of 92 cm in males, 90 cm in females, and 91 cm overall corresponded with this peak. Similarly, a hip circumference of 100 cm in males, 102 cm in females, and 101 cm overall, along with a thigh circumference of 46 cm in males, 49 cm in females, and 47.5 cm overall, was linked to the same distribution of diabetes incidence.

Table 3: Mean Waist to Hip Ratio and Waist to Height Ratio among Type 2 Diabetic Patients

Age		WHR	WHtR
25-34	Male	0.89 (7%)	0.51 (7%)
	Female	0.85 (6%)	0.52 (6%)
	Both	0.87 (7%)	0.52 (13%)
35-44	Male	0.92 (10%)	0.54 (10%)
	Female	0.88 (7%)	0.56 (7%)
	Both	0.90 (17%)	0.55 (17%)
45-54	Male	0.92 (18%)	0.53 (18%)
	Female	0.88 (12%)	0.56 (12%)
	Both	0.90 (30%)	0.54 (30%)
55-64	Male	0.94 (13%)	0.58 (13%)
	Female	0.91 (9%)	0.6 (9%)
	Both	0.93 (22%)	0.59 (22%)
>65	Male	0.97 (10%)	0.62 (10%)
	Female	0.93 (8%)	0.61 (8%)
	Both	0.95 (18%)	0.61 (18%)
25-65+	Male	0.93 (58%)	0.56 (58%)
	Female	0.89 (42%)	0.57 (42%)
	Both	0.91 (100%)	0.56 (100%)
Correlation Coefficient (r)	Male	0.97	0.94
	Female	0.62	0.70
	Both	0.98	0.94

Table 3 shows the Waist to Hip Ratio and Waist to Height Ratio among type 2 diabetic patients. A mean Waist-to-Hip Ratio (WHR) of 0.92 in males, 0.88 in females, and 0.90 overall, along with a Waist-to-Height Ratio (WHtR) of 0.53 in males, 0.56 in females, and 0.54 overall, were associated with the highest type 2 diabetes

incidence—18% in males, 12% in females, and 30% collectively.

DISCUSSION

Type-2 DM is the most common form of Diabetes (90-95%), exhibiting an alarming prevalence among peoples. Its main risk factors include obesity, rapid urbanization, physical inactivity, aging, nutrition transition & socioeconomic changes. DM and obesity have a complex relationship, with type-2 Diabetes strongly associated obesity. Obesity has now an emerged as an important clinical & public health problem worldwide including middle- & low-income country [40]. In 2013, the World Health Organization (WHO) reported that 1.4 billion adult aged>20 was overweight, and of these, over 200 million men and nearly 300 million women were obese. Epidemiological studies have shown overweight and obesity as an independent risk factor of type-2 Diabetes [41]. Since the study conducted among type 2 Diabetes patients,30% were within 45-54 years and 22% were within 55-64 years of age. i.e. 52% of the total population under the study was within 45-64 years of age. The mean age of total type 2 Diabetes patients was 45.75 ±12.72 years, of them male and female were 45 and 42 years respectively. The age range of this study population was from 25-65+ years. In DMCH & BIRDEM study, the majority of the type 2 Diabetic patients were of above 35 years & peak age incidence was within 45-64 years. As the prevalence of Diabetes increases, the population of young people with Diabetes also increases [42]. Most of the participants were male (58%) in comparison to female (42%). The ratio was 3:2. The prevalence of Diabetes is higher in men than women. In DMCH & BIRDEM it was 3:2. Most of the patients (47%), whose monthly income were above 20,000 takas, where as 43% who had monthly income between 10,000-20,000 takas, only 10% patients had monthly income less than 10,000 taka. As most of the participants were businessmen, they belong to high socioeconomic condition. There is no such data in Bangladesh to suggest that high socioeconomic condition is associated with higher rate of Diabetes. But various recent studies have shown an association between urbanization, economic development and increase prevalence of DM in developing countries [42].

Among anthropometric measurement of type 2 Diabetes patients, a mean WC of 92cm for male, 90cm for female and 91cm for both sexes were associated with highest diabetes incidence, 18%, 12%, and 30% respectively. In other study, it was suggested that a WC of 82 cm for men, 81 cm for women and 82 cm for both sex (Canada rural Diabetic study). Recently a national survey of non-communicable disease (NCD) risk factor conducted by Bangladesh Society of Medicine under guidance of Director General of Health service ((DGHS) with technical assistance of from WHO, was carried out in Bangladesh from November 2009 to April 2010 in adult aged 25 years or older. The survey shows that mean WC in both sexes among Bangladeshi people is 76.6 (76.4-76.8) and percentage of increased WC (mean>91cm, women>80 cm) in both sexes is 21.7 (20.9-22.6) (Bangladesh NCD risk factor survey, 2010). Our findings almost consistent with this survey, further longitudinal studies in a large scale are necessary in future. Other anthropometric indices like HC were also associated with type 2 DM. This study showed that a mean HC of 100 cm for male,102 cm for female and 101 cm for both sexes were associated with highest diabetic incidents 18%,12%&30% respectively. Also found the similarity where a mean HC of 105 cm were strongly associated with highest diabetic events among UK population [43]. Unlike some other studies, this study did not find the protective effect of a larger HC. A relatively small sample size or imprecision of the measurements cannot be excluded as possible explanation. This study also showed that WHR of 0.92 for male, 0.88 for female &0.90 for both sexes were associated with highest diabetic incidents 18%, 12% &30% respectively. This study also showed that a mean WHtR of 0.53 for male, 0.56 for female, 0.54 for both sexes were associated with highest diabetic incidents 18%, 12% & 30% respectively. Mean thigh circumference of 46 cm for male, 49 cm for female& 47.5 cm for both sexes were associated with highest diabetic incidents 18%,12% & 30% respectively. Larger thigh & hip circumferences could also reflect increased femoral & gluteal subcutaneous fat respectively. Particularly women these depots have a relatively high lipoprotein lipase activity& a relatively low rate of basal & stimulated lipolysis these depots may protect the liver & muscle from a high exposure to free fatty acids through uptake and storage [44]. The interpretation of the hip circumferences however may be different between in men & women. It is possible that the variation in the gluteal fat mass & the pelvic width, whereas in men, the muscle mass might be the main determinant. WHO threshold cut off values adopted for anthropometrical parameters were BMI=>25kg/m^2,WC=> 85cm for males and =>80cm for females, WHR=>0.90 for males and=>0.85 for females and WHtR=>0.53 for both men and women in Asian People [45]. The present study shows that, the mean values were above the threshold cut off values for 4 of 5 measured anthropometric parameters and the duration of diabetes mellitus has a positive correlation with WC, HC, WHR, WHtR. Whereas a negative correlation with the thigh circumferences. Further research is needed to elucidate the underlying mechanism that may lead to the negative association of the thigh circumferences with diabetes mellitus.

Limitations of the study

Since our study was conducted at a single center. Firstly, the study may have been limited by a relatively small sample size, which could affect the generalizability of the findings to a larger population. Additionally, anthropometric measurements were taken after the diagnosis of type 2 diabetes, which may not accurately reflect the participants' premorbid obesity status. Measurement error is also a possibility,

particularly since waist circumference was recorded at the umbilical level instead of the standard midpoint between the lower rib and iliac crest. Furthermore, the study employed a cross-sectional design and data were collected from only two urban hospitals, which limits the representation of the broader national population. Lastly, the study was conducted over a short duration, restricting the scope of long-term

CONCLUSION

This study shows that there is a strong correlation between Type-2DM and anthropometry. As age advances, the chance of DM increases in both men & women with elevation in WC or WHR. It is most common in obese, between the ages of 45-64 years. Among the various anthropometric measurements, WHR is the single best anthropometric measurement which strongly correlates well with DM. WHR includes a measurement of HC also. Although there may be advantages of the WHR over the WC, WHR is more difficult to perform & a less reliable measure than WC. Furthermore, WHR may be in appropriate to assess obesity or weight loss. A non-obese & an obese individual could theoretically have the same WHR, which could remain constant during weight change. Besides this, patients may show reluctance to allow hip measurements to be taken, as this requires disrobing. Thus the choice to use WC or WHR may depend on the setting, as in a physicians' office it is more feasible to measure WC, whereas in research studies, it appears to be more informative to measure WHR.

Anthropometric measurements are simple, non-invasive, inexpensive, highly available and very much practical in our routine clinical practice in medicine as assessment tool, especially for our country. It may be used in screening programs to predict the risk of obesity-related diseases like type-2DM etc. Thus, we will be able to intervene accordingly to reduce the morbidity and mortality of diabetes. Moreover, further longitudinal studies are necessary considering above mentioned limitations to validate & expand these results & its value as a prognostic marker, as well as the cut-off values that better fit.

REFERENCES

1. Hussain A, Rahim MA, Khan AKA, Ali SMK, Vaaler S. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh .2006; 22(7): 931-936.
2. American Diabetes Association. Standards of medical care for patients with diabetes mellitus. In: Clinical Practice Recommendations. Diabetes Care 2001; 24(1):S33-43.
3. Berber A, Gomez-Santos R, Fanghanel G and Sanchez-Reyes L. Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidaemia in a Mexican population. 2001; 25(12): 1794-1799.
4. Rahim M A, Hussain A, Khan A K A, Sayeed M A, Ali S M K, Vaaler S, et al. Rising prevalence of type 2 diabetes in rural Bangladesh: a population based study 2007; 77(2): 261-264.
5. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH, et al. The disease burden associated with overweight and obesity. JAMA 1999; 282:1523-1529.
6. Sayeed M A, Banu A, Khan A R, Hussain M Z. Prevalence of Diabetes and Hypertension in a rural population of Bangladesh: 1995;18(4): 555-558.
7. Han TS, McNeill G, Seidell JC, Lean ME. Predicting intra-abdominal fatness from anthropometric measures: The influence of stature, Int J Obes Relat Metab Disord. 1997; 21:587-93.
8. Snehalatha C, Viswanathan V, Ramchandran A. American Diabetic Association. Cutoff values for Normal Anthropometric Variables in Asian Indian Adults 2012: 8-12.
9. World Health Organization: WHO Recommendations: Obesity: Preventing and Managing the Global Epidemic. World Health Org: Geneva, 2000
10. European Journal of Scientific research. A Study of Correlation between derived and Basic Anthropometric indices in Type 2 Diabetes Mellitus. Euro Journals Publishing, Inc ISSN 1450-216X. 2009; 36 (3): 437-444.
11. Dambal A, Padaki AHS, Patil S Manjula R. The correlation of the duration of Diabetes with Anthropometric Indices in Type-2 Diabetes Mellitus. 2011; 5 (2): 257-259.
12. Executive Summary of the Third Report to the National Cholesterol Education Program (NCEP) Expert panel on detection evaluation and treatment of high blood cholesterol in adults (Adult Treatment Panel III), JAMA 2001; 285:16-19.
13. Flora MS, Mascie-Taylor CGN, Rahman M. Waist-to-height ratio and socio-demographic Characteristics of Bangladeshi adults. 2010; 4 (2): 49-58.
14. Large V, Arner P. Regulation of lipolysis in humans. Pathophysiological in obesity, diabetes, and Hyperlipidaemia Diabetes Metab 1998; 24: 409-418.
15. Balaji PA, Smitha R, Varne BNYS, Ali SS. Effects of Yoga- paranyama practices on metabolic parameters and anthropometry in type-2 diabetes. Int'l Multidisciplinary Research Journal 2011; 1(10):01-04.
16. Visscher T, Seidell JC.The Public health impact of obesity. Ann Rec Public Health 2001;22:355-75.
17. Kahn BB,Flier JS.Obesity and insulin resisteance.J Clin Invest 2000;106:473-481.
18. Despres JP, Lemieux I. Abdominal obesity and the metabolic syndrome. Nature 2006;444:881-887.
19. Garg A.The role of body fat distribution in insulin resistance. In: Reaven GM, Laws A, eds. Contemporary Endocrinology: Insulin Resistance. New Jersey, Human Press 1999:83-96.

20. Misra A, Grag A, Abate N, Peshock RM,Stray-Gundersen J,Grundy SM,et al.Relationship of anterior and posterior subcutaneous abdominal fat to insulin sensitivity in non diabetic men. Obes Res 1997;5:93-99.
21. Abate N, Burns D, Pershock R, Garg A, and Grundy SM. Estimation of adipose tissue mass by magnetic resonance imaging: validation against dissection in human cadavers. J Lipid Res 1994;35:1490-6.
22. Deurenberg P, Yap M. The assessment of obesity: methods for measuring body fat and global prevalence of obesity.Bailliere Clin Endocrinal Metab 1999;13:1-11.
23. Lapidus L, Bengtsson C, Larsson B.Distribution of adipose tissue and risk of cardiovascular disease and death:a 12-yeare follow up of participants in the population study of women in Gothenburg,Sweden.Br Med J 1984;289:1257-61.
24. WHO MONICA Project. Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years. World Health Stat Q. 1988;41:115-40.
25. Willett WC, Dietz WH, Colditz GA. Guideline for healthy weight. N Eng J Med 1999;341:427-434
26. Kopelman PG.Obesity as a medical problem.Nature 2000;404:635-643.
27. Fang J,Wylie-Rosett J, Cohen HW et al. Exercise,body mass index,caloric intake, and cardiovascular mortality.Am J Prev Med 2003;25:283-9.
28. Lawrence de Koning, Anwar T. Merchant et al. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. Eur Heart J 2007;28:850-856.
29. Gang Hu, Jaakko Tuomilehto, Karri Silventoinen. Joint effects of physical activity, body mass index, waist circumference and waist –to-hip ratio with the risk of cardiovascular disease among middle –aged Finnish men and women. Eur Heart J 2004;25:2212-2219
30. Nicholas A, Boon, Nicki R, Colledge, Brian R,Walker: Davidson's principles and Practice of Medicine, 20th edition ;2006:1200.
31. Rimm EB, Stamfer MJ, Colditz GA. Validity of self-reported waist and hip circumferences in men and women. Epidemiology 1990;1:466-73.
32. Hsieh SD, Muto T. Metabolic syndrome in Japanese men and women with special reference to the anthropometric criteria for the assessment of obesity: Proposal to use the waist-to-height ratio. Prev Med 2006;42:135-9.
33. Kannel WB,Cupples LA,Ramaswami R,Stokes III J,Kreger BE,Higgins M, et al.Regional obesity and risk of cardiovascular disease:the Framingham Study.J.Clin.Epidemiol.1991;44:183-190.
34. Lemieux S, Prud'homme D, Tremblay A, Bouchard C & Despress JP. Anthropometric correlates to changes in visceral adipose tissue over 7 years in women.Int.J.Obes.Relat.Metab.Disord.1996; 20, 618-624.
35. Vadstrup ES,Petersen L,Sorensen TI &Gronbaek M.Waist circumference in relation to history of amount and type of alcohol:results from the Copenhagen city heart study.Int.J.Obes. Relat. Metab.Disord. 2003;27:238-246.
36. Bjorntorp P. "adipose tissue as a generator of risk factors for cardiovascular disease and diabetes. Arteriosclerosis 1990;10:493-6.
37. Bjorntorp P. The associations between obesity,adipose tissue distribution and disease.Acta Med Scand Suppl 1988;723:121-34.
38. Kannel WB,Cupples LA,Ramaswami R,Stokes III J,Kreger BE,Higgins M, et al.Regional obesity and risk of cardiovascular disease:the Framingham Study. J.Clin.Epidemiol.1991;44:183-190.
39. Lawrence de Koning, Anwar T. Merchant et al. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. European Heart Journal 2007;28:850-856.
40. Sayeed MA, Banu A, Khanam PA. Risk of obesity for hypertension differs between Diabetic and non-diabetic subjects, January 2007; 1(1): 1-6.
41. World Health Organization. Obesity and overweight. WHO:Geneva,2013.
42. Ramchandran A, Snahalatha C, Kapur A, Vijay V, Mohan V, Das AK, et al. High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia 2001;44:1094-1101.
43. Nawawi HM, Muhajir M, Kian YC, Mohamud WN, Yusoff K, Khalid BA, et al. Type of diabetes and waist-hip ratio are important determinants of serum lipoprotein(a) levels in diabetic patients. Diabetes Res Clin Pract 2002;56:221-227.
44. Snijder MB, Dekker JM, Visser M, Yudkin JS, Stehouwer CD, Bouter LM, et al. Larger thigh and hip circumferences are associated with better glucose tolerance: The Hoom study. Obes Res, 2003;11:104-11.
45. World Health Organization. Prevention and Management of the Global Epidemic of Obesity. Repot of the WHO Consultation on Obesity. WHO:Geneva,1998.