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Original Article

Waist-to-Height Ratio vs BMI - A Better Predictor of Type-2 Diabetes Mellitus

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ABSTRACT

Background: *Despite evidence supporting WHtR as a superior metabolic risk predictor, its clinical utility across populations remains unclear. This study compares WHtR and BMI in predicting T2DM to determine the superior measure.* ***Objective:*** *The aim of the study was to compare the predictive accuracy of waist-to-height ratio (WHtR) and body mass index (BMI) for identifying type 2 diabetes mellitus (T2DM) and determine which anthropometric measure offers superior clinical utility.* ***Methods & Materials:*** *This hospital-based cross-sectional observational study was conducted at the Department of Medicine and Endocrinology of Dhaka Medical College Hospital (DMCH) and Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders (BIRDEM) (July-December 2012) enrolled 100 adults (>25 years) with type 2 diabetes. Using standardized protocols, we collected anthropometric measurements (weight, height, waist/hip circumferences) to calculate BMI and WHtR. Diabetes was confirmed by standard glycemic criteria (FPG ≥7.0 mmol/L, HbA1c >6.5%, etc.). Data were analyzed using SPSS 22.0 (Pearson correlations, p<0.05). Ethical approval and informed consent were obtained.* ***Results:*** *WHtR surpassed BMI for T2DM prediction (r=0.94 vs 0.88), with all values exceeding the 0.5 risk threshold. Strongest in males (r=0.94) and older adults (0.61 at 65+), WHtR offers simpler risk stratification than BMI in our 100-patient cohort (58M/42F, peak prevalence 30% at 45-54y).* ***Conclusion:*** *Waist-to-height ratio (WHtR) is a superior predictor of type 2 diabetes risk compared to BMI, advocating its use in routine clinical practice for more effective screening.*

Keywords: *Waist-to-Height Ratio, BMI, Type-2 Diabetes Mellitus.*

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a rapidly growing non-communicable disease, with India ranking second worldwide, recording over 74 million cases in 2021. The IDF Diabetes Atlas (2021)[1] projects a 68% increase to 124.9 million individuals by 2045, highlighting a substantial global health challenge. More than 650 million people worldwide live with obesity,[2] which was associated with 4 million deaths and 120 million disability-adjusted life-years in 2015. As a major worldwide epidemic affecting over 300 million people, obesity plays a crucial role in the pathogenesis of T2DM, a chronic disorder of carbohydrate, fat, and protein metabolism. A prospective epidemiological study further emphasized that increased abdominal fat accumulation is an independent risk factor for cardiovascular disease.[3] Common T2DM risk factors include excess weight, obesity, and sedentary lifestyles, though other contributing factors remain largely unexplored.[4,5,6] Given the rising burden of diabetes and its complications, effective assessment tools for identifying at-risk individuals are essential.

Body Mass Index (BMI), calculated as weight divided by height squared, is the most widely used metric for assessing obesity.[7] However, it has several limitations, including its inability to distinguish between fat and muscle mass or to account for regional fat distribution. Waist circumference and waist-to-hip ratio have traditionally been used as measures of central obesity, as visceral adipose tissue is strongly linked to metabolic complications. Studies using computed tomography and magnetic resonance imaging have further confirmed that central obesity and visceral fat are major contributors to these complications.[8,9,10,11] However, BMI cannot fully capture the complexity of adiposity, as it does not differentiate between normal-weight central obesity and metabolically healthy obesity.[12] Additionally, waist circumference alone may overestimate fat mass in tall individuals and underestimate it in shorter individuals, requiring population-specific cut-off values for different ethnicities.[13] These limitations have led to growing interest in alternative indices, such as the waist-to-height ratio (WHtR), which may provide a more accurate assessment of metabolic risk.

Central obesity has emerged as a stronger predictor of metabolic disorders compared to general obesity, with growing evidence supporting its role in Type 2 Diabetes Mellitus (T2DM) risk assessment. Research suggests that waist-to-height ratio (WHtR), a measure of central obesity, may provide better insights into predicting cardio-metabolic abnormalities than BMI and waist circumference (WC).[14] Global studies indicate that the effectiveness of anthropometric measures varies across populations, emphasizing the need to assess their predictive capabilities in distinct ethnic and geographic groups.[15] Epidemiological research has consistently demonstrated that BMI, WC, and waist-to-hip ratio (WHR) are all significant indicators of T2DM risk, yet the clinical distinction between visceral and total fat often does not translate into clear differences in diabetes prediction between BMI and WC.[16] While some studies suggest WC is a better predictor of T2DM than BMI, findings remain inconclusive.[17,18,19] Notably, among Asian populations, central obesity has been identified as a more consistent predictor of diabetes than general obesity, underscoring the importance of refining obesity indices to enhance risk stratification.[20]

In recent years, WHtR has gained attention as a superior screening tool for obesity-related health risks, including diabetes, hypertension, and cardiovascular diseases.[21,22,23] Unlike BMI, which does not account for fat distribution or muscle mass, WHtR has been shown in cross-sectional and prospective studies to be a better predictor of cardiometabolic risk. Studies have found that WHtR outperforms BMI in identifying individuals at risk for diabetes, further strengthening its credibility as a predictive marker.[14] Additionally, WHtR is highly correlated with abdominal fat measured by imaging techniques and has been recognized as a better indicator of early health risk in the general population.[14,24] One of its key advantages is its simplicity—WHtR is not influenced by age, sex, or ethnicity and does not require weight measurement, making it a practical public health tool. With a recommended cutoff value of 0.5, meaning waist circumference should be less than half of one's height, WHtR provides a clear and effective metric for assessing obesity-related risks.[25]

Despite growing evidence supporting WHtR as a superior predictor of metabolic risk, its clinical utility remains underexplored across different populations. Given the variations in diabetes prevalence and obesity patterns among ethnic groups, it is essential to assess whether WHtR provides a more reliable risk assessment compared to traditional measures like BMI and WC. The purpose of the study was to compare the predictive accuracy of waist-to-height ratio (WHtR) and body mass index (BMI) for identifying type 2 diabetes mellitus (T2DM) and determine which anthropometric measure offers superior clinical utility.

Objective

- The aim of the study was to compare the predictive accuracy of waist-to-height ratio (WHtR) and body mass index (BMI) for identifying type 2 diabetes mellitus (T2DM) and determine which anthropometric measure offers superior clinical utility.

METHODS & MATERIALS

This hospital-based cross-sectional observational study was conducted at the Department of Medicine and Endocrinology of Dhaka Medical College Hospital (DMCH) and Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders (BIRDEM) from July 2012 to December 2012. We enrolled 100 adults (>25 years) with type 2 diabetes using purposive sampling. The sample size was calculated based on Bangladesh's urban diabetes prevalence (8%) at a 95% confidence level with a 5% margin of error.

Inclusion Criteria

- Type 2 diabetic patients admitted to the Medicine and Endocrine Departments of DMCH and BIRDEM.
- Adults aged above 25 years.
- Participants (or legally accepted guardians) who provided informed consent and agreed to comply with study procedures.

Exclusion Criteria

- Type 2 diabetic patients with other comorbid conditions.
- Individuals aged below 25 years.
- Patients or attendants unwilling to participate in the study.

Data collection was conducted over 180 days using a structured questionnaire to obtain demographic and clinical information, including age, gender, socioeconomic status (monthly income), medical history, and anthropometric measurements, with each participant requiring approximately one hour for assessment. Anthropometric measurements included weight (nearest 0.1 kg) using a digital weight recorder, height (nearest 0.1 cm) using a wall-fixed stadiometer, waist circumference measured at the midpoint between the lowest rib margin and iliac crest using a steel measuring tape, hip circumference measured at the widest point over the buttocks, and thigh circumference measured directly below the gluteal fold. Body Mass Index (BMI) was calculated as weight (kg) ÷ height^2 (m^2), while the Waist-to-Height Ratio (WHtR) was determined by dividing waist circumference (cm) by height (cm). The required equipment included a digital weight recorder, stadiometer, measuring tape, calculator, and clipboard. Diabetes mellitus was defined based on blood glucose levels, with at least one of the following criteria: fasting plasma glucose (FPG) ≥ 7.0 mmol/L, 2-hour postprandial glucose ≥ 11.1 mmol/L, HbA1c > 6.5%, or random plasma glucose ≥ 200 mg/dL in symptomatic individuals. Ethical approval was obtained from the Ethical Review Committee of DMCH, and all participants provided

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informed consent, ensuring voluntary participation, confidentiality, and the right to withdraw at any time. Data analysis was performed using SPSS version 22.0, with continuous variables expressed as mean ± standard deviation (SD) or median, and categorical variables as percentages. Associations between age and anthropometric indices (BMI and WHtR) were analyzed using correlation coefficient (r) tests, with a p-value < 0.05 considered statistically significant.

RESULTS

Table I presents the distribution of type 2 diabetes mellitus (T2DM) patients by age group and gender. The total sample includes 58 males and 42 females, with the highest prevalence of T2DM observed in the 45-54 age group (30%), followed by the 55-64 age group (22%) and the 65+ age group (18%). Males are more affected than females across all age categories, with males accounting for 58% and females for 42% of the total cases. The age group with the least number of cases is 25-34, comprising 13% of the total sample.

Table – I: Distribution of Type 2 Diabetes Mellitus (T2DM) Patients by Age Group and Gender (*n*=100)

Age Group	Male (n)	Female (n)	Total Frequency (n)	Percentage (%)
25-34	7	6	13	13.0%
35-44	10	7	17	17.0%
45-54	18	12	30	30.0%
55-64	13	9	22	22.0%
65+	10	8	18	18.0%
Total	58	42	100	100.0%

Table II presents the monthly income distribution of the study population. The majority of participants (47%) earn more than 20,000 Tk per month, followed by 43% earning between 10,000 and 20,000 Tk. Only 10% of the population reports a monthly income of less than 10,000 Tk.

Table – II: Monthly Income Distribution of Study Population (*n*=100)

Monthly Income (Tk)	Frequency (n)	Percentage (%)
<10,000	10	10.0%
10,000–20,000	43	43.0%
>20,000	47	47.0%

Table III presents the mean Waist-to-Height Ratio (WHtR) values for type 2 diabetic patients across different age groups, with data separated by gender. The highest mean WHtR for both males and females was observed in the >65 years age group, with values of 0.62 for males and 0.61 for females. The overall mean WHtR for both sexes combined was 0.56, with males showing a mean of 0.56 and females 0.57. The correlation coefficients (r) for males (0.94), females (0.7), and both sexes combined (0.94) indicate a strong positive correlation between age and WHtR, particularly for males.

Table – III: Mean Waist-to-Height Ratio (WHtR) among Type 2 Diabetic Patients

Age (Years)	Male (n=58)	Female (n=42)	Both Sexes (n=100)
25-34	0.51 (7%)	0.52 (6%)	0.52 (13%)
35-44	0.54 (10%)	0.56 (7%)	0.55 (17%)
45-54	0.53 (18%)	0.56 (12%)	0.54 (30%)
55-64	0.58 (13%)	0.60 (9%)	0.59 (22%)
>65	0.62 (10%)	0.61 (8%)	0.61 (18%)
25-65+ (Mean)	0.56 (58%)	0.57 (42%)	0.56 (100%)
Correlation Coefficient (r)	0.94	0.7	0.94

Table IV presents the mean Body Mass Index (BMI) values for type 2 diabetic patients across different age groups, separated by gender. The highest mean BMI for both males and females was observed in the >65 years age group, with values of 28.4 ± 3.0 for males and 27.9 ± 2.8 for females. The overall mean BMI for both sexes combined was 25.8 ± 2.6, with males showing a mean of 26.1 ± 2.6 and females 25.5 ± 2.6. The correlation coefficients (r) indicate a strong positive correlation between age and BMI, particularly for males (r = 0.89) and both sexes combined (r = 0.88), with a moderate correlation for females (r = 0.65). Compared to WHtR, BMI also increases with age but shows slightly lower correlation values, suggesting that WHtR may be a more sensitive predictor of T2DM risk progression.

Table IV: Body Mass Index (BMI) among Type 2 Diabetic Patients

Age Group (Years)	BMI - Male (n=58)	BMI - Female (n=42)	BMI - Both Sexes (n=100)
25-34	23.7 ± 2.0	23.0 ± 2.2	23.3 ± 2.1
35-44	24.9 ± 2.3	24.3 ± 2.4	24.6 ± 2.4
45-54	25.6 ± 2.5	25.1 ± 2.6	25.3 ± 2.6
55-64	27.0 ± 2.8	26.3 ± 2.7	26.7 ± 2.7
>65	28.4 ± 3.0	27.9 ± 2.8	28.2 ± 2.9
Total (Mean)	26.1 ± 2.6	25.5 ± 2.6	25.8 ± 2.6
Correlation (r)	0.89	0.65	0.88

DISCUSSION

This study evaluates the predictive accuracy of Waist-to-Height Ratio (WHtR) and Body Mass Index (BMI) in identifying type 2 diabetes mellitus (T2DM) among adults in a hospital-based population in Bangladesh. As obesity-related metabolic disorders continue to rise, the need for reliable and practical screening tools has become increasingly important. Our findings highlight the significant correlation between WHtR and age, suggesting that central obesity may be a stronger predictor of diabetes risk than overall body mass. The results emphasize the potential clinical utility of WHtR as a simple yet effective alternative to BMI for early detection and risk assessment of T2DM.

In this study, the highest prevalence of type 2 diabetes mellitus (T2DM) was observed in the 45-54 age group (30%), followed by the 55-64 age group (22%) and the 65+ age group (18%), indicating an increasing trend with age. This pattern aligns with findings from the CDC, which report that adults aged 45 to 64 are the most commonly diagnosed with diabetes, with prevalence rates continuing to rise in older age groups.[26] Additionally, the CDC highlights that the percentage of adults with diabetes reaches 29.2% among those aged 65 years or older, further supporting the observed trend in this study.[27] These similarities reinforce the well-established association between aging and an increased risk of T2DM, likely due to a combination of insulin resistance, declining pancreatic function, and the cumulative effects of lifestyle factors over time. Furthermore, a higher prevalence of T2DM in men is consistent with several studies. A study published in the Journal of Clinical Endocrinology & Metabolism found that among 70-year-old participants, 14.6% of men had T2DM compared to 9.1% of women.[28] This gender disparity was attributed to men having a larger amount of visceral fat, which is associated with an increased risk of developing diabetes. Additionally, the Bangladesh Demographic and Health Survey data showed that men had a higher prevalence of diagnosed diabetes (7%) compared to women (6%).[29] These findings corroborate the gender differences observed in the current study and suggest that male gender may be a risk factor for T2DM.

The monthly income distribution of the study population reveals that a significant portion of participants fall within the higher income brackets. The largest group (47%) earns above 20,000 Tk, followed by 43% of participants earning between 10,000 and 20,000 Tk. Only 10% of the study population reported earning less than 10,000 Tk per month. This distribution suggests that the majority of individuals in this study are from a relatively higher income background, which may reflect economic factors influencing access to healthcare and the management of type 2 diabetes mellitus.

This study found that a mean waist-to-height ratio (WHtR) of 0.53 for males, 0.56 for females, and 0.54 for both sexes was linked to the highest incidence of diabetes, with rates of 18%, 12%, and 30%, respectively. According to WHO guidelines, the threshold cut-off values for anthropometric parameters in Asian populations are BMI ≥25 kg/m^2, waist circumference ≥85 cm for males and ≥80 cm for females, waist-to-hip ratio ≥0.90 for males and ≥0.85 for females, and waist-to-height ratio ≥0.53 for both genders.[30] The results of this study showed that the mean WHtR values exceeded these threshold cut-off values, suggesting a significant association with higher diabetes incidence. This supports the conclusion that WHtR is a better predictor of Type-2 Diabetes Mellitus, demonstrating a strong correlation with the increased risk of diabetes.

In this study, BMI increased with age among type 2 diabetic patients, with the highest mean BMI observed in individuals aged >65 years (28.4 ± 3.0 in males and 27.9 ± 2.8 in females). The correlation coefficient (r = 0.89 in males and 0.65 in females) indicates a strong positive association between BMI and age, particularly for males. However, the correlation is moderate for females, suggesting that BMI may not be an equally reliable predictor of type 2 diabetes risk across genders. When comparing these findings with the results of Petermann et al.[31], where BMI showed the lowest AUC for predicting diabetes, this study reinforces the idea that BMI alone may not be an optimal measure for accurately identifying diabetes risk. These results emphasize the need for alternative anthropometric measures, such as WHtR, which could offer a more sensitive and gender-neutral indicator of diabetes susceptibility.

CONCLUSION

This study confirms that waist-to-height ratio (WHtR) outperforms BMI as a practical tool for identifying type 2 diabetes risk. WHtR demonstrated stronger predictive ability across all age groups, particularly in men, while providing clearer clinical thresholds for risk assessment. Its simple measurement and consistent interpretation make WHtR superior to BMI for diabetes screening, especially in middle-aged populations (peak prevalence 30% at 45-54 years) where diabetes prevalence peaks. These findings advocate for WHtR's adoption in routine clinical practice as a more effective anthropometric indicator of diabetes risk.

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LIMITATIONS OF THE STUDY

This study has certain limitations. Being a hospital-based observational study, the findings may not fully represent the overall population or the broader community. Further large-scale studies are needed to explore other underlying etiological factors and validate these findings in a more diverse population.

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication.

Author Contributions

Dr. Sharmin Sultana: Conceptualization, methodology, formal analysis, investigation, data interpretation, and writing—original draft preparation. She also contributed to the revision of the manuscript, provided critical insights during data analysis, and supervised the overall study. Additionally, Dr. Sultana was involved in project administration and ensured the ethical compliance of the research process.

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Conflict of Interest

The authors declare no conflict of interest.

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