Assessment of Obesity Indices in Predicting Hyperglycemia in Adults of Duwakot, Bhaktapur

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ABSTRACT

Background

Obesity is a major risk factor for metabolic disorders, including hyperglycemia, which is a precursor to diabetes. Various obesity indices, such as Body Mass Index (BMI), Waist Circumference (WC) and Waist-to-Height Ratio (WHtR), are used to assess adiposity.

Objective

To evaluate and compare the effectiveness of obesity indices in predicting hyperglycemia among adults in Duwakot, Bhaktapur.

Method

This was a cross-sectional study conducted among 128 adults visiting Kathmandu Medical College Public Limited, Duwakot from August 2024 to January 2025. Anthropometric measurements (BMI, WC and WHtR) were recorded, and fasting blood glucose (FBG) levels were measured to define hyperglycemia (FBG ≥ 126 mg/dL). Pearson correlation was used to evaluate the relationship between obesity indices and FBG levels, while an independent t-test compared the mean values between males and females. The predictive ability of obesity indices was assessed using Receiver Operating Characteristic (ROC) curve analysis, and the area under the curve (AUC) and optimal cut-off values were determined. Values of $p \leq 0.05$ were considered statistically significant.

Result

The prevalence of hyperglycemia among the participants was 17.2 %. Pearson correlation analysis showed that FBG was significantly correlated with WC (Male: $r = 0.233$, $p < 0.05$; Female: $r = 0.459$, $p < 0.05$), and WHtR (Male: $r = 0.227$, $p < 0.05$; Female: $r = 0.482$, $p < 0.05$). Independent t-test analysis revealed a statistically significant difference in WC ($p = 0.025$) and WHtR ($p = 0.014$), with males having higher WC and females having higher WHtR. However, BMI ($p = 0.179$) did not show a significant difference between the two groups. ROC curve analysis revealed that WHtR had the highest AUC (Male:0.607, Female:0.721), followed by WC and BMI.

Conclusion

This study found that WHtR was the strongest predictor of hyperglycemia, followed by WC, and BMI. WHtR could be an effective screening tool for early hyperglycemia detection in community settings.

KEY WORDS

Hyperglycemia, Predictive value, Obesity indices

INTRODUCTION

Obesity is a well-established risk factor for metabolic disorders, including hyperglycemia and type 2 diabetes mellitus.[1] The rate of obesity has increased in many developing nations, including Nepal. About 24.3% of Nepalese adults are obese or overweight.[2] Early identification of individuals at risk of hyperglycemia is crucial for preventing the onset of diabetes.

There are several recognized methods for assessing obesity, including body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), and waist-to-height ration (WHtR), which are widely accepted internationally. BMI is used to identify and classify generalized obesity, while WC, WHR, and WHtR are simpler measures for evaluating fat distribution and central obesity.[3] Therefore, selection of appropriate obesity indices can help in early detection, prevention, and better management of diabetes progression.[4]

In Nepal, the burden of obesity and diabetes is rising due to urbanization and lifestyle changes.[2] However, limited studies have evaluated the ability of different obesity indices to predict hyperglycemia in the Nepalese population. Identifying the most accurate predictor can help in early screening and intervention. This study aims to assess and compare the predictive ability of BMI, WC and WHtR in identifying hyperglycemia among adults in Duwakot, Bhaktapur.

METHODS

This was a cross sectional study carried out in Kathmandu Medical College and Teaching Hospital, Duwakot, Bhaktapur during the period from August 2024 to January 2025. Participants were selected from the local community using a convenience sampling method. The sample size was calculated using the formula $n=(z^2 X pq)/e^2$, assuming a confidence level of 95% (Z = 1.96), prevalence of hyperglycemia as 9.2 % and a margin of error (e) of 5%.[5] Substituting these values, the required sample size was calculated as: $n = (1.96)^2 X(0.092)(0.908)/(0.05)^2 = 128$.

The ethical approval for the study was taken from Institutional Review Committee of Kathmandu Medical College Teaching Hospital, Sinamangal with reference number 12082024/05. The written informed consent was obtained from each participants. Inclusion criteria included adults aged 18 years and older, both males and females, who provided written informed consent. Exclusion criteria included individuals with diagnosed diabetes, pregnant and lactating women. Throughout the study period, individuals from Duwakot meeting the inclusion criteria were offered free fasting blood glucose testing and assessments of obesity indices during their hospital visits. All testing and measurements were performed during 8 am to 11 am. Demographic data, including age, gender, and medical history, were collected using structured questionnaires. All participants were informed about the study's purpose and process before signing the consent form.The obesity indices such as BMI, WC and WHtR were measured for each participant.

Weight was measured using a digital weighing scale (accurate to 0.1 kg), and height was measured with a stadiometer (accurate to 0.1 cm). BMI was calculated using the formula: $BMI=Weight(kg)/Height^2(m^2)$ and categorized as < 18.5-underweight; 18.5 to 22.9-Normal; 23 to 24.9-Overweight and ≥ 25 as obese.[3] WC was measured at the midpoint between the lower rib and the iliac crest using a flexible measuring tape. The measurement was taken at the end of normal expiration. WC cutoff was taken as ≥ 90 cm for male and ≥ 80 cm for female participants.[6] WHtR was calculated by dividing WC (in cm) by height (in cm). WHtR cutoff was taken as ≥ 0.5 for all participants.[6]

Fasting blood samples were collected from participants after a 12-hour overnight fast. Blood glucose levels were determined using the glucose oxidase-peroxidase method. A fasting blood glucose level ≥ 126 mg/dL was considered indicative of hyperglycemia.[7]

The data was entered and analyzed using the statistical Package for Social Science (SPSS version 22.0). Descriptive statistics, including mean, standard deviation, and frequency distribution, were used to summarize participant characteristics and obesity indices. An independent t-tests was used to compare the mean values between male and female participants. Pearson correlation test was used to evaluate the relationship between obesity indices and FBG levels. Receiver Operating Characteristic (ROC) curve analysis was performed to assess the diagnostic ability of each obesity index (BMI, WC, and WHtR) in predicting hyperglycemia. The Area Under the Curve (AUC) was calculated along with the 95% confidence intervals (CI). The optimal cutoff value for each index, sensitivity and specificity was determined based on the maximum Youden index.[8] A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 128 apparently healthy adults (84 males and 44 females) from Duwakot participated in the study. Males were significantly older and had higher weight and height than females. Among obesity indices, males had a higher WC, while females had a higher WHtR. Fasting blood glucose levels were similar between the groups (Table 1).

Prevalence of Hyperglycemia (FBG ≥ 126 mg/dL) was 17.2% among all participants, with no significant difference between males (15.5%) and females (20.5%, p = 0.478). Obesity (BMI ≥ 25 kg/m^2) was observed in 39.8%, higher in females (50%) than males (34.5%). Waist circumference was significantly higher in females (68.2%) than males

Table 1. Baseline characteristics of study participants

Parameters	Males (n=84)	Females (n=44)	p-value
Age (years)	38.27± 8.18	34.98± 7.62	0.026
Fasting blood glucose (mg/dl)	111.57±23.74	111.73±13.31	0.962
Weight (kg)	67.25±7.56	58.61±8.33	0.000
Height (cm)	168.02±4.07	154.39±3.41	0.000
Body mass index (kg/m²)	23.84±2.78	24.62±3.60	0.179
Waist circumference (cm)	89.31±6.84	86.07±9.00	0.025
Waist to height ratio	0.53±0.04	0.55±0.05	0.014

(48.8%, p = 0.036), indicating a greater risk of central obesity in females. Waist-to-height ratio ≥ 0.5 was common (73.4%), with no significant gender difference (Table 2).

Table 2. Distribution of Fasting Blood Glucose, BMI, Waist Circumference, and Waist-to-Height Ratio among study participants

Parameter	Total (n=128)	Male (n=84)	Female (n=44)	χ^2 value	p-value
Fasting Blood Glucose (FBG)					
Low (< 126 mg/dL)	106(82.8%)	71 (84.5%)	35 (79.5%)	0.504	0.478
High (≥ 126 mg/dL)	22 (17.2%)	13 (15.5%)	9 (20.5%)		
BMI Categories (kg/m²)					
<18.5	9 (7.0%)	6 (7.1%)	3 (6.8%)	3.093	0.376
18.5-22.9	37 (28.9%)	26 (31.0%)	11 (25.0%)		
23-24.9	31 (24.2%)	23 (27.4%)	8 (18.2%)		
≥ 25	51 (39.8%)	29 (34.5%)	22 (50.0%)		
Waist Circumference (WC in cm)					
Normal	57 (44.5%)	43 (51.2%)	14 (31.8%)	4.385	0.036
High	71 (55.5%)	41 (48.8%)	30 (68.2%)		
Waist-to-Height Ratio (WHtR)					
Low (< 0.5)	34 (26.6%)	23 (27.4%)	11 (25.0%)	0.083	0.772
High (≥ 0.5)	94 (73.4%)	56 (72.6%)	38 (75.0%)		

There was a significant positive correlation between WC and fasting blood glucose in both males (r = 0.233, p = 0.033) and females (r = 0.459, p = 0.002). Additionally, in females, there was a significant positive correlation between the waist-to-height ratio and fasting blood glucose (r = 0.482, p = 0.001). In males, the correlation was weaker but still significant (r = 0.227, p = 0.038). Other parameters (age, weight, height, and BMI) showed no significant correlation with fasting blood glucose (Table 3).

For males, WHtR had the highest AUC (0.607) and sensitivity (92.3%) but low specificity (36.6%), while BMI had the lowest AUC = 0.578. None were statistically significant. For females, WHtR was the best predictor (AUC = 0.721, p = 0.043) with perfect sensitivity (100%) but low specificity (45.7%). WC showed moderate accuracy (AUC = 0.690, p = 0.081). Overall, WHtR was the strongest predictor in both sexes but had low specificity (Table 4).

Table 3. Correlation of Various Parameters with Fasting Blood Glucose in Males and Females

Parameter	Male		Female	
	r	p	r	p
Age	0.000	0.99	0.042	0.786
weight	0.116	0.293	0.083	0.593
Height cm	0.039	0.728	-0.134	0.386
BMI	0.102	0.355	0.121	0.435
WC (cm)	0.233	0.033	0.459	0.002
Waist to Height Ratio (WHtR)	0.227	0.038	0.482	0.001

Table 4. Predictive performance of obesity indices for hyperglycemia (≥ 126 mg/dl)

Gender	Parameter	AUC (95% CI)	p value	Cut Off	Sensitivity %	Specificity %
Male (n=84)	BMI	0.578 (0.401-0.755)	0.373	23.36	76.90	49.3
	WC	0.601 (0.469-0.732)	0.250	86.50	84.6	54.9
	WHtR	0.607 (0.481-0.734)	0.221	0.504	92.3	36.6
Female (n=44)	BMI	0.635 (0.401-0.868)	0.216	23.59	77.8	45.70
	WC	0.690 (0.522-0.859)	0.081	88.50	66.7	65.7
	WHtR	0.721 (0.553-0.889)	0.043	0.525	100	45.70

The ROC curve for males shows that WHtR and WC have better discriminatory ability compared to BMI, as seen in their higher curves above the reference line. The ROC curve for females shows that WHtR has the best discriminatory ability, with its curve rising highest above the reference line, making it a significant predictor (Fig. 1).

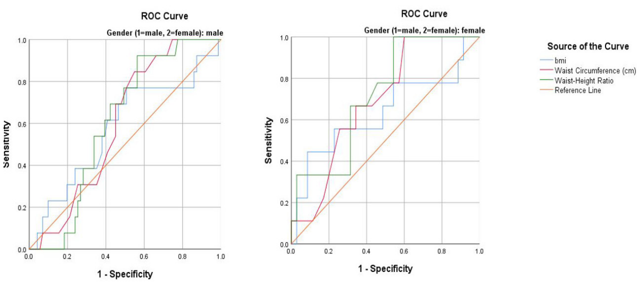

Figure 1. ROC Curve Comparison of Obesity Indices for Predicting Hyperglycemia (≥ 126 mg/dL) in Males and Females

DISCUSSIONS

This study aimed to evaluate the relationship between obesity indices and hyperglycemia in adults from Duwakot, Bhaktapur. Males in the study were significantly older and had higher body weight and height than females. These findings are consistent with the study done in India showing that males tend to have greater height and weight due to their higher muscle mass and physical structure.[3] However, no significant differences in FBG levels were observed between males and females (111.57 ± 23.74 mg/dl vs. 111.73 ± 13.31 mg/dl, p = 0.962), which suggests that, despite differences in physical characteristics, both groups have similar glycemic levels. Males had a higher WC compared to females, while females had a higher WHtR than males. Despite the larger WC in males, the higher WHtR in females suggests a greater relative risk of central obesity.

This study found that 17.2% of participants had high fasting blood glucose (FBG) levels, with no significant gender difference (p = 0.478). A systematic review and meta-analysis of studies in Nepal found diabetes prevalence rates ranging from 0.8% to 19.0%, with some studies reporting a higher prevalence in males, while others showed no significant gender differences.[5] The prevalence of obesity, defined as BMI ≥ 25 kg/m^2, was found to be higher in females (50%) than males (34.5%) (Table 2). In Nepal, the 2016 Nepal Demographic Health Survey reported that 32.87% of women and 28.77% of men were overweight or obese, with a higher prevalence of both underweight and overweight/obesity among women.9 Women tend to have more subcutaneous fat than visceral fat, but menopause accelerates visceral fat accumulation, contributing to obesity.[10]

The study also found significant positive correlations between WC and FBG in both males (r = 0.233, p = 0.033) and females (r = 0.459, p = 0.002), with females showing a stronger correlation (Table 3). Similarly, the WHtR was positively correlated with FBG in both sexes, with females again showing a stronger association (r = 0.482, p = 0.001). These results align with previous research done in India indicating that central obesity, as measured by WC and WHtR, is more strongly associated with increased risk of hyperglycemia than general obesity (BMI).[3] Another study in Jordanian adults showed that WHtR had the highest correlation compared to other anthropometric indices with FBG.[11] Research in Northern Iran revealed a positive correlation between WC and FBG levels in both genders, with the cut-off point of WC for detecting diabetes being higher in women than in men.[12] While another study have found no correlation between blood glucose level and obesity indices.[6]

In terms of predictive performance for hyperglycemia (FBG ≥ 126 mg/dL), WHtR emerged as the most significant index in both sexes. In males, WHtR had the highest area under the curve (AUC = 0.607), with a sensitivity of 92.3%, although its specificity was relatively low (36.6%) (Table 4). For females, WHtR showed an AUC of 0.721 (p = 0.043), with perfect sensitivity (100%) but a low specificity of 45.7%. These findings suggest that while WHtR is a strong predictor of hyperglycemia, its low specificity may limit its ability to accurately identify individuals without hyperglycemia, thus necessitating further diagnostic evaluation. WHtR has been found to be a more effective measure than BMI alone, particularly for predicting diabetes-related complications and early health risks linked to central obesity.[13] A study involving 13,044 Chilean adults found that WHtR had the highest area under the curve (AUC) for predicting both hypertension and diabetes in both sexes, outperforming BMI and WC. The AUC for diabetes prediction using WHtR was 0.71 for both women and men.[14] While another study on Mexican adolescents found that WHtR had a lower predictive performance for hyperglycemia compared to other anthropometric indices. The overall AUC for WHtR was 0.606, with a sensitivity of 60.0% and specificity of 69.5%. These findings suggest that WHtR's effectiveness in predicting hyperglycemia may vary based on age, gender, and population.[15] A study conducted by Li et al. among Taiwanese adults concluded that a WHtR above 0.5 is a simple yet reliable indicator of central obesity and associated cardiometabolic risk, even in those considered healthy according to BMI and WC.[16]

Waist circumference also demonstrated moderate predictive value in females (AUC = 0.690, p = 0.081), highlighting the significance of abdominal obesity in assessing hyperglycemia risk. Another study done in the Nepalese population of Kavre district, concluded that WC is a strong predictor of type 2 diabetes mellitus, with WC being the strongest predictor in males (AUC = 87.0%) and showing moderate predictive value in females (AUC = 70.2%).[17]

This study has important clinical and public health implications. Waist-to-height ratio and waist circumference are simple measures that can help identify adults at higher risk of high blood sugar, allowing for early lifestyle or medical actions. Since these measures were more closely linked to hyperglycemia, it shows the need to focus on abdominal fat in routine check-ups, possibly using different cutoffs for men and women. In the community, these measures can be used for easy screening and prevention programs. The findings also provide a base for future studies and may help shape national guidelines for diabetes prevention. Apart from the importance, several limitations should be considered. One limitation of this study is that waist–hip ratio was not assessed, which may have provided additional insight into central obesity. Another limitation is the relatively small sample size, which may limit the generalizability of the findings. A further limitation is the cross-sectional design, which prevents establishing causal relationships between obesity indices and hyperglycemia. Additionally, other factors such as diet, physical activity, and family history of diabetes were not considered, which could influence glycemic levels.

CONCLUSION

This study found that waist-to-height ratio (WHtR) and waist circumference (WC) were more effective than BMI in predicting hyperglycemia among adults in Duwakot, Bhaktapur, with WHtR showing the strongest association. These findings suggest that central obesity measures should be prioritized in routine screening to identify individuals at risk. Public health interventions should focus on reducing abdominal obesity, and future research should validate population-specific cutoffs for WHtR and WC.

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