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ASSOCIATION BETWEEN ANTHROPOMETRIC INDICATORS AND GLYCEMIC STATUS AMONG DIABETIC ADULTS OF BHUBANESWAR, ODISHA

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ABSTRACT

Globally, type 2 *diabetes mellitus* (T2DM) has become a common chronic illness due to dietary changes, sedentary lifestyles and urbanisation.With the rising prevalence of diabetes, understanding the role of nutrition is crucial for effective management. A study was conducted in 2023 with 100 diabetic adults, to assess their dietary intake, anthropometric measurements and blood sugar levels. Nutritional status was evaluated using standard indices *viz.*, Body Mass Index (BMI),Waist circumference (WC) and Abdominal fat (AF). The association between nutritional status and blood sugar levels among diabetic adults was also statistically analyzed. The mean waist circumference was found to be 96.84±13.13 cm for males and 100.5±14.69 cm for females which is greater than the normal value. A large number of diabetic adults (50.0%) were found to have a higher FBS (>125mg/dl) and 49.0 percent of the respondents were seen to have higher PPBS levels (>200 mg/dl). The blood parameters of the respondents were found to be greater than the normal values. A positively significant association was found between Body Mass Index and Central Obesity with elevated blood sugar levels as the χ^2 observed value (19.035) was found to be less than the χ^2 calculated value (19.975). Participants with a balanced diet exhibited better glycemic control, while those with inadequate nutrient intake showed higher fasting blood sugar levels. These findings implicate that nutritional interventions are vital for good diabetes management and reducing complications.

Keywords: Blood sugar level, Diabetic, Nutritional status.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has become a prevalent chronic disease globally, driven by urbanization, sedentary lifestyle and dietary changes. The global prevalence of diabetes has been steadily increasing, with approximately 537 million adults affected in 2021. This number is projected to rise significantly, reaching over 780 million by 2045 (Sun *et al*., 2022). Obesity, particularly central obesity, is a key risk factor for insulin resistance and the development of diabetes. Anthropometric measures like Body Mass Index (BMI) and Waist Circumference (WC) are vital for assessing obesity and fat distribution, with both strongly linked to glycemic control and diabetes complications.

Body Mass Index (BMI), calculated from weight and height, categorizes individuals into

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weight classes but does not account for fat distribution or distinguish between fat and lean mass. Despite these limitations, a higher BMI is consistently associated with a higher risk of T2DM, insulin resistance and poor glycemic control (World Health Organization, 2016).Waist circumference (WC), on the other hand, specifically indicates central obesity, which is strongly tied to insulin resistance and cardiovascular risks in diabetic adults due to release of pro-inflammatory cytokines by visceral fat. (Huang *et al*., 2023).

In addition to anthropometric measures, blood parameters such as Fasting blood glucose (FBG) and Hemoglobin A1c (HbA1c) are critical for assessing diabetes severity and management (Antwi-Baffour *et al*., 2023). Poor glycemic control, often accompanied by dyslipidemia, exacerbates the risk of cardiovascular complications. Clinical symptoms such as polyuria, polydipsia and peripheral neuropathy further underline the importance of effective diabetes management, particularly in individuals with higher WC and BMI (Alshammari *et al.,*2022).This study investigated the association between nutritional status and blood sugar levels among diabetic adults in Bhubaneswar, Odisha, with a focus on anthropometric and biochemical markers to enhance understanding of diabetes management.

MATERIAL AND METHODS

The present study conducted at different locations of Bhubaneswar, Odisha during 2023 (6 months).Adults (both male and female) aged 35 to 55 years were included as respondents in this study. The criteria adopted by Kuppuswamy, 2017 was followed.

Inclusion criteria

1. Adults with a blood sugar level above 100 mg/dL.
2. Individuals diagnosed with Type 2 Diabetes for more than six months.
3. Individuals aged 35 to 55 years.

Exclusion criteria

1. Individuals with Type1diabetes.
2. Patients with gestational diabetes (pregnant women).
3. Individuals not within the age range of 35-55 years.

Bhubaneswar, Odisha, was chosen as the study location for its diverse population and accessible healthcare facilities. A simple random sampling technique was employed to select 100 adults (50 males and 50 females), aged 35–55 years, with blood sugar levels >100 mg/dL from health care centers and local clinics. A pre-tested semi-structured questionnaire was used to gather data on socio- demographic profile and clinical symptoms of the patients.Ethical guidelines were followed, ensuring informed consent from participants, confidentiality, and adherence to ethical standards in data collection and analysis.

Blood sugar levels were recorded from respondents' recent medical reports. Anthropometric measurements including height, weight, waist circumference and hip circumference were taken following standard procedures. WHR (Waist-Hip Ratio) and BMI was calculated using the formula, {BMI=Weight (Kg) /Height^2 (m^2)} and the respondents were classified in different groups according to WHO guidelines. The respondents were placed under different socio-economic classes based on Kuppuswamy's scale.

Data were analyzed using SPSS software. Percentage, mean, standard deviation, and chi-square tests were applied to interpret the results.Chi square test was employed to establish statistical significant association between blood sugar levels with BMI and waist circumference of respondents.

RESULTS AND DISCUSSION

The demographic data of the subjects in table 1 indicated that the majority of diabetic adults were aged 46–55 years (58.0%), followed by 42.0 percent in the age group of

Table 1. Distribution of samples according to socio demographic characteristics

n=100

S.No.	Specifications	Categories	Frequency (%)	
			Male(n=50) No. (%)	Female (n=50)No. (%)
1	Age	35-45 years	13 (26.0)	29 (58.0)
		45-55 years	37(74.0)	21 (42.0)
2	Educational Status	Post-Graduation	18(36.0)	8(16.0)
		Graduation	28(56.0)	25(50.0)
		Higher Secondary	3(6.0)	7(14.0)
		High School	1(2.0)	5(10.0)
		Primary School	-	5(10.0)
3	Occupation	Govt. Job	29(58.0)	12 (24.0)
		Private Job	11(22.0)	5 (10.0)
		Self-Employed	10 (20.0)	01 (2.0)
4	Family type	Nuclear	48 (96.0)	49 (98.0)
		Joint	02(4.0)	01 (2.0)
5	Socio-economic status	Upper	22(44.0)	31 (62.0)
		Upper middle	25 (50.0)	14 (28.0)
		Lower middle	03 (6.0)	02 (4.0)

*Figures in parenthesis indicates percentages

35–45 years. Majority of the participants (97.0%) belonged to nuclear families. It was observed that the male participants had higher representation at postgraduate and graduate levels, while females were more prominent at the higher secondary level. Similarly, a larger number of male participants were employed in Government sectors in comparison to their female counterparts.Socioeconomic analysis showed that 53.0 percent were from the upper group, 39.0 percent from the upper middle group, and 5.0 percent from the lower middle group.

Majority (38.0%) of the male subjects were in the pre-obese BMI category, while 44.0 percent of female subjects were classified as obese. Under normal category, 18.0 percent of the male subjects were in the normal category, whereas only 6.0 percent female participants were found to be in normal category. Similarly, 12.0 percent males and 8.0 percent females were underweight. Higher prevalence of obesity indicates excess weight gain and is a major issue among the diabetic adults.

Similarly, in majority of the participants, waist circumference exceeded the normal values, 92.0 percent of females and 82.0 percent of males showed higher abdominal fat. Central obesity i.e. excess waist circumference is considered as a risk factor for the development of diabetes. Abdominal obesity, defined by Waist-to-Hip ratio (WHR), was observed in 56.0 percent of males (WHR >1.0) and 62.0 percent of females (WHR >0.8). Among males, 26.0 percent had normal WHR and 18.0 percent had low WHR, while among females, these values were 30.0 percent and 8.0 percent, respectively.Body Mass Index (BMI) and Waist Circumference (WC) are widely recognized anthropometric measures for evaluating obesity and abdominal fat, both of which are critical indicators of metabolic health. These measures are strongly associated with insulin resistance, a central factor in the

Table 2. Distribution of samples according to BMI **n=100**

S.No.	Body weight category	BMI (kg/m²)	
		Male(n=50)	Female (n=50)
1	Underweight(<18.5)	6 (12.0)	4 (8.0)
2	Normal(18.5-22.9)	9 (18.0)	3 (6.0)
3	Overweight (23-24.9)	10 (20.0)	3 (6.0)
4	Pre-obese(25-29.9)	19 (38.0)	10 (20.0)
5	Obese(e”30)	13 (26.0)	22 (44.0)
Central obesity (Waist circumference in cm)			
6	Ideal value	94	80
7	Observed value(Mean±SD)	96.84±13.13	100.5±14.69
WHR(Abdominal fat)			
8	Excess(male : >1 female: >0.8)	28 (56.0)	31 (62.0)
9	Normal(male : 1 female: 0.8)	13 (26.0)	15 (30.0)
10	Low(male : <1 female:<0.8)	09 (18.0)	04 (08.0)

*Figures in parenthesis indicate percentages

pathophysiology of Type 2 diabetes (T2D) (Wondmkun, 2020).

Elevated BMI contributes to insulin resistance by promoting the secretion of adipokines and inflammatory markers that impair insulin signaling, leading to hyperglycemia (Zatterale *et al*., 2020). The findings of the present study indicates that a significant proportion of participants exceeded the normal BMI range, reflecting a shift toward excessive weight gain. This aligns with findings by Patel *et al*. (2023), which reported significantly higher BMI values in diabetic patients compared to healthy control population. Additionally, WC measurements indicated a high prevalence of central obesity, particularly among females, consistent with gender-specific fat distribution patterns. Elevated WHR further highlighted the prevalence of abdominal obesity, with higher risks of metabolic complications such as T2D and cardiovascular diseases (Huang *et al.,* 2012). Studies carried out by Aghaei *et al*., (2024) also reported similar trends, confirming WC and WHR as stronger predictors of insulin resistance than BMI.

The biochemical parameters of both male and female participants were recorded and compared to the reference value. The findings were displayed in Table 3. The Z values ($p<0.01$) indicate a significantly higher hemoglobin, PPBS, total cholesterol, HbA1c, HDL, HbA1c and blood pressure were observed indiabetic males than in their female counterparts.Whereas LDL, TG levels were significantly higher ($p<0.01$) in females as compared to the males. The level of FBS, did not vary significantly between male and female diabetic patients.

The comparative study indicated that diabetic males had significantly higher levels ($p<0.01$) of hemoglobin, blood PPBS, total cholesterol, HbA1c, HDL, and blood pressure than females. In contrast, diabetic females exhibited significantly higher ($p<0.01$) levels of LDL and triglycerides (TG) than males. The fasting blood sugar (FBS) levels did not show a significant difference between sexes among diabetic patients. Findings of the study

Table 3. Distribution of samples according to Biochemical parameters n=100

S.No.	Parameters		Male (mean ± SD)	Female (mean ± SD)	Reference value	Z-Value
1	Haemoglobin		12.0±1.25	10.0±1.26	13(M)12.5(F)	8.28**
2	FBS (mg/dl)		132.8±28.99	124.34±15.40	100	1.836(NS)
3	PPBS (mg/dl)		184.5±46.17	158.92±28.16	140	3.336**
4	Cholesterol (mg/dl)		225.9±24.36	203.82±29.88	200	3.953**
5	HDL (mg/dl)		41.8±13.46	40.94±19.03	40	1.077**
6	LDL (mg/dl)		103.0±17.30	108.38±15.42	100	1.712**
7	TG (mg/dl)		154.0±17.01	158.36±16.89	150	1.203**
8	HbA1c (%)		11.0±2.36	9.0±1.79	08	2.2688**
9	SystolicB.P (mmHg)		130.22±10.09	125.06±7.91	120	0.004**
10	DiastolicB.P (mmHg)		84.52±4.904	82.28±5.07	80	2.24**
11	FBS (mg/dl)	<110	11 (22.0)	13 (26.0)	-	-
		110-125	14 (28.0)	25 (50.0)	- -	-
		>125	17 (34.0)	20 (40.0)		
12	PPBS (mg/dl)	<140	13 (26.0)	16 (32.0)	-	
		140-199	12 (24.0)	14 (28.0)	-	
		>200	29 (58.0)	20 (40.0)	-	

FBS: Fasting blood sugar, PPBS: Postprandial Blood sugar, HDL: High Density Lipoprotein, LDL: Low Density Lipoprotein,TG:Triglyceride,HbA1c: Glycosylated Haemoglobin, B.P:Blood Pressure (Parenthesis"**"denotes significant variation(p<0.01)NS:Non-significant)

revealed that blood parameters have a significant relationship with the gender of the participants. Higher HbA1c levels among the males,shows poorer long-term glycemic control, potentially due to differences in treatment adherence or insulin sensitivity. Lipid profile analysis showed that females had elevated LDL and triglycerides, key risk factors for aterosclerosis and cardiovascular disease (CVD), while males exhibited higher total cholesterol and HDL levels (p<0.01). These findings echo the concerns raised by Zheng *et al*. (2019) and Hyassat *et al.* (2022), emphasizing the need for improved lipid management in diabetic patients. Hypertension was also prevalent among diabetic participants, with blood pressure exceeding 130/80 mmHg. Proper food management, including lifestyle changes and antihypertensive medications such as ACE inhibitors or ARBs, is crucial for mitigating cardiovascular risks (Zhen *et al*., 2022).

The observed values of blood sugar of the subjects under differentranges were presented in Table4.The analysis of fasting blood sugar (FBS) levels revealed that 45.0 percent of participants had FBS >125 mg/dL, indicating poor glycemic control, with a higher proportion of males (50.0%) compared to females (40.0%). In the prediabetic range (110–125 mg/dL), 28.0 percent males and 34.0 percent females, while 24.0 percent had normal FBS levels (<110 mg/dL).

Postprandial blood sugar (PPBS) levels showed that 49.0 percent of participants had

Table 4. Distribution of samples according to blood sugar level **n=100**

S.No.	Categories		Total	Male(n=50) No.(%)	Female(n=50) No.(%)
1	FBS(mg/dl)	<110	24	11 (22.0)	13 (26.0)
		110-125	31	14 (28.0)	17 (34.0)
		>125	45	25 (50.0)	20 (40.0)
2	PPBS(mg/dl)	<140	29	13 (26.0)	16 (32.0)
		140-199	26	12 (24.0)	14 (28.0)
		>200	49	29 (58.0)	20 (40.0)

values >200 mg/dL, with males (58.0%) outnumbering females (40.0%). In the intermediate range (140–199 mg/dL), 26.0 percent of participants were recorded, including 24.0 percent males and 28.0 percent females. Only 29.0 percent of participants had PPBS <140 mg/dL, with slightly more females (32.0%) than males (26.0%).

The findings highlight that a significant proportion of the sample had poor glycemic control, particularly among males. This underscores the need for targeted interventions to improve blood sugar management in diabetic adults. Blood sugar analysis revealed significant differences between diabetic males and females. Males showed higher fasting blood sugar (FBS) levels, indicating poorer glycemic control, while females had a higher prevalence in the prediabetic range, reflecting an elevated risk of diabetes progression. This finding aligns with studies by Patel *et al*., (2023), which reported poor glycemic control among diabetic patients.

The clinical signs of the subjects were recorded, and the frequency percentages distribution were shown in Figure 1. It is evident from the figure that, the frequency for observing fatigue was more in males (70.0%) than in females (64.0%) but, that of blurred vision was calculated less for males (22.0%) than in females (18.0%). Further, 42.0 percent males and 46.0 percent females were found to have polyuria. Similarly, polydipsia was seen in 56.0 percent of the males and 58.0 percent females, loss of weight without any heavy physical activity is seen in 24.0 percent males and 22.0 percent females. Slow wound healing is seen in 46.0 percent males and 32.0 percent females.

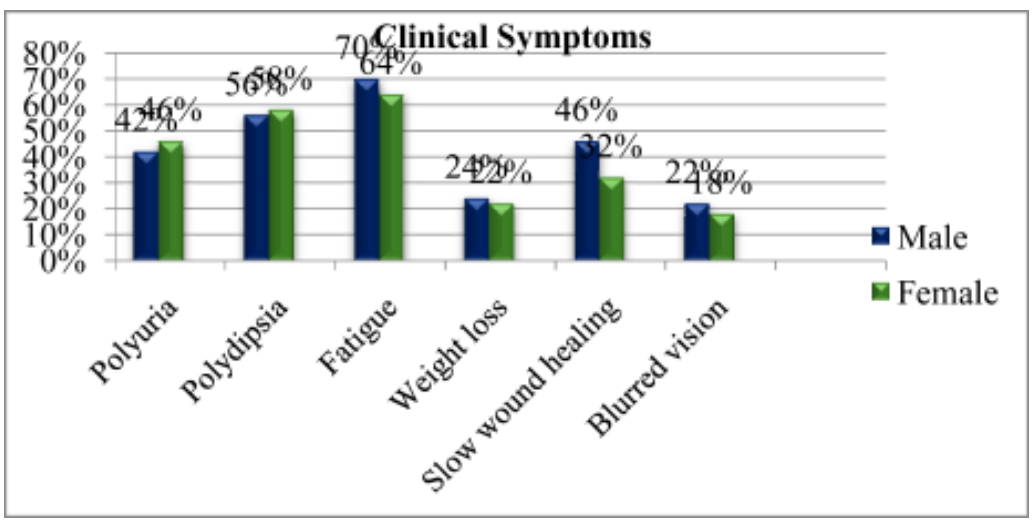

Fig. 1 Clinical signs among diabetic adults in Bhubaneswar

Table 5. Association of blood sugar level with BMI of samples **n=100**

S.No.	BMI	FBS (mg/dl)			PPBS (mg/dl)		
		<110	110-125	>125	<140	140-200	>200
1	Underweight (10)	6	4	0	8	2	0
2	Normal (26)	2	3	7	2	3	7
3	Overweight (29)	3	3	8	3	4	7
4	Pre-obese (29)	4	7	18	4	10	15
5	Obese (35)	3	11	21	8	10	17
6	Total (100)	18	28	54	25	29	46
7	χ^2(Table):15.51d.f:8 at 5%level of significance	χ^2**(Calculated)** =19.035			χ^2 **(Calculated)** = 19.975		

The ranges of the fasting blood sugar value increased with the increasing BMI as shown in Table 5. As the BMI falls, the fasting blood sugar level among there spondents were found to be less. A positive correlation was observed between the BMI and fasting blood sugar of the respondents. The PPBS was significantly increasing with the increasing BMI. The χ^2 calculated (19.975) value was greater than the χ^2 table value (15.51). The findings highlight association of BMI with the PPBS range. Table 6 also illustrates that fasting blood sugar values tended to rise with increasing BMI. Conversely, as BMI decreased, fasting blood sugar levels among respondents were also lower, indicating a positive correlation between BMI and fasting blood sugar. Similarly, postprandial blood sugar (PPBS) levels significantly increased with higher BMI values. The calculated chi-square (χ^2) value of 19.975 exceeded the table value of 15.51, confirming an association between BMI and PPBS range.Agrawal *et al.* (2017) also observed a positive correlation between BMI and FBS, and is consistent with the present study.

It has been observed from the Table 6 that, the male respondents having larger waist circumference showed a higher range of fasting blood sugar level as well as PPBS. The FBS was found to increase with increasing waist circumference of female respondents. The χ^2 calculated value (9.65) was greater than the χ^2 table (9.49) value.The table shows that the respondents having normal waist circumference possessed a lower range of PPBS range. The χ^2 calculated value was found to be greater than the χ^2 table value in both male and female respondents. So, it is supposed that there may be a direct relation between the Waist Circumference and the PPBS range of the respondents(Table 6).

It was further observed that male respondents with larger waist circumferences exhibited higher fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels. Among female respondents, FBS also increased with waist circumference. The chi-square (χ^2) calculated value of 9.65 exceeded the table value of 9.49, confirming a significant association.The table also shows that respondents with normal waist circumference had lower PPBS levels. In both male and female respondents, the calculated χ^2 values exceeded the table values, suggesting a potential direct relationship between waist circumference and PPBS levels.

CONCLUSION

The present study highlights a positively significant association between anthropometric indicators and glycaemic control among diabetic adults in Bhubaneswar, Odisha. A gradual increase in fasting and postprandial blood sugar values was recorded as the BMI increased from normal to obese category.The chi-square results for both fasting (χ^2 = 19.035) and postprandial (χ^2 = 19.975) glucose levels were greater than the table

Table 7. Association between Waist Circumference and Blood sugar level n=100

S.No.	Waist circumference	FBS(Male) mg/dl				PPBS(Male)mg/dl		
		<110	110-125	>125	Total	<140	140-200	>200
1	<94	6	2	1	9	5	4	0
2	94-102	2	4	7	13	2	4	7
3	>102	5	9	14	28	4	10	14
4	Total	13	15	22	50	11	18	21
5	χ^2Calculated value:9.95					χ^2Calculated value:10.54		
6	FBS (Female) mg/dl					PPBS (Female) mg/dl		
7	<80	3	1	0	4	3	1	0
8	80-88	1	6	8	15	0	6	9
9	>88	6	11	14	31	5	11	15
10	Total	10	18	22	50			
11	χ^2 Calculated value:9.65					χ^2Calculated value:17.19		
	χ^2 Table value:9.49, df:4 a t5% level of significance							

value (χ^2 = 15.51 at 5% level), confirming a positively significant association between BMI and blood sugar status.Similarly, waist circumference has an interrelationship with blood sugar levels in both male and female participants. Those with a waist circumference above the standard cut-off (>102 cm for males and >88 cm for females) had consistently higher fasting and postprandial glucose levels.These findings emphasize that excessive body weight and central obesity are important determinants of diabetes management outcomes. Routine assessment of anthropometric parameters should therefore be integrated into diabetes care to identify at-risk individuals and guide personalized dietary, lifestyle, and therapeutic interventions.Regular physical exercise, adherence to a balanced and portion-controlled diet, periodic monitoring of anthropometric indices,health education and community awareness programmes should form an integral part of diabetes management.

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