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# The relationship between body mass index and waist-to-hip ratio among type 2 diabetic women: A in depth analysis

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**Abstract**
This cross-sectional study observed at the link between Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR) in 100 female Type 2 diabetic patients aged 30 to 50 in Udaipur, Rajasthan. Participants were selected from five hospitals and examined using standardised anthropometric measurements. The study tells that 79% of participants were overweight or obese (mean BMI 30.67 ± 5.80), whereas just 20% had a normal BMI. Significantly, 92% of subjects had elevated WHR (≥0.85), suggesting central adiposity and increased health risk. A cross-tabulation study identified a significant relationship between BMI and WHR categories ($p = 0.04$). The data suggest that central fat distribution, as evaluated by WHR, may be a more common concern in this diabetic population than general obesity. This study highlights that the relevance of using BMI and WHR as going well with measurements for assessing diabetic women's overall health.

**Keywords:** Body Mass Index, Waist-to-Hip Ratio, Type 2 Diabetes, Central Obesity

## Introduction

Type 2 diabetes mellitus (T2DM) is one of the most vital public health concerns of the twenty-first century, affecting more than 463 million adults worldwide, with women accounting for over half of this population. (International Diabetes Federation, 2019).The World Health Organization identifies obesity as a significant risk factor for various chronic illnesses, such as heart disease, type 2 diabetes, metabolic syndrome, and specific types of cancer(Ng *et al*., 2014). Obesity, especially central obesity, has an important role in the pathophysiology and management ofT2DM. Millets provide nutraceutical benefits that are especially useful in the prevention and treatment of Type 2 Diabetes Mellitus. (Soni, Wadhawan, Rahal, & Meghwal, 2023) [3] Central obesity accounts for 80-95% of T2DM incidences, hence adding to the enormity of the medical burden to T2DM. (Argade, D., & Wadhawan, N,(2025) [4] The evaluation of body composition and fat distribution is especially significant for women due to specific physiological factors tied to hormonal changes, reproductive health, and the likelihood of developing gender-related diseases (Palmer & Clegg, 2015) [5]. Traditional anthropometric assessments have long been essential for assessing nutritional health and associated risks in both clinical and research environments. The Body Mass Index (BMI), which is determined by dividing weight in kilograms by the square of height in meters, remains the most commonly utilized screening method to classify individuals into categories of underweight, normal weight, overweight, and obesity (Keys *et al*., 1972) [6]. Its budget friendliness, ease of use, and validated reference standards have contributed it an essential element of health evaluations worldwide (Nuttall, 2015) [7].

The shortcomings of BMI in differentiating between muscle and fat mass, along with its failure to indicate fat distribution, have led researchers to investigate additional anthropometric measures (Rothman, 2008) [8]. Waist-to-Hip Ratio (WHR) is derived by dividing the circumference of the waist by that of the hips and has become an important indicator of central fat accumulation and the distribution of body fat (Ashwell *et al*., 2012) [9]. This ratio offers an understanding of fat distribution patterns, differentiating between android (apple-shaped) and gynoid (pear-shaped) body types, each associated with distinct health risks (Kissebah & Krakower, 1994) [10]. The connection between Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR) is influenced by a variety of factors, including genetics, hormones, lifestyle choices, and environmental conditions, all of which affect body composition in women (Karastergiou *et al*., 2012) [11]. While BMI gives a broad evaluation of overall body fat, WHR provides detailed insights into fat distribution around the abdomen, which has consistently been associated with metabolic issues and increased cardiovascular risk (Yusuf *et al*., 2005) [12]. Understanding the relationship between these two measurements is essential for creating thorough health assessment protocols and recognizing individuals who are at risk for complications associated with obesity (Després, 2012) [13].

Research has shown that central obesity, characterized by a high waist-to-hip ratio (WHR), may present greater health risks than general obesity on its own (Canoy, 2008) [14]. Women with elevated waist-to-hip ratios, even when their body mass index is considered normal, might face a higher likelihood of developing insulin resistance, abnormal lipid levels, and cardiovascular issues (Schneider *et al*., 2010) [15]. The distribution of fat in the body plays a crucial role in the onset of non-insulin dependent diabetes mellitus, commonly known as Type 2 diabetes. Central fat accumulation has been repeatedly linked to insulin resistance and difficulties in glucose metabolism (Carey *et al*., 1997) [16]. Visceral fat, which builds up around the internal organs and is indicated by elevated waist-to-hip ratio (WHR) values, releases a range of adipokines and inflammatory substances that play a role in metabolic dysfunction and the development of diabetes (Bjorntorp, 1991 [17]; Wajchenberg, 2000) [18]. Research indicates that women exhibiting android fat distribution patterns (characterized by a higher waist-to-hip ratio) have a considerably elevated risk of developing Type 2 diabetes when compared to those with gynoid fat distribution patterns, regardless of their overall body weight (Lundgren *et al*., 1989 [19]; Ohlson *et al*., 1985) [20]. Some women who have a high BMI but display favorable patterns of fat distribution may actually show a lower risk of metabolic issues and a decreased likelihood of developing diabetes (Kuk *et al*., 2007) [21]. The intricacy of this matter highlights the necessity of analyzing both factors together instead of depending on just one anthropometric measurement (Ashwell *et al*., 2012) [9].

Although the significance of both Body Mass Index (BMI) and Waist-Hip Ratio (WHR) in health evaluations is well recognized, there is still a demand for detailed comparative studies that explore their relationship across various groups of women. Previous research has frequently concentrated on single measures or has been constrained by small participant numbers, specific age brackets, or particular ethnic groups (Hu, 2008) A detailed comparative study investigating the relationship between BMI and WHR can yield important insights into their supportive functions in evaluating health and determining risk levels (Huxley *et al*., 2010) [23].

Additionally, grasping the extent of correlation among these measurements can provide valuable insights for clinical practice on when to evaluate both factors as opposed to when one may be adequate. This understanding is especially crucial in settings with limited resources, where thorough anthropometric evaluations might not always be practical, requiring healthcare providers to prioritize measurements based on their diagnostic importance. (Stevens *et al*., 2012) [24].

This study intends to enhance the current understanding of knowledge by performing a thorough comparative analysis of the connection between Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR) in women. The main goals include measuring the BMI and WHR values within the chosen group and evaluating the statistical correlation between these two anthropometric measures. This research aims to provide reliable insights that can improve the assessment of body composition and lead to more effective health screening practices for women.

## Materials and Methods

This cross-sectional study was carried out in Udaipur City, Rajasthan, on female Type 2 diabetic patients. The study participants were drawn from five hospitals in the city, one of which was a government hospital and the other four were private. The study only recruited women aged 30 to 50 who had a verified history of Type 2 diabetes for at least two years prior to enrolment. Based on the inclusion criteria, 20 subjects were initially recruited from each of the five institutions, yielding a final study population of 100 female Type 2 diabetes patients. All anthropometric measures were obtained with standardised equipment to ensure accuracy and uniformity. Height was measured using an anthropometric rod, and weight was recorded with a weighing scale. Hip and waist circumferences were measured using a measuring tape in accordance with conventional standards. Body Mass Index (BMI) was determined using these fundamental measurements as weight in kilogrammes divided by height in meters squared, and waist-to-hip ratio (WHR) as waist circumference divided by hip circumference. This study used a cross-sectional design, with each participant assessed at a single time point. To ensure consistency in measuring methodologies and data recording procedures, data was collected in a systematic manner across all five institutions.

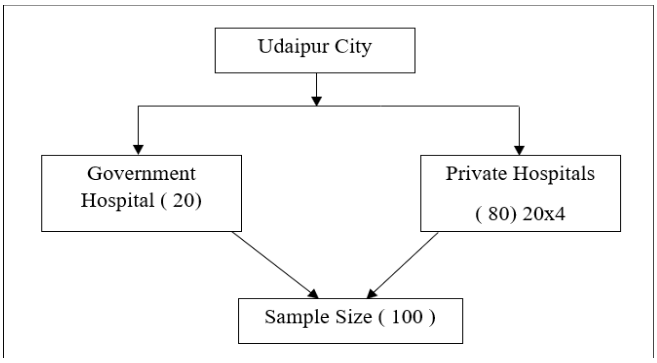


**Fig 1:** Population of Study Flow Chart

## Data collection

A structured questionnaire was designed specifically for this study to obtain comprehensive baseline information from all participants. Data were gathered through face-to-face interviews conducted by researcher itself following standardized procedures. The data collection process encompassed both subjective and objective variables. General background factors such age, education, marital status, caste, religion, family type, number of family members, yearly income, health habits, supplement consumption, and medical history based on available medical records were all considered subjective information. Objective measurements included anthropometric evaluations such as Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR). To guarantee accuracy and consistency during the course of the study, all data gathering methods were standardised.

## Results and Discussion

### Demographic details

This demographic data represents a survey of 100 respondents, highlighting a predominantly middle-aged, Indian population. The age distribution shows most participants are between 41-50 years old (61% combined), with Hindu religion being dominant at 76%, followed by Muslim (13%) and Jain (9%) communities. Family structures are fairly balanced between nuclear (53%) and joint families (47%), with the vast majority being married individuals (81%). The socioeconomic profile indicates a diverse caste representation, with General category forming the largest group (46%), followed by OBC (31%), and smaller percentages from SC, ST, and EWS categories. Income levels cluster primarily in the middle-income brackets, with 49% earning between 6-12 lakhs annually and 22% in the 3-6 lakh range, suggesting a predominantly middle-class sample. Educational qualifications vary significantly, with 34% being illiterate, 27% having graduation degrees, and 16% with secondary education, indicating mixed literacy levels. The occupational distribution reveals a striking pattern where homemakers constitute 71% of the sample, followed by private job holders (10%) and self-employed individuals (9%). This suggests the survey may have been conducted in a setting where women, particularly homemakers, were the primary respondents, possibly reflecting traditional household structures in Indian society.

**Table 1:** General Characteristics of the study population (n = 100)

| Categories | Frequency | Percentage |
|---|---|---|
| **Age** | | |
| 30–35 | 17 | 17.0 |
| 36–40 | 22 | 22.0 |
| 41–45 | 32 | 32.0 |
| 46–50 | 29 | 29.0 |
| **Religion** | | |
| Hindu | 76 | 76.0 |
| Muslim | 13 | 13.0 |
| Jain | 9 | 9.0 |
| Other | 2 | 2.0 |
| **Type of Family** | | |
| Nuclear | 53 | 53.0 |
| Joint | 47 | 47.0 |
| **No. of Family Members** | | |
| 2–4 | 30 | 30.0 |
| 4–8 | 43 | 43.0 |
| >8 | 27 | 27.0 |
| **Marital Status** | | |
| Married | 81 | 81.0 |
| Unmarried | 4 | 4.0 |
| Widow | 13 | 13.0 |
| Divorced / Separated | 2 | 2.0 |
| **Caste Based Categorization** | | |
| General | 46 | 46.0 |
| OBC | 31 | 31.0 |
| Economically Weaker Section (EWS) | 4 | 4.0 |
| Scheduled Tribes (ST) | 9 | 9.0 |
| Scheduled Castes (SC) | 11 | 11.0 |
| **Total Annual Income of Family (in ₹ lakh)** | | |
| Lower Income Group (3–6 lakh) | 22 | 22.0 |
| Middle-Income Group – 1 (6–12 lakh) | 49 | 49.0 |
| Middle-Income Group – 2 (12–18 lakh) | 20 | 20.0 |
| Higher-Income Group (Above 18 lakh) | 9 | 9.0 |
| **Educational Qualification** | | |
| Illiterate | 3 | 3.0 |
| Primary | 9 | 9.0 |
| Secondary | 0 | 0.0 |
| Senior Secondary | 10 | 10.0 |
| Graduation | 71 | 71.0 |
| Post Graduation | 6 | 6.0 |
| **Occupation** | | |
| Government Job | 34 | 34.0 |
| Private Job | 11 | 11.0 |
| Self-employed | 16 | 16.0 |
| Daily Wage Worker | 6 | 6.0 |
| Homemaker | 27 | 27.0 |
| Student | 6 | 6.0 |
| Retired | 1 | 1.0 |

**Distribution of BMI categorization of the respondents**

Table 2 show the BMI distribution of n =100 female participants with non-insulin dependent diabetes mellitus using WHO BMI standards. The statistics show a worrying trend of weight distribution in the study population. Only 20% (n=20) of participants had a normal BMI, indicating a healthy weight. The majority of participants were overweight or obese, with 27% (n=27) classed as pre-obesity, the most common category. Among the obese classifications, 26% (n=26) fell into obese class 1 (BMI 30-34.9), followed by 23% (n=23) in obese class 2 (BMI 35-39.9), and 4% (n=4) in the most severe obese class 3 (BMI > 40). Collectively, 79% of the study subjects were overweight (pre-obesity and obese combined), with 53% clinically obese (classes 1–3).

**Table 2:** Percentage and distribution of BMI categorization of the respondents (n = 100)

| Categories | BMI (kg/m$^2$) | Frequency | Percentage |
|---|---|---|---|
| Underweight | Below 18.5 | 0 | 0.0 |
| Normal | 18.5–24.9 | 20 | 20.0 |
| Pre-Obesity | 25.0–29.9 | 27 | 27.0 |
| Obese class 1 | 30.0–34.9 | 26 | 26.0 |
| Obese class 2 | 35.0–39.9 | 23 | 23.0 |
| Obese class 3 | >40 | 4 | 4.0 |
| Total | | 100 | 100.0 |

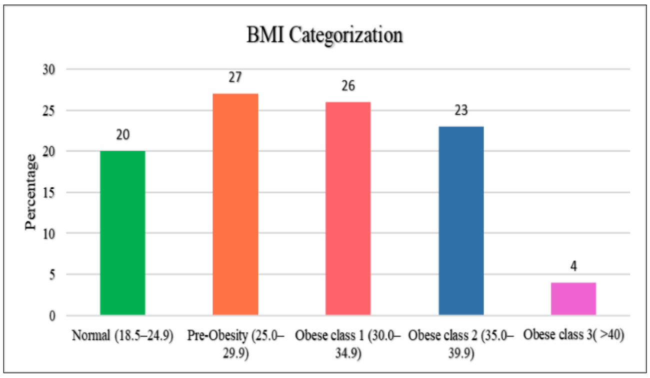


**Fig 2:** BMI Categorization of the respondent

**Distribution of WHR wise distribution of NIDDM women**

Table 3 shows only 8% of participants (n=8) had a WHR less than 0.85 cm, which is considered healthy and associated with a lower risk of cardiovascular disease and metabolic consequences. In contrast, an overwhelming 92% (n=92) of participants had a WHR of 0.85 cm or greater, indicating substantial abdominal fat distribution and increased health risk. This pattern of central obesity is especially problematic in diabetic women, as high WHR is closely associated with insulin resistance, poor glycemic management, and an increased risk of cardiovascular problems. The mean WHR of 0.91 ± 0.87 in anthropometric measurements supports this tendency, indicating that the typical participant exceeded the healthy threshold. The predominance of elevated WHR values (92%) compared to obesity prevalence based on BMI (79%) suggests that abdominal fat distribution may be an even more prevalent issue in this population, emphasizing the importance of waist-hip ratio as a complementary measure to BMI in assessing health risks among diabetic women.

**Table 3:** Percentage and distribution of WHR Wise Distribution of NIDDM Women (n = 100)

| WHR | Frequency | Percentage |
|---|---|---|
| <0.85 cm | 8 | 8.0 |
| ≥0.85 cm | 92 | 92.0 |
| Total | 100 | 100.0 |

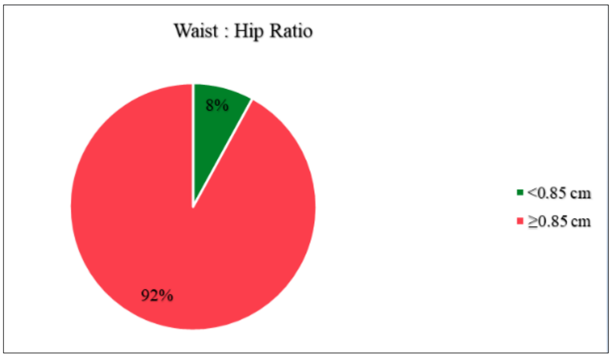


**Fig 3:** Waist to hip ratio among the respondents

**Assessment of relationship between BMI and WHR**

The Relationship between BMI and WHR: A cross-tabulation table shows the distribution of participants across combined BMI and WHR categories, indicating significant patterns in the association between general obesity and abdominal fat distribution among 100 female participants with non-insulin dependent diabetes mellitus. The table compares three BMI categories (normal, pre-obesity and obese) to WHR classifications (<0.85 cm and ≥0.85 cm). In the normal category, all 20 participants (100%) had increased WHR (≥0.85 cm), with none having healthy WHR values. The pattern is even more obvious in obese category, where just three out of 53 participants (5.7%) had healthy WHR values, whereas 50 people (94.3%) had increased WHR. This progressive association shows that when BMI rises, the risk of having unhealthy abdominal fat distribution rises significantly. The results were statistically significant (p=0.04). (Table 4)

**Table 4:** Assessment of relationship between BMI and WHR (n = 100)

| BMI Categories | WHR Categories | | Chi – square value | P value |
|---|---|---|---|---|
| | <0.85 | ≥0.85 | | |
| Normal (18 – 24.9 kg / m$^2$) | 0 | 20 | 6.192 | 0.04 |
| Pre obesity (25 – 29.9 Kg/m$^2$) | 5 | 22 | | |
| Obese (> 30 kg/m$^2$) | 3 | 50 | | |
| Total | 8 | 92 | | |

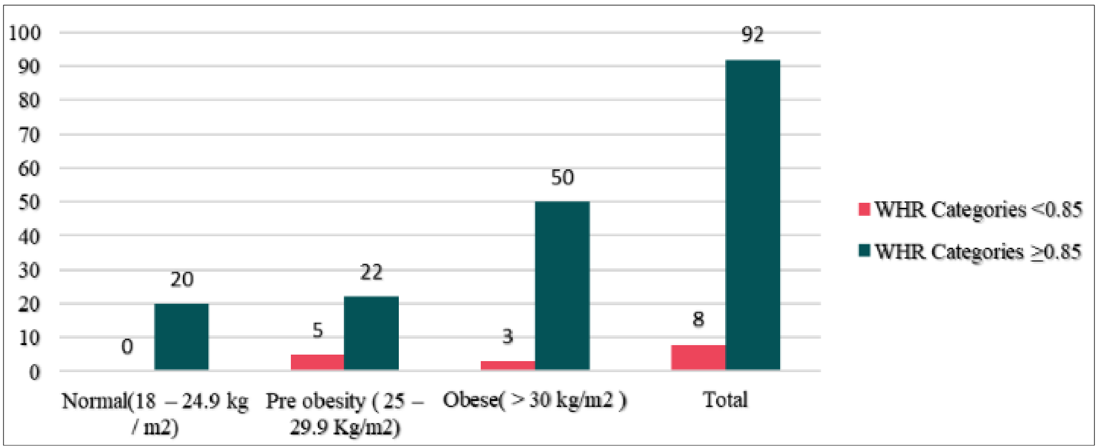


**Fig 4:** Relationship between BMI & WHR

## Conclusion

The study found a strong link between BMI and WHR among Type 2 diabetic women, with the majority showing both general and central obesity characteristics. The prevalence of increased WHR values (92%), measured against to obesity prevalence based on BMI (79%), implies that abdominal fat distribution may be a more important health indicator in this population. The significant statistical relationship between these anthropometric parameters offers a evidence to their synergistic use in clinical practice. Healthcare professionals should focus on both measurements for risk assessment, especially in resource-constrained settings where detailed evaluations may not always be feasible. These findings provide important information for establishing more effective health screening protocols and body composition assessment strategies for diabetic women.

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