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Association between central obesity assessed by waist-to-height ratio and oral glucose tolerance test glucose dynamics in prediabetes

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ABSTRACT

OBJECTIVE: Prediabetes is a heterogeneous metabolic condition associated with variable risk of progression to type 2 diabetes and cardiovascular complications. Conventional glycemic markers may fail to detect early metabolic deterioration. Recent evidence suggests that oral glucose tolerance test (OGTT)-derived glucose dynamics may provide additional insight into early metabolic alterations. Waist-to-height ratio (WHtR) has emerged as a simple and reliable anthropometric marker of central obesity that may outperform body mass index (BMI) in identifying individuals with increased cardiometabolic risk, including those with prediabetes. However, the relationship between central obesity and early OGTT glucose responses remains insufficiently investigated. To evaluate the association between central obesity assessed by WHtR and OGTT-derived glucose dynamics in individuals with prediabetes.

METHODS: This cross-sectional study included 86 individuals with prediabetes who underwent a standard 75-g OGTT. Anthropometric measurements including BMI and WHtR were recorded. OGTT-derived parameters including peak glucose, time to peak, glucose excursion, early and late glucose exposure (area under the curve), and 1-h glucose levels were analyzed. Associations were evaluated using correlation analyses and group comparisons. Multivariable linear regression adjusted for age and hemoglobin A1c was performed.

RESULTS: WHtR was significantly associated with early OGTT glucose parameters including 30-min glucose (r=0.222, p=0.042), peak glucose (r=0.247, p=0.022), early glucose exposure (r=0.249, p=0.022), and glucose excursion (r=0.245, p=0.023). BMI was not associated with OGTT glucose dynamics. Individuals with elevated 1-h glucose (≥155 mg/dL) had significantly higher WHtR values (p=0.029). In multivariable analysis, WHtR showed a trend toward significance for early glucose exposure.

CONCLUSION: WHtR was associated with early OGTT glucose abnormalities, whereas BMI was not, suggesting that central obesity may be linked to early metabolic alterations before overt dysglycemia develops. WHtR may serve as a simple and practical marker to identify individuals who may benefit from early metabolic risk assessment when evaluated together with OGTT-derived glucose dynamics.

Keywords: Body mass index; central obesity; oral glucose tolerance test; prediabetes; waist-to-height ratio.

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Prediabetes represents an intermediate metabolic state with variable risk of progression to type 2 diabetes and cardiovascular complications [1, 2]. However, conventional glycemic markers may not fully capture early metabolic alterations, as dysglycemic changes often begin before diagnostic thresholds are reached [2–4]. Therefore, there is increasing interest in identifying earlier metabolic markers that may improve risk stratification before the development of overt dysglycemia [4, 5].

Recent evidence has increasingly focused on the role of dynamic glucose responses during the oral glucose tolerance test (OGTT) in identifying early metabolic abnormalities beyond conventional fasting and 2-h measurements [1, 4]. In particular, glucose levels measured at earlier time points have been shown to provide additional prognostic information regarding future metabolic risk [4, 6]. Furthermore, individuals classified as normoglycemic based on standard criteria may still exhibit elevated glucose responses in the early phase of OGTT, which have been linked to underlying metabolic dysfunction [6, 7]. In addition, patterns observed in the glucose response curve, including the timing of peak glucose and early-phase elevations, have been associated with alterations in insulin sensitivity and β-cell function [8–10]. These findings suggest that early-phase glucose exposure and peak glucose levels may reflect metabolic deterioration before overt dysglycemia develops, highlighting the potential value of earlier risk identification and timely preventive interventions [8–10].

Central obesity is a key determinant of insulin resistance and cardiometabolic risk [1, 11, 12]. Among anthropometric indices, waist-to-height ratio (WHtR) has been recently proposed as a simple and reliable marker of central adiposity and metabolic risk that may outperform traditional measures such as body mass index (BMI) [11, 12]. Previous studies have demonstrated associations between WHtR and insulin resistance, dyslipidemia, and increased diabetes risk across different populations [11–13]. However, most of these studies have focused on conventional glycemic outcomes rather than OGTT-derived glucose dynamics [11, 12].

Although both OGTT-derived glucose dynamics and central obesity are independently associated with metabolic risk, the relationship between central adiposity and early glucose response patterns during OGTT remains insufficiently investigated, particularly in individuals with prediabetes [4, 8, 11]. Understanding this relationship may provide additional insight into early metabolic deterioration and help identify high-risk individuals before the development of overt dysglycemia [4, 8]. Based on emerging evidence linking central adiposity with early metabolic dysfunction and insulin resistance, we hypothesized that higher WHtR would be associated with unfavorable OGTT glucose dynamics independent of conventional glycemic classification. These parameters were selected because they capture early-phase glucose dysregulation, which has been shown to reflect β-cell dysfunction and insulin resistance more sensitively than conventional 2-h glucose measurements [8–10]. Therefore, the aim of this study was to investigate the association between central obesity assessed by WHtR and OGTT-derived glucose dynamics including peak glucose, early glucose exposure, and glucose excursion in individuals with prediabetes.

Highlight key points

- WHtR is associated with early OGTT-derived glucose abnormalities in prediabetes.
- WHtR correlates with early glucose exposure and glucose excursion.
- BMI may be delayed or inadequate in reflecting early glucose dynamics.
- Elevated 1-h glucose is associated with higher WHtR.
- WHtR may help identify early metabolic risk beyond conventional markers.

MATERIALS AND METHODS

Study Design and Population

This cross-sectional analysis was conducted using retrospective data from consecutive individuals with prediabetes who had undergone 75-g OGTT as part of routine clinical evaluation at an endocrinology outpatient clinic of Gazi University between June 2025 and February 2026.

Prediabetes was classified based on established diagnostic thresholds for fasting glucose, 2-h OGTT glucose, and hemoglobin A1c (HbA1c) levels [14].

Individuals with previously diagnosed diabetes mellitus, use of glucose-lowering medications, pregnancy, active infection, malignancy, missing clinical data, or current use of systemic corticosteroids were excluded. Demographic characteristics, anthropometric measurements, and laboratory parameters were obtained from medical records.

Table 1. Demographic and metabolic characteristics of the study population

Variables	Total (n=86)	Female (n=61)	Male (n=25)
Age (years)	51±12	50±11	51±13
HbA1c (%)	5.96±0.22	5.99±0.21	5.90±0.25
BMI (kg/m^2)	26.46±3.44	26.61±3.31	26.11±3.77
WHtR	0.57 (0.52–0.61)	0.57 (0.52–0.61)	0.57 (0.52–0.60)

Data are presented as mean±SD or median (IQR). IQR: Interquartile range; BMI: Body mass index; HbA1c: Hemoglobin A1c; SD: Standard deviation; WHtR: Waist-to-height ratio.

Ethical approval for the study was obtained from the Gazi University Ethics Committee (Approval No: 2026-684; Date: March 31, 2026). The study protocol adhered to the ethical standards outlined in the Declaration of Helsinki. Given the retrospective nature of the study, the need for informed consent was waived.

Anthropometric Measurements

Anthropometric measurements were retrieved from patient records and included height, body weight, and waist circumference. BMI was derived by dividing body weight in kilograms by height in meters squared. Waist circumference was assessed at the midpoint between the lower rib margin and the iliac crest at the end of a normal expiration. The WHtR was calculated as the ratio of waist circumference to height, and a value of ≥0.5 was used to define central obesity [15, 16].

Laboratory Measurements and OGTT-derived Glucose Dynamics

Laboratory data including fasting plasma glucose, OGTT glucose measurements, and HbA1c levels were obtained from medical records. Glucose measurements were performed using standard automated laboratory methods, and HbA1c was measured using high-performance liquid chromatography.

OGTT measurements were retrospectively retrieved from patient records. All individuals had undergone a standard 75-g glucose challenge following overnight fasting, as part of routine clinical evaluation. Plasma glucose levels at predefined time points (0, 30, 60, 90, and 120 min) were recorded.

Peak glucose was defined as the highest glucose value during OGTT, and time to peak as the time point at which this value occurred. Glucose excursion was defined as the difference between peak and fasting glucose levels. Glucose exposure was quantified using the area under the curve (AUC), calculated based on serial glucose measurements using the trapezoidal approach. Early and late phases were evaluated separately to reflect temporal glucose dynamics. Early AUC and late AUC were defined as glucose exposure between 0–60 min and 60–120 min, respectively, based on the established distinction between early-phase insulin secretion and late-phase glucose clearance during OGTT, which reflect different pathophysiological processes including hepatic glucose output and peripheral insulin sensitivity [6, 7, 17]. The early-to-late AUC ratio was calculated to reflect the relative contribution of early versus late glucose exposure. Late glucose clearance was defined as the difference between peak glucose and 120-min glucose levels. Elevated 1-h glucose was defined as ≥155 mg/dL [3]. Multivariable linear regression analysis was performed to evaluate the independent association of WHtR with early glucose exposure (early AUC), adjusting for age and HbA1c as potential confounders.

Statistical Analysis

All statistical analyses were carried out using IBM Statistical Package for the Social Sciences Statistics (version 31.0; IBM Corp., Armonk, NY, USA). The final dataset consisted of 86 individuals with complete OGTT data.

Data distribution was evaluated with the Shapiro–Wilk test. Continuous variables are reported as mean±standard deviation or median (interquartile range), depending on distribution, whereas categorical variables are presented as counts and percentages.

The relationships between anthropometric indices and OGTT-derived parameters were examined using Pearson or Spearman correlation coefficients, as appropriate. Group comparisons were performed using inde-

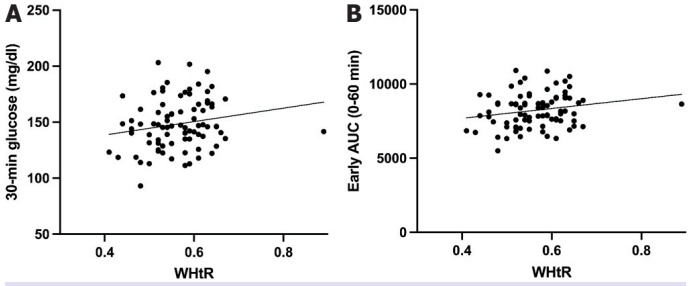

Figure 1. Relationship between waist-to-height ratio (WHtR) and early oral glucose tolerance test glucose parameters. **(A)** Scatter plot showing the association between WHtR and 30-min plasma glucose levels. **(B)** Scatter plot showing the association between WHtR and early glucose exposure assessed by the area under the curve (AUC) between 0 and 60 min (Early AUC). Correlations were assessed using Spearman analysis. Solid lines represent linear regression lines.

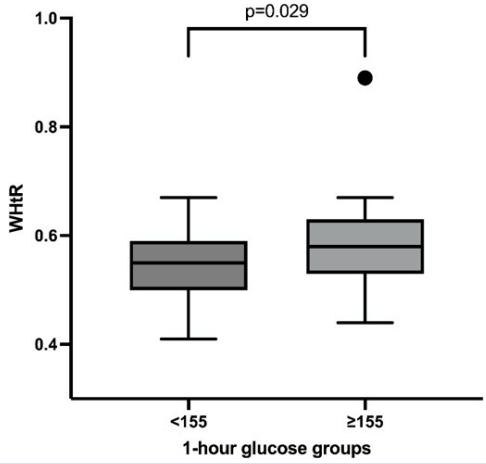

Figure 2. Comparison of waist-to-height ratio (WHtR) according to 1-h glucose levels. Individuals with elevated 1-h glucose (≥155 mg/dL) had significantly higher WHtR values compared to those with lower levels (p=0.029). Boxes represent the median and interquartile range; whiskers represent the minimum and maximum values.

pendent samples t-test or Mann–Whitney U test based on data characteristics. A two-sided $p<0.05$ was considered statistically significant.

RESULTS

Study Population Characteristics

A total of 86 individuals with prediabetes were included in the study. The mean age was 51±12 years, and 70.9% of participants were female. The mean HbA1c level was 5.96±0.22%, and the mean BMI was 26.46±3.44 kg/m^2. The median WHtR was 0.57 (0.52–0.61). Baseline demographic and metabolic characteristics are presented in Table 1.

Table 2. Correlation of central obesity indices with OGTT-derived glucose dynamics

Variables	WHtR		BMI	
	r	p	r	p
Fasting glucose	0.095	0.383	-0.032	0.769
30-min glucose	**0.222**	**0.042**	0.210	0.054
60-min glucose	0.161	0.140	0.045	0.680
90-min glucose	0.191	0.082	-0.022	0.842
120-min glucose	0.159	0.147	-0.010	0.926
Total glucose AUC	0.184	0.096	0.028	0.798
Peak glucose	**0.247**	**0.022**	0.105	0.335
Time to peak	0.102	0.355	-0.092	0.402
Early AUC	**0.249**	**0.022**	0.142	0.196
Late AUC	0.176	0.112	-0.020	0.854
Early/Late ratio	-0.077	0.487	0.126	0.256
Glucose excursion	**0.245**	**0.023**	0.129	0.237
Late clearance	0.044	0.689	-0.062	0.571

Spearman correlation analysis was used for WHtR and Pearson correlation analysis for BMI. Statistically significant associations are shown in bold. AUC: Area under the curve; WHtR: Waist-to-height ratio; BMI: Body mass index; OGTT: Oral glucose tolerance test.

Correlation between Central Obesity Indices and OGTT Glucose Dynamics

Correlation analysis demonstrated that WHtR was significantly associated with early OGTT glucose parameters including 30-min glucose levels ($r=0.222$, $p=0.042$) (Fig. 1A), peak glucose ($r=0.247$, $p=0.022$), early AUC ($r=0.249$, $p=0.022$) (Fig. 1B), and glucose excursion ($r=0.245$, $p=0.023$). BMI did not show significant correlations with OGTT glucose dynamic parameters (Table 2). In multivariable linear regression analysis including age and HbA1c, WHtR showed a trend toward significance for early AUC ($\beta=0.3385$, $p=0.071$). WHtR remained the strongest predictor among the variables included in the model.

Association between WHtR and Elevated 1-h Glucose

Participants with elevated 1-h glucose levels (≥155 mg/dL) had significantly higher WHtR values compared to those with lower 1-h glucose levels ($p=0.029$) (Fig. 2).

DISCUSSION

In this study, we found that central obesity assessed by WHtR was associated with early OGTT glucose dynamics including 30-min glucose, peak glucose, early glucose exposure, and glucose excursion, whereas BMI was not associated with these parameters. These findings suggest that central adiposity may contribute to early metabolic deterioration before abnormalities in conventional glycemic markers become evident. Similar observations have been reported in previous studies showing that early glucose abnormalities at OGTT may reflect early metabolic dysfunction not detected by traditional glycemic classification [1, 4, 8]. Although the observed correlation coefficients were modest in magnitude, they are consistent with the complexity of metabolic interactions in prediabetes and suggest a clinically meaningful, albeit partial, contribution of central adiposity to early glucose dysregulation.

Another important finding of our study was that WHtR was associated particularly with early glucose exposure rather than late OGTT parameters. This may indicate that central obesity may primarily affect early metabolic defects such as hepatic insulin resistance and early-phase insulin response. Previous studies have demonstrated that early OGTT glucose elevations and delayed peak glucose timing are associated with β-cell dysfunction and progression of dysglycemia [8, 18, 19]. In contrast, late-phase OGTT parameters have been more closely associated with impaired glucose clearance and peripheral insulin resistance, suggesting that early and late glucose dynamics may reflect different pathophysiological processes [6, 7, 17]. In our study, WHtR showed the strongest associations with 30-min glucose, peak glucose levels, and early AUC, highlighting its particular relevance to early-phase glucose dysregulation. Importantly, our findings extend the existing literature by demonstrating that central obesity, as reflected by WHtR, is specifically associated with early glucose abnormalities at OGTT, suggesting a closer link with early β-cell dysfunction rather than later disturbances in glucose metabolism.

We also observed that BMI was not significantly associated with OGTT glucose dynamics, in contrast to WHtR. Notably, while BMI showed only borderline or non-significant correlations, WHtR demonstrated consistent and statistically significant associations with early glucose parameters. This finding is consistent with previous studies suggesting that BMI may not adequately reflect visceral fat distribution or metabolic risk, since individuals with similar BMI values may have substantially different metabolic profiles [11–13]. Studies comparing anthropometric indices have also demonstrated that WHtR may be superior to BMI in identifying individuals at increased metabolic risk [11, 12, 20, 21]. Consistent with this, recent obesity guidelines such as the NICE guideline recommend the use of WHtR alongside BMI to assess central adiposity and stratify cardiometabolic risk [15]. Our results support these findings and suggest that WHtR may be a more sensitive marker of early metabolic abnormalities compared with BMI.

From a clinical perspective, our findings suggest that combining WHtR with OGTT-derived glucose dynamics may improve the early identification of individuals at increased metabolic risk who may otherwise be classified as low risk based on conventional glycemic criteria. WHtR is an inexpensive, easily obtainable, and reproducible anthropometric marker that can be readily implemented in routine clinical practice. Such an approach may allow earlier lifestyle interventions before progression to overt diabetes. Therefore, WHtR may serve as a practical screening tool to identify individuals who may benefit from more detailed metabolic evaluation.

A major strength of this study is the detailed OGTT assessment with multiple time points, allowing a comprehensive evaluation of glucose dynamics. However, this study has several limitations. The cross-sectional design limits causal inference, and the relatively small sample size and single-center setting may affect generalizability. In addition, direct measures of visceral adiposity or body fat distribution were not available, which may limit the interpretation of WHtR as a surrogate marker of central obesity. Furthermore, the absence of direct measures of insulin resistance such as fasting insulin or homeostatic model assessment of insulin resistance, as well as lifestyle-related variables including physical activity and dietary habits, represents an additional limitation that may have influenced the observed associations.

Conclusion

WHtR was associated with early OGTT glucose abnormalities and demonstrated stronger associations with early glucose dynamics than BMI, suggesting that central adiposity may be linked to early metabolic alterations before the development of overt dysglycemia. These findings indicate that WHtR may serve as a simple and practical clinical marker for early metabolic risk assessment, particularly when evaluated together with OGTT-derived glucose dynamics. Our findings also support the integration of anthropometric markers such as WHtR with dynamic metabolic testing to improve early risk stratification.

Ethics Committee Approval: This study was approved by the Gazi University Ethics Committee (Approval No: 2026-684; Date: March 31, 2026).

Informed Consent: The requirement for informed consent was waived due to the retrospective nature of the study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – ISK, AEA; Design – ISK, AEA; Supervision – AEA; Resource – ISK, AEA; Materials – ISK, AEA; Data Collection and/or Processing – ISK, FY, AEA; Analysis and/or Interpretation – ISK, FY, ETC, MMY, MA, FT, MAK, AEA; Literature Search – ISK, AEA; Writing – ISK, FY, ETC, MMY, MA, FT, MAK, AEA; Critical Reviews – ISK, FY, ETC, MMY, MA, FT, MAK, AEA.

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