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Significance of measuring anthropometric and atherogenic indices in patients with polycystic ovary syndrome

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Abstract

Background Polycystic ovary syndrome (PCOS) is a prevalent hormonal disorder affecting 5–15% of women of reproductive age, characterized by ovulatory dysfunction, hyperandrogenism, and polycystic ovarian morphology. PCOS is associated with metabolic disturbances such as dyslipidemia, insulin resistance (IR), and an increased risk of type 2 diabetes (T2DM) and cardiovascular disease.

Objective The aim of this study is to apply new anthropometric indices [body adiposity index (BAI), visceral adiposity Index (VAI), lipid accumulation product (LAP), body roundness index (BRI), a body shape index (ABSI)] and new atherogenic indices [Castelli index-I, Castelli index-II, atherogenic risk of plasma (AIP), atherogenic coefficient (AC), lipoprotein combined index (LCI), triglycerides to high-density lipoprotein cholesterol (TG/HDL-C) ratio, metabolic score for insulin resistance (METS-IR), triglyceride glucose (TyG) index, triglyceride glucose-dody mass (TyG-BMI) index, triglyceride glucose-waist circumference (TyG-WC) index] metabolic score of insulin resistance to patients with PCOS.

Methods A retrospective analysis was conducted on 248 women diagnosed with PCOS based on the 2003 Rotterdam criteria. Anthropometric measurements, biochemical parameters, and atherogenic indices were collected from patient records. Statistical analyses were performed using Statistical Package for the Social Sciences software version 28.0.

Results Significant correlations were found between fasting glucose and various anthropometric indices, such as Body mass index (BMI), waist-height ratio (WHtR), and BAI, indicating a link between adiposity and glucose metabolism in PCOS. Atherogenic indices like Castelli's risk indices, AIP, and AC showed positive correlations with glucose and insulin levels, reinforcing their role in assessing cardiovascular risk. Novel indices such as METS-IR and TyG demonstrated strong correlations with both glucose and insulin profiles, highlighting their potential as reliable markers for IR and cardiometabolic risk.

Conclusion The study underscores the importance of using a range of anthropometric and atherogenic indices for comprehensive metabolic assessment in women with PCOS. Indices like METS-IR and TyG offer valuable insights into insulin sensitivity and cardiovascular risk, potentially aiding in better management and prognosis of PCOS.

Keywords PCOS, Insulin resistance, Metabolic indices, Atherogenic indices, Cardiometabolic risk, Anthropometry

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Introduction

Polycystic ovary syndrome (PCOS) is a common and complex hormonal disorder affecting women of reproductive age, with a prevalence of approximately 5–15% [1]. It is characterized by ovulatory dysfunction, hyperandrogenism, and polycystic ovarian morphology. In addition, PCOS can lead to dyslipidemia, hyperinsulinemia, insulin resistance (IR), impaired glucose metabolism, type 2 diabetes (T2DM), metabolic syndrome, infertility, and oxidative stress disorders [2–4]. Women with PCOS have a higher risk of cardiovascular disease than other women. In particular, factors such as insulin resistance and metabolic syndrome can increase the risk of heart disease and stroke.

The pathogenesis of PCOS is complex and its etiology remains incompletely understood. Numerous studies have investigated the mechanisms of metabolic dysregulation (glucose and lipids) and inflammatory mechanisms in the pathogenesis of PCOS. IR is now a well-known feature of PCOS and, along with hypertension and dyslipidemia, increases the risk of cardiovascular and cerebrovascular events. These risk factors are further exacerbated by central obesity and metabolic syndrome, which are present in most women with PCOS [5, 6]. Almost 55% of women suffering from PCOS also have concurrent obesity [7]. Because the high IR in PCOS makes it easier to gain weight and obesity is frequently seen in these patients. Obesity can have a negative impact on PCOS, which can place additional burden on metabolic health.

Many studies have shown that women with PCOS have significantly higher levels of triglyceride to high-density lipoprotein (HDL) cholesterol ratio, indicating an important association with IR and cardiometabolic risk factors [8, 9]. Lipid indices are highly correlated with impaired insulin metabolism and hyperandrogenemia [10, 11]. A study by Zheng et al. indicated that new metabolic lipid indices (TyG index - triglyceride glucose index; TyG-BMI index - triglyceride-body mass index; TyG-WC index - triglyceride-waist circumference index) are useful in the early identification of prediabetes risk [12]. Given that adipose tissues secrete adipokines, inflammatory cytokines, and reactive oxygen species, leading to various metabolic disorders, such indices may be better predictors of IR than the triglyceride glucose (TyG) index alone [13, 14]. Additionally, a new non-insulin-based score, METS-IR (Metabolic Score for Insulin Resistance), may be useful in assessing insulin sensitivity and detecting IR in patients at risk of developing T2DM [15]. Therefore, METS-IR, along with the lipoprotein combined index (LCI), a new risk determinant for coronary artery disease (CAD), are promising scores for evaluating cardiometabolic risk in women with PCOS [16].

Adiposity plays a significant role in the prevention and management of PCOS. Anthropometric indices such as waist-hip ratio (WHR), waist-height ratio (WHtR), visceral adiposity index (VAI), body adiposity index (BAI), lipid accumulation product (LAP), body roundness index (BRI), and a body shape index (ABSI) may serve as indicators of adipose tissue abnormalities and cardiovascular disease risk in patients with PCOS [17, 18].

The aim of this study is to apply new anthropometric indices (BAI, VAI, LAP, BRI, ABSI) and new atherogenic indices [Castelli index-I, Castelli index-II, atherogenic risk of plasma (AIP), atherogenic coefficient (AC), lipoprotein combined index (LCI), triglycerides to HDL-Cholesterol ratio (TG/HDL-C ratio), metabolic score of insulin resistance (METS-IR), triglyceride glucose index (TyG index), triglyceride glucose-body mass index (TyG-BMI index), triglyceride glucose-waist circumference index (TyG-WC index)] to patients with PCOS. Additionally, an attempt was made to evaluate the significance of atherogenic indices in PCOS patients' assessments.

Material method

Study group

This study was conducted retrospectively at Mardin Training and Research Hospital, reviewing patient records from 2022 to 2023. A total of 248 women diagnosed with PCOS according to the 2003 Rotterdam criteria were included in the study. The sample size was calculated using the formula recommended in a paper by Hajian-Tilaki [19].

2003 Rotterdam Criteria.

1) *Oligo-ovulation or anovulation.*
2) *Clinical and/or biochemical hyperandrogenism.*
3) *Polycystic ovaries seen on ultrasound (12 or more follicles 2–9 mm in size).*

PCOS was diagnosed if at least two of these three criteria were met.

Exclusion Criteria: The exclusion criteria were as follows: refusal to participate in the study; pregnancy; hemolyzed samples; use of hormonal contraceptives, glucocorticosteroids, oral steroids, lipid-lowering medications, or drugs affecting glucose metabolism; previously diagnosed and treated diabetes; decompensated thyroid disorders; diseases associated with androgen excess (congenital or late-onset congenital adrenal hyperplasia, hyperprolactinemia, Cushing's disease/syndrome, androgen-secreting tumors, idiopathic hirsutism); depressive disorders and treatment for depression.

Laboratory measurements and indices

Patient records from 2022 to 2023 were retrospectively reviewed. Demographic data (height, weight, waist

circumference, hip circumference) and laboratory results (fasting glucose, fasting insulin, HDL-C, triglycerides, LDL-C (low-density lipoprotein cholesterol)) were collected from patient records. For this study, no additional blood was drawn from patients beyond what was required for their diagnosis and follow-up.

- The value of the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) index was calculated using the following formula:

HOMA-IR=fasting insulin (mU/L) × fasting glucose (mmol/L) / 22.5 [20].

- The value of METS-IR (Metabolic Score for Insulin Resistance) was calculated as follows:

METS-IR = (In ((2 x fasting glucose) (mU/L)+TG (mg/dL) x Body mass index)/(ln (HDL-C) (mg/dL)) [21].

- The TyG index was calculated using the following formula:

ln[fasting glucose (mg/dL) x TG (mg/dL)/2] [20].

- The TyG-BMI index is defined as follows:

ln[fasting glucose (mg/dL) x fasting triglycerides (mg/dL)/2] x BMI [22].

- TyG-WC is defined as:

ln[fasting glucose (mg/dL) x TG (mg/dL)/2] x WC [22].

- LCI was calculated using the following formula:

((TC, *Total Cholesterol*, (mg/dL) × TG (mg/dL) × LDL-C (mg/dL))/HDL-C (mg/dL)) [23].

- Castelli risk index-I was calculated according to the formula = (TC/HDL-C) [10].
- Castelli risk index-II was calculated according to the formula = (LDL-C/HDL-C) [10].
- Atherogenic coefficient (AC) was calculated according to the formula = ((TC-HDL-C)/HDL-C) [10].
- The atherogenic index (AIP) of plasma was calculated according to the formula = (log(TG/HDL-C)) [10].
- The ratio of triglyceride to HDL-cholesterol was calculated according to the formula = (TG/HDL-C) [10].

Anthropometric parameters were measured using standard methods. These measurements included body weight [kg], height [cm], waist circumference [cm], and hip circumference [cm].

- Body mass index (BMI) is calculated according to the following formula: BMI = body weight [kg]/height [m]2 [24].
- Waist-to-hip ratio (WHR) was calculated according to the following formula: WHR = waist circumference [cm]/hip circumference [cm] [25].
- Waist-height ratio (WHtR) was calculated according to the following formula: WHtR = waist circumference [cm]/height [cm] [25].
- Body adiposity index (BAI) was calculated according to the following formula: BAI = ((hip circumference [cm]/height [m]1.5)-18) [26].
- Visceral Adiposity Index (VAI) was calculated according to the following formula: VAI = [waist circumference [cm]/(36.58 + (1.89 × BMI))] × (triglyceride concentration [triglyceride]/0.81) × (1.52/ HDL concentration [mg/dL]) [20].
- Lipid Accumulation Product (LAP) was calculated according to the following formula: LAP = (waist circumference [cm] − 58) × (triglyceride concentration [triglyceride]) [20].
- Body Roundness Index (BRI) was calculated according to the following formula: BRI = 365.2 − 365.5 × √(1 − (((WC/2π)2)/[(0.5 × height)]2) [27].
- A Body Shape Index (ABSI) was calculated according to the following formula: ABSI = WC[m]/[(BMI)2/3) × (height [m])1/2)] [27].

Statistical analysis

The data obtained in the study will be analyzed using SPSS software version 28.0. The Shapiro-Wilk test was used to assess the distribution of the data. Continuous variables are expressed as mean ± standard deviation (for normally distributed data) or median and interquartile range (for non-normally distributed data). For normally distributed data, the Student's t-test will be used, while the Mann-Whitney U test will be used for non-parametric data. Correlation between variables will be evaluated using the Pearson correlation coefficient (for normally distributed data) and Spearman's rank correlation coefficient (for non-normally distributed data). A p-value of less than 0.05 will be considered statistically significant.

Result

The anthropometric measurements, biochemical parameters, and atherogenic index results of women diagnosed with PCOS are presented in Table 1.

Table 1 Anthropometric measurements, biochemical parameters, and Atherogenic Index results of women diagnosed with PCOS

	N (248)	Mean ± SD	Median (25th-75th Quarter)
Age		22.72 ± 4.07	
Anthropometric Measurements			
Weight (kg)		77.30 ± 17.81	
Height (cm)		162.54 ± 4.95	
Waist Circumference (cm)		83.91 ± 12.80	
Hip Circumference (cm)		109.26 ± 15.01	
BMI (kg/m^2)		29.24 ± 6.72	
WHtR		0.52 ± 0.08	
BAI (%)		34.85 ± 7.88	
BRI		3.81 ± 1.59	
WHR			0.76 (0.74–0.78)
VAI			3.85 (2.65–5.97)
LAP			5325 (3074–7176)
ABSI			0.07 (0.07–0.07)
Biochemical Parameters			
120 min Glucose (mg/dL)		141.97 ± 23.35	
60 min Insulin (mU/L)		111.31 ± 19.66	
HbA1c (%)		5.39 ± 0.59	
Total Cholesterol (mg/dL)		171.19 ± 30.22	
HDL Cholesterol (mg/dL)		55.68 ± 14.43	
LDL Cholesterol (mg/dL)		95.92 ± 25.95	
Fasting Glucose (mg/dL)			89 (84–95)
Fasting Insulin (mU/L)			12.30 (8.05–15.64)
60 min Glucose (mg/dL)			89 (85–94)
Triglycerides (mg/dL)			94.50 (71.50–131.00)
HOMA-IR Index			47.36 (32.72–67.21)
Atherogenic Indexes			
Castelli's Risk Index-I		3.25 ± 0.90	
Castelli's Risk Index-II		1.86 ± 0.74	
AIP		0.26 ± 0.24	
AC		2.25 ± 0.90	
METS-IR		41.75 ± 11.03	
TyG Index		8.38 ± 0.48	
TyG-BMI		245.54 ± 60.78	
TyG-Waist Circumference Index		917.80 ± 148.37	
LCI			28481.54 (15771.24–47946.00)
TG/HDL-C			1.74 (1.16–2.62)

BMI: Body mass index, WHtR: Waist-height ratio, BAI: Body adiposity index, BRI: Body Roundness Index, WHR: Waist-to-hip ratio, VAI: Visceral Adiposity Index, LAP: Lipid Accumulation Product, ABSI: A Body Shape Index, HbA1c: Hemoglobin A1c, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, HOMA-IR: Homeostatic Model Assessment for Insulin Resistance, AIP: Atherogenic risk of plasma, AC: atherogenic coefficient, METS-IR: Metabolic score of insulin resistance, TyG Index: triglyceride glucose index, TyG-BMI: triglyceride glucose-body mass index, LCI: lipoprotein combined index, TG/HDL-C: Triglycerides to HDL-cholesterol ratio

The relationships between anthropometric measurements, atherogenic indices, and glucose profile in the study group are presented in Table 2.

Upon examining Table 2, a low positive correlation was found between fasting glucose (mmol/L) and weight, waist circumference, hip circumference, BMI, WHR, WHtR, BAI, VAI, LAP, BRI, Castelli's risk index-I, Castelli's risk index-II, AIP, AC, LCI, TG/HDL-C, and TyG index; a moderate positive correlation was found between fasting glucose and METS-IR, TyG-BMI, and TyG-waist circumference index ($p<0.001$, $p<0.01$, $p<0.05$), with no significant relationship observed between fasting glucose and ABSI ($p>0.05$).

60 min glucose (mg/dL) showed a low positive correlation with weight, WHR, VAI, LAP, Castelli's risk index-I, Castelli's risk index-II, AIP, AC, LCI, and TG/HDL-C; and a moderate positive correlation with waist circumference, hip circumference, BMI, WHtR, BAI, BRI, METS-IR, TyG index, TyG-BMI, and TyG-waist circumference index ($p<0.001$, $p<0.01$), with no significant relationship observed with ABSI ($p>0.05$).

120 min glucose (mg/dL) demonstrated a low positive correlation with WHR, VAI, Castelli's risk index-I,

Table 2 Relationship between anthropometric measurements, atherogenic indices, and glucose Profile in the Study Group

	***N* (248)**	**Fasting Glucose (mg/dL)**		**60 min Glucose (mg/dL)**		**120 min Glucose (mg/dL)**	
		r	***p***	***r***	***p***	***r***	***p***
Weight (kg)		*0.265*	**< 0.001**	*0.294*	**< 0.001**	0.419	**< 0.001**
Waist Circumference (cm)		*0.267*	**< 0.001**	*0.323*	**< 0.001**	0.473	**< 0.001**
Hip Circumference (cm)		*0.254*	**< 0.001**	*0.321*	**< 0.001**	0.487	**< 0.001**
BMI		*0.276*	**< 0.001**	*0.331*	**< 0.001**	0.428	**< 0.001**
WHR		*0.162*	**0.010**	*0.195*	**0.002**	*0.188*	**0.003**
WHtR		*0.267*	**< 0.001**	*0.335*	**< 0.001**	0.473	**< 0.001**
BAI (%)		*0.240*	**< 0.001**	*0.322*	**< 0.001**	0.475	**< 0.001**
VAI		*0.156*	**0.014**	*0.272*	**< 0.001**	*0.200*	**0.002**
LAP		*0.161*	**0.011**	*0.299*	**< 0.001**	*0.419*	**< 0.001**
BRI		*0.267*	**< 0.001**	*0.335*	**< 0.001**	0.458	**< 0.001**
ABSI		*-0.036*	0.572	*0.013*	0.839	*0.075*	0.242
Castelli's Risk Index-I		*0.274*	**< 0.001**	*0.267*	**< 0.001**	0.171	**0.007**
Castelli's Risk Index-II		*0.233*	**< 0.001**	*0.210*	**< 0.001**	0.173	**0.006**
AIP		*0.170*	**0.007**	*0.279*	**< 0.001**	0.146	**0.022**
AC		*0.274*	**< 0.001**	*0.267*	**< 0.001**	0.171	**0.007**
LCI		*0.182*	**0.004**	*0.259*	**< 0.001**	*0.333*	**< 0.001**
TG/HDL-C		*0.170*	**0.007**	*0.279*	**< 0.001**	*0.172*	**0.007**
METS-IR		*0.372*	**< 0.001**	*0.410*	**< 0.001**	0.382	**< 0.001**
TyG Index		*0.275*	**< 0.001**	*0.390*	**< 0.001**	0.290	**< 0.001**
TyG-BMI		*0.326*	**< 0.001**	*0.399*	**< 0.001**	0.452	**< 0.001**
TyG- Waist Circumference Index		*0.308*	**< 0.001**	*0.399*	**< 0.001**	0.506	**< 0.001**

BMI: Body mass index, WHtR: Waist-height ratio, BAI: Body adiposity index, BRI: Body Roundness Index, WHR: Waist-to-hip ratio, VAI: Visceral Adiposity Index, LAP: Lipid Accumulation Product, ABSI: A Body Shape Index, HbA1c: Hemoglobin A1c, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, HOMA-IR: Homeostatic Model Assessment for Insulin Resistance, AIP: Atherogenic risk of plasma, AC: atherogenic coefficient, METS-IR: Metabolic score of insulin resistance, TyG Index: triglyceride glucose index, TyG-BMI: triglyceride glucose-body mass index, LCI: lipoprotein combined index, TG/HDL-C: Triglycerides to HDL-cholesterol ratio. Correlation coefficients given in italics were calculated using Spearman's rank correlation test.

Castelli's risk index-II, AIP, AC, TG/HDL-C, and TyG index; and a moderate positive correlation with weight, waist circumference, hip circumference, BMI, WHtR, BAI, LAP, BRI, LCI, METS-IR, TyG-BMI, and TyG-waist circumference index ($p<0.001$, $p<0.01$, $p<0.05$), with no significant relationship observed with ABSI ($p>0.05$).

The relationships between anthropometric measurements, atherogenic indices, and insulin profile in the study group are presented in Table 3.

Upon examining Table 3, a low positive correlation was found between fasting insulin (mU/L) and WHR, LAP, Castelli's risk index-I, Castelli's risk index-II, AC and LCI; a moderate positive correlation was found between fasting insulin and weight, waist circumference, hip circumference, BMI, WHtR, BAI, BRI, METS-IR TyG-BMI and TyG-waist circumference index ($p<0.001$, $p<0.01$, $p<0.05$). No significant relationship was observed with VAI, ABSI, AIP, TG/HDL-C, TyG Index ($p>0.05$).

60 min insulin (mU/L) showed a low positive correlation with WHR, VAI, Castelli's risk index-I, Castelli's risk index-II, AIP, AC, TG/HDL-C, and TyG index; and a moderate positive correlation with weight, waist circumference, hip circumference, BMI, WHtR, BAI, LAP, BRI, LCI, METS-IR, TyG-BMI, and TyG-waist circumference index ($p<0.001$, $p<0.01$, $p<0.05$). No significant relationship was observed with ABSI ($p>0.05$).

The relationships between anthropometric measurements, atherogenic indices, and hemoglobin A1c (HbA1c) and HOMA-IR index in the study group are presented in Table 4.

Upon examining Table 4, a low positive correlation was found between HbA1c (%) and waist circumference, hip circumference, BMI, WHR, WHtR, BAI, LAP, BRI, Castelli's risk index-I, Castelli's risk index-II, AC, LCI, TG/HDL-C, METS-IR, TyG index, TyG-BMI, and TyG-waist circumference index; a moderate positive correlation was found with weight; and a low negative correlation was found with ABSI ($p<0.001$, $p<0.01$, $p<0.05$). No significant relationship was observed with VAI, AIP, and TG/HDL-C ($p>0.05$).

For the HOMA-IR index, a low positive correlation was found with hip circumference, BAI, LAP, Castelli's risk index-I, Castelli's risk index-II, AIP, AC, LCI, TG/HDL-C, TyG index, and TyG-waist circumference index; a moderate positive correlation was found with weight, waist circumference, BMI, WHtR, BRI, and METS-IR ($p<0.001$, $p<0.01$, $p<0.05$). No significant relationship was observed with WHR, VAI, and ABSI ($p>0.05$).

Table 3 Relationship between anthropometric measurements, atherogenic indices, and insulin Profile in the Study Group

	N (248)	Fasting Insulin (mU/L)		60 min Insulin (mU/L)	
		R	*p*	*r*	*p*
Weight (kg)		*0.336*	**< 0.001**	0.406	**< 0.001**
Waist Circumference (cm)		*0.321*	**< 0.001**	0.475	**< 0.001**
Hip Circumference (cm)		*0.312*	**< 0.001**	0.527	**< 0.001**
BMI (kg/m^2)		*0.345*	**< 0.001**	0.396	**< 0.001**
WHR		*0.132*	**0.038**	*0.161*	**0.011**
WHtR		*0.331*	**< 0.001**	0.464	**< 0.001**
BAI (%)		*0.313*	**< 0.001**	0.497	**< 0.001**
VAI		*0.112*	**0.079**	*0.245*	**< 0.001**
LAP		*0.187*	**0.003**	*0.432*	**< 0.001**
BRI		*0.331*	**< 0.001**	0.456	**< 0.001**
ABSI		*-0.015*	0.817	*0.102*	0.109
Castelli's Risk Index-I		*0.160*	**0.012**	0.290	**< 0.001**
Castelli's Risk Index-II		*0.134*	**0.036**	0.290	**< 0.001**
AIP		*0.116*	0.068	0.170	**0.007**
AC		*0.160*	**0.012**	0.290	**< 0.001**
LCI		*0.129*	**0.042**	*0.388*	**< 0.001**
TG/HDL-C		*0.116*	0.068	*0.219*	**< 0.001**
METS-IR		*0.364*	**< 0.001**	0.392	**< 0.001**
TyG Index		*0.105*	0.099	0.268	**< 0.001**
TyG-BMI		*0.342*	**< 0.001**	0.430	**< 0.001**
TyG- Waist Circumference Index		*0.292*	**< 0.001**	0.539	**< 0.001**

BMI: Body mass index, WHtR: Waist-height ratio, BAI: Body adiposity index, BRI: Body Roundness Index, WHR: Waist-to-hip ratio, VAI: Visceral Adiposity Index, LAP: Lipid Accumulation Product, ABSI: A Body Shape Index, HDL: High-density lipoprotein, AIP: Atherogenic risk of plasma, AC: atherogenic coefficient, TyG Index: triglyceride glucose index, TyG-BMI: triglyceride glucose-body mass index, LCI: lipoprotein combined index, TG/HDL-C: Triglycerides to HDL-cholesterol ratio. Correlation coefficients given in italics were calculated using Spearman's rank correlation test.

Table 4 Relationship between anthropometric measurements, atherogenic indices, and HbA1c and HOMA-IR index in the Study Group

	N (248)	HbA1c (%)		HOMA-IR Index	
		R	*p*	*r*	*p*
Weight (kg)		0.340	**< 0.001**	*0.363*	**< 0.001**
Waist Circumference (cm)		0.203	**0.001**	*0.308*	**< 0.001**
Hip Circumference (cm)		0.207	**0.001**	*0.299*	**< 0.001**
BMI (kg/m^2)		0.283	**< 0.001**	*0.369*	**< 0.001**
WHR		*0.132*	**0.038**	*0.117*	0.065
WHtR		0.181	**0.004**	*0.315*	**< 0.001**
BAI (%)		0.166	**0.009**	*0.294*	**< 0.001**
VAI		*0.096*	0.133	*0.114*	0.074
LAP		*0.144*	**0.024**	*0.180*	**0.005**
BRI		0.175	**0.006**	*0.315*	**< 0.001**
ABSI		*-0.198*	**0.002**	*-0.086*	0.178
Castelli's Risk Index-I		0.204	**< 0.001**	*0.177*	**0.005**
Castelli's Risk Index-II		0.223	**< 0.001**	*0.149*	**0.019**
AIP		0.086	0.175	*0.128*	**0.043**
AC		0.204	**0.001**	*0.177*	**0.005**
LCI		*0.177*	**0.005**	*0.133*	**0.036**
TG/HDL-C		*0.104*	0.101	*0.128*	**0.043**
METS-IR		0.276	**< 0.001**	*0.398*	**< 0.001**
TyG Index		0.175	**0.006**	*0.140*	**0.027**
TyG-BMI		0.290	**< 0.001**	*0.373*	**< 0.001**
TyG- Waist Circumference Index		0.222	**< 0.001**	*0.296*	**< 0.001**

BMI: Body mass index, WHtR: Waist-height ratio, BAI: Body adiposity index, BRI: Body Roundness Index, WHR: Waist-to-hip ratio, VAI: Visceral Adiposity Index, LAP: Lipid Accumulation Product, ABSI: A Body Shape Index, OGTT: Oral glucose tolerance test, HbA1c: Hemoglobin A1c, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, HOMA-IR: Homeostatic Model Assessment for Insulin Resistance, AIP: Atherogenic risk of plasma, AC: atherogenic coefficient, METS-IR: Metabolic score of insulin resistance, TyG Index: triglyceride glucose index, TyG-BMI: triglyceride glucose-body mass index, LCI: lipoprotein combined index, TG/HDL-C: Triglycerides to HDL-cholesterol ratio. Correlation coefficients given in italics were calculated using Spearman's rank correlation test

Discussion

The findings of this study provide valuable insights into the relationships between various anthropometric, biochemical, and atherogenic indices and their relevance to glucose and insulin profiles in women with PCOS. This study reinforces the importance of comprehensive metabolic assessment in managing PCOS and highlights the potential utility of newer indices like METS-IR, TyG, and LCI in clinical practice.

Anthropometric indices and glucose profile

The positive correlations between fasting glucose and anthropometric indices such as BMI, WHtR, and BAI indicate that central and overall adiposity are significant contributors to glucose dysregulation in PCOS patients. This aligns with previous studies that have shown a strong link between obesity and impaired glucose metabolism in PCOS [1, 5]. The lack of significant correlation with ABSI suggests that this index may not be as sensitive in detecting metabolic disturbances associated with PCOS compared to other measures of adiposity.

Atherogenic indices and cardiometabolic risk

Depending on the population being investigated and the particular cardiovascular risk assessment recommendations being followed, cut off values for atherogenic indices may change. Nonetheless, it is acknowledged that having high values for these indices increases the risk of cardiovascular illnesses [28]. Therefore, in PCOS patients, there are no established cutoff values for atherogenic indices, nor, although some research on these patients indicates that their lipid profiles alter and their cardiovascular risk factors rise [16, 17]. In the current study, atherogenic indices such as Castelli's risk index-I and II, AIP, and AC showed positive correlations with both fasting glucose and insulin levels, reinforcing their role in assessing cardiovascular risk in PCOS patients. These findings are consistent with the understanding that dyslipidemia is a common feature in PCOS and contributes to the heightened cardiovascular risk [2, 3]. In the studies of Zheng et al. and Ahn et al., the novel indices,

particularly the TyG index and its derivatives (TyG-BMI, TyG-WC), demonstrated robust correlations with glucose and insulin parameters, underscoring their utility as predictors of insulin resistance and cardiometabolic risk [12, 20]. Contrary to these studies in the literature, in general, all the relationships between anthropometric indices and atherogenic indices with glucose and insulin profiles were weak or moderate in the current study. Not a single one was strong.

Compared to conventional endocrinological testing, we think that atherogenic index values can offer patients with PCOS more useful information. Thus, additional research on these subject encounters to be done. Early diagnosis can be accomplished and patient risk values for cardiovascular diseases can be ascertained if the cutoff values of the atherogenic indices in PCOS patients can be established for each group.

Insulin resistance and metabolic indices

The significant correlations between METS-IR and both glucose and insulin profiles highlight its potential as a reliable marker for insulin resistance in PCOS. In parallel, in the study of Bello-Chavolla et al., it was stated that METS-IR, which combines both metabolic and anthropometric parameters, provides a comprehensive evaluation of insulin sensitivity [15]. This result is particularly valuable in PCOS, because insulin resistance plays a central role in the pathophysiology contributing to the risk of developing T2DM and cardiovascular disease [6, 13].

Clinical implications

The results of this study suggest that incorporating a range of anthropometric and atherogenic indices into routine clinical assessment could enhance the identification and management of metabolic and cardiovascular risks in women with PCOS. Indices such as the TyG and METS-IR, which are simple to calculate and do not require complex testing, could be particularly useful in resource-limited settings.

Limitations and future research

This study has several limitations, including its retrospective design and reliance on existing patient records, which may introduce selection bias and limit the generalizability of the findings. This study also did not take into account other potential risk factors for cardiovascular diseases, such as diet and physical activity. Furthermore, just one group in one area was included in the study, and more investigation is required to confirm these results in groups with greater diversity. Prospective cohort studies with larger sample sizes and longitudinal follow-up can be conducted to determine the predictive value of these indices for long-term metabolic and cardiovascular outcomes in PCOS. Spearman's rank correlation test was used in this study, and it should be noted that this method cannot predict causality.

Conclusion

In conclusion, this study highlights the significant relationships between various metabolic indices and glucose and insulin profiles in women with PCOS. The findings support the use of newer indices such as METS-IR, TyG, and LCI as effective tools for assessing metabolic and cardiovascular risk in PCOS. Incorporating these indices into clinical practice could improve the management and prognosis of PCOS, ultimately leading to better health outcomes for affected women.

Abbreviations

ABSI	A Body Shape Index
AC	Atherogenic Coefficient
AIP	Atherogenic Risk of Plasma
BAI	Body Adiposity Index
BMI	Body Mass Index
BRI	Body Roundness Index
CAD	Coronary Artery Disease
HbA1c	Hemoglobin A1c
HDL	High-Density Lipoprotein
HOMA-IR	Homeostatic Model Assessment for Insulin Resistance
IR	Insulin Resistance
LAP	Lipid Accumulation Product
LCI	Lipoprotein Combined Index
LDL	Low-Density Lipoprotein
METS-IR	Metabolic Score for Insulin Resistance
OGTT	Oral Glucose Tolerance Test
PCOS	Polycystic Ovary Syndrome
SPSS	Statistical Package for the Social Sciences
T2DM	Type 2 Diabetes Mellitus
TC	Total Cholesterol
TG/HDL-C	Triglycerides to High-Density Lipoprotein Cholesterol Ratio
TyG	Triglyceride Glucose Index
TyG-BMI	Triglyceride Glucose-Body Mass Index
TyG-WC	Triglyceride Glucose-Waist Circumference Index
VAI	Visceral Adiposity Index
WC	Waist Circumference
WHR	Waist-to-Hip Ratio
WHtR	Waist-Height Ratio

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Author contributions

Study conception and design: EU Designed and prepared the text messages: EU, OT, MI and MAPerformed the analysis: EUWrote the Manuscript: EU and MA Collected the data: OT, ES and DFAll of the authors reviewed the results and approved the final version of the manuscript.

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Data availability

The datasets used in this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

The objectives of the study were explained in detail to the study participants. The collection of demographic information and the data obtained from all patients participating in this research were done after obtaining informed consent and willingness to participate in the study. Also, all the information

remained confidential and the results were published anonymously and only statistically. Ethical approval for the study was obtained from the Ethics Committee of Mardin Artuklu University (Decision number: 2024/3–21). The authors confirm that all experiments were performed following the relevant Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Conflict of interest
The authors declare no conflict of interest.

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