



Hematological, Metabolic and Hepatic Alterations in Women with Polycystic Ovary Syndrome: A Cross-Sectional Study from Amravati District, Maharashtra, India

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Abstract

Polycystic ovary syndrome (PCOS) is a heterogeneous endocrine–metabolic disorder associated with reproductive, metabolic, and systemic abnormalities. This cross-sectional observational study evaluated selected hematological and biochemical parameters among 1,160 women, comprising 580 women with PCOS and 580 age-matched controls, from Amravati District, Maharashtra, India. PCOS was diagnosed using the Rotterdam criteria, and participants with alternative causes of hyperandrogenism or menstrual dysfunction were excluded. Hematological and biochemical parameters were analyzed using automated validated methods, and between-group differences were assessed using Student's t-test and chi-square test, with $p < 0.05$ considered significant. Women with PCOS showed significantly higher leukocyte count, granulocyte percentage, hematocrit, and mean platelet volume. They also had significantly higher serum urea, uric acid, total cholesterol, triglycerides, LDL-cholesterol, AST, ALT, and ALP, along with lower HDL-cholesterol, whereas creatinine and several conventional hematological indices did not differ significantly. Overall, the findings demonstrate distinct hematological, metabolic, and hepatic alterations in women with PCOS and further support the multisystem nature of the disorder.

Keywords: Polycystic ovary syndrome, PCOS, Hematological parameters, Lipid profile, Liver enzymes, Metabolic dysfunction, Uric acid, Insulin resistance.

Introduction

Polycystic ovary syndrome (PCOS) is a common and complex endocrine–metabolic disorder affecting women of reproductive age and is now recognized as one of the leading causes of anovulatory infertility worldwide (Azziz *et al.*, 2016; Teede *et al.*, 2018). The syndrome is characterized by a combination of hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, although its clinical expression varies widely across individuals and populations (Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004). This heterogeneity makes PCOS not only a reproductive disorder but also a multisystem condition with significant metabolic, hormonal, dermatological, psychological, and obstetric implications (Escobar-Morreale, 2018). Globally, the prevalence of PCOS varies considerably depending on the diagnostic criteria used, study design, ethnicity, and population characteristics. Earlier reviews have shown that prevalence estimates may range from approximately 6% to 20%, with broader variation when different criteria such as the National Institutes of Health (NIH), Rotterdam, or Androgen Excess Society definitions are applied (Azziz *et al.*, 2016; Bozdag *et al.*, 2016). Among

these, the Rotterdam Criteria remain the most widely used in epidemiological and clinical studies because they capture the broader phenotypic spectrum of the syndrome (Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004). However, this broader definition may also contribute to variability in reported prevalence, making region-specific epidemiological investigations especially important.

PCOS is associated with a wide range of physical and biochemical abnormalities. Clinically, affected women may present with menstrual irregularities, hirsutism, acne, obesity, and infertility, while biochemically they often demonstrate hyperinsulinemia, dyslipidaemia, impaired glucose metabolism, and hormonal imbalance (Teede *et al.*, 2018). Insulin resistance is considered a central pathophysiological feature in many women with PCOS and contributes substantially to the development of metabolic syndrome, type 2 diabetes mellitus, and cardiovascular risk factors (Moran *et al.*, 2010; Fauser *et al.*, 2012). Altered lipid profiles, elevated fasting glucose, and increased insulin concentrations are therefore clinically relevant markers in understanding the broader health burden of the syndrome. In addition, endocrine

markers such as luteinizing hormone (LH), follicle-stimulating hormone (FSH), testosterone, prolactin, and thyroid-stimulating hormone (TSH) are often assessed to support diagnosis and exclude related disorders (Goodman *et al.*, 2015).

Beyond metabolic dysfunction, PCOS has important reproductive and obstetric consequences. Women with PCOS are at increased risk of subfertility, miscarriage, gestational diabetes mellitus, pregnancy-induced hypertension, preeclampsia, and other pregnancy-related complications (Palomba *et al.*, 2015; Teede *et al.*, 2018). These consequences extend the significance of PCOS beyond gynecological morbidity alone, underscoring the need for early identification and continued clinical monitoring. Moreover, increasing evidence suggests that PCOS often begins during adolescence, when symptoms such as irregular menstruation, acne, obesity, and early hyperandrogenic features may first become apparent. Despite this, awareness among adolescents and young women remains limited, which frequently delays diagnosis and intervention (Ibáñez *et al.*, 2017). Low awareness is particularly concerning in community settings where cultural barriers, poor access to specialist care, and lack of reproductive health education may hinder timely recognition of the disorder.

Reliable epidemiological assessment of PCOS requires not only appropriate sampling and diagnostic criteria but also robust laboratory evaluation. Hematological and biochemical investigations are essential for characterising the systemic effects of the syndrome and for identifying associated metabolic abnormalities. The validity of such measurements depends heavily on strict pre-analytical and analytical quality control, including proper venous blood collection, timely transport, appropriate sample processing, and the use of validated automated analyzers (Narayanan, 2000; Plebani, 2006; World Health Organization, 2010). Standardised laboratory methods are particularly important in large observational studies, where variability in specimen handling can affect data accuracy and interpretation.

Materials and Methods

This cross-sectional, observational epidemiological study assessed the prevalence of Polycystic Ovary Syndrome (PCOS) and its biochemical, hormonal, and metabolic profile among women in urban and rural populations of Amravati District, Maharashtra, India. Data were collected from government and private hospitals, pathology laboratories, and diagnostic centers to ensure broad socioeconomic representation. The study was conducted on a total sample of 1160 participants.

Diagnostic Criteria

PCOS was diagnosed using the Rotterdam Criteria (Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004). Women diagnosed with PCOS according to these criteria were included (Fauser *et al.*, 2012). Women with other causes of hyperandrogenism or menstrual dysfunction (e.g., congenital adrenal hyperplasia, androgen-secreting tumors, Cushing's syndrome, thyroid disorders, and hyperprolactinemia) were excluded (Legro *et al.*, 2013).

Blood Sample Collection

Venous blood samples (5–10 mL) were collected from PCOS-affected and non-affected females at hospitals in and around Amravati district under aseptic conditions by qualified phlebotomists (Clinical and Laboratory Standards Institute,

2017). Samples were collected in EDTA tubes for hematological analysis and plain tubes for biochemical analysis (WHO, 2010), and transported to accredited laboratories within one hour of collection under cold chain conditions (Plebani, 2006).

Hematological Analysis

Hematological parameters, including hemoglobin, total RBC count, total WBC count, platelet count, hematocrit (PCV), MCV, MCH, and MCHC, were analyzed using validated automated hematology analyzers according to standardized procedures (England *et al.*, 1984). Routine calibration and internal and external quality-control procedures were performed to ensure analytical reliability.

Biochemical Analysis

Serum was separated by centrifugation at 3,000 rpm for 10 minutes at room temperature. Biochemical parameters included fasting blood glucose, total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol, and serum insulin. Where clinically indicated, hormonal investigations including LH, FSH, testosterone, prolactin, and TSH were performed for assessment of the PCOS phenotype and exclusion of alternative endocrine disorders (Azziz *et al.*, 2016). All parameters were analyzed using validated automated laboratory methods.

Statistical Analysis

Data were analyzed using appropriate descriptive and inferential statistics. Continuous variables were expressed as mean $\pm$ standard deviation and compared using the student's t-test; categorical variables were expressed as frequencies and percentages and analyzed using the chi-square test. A p-value < 0.05 was considered statistically significant.

Results

A total of 1,160 subjects were recruited in the study, comprising 580 women with PCOS and 580 age-matched controls. The hematological and biochemical profiles of these subjects are presented in Table 1, 2 and 3. Among the hematological indices, total leukocyte count was significantly higher in women with PCOS compared with controls accompanied by a higher granulocyte percentage. Hematocrit (HCT) and mean platelet volume (MPV) were also significantly elevated in women with PCOS compared with age-matched controls. In contrast, hemoglobin, erythrocyte count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), lymphocyte percentage, and platelet count were comparable between the two groups (all $p > 0.05$). (Figure. 1)

Markers of hepatic function also differed between the groups. Women with PCOS demonstrated significantly higher aspartate aminotransferase (AST) alanine aminotransferase (ALT) ($p < 0.001$), and alkaline phosphatase (ALP) levels. Conversely, serum albumin levels were significantly lower in women with PCOS than in controls. Total bilirubin and total protein levels did not differ significantly between the groups. (Figure. 2)

The biochemical profile demonstrated significant differences between women with PCOS and controls. Fasting glucose levels were significantly higher among women with PCOS compared with controls. Similarly, total cholesterol and LDL-cholesterol levels were significantly higher in the PCOS group than in the control group. In contrast, HDL-cholesterol

levels were significantly lower among women with PCOS. Triglyceride levels were also significantly elevated in women

with PCOS compared with controls indicating an overall less favorable lipid profile in the PCOS group. (Figure.3)

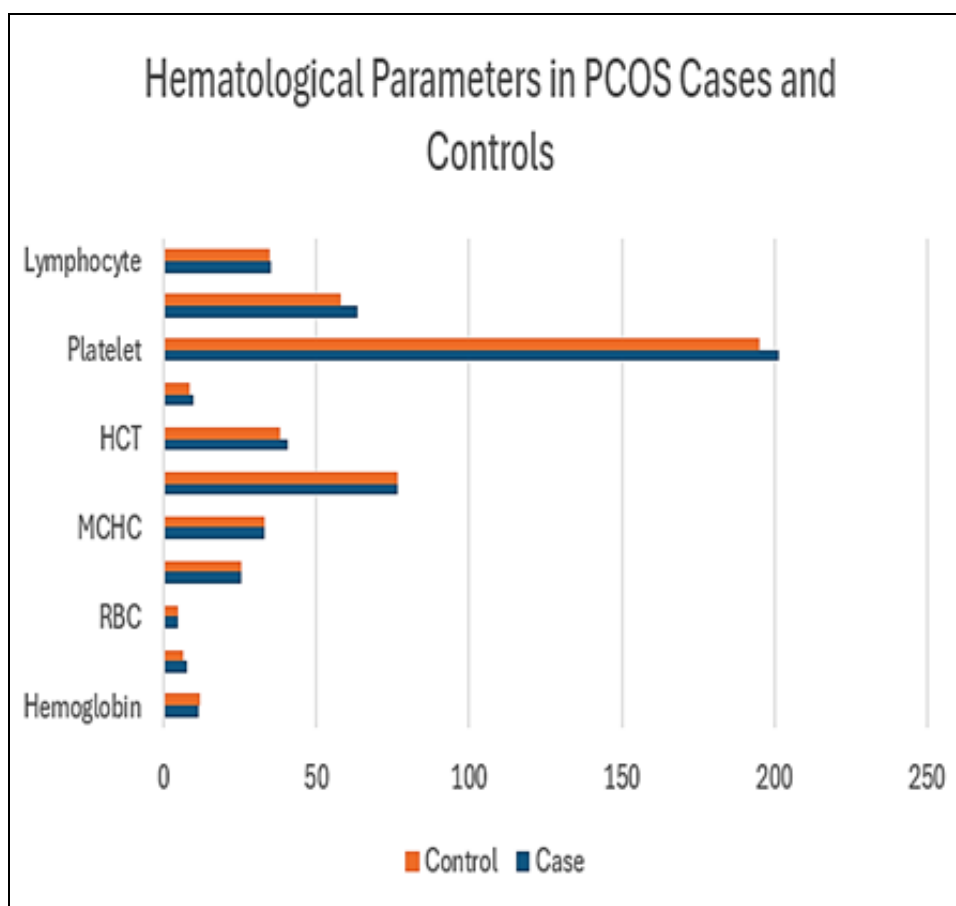


Fig 1: Hematological parameters in PCOS cases and control

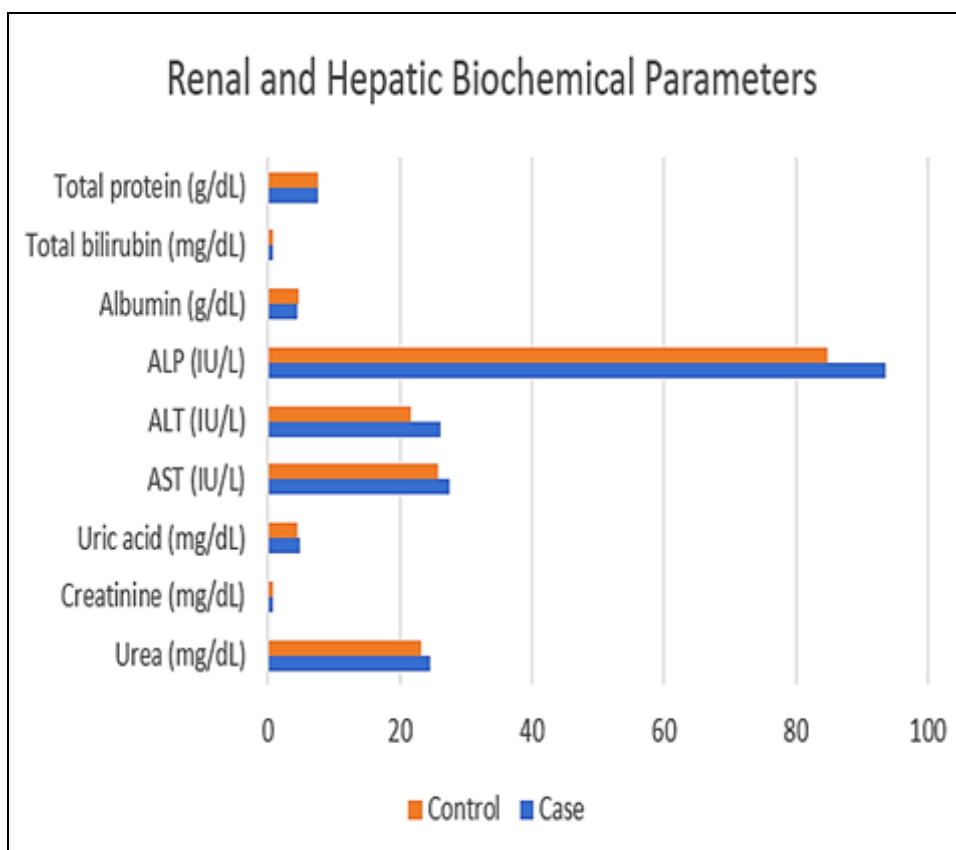


Fig 2: Renal and Hepatic Biochemical parameters.

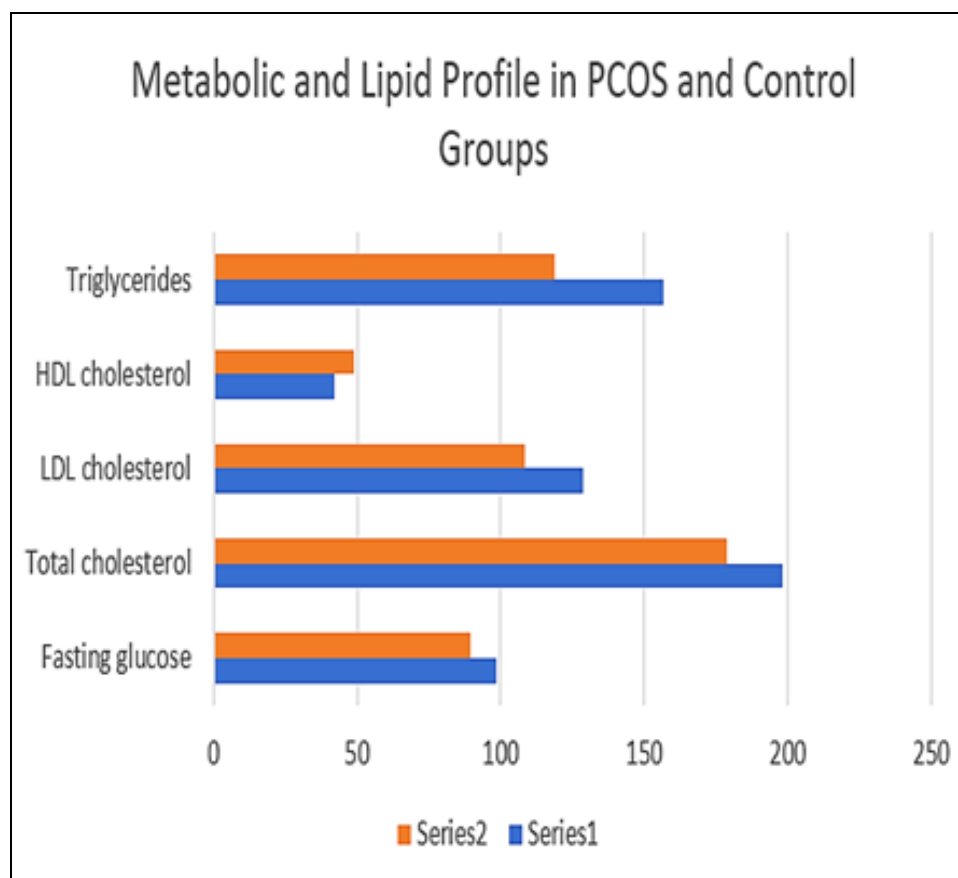


Fig 3: Metabolic and lipid profile in PCOS and control groups.

Values are mean $\pm$ SD; p-values are provided in the accompanying table

Table 1: The hematological profiles of 1160 subjects.

Parameter	Case (n=580)	Control (n=580)	p-value
Hemoglobin (g/dL)	11.62 $\pm$ 1.20	11.68 $\pm$ 1.59	0.684
WBC (10^9 /L)	7.55 $\pm$ 1.75	6.28 $\pm$ 1.70	< 0.001
RBC (10^{12} /L)	4.73 $\pm$ 0.45	4.70 $\pm$ 0.52	0.421
MCH (pg)	25.48 $\pm$ 2.51	25.46 $\pm$ 2.68	0.884
MCHC (g/dL)	33.08 $\pm$ 1.62	32.91 $\pm$ 1.96	0.542
MCV (fL)	76.65 $\pm$ 7.18	76.41 $\pm$ 7.39	0.721
HCT (%)	40.42 $\pm$ 4.52	38.01 $\pm$ 5.11	< 0.001
MPV (fL)	9.83 $\pm$ 1.39	8.61 $\pm$ 1.59	< 0.001
Platelet (10^9 /L)	201.56 $\pm$ 65.91	195.27 $\pm$ 64.82	0.319
Granulocyte (%)	63.44 $\pm$ 8.22	57.96 $\pm$ 17.61	0.003
Lymphocyte (%)	35.08 $\pm$ 7.86	34.73 $\pm$ 7.92	0.812

Table 2: Renal and hepatic biochemical parameters.

Parameter	Case (n=580)	Control (n=580)	P-value
Urea (mg/dL)	24.51 $\pm$ 5.31	23.29 $\pm$ 5.28	0.021
Creatinine (mg/dL)	0.81 $\pm$ 0.15	0.80 $\pm$ 0.15	0.241
Uric Acid (mg/dL)	4.86 $\pm$ 1.08	4.51 $\pm$ 0.88	< 0.001
AST/OT (IU/L)	27.54 $\pm$ 7.41	25.81 $\pm$ 6.15	0.009
ALT/PT (IU/L)	26.17 $\pm$ 8.18	21.57 $\pm$ 8.19	< 0.001
ALP (IU/L)	93.51 $\pm$ 20.89	84.76 $\pm$ 21.32	< 0.001
Albumin (g/dL)	4.41 $\pm$ 0.32	4.64 $\pm$ 0.39	< 0.001
Total bilirubin (mg/dL)	0.65 $\pm$ 0.28	0.63 $\pm$ 0.25	0.615
Total Protein (g/dL)	7.58 $\pm$ 0.50	7.51 $\pm$ 0.52	0.112

Table 3: The biochemical profiles of 1160 subjects.

Parameter	PCOS (n=580)	Control (n=580)	p-value
Fasting glucose (mg/dL)	98.7 $\pm$ 18.5	89.3 $\pm$ 12.4	<0.001
Total cholesterol (mg/dL)	198.4 $\pm$ 42.7	178.9 $\pm$ 35.2	<0.001
LDL cholesterol (mg/dL)	128.7 $\pm$ 38.1	108.5 $\pm$ 29.7	<0.001
HDL cholesterol (mg/dL)	42.3 $\pm$ 8.9	48.7 $\pm$ 10.2	<0.001
Triglycerides (mg/dL)	156.8 $\pm$ 67.4	118.9 $\pm$ 45.3	<0.001

Discussion

PCOS is a heterogeneous endocrine-metabolic disorder with reproductive, metabolic, and inflammatory manifestations. In the present study, significant differences in selected hematological, metabolic, and hepatic parameters were observed between women with PCOS and age-matched controls, supporting the multisystem nature of the disorder (Azziz *et al.*, 2016; Escobar-Morreale, 2018; Teede *et al.*, 2018). Higher total leukocyte count and granulocyte percentage may reflect the low-grade inflammatory milieu associated with PCOS; however, these parameters are nonspecific and can be influenced by obesity, infection, medications, smoking, and other inflammatory conditions. Thus, the present findings indicate associated hematological alterations rather than PCOS-specific inflammation (González *et al.*, 2012).

Hematocrit and MPV were also significantly higher in the PCOS group. Increased MPV has been associated with altered platelet activity, insulin resistance, and cardiometabolic risk in PCOS (Li *et al.*, 2022). However, MPV is influenced by pre-analytical and analytical factors, including anticoagulant type, processing time, storage conditions, and analyzer characteristics (Narayanan, 2000; Lippi *et al.*, 2018). The higher hematocrit may be related to metabolic or hormonal differences, although the present study cannot establish a

specific mechanism. The absence of significant differences in hemoglobin, erythrocyte count, MCV, MCH, MCHC, lymphocyte percentage, and platelet count suggests that the hematological changes were selective rather than generalized. Such variation between studies may reflect differences in BMI, age, nutritional status, menstrual characteristics, and study populations (Alhabardi *et al.*, 2020).

The most pronounced differences were observed in the metabolic profile. Women with PCOS had higher total cholesterol, triglycerides, and LDL-cholesterol and lower HDL-cholesterol, consistent with the recognized association of PCOS with insulin resistance, obesity, and dyslipidemia (Sirmans & Pate, 2014). This adverse lipid profile may contribute to the increased long-term cardiometabolic burden associated with PCOS (Escobar-Morreale, 2018; Amiri *et al.*, 2020). Serum uric acid and urea were also significantly higher, whereas creatinine did not differ between groups. Increased uric acid may be associated with insulin resistance and metabolic abnormalities in PCOS, while urea can be influenced by hydration, dietary intake, and protein metabolism. Therefore, the higher urea level should not be interpreted as evidence of renal impairment. Similarly, creatinine alone is insufficient for comprehensive assessment of renal function.

Significantly higher AST, ALT, and ALP levels were observed in women with PCOS. These abnormalities may be related to the metabolic disturbances and hepatic steatosis associated with PCOS, including the recognized coexistence of PCOS and metabolic dysfunction-associated steatotic liver disease (MASLD) (Manzano-Núñez *et al.*, 2023). However, liver enzymes are nonspecific; therefore, the present findings cannot establish hepatic steatosis without imaging or additional clinical and biochemical assessment.

The use of the Rotterdam criteria allowed identification of the broader phenotypic spectrum of PCOS by requiring two of three features—ovulatory dysfunction, hyperandrogenism, and polycystic ovarian morphology—after exclusion of alternative diagnoses (Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004). Because these criteria encompass a broader phenotype than the NIH definition, diagnostic criteria may influence reported prevalence and phenotype distribution (Bozdag *et al.*, 2016). Accordingly, comparisons with other studies should consider differences in diagnostic criteria, participant characteristics, and study setting. The current international guideline also supports the two-of-three diagnostic approach in adults following appropriate exclusion of alternative diagnoses (Teede *et al.*, 2023).

Conclusion

This study demonstrated significant hematological, metabolic, and hepatic alterations in women with PCOS compared with age-matched controls, including an adverse lipid profile, elevated uric acid, liver enzymes, leukocyte count, hematocrit, and MPV, with reduced HDL-cholesterol. These findings support the multisystem endocrine-metabolic nature of PCOS and highlight the importance of comprehensive cardiometabolic and hepatic assessment. However, the findings should be interpreted cautiously given the cross-sectional design and potential confounding factors.

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