Lipid Accumulation Product and Visceral Adiposity Index in obese/overweight Women with Polycystic Ovary Syndrome

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is the most prevalent endocrine and metabolic condition in women, it is a complex syndrome characterized by hyperandrogenism, infertility, chronic oligo- or anovulation, menstrual irregularities, and polycystic ovarian morphology on ultrasonographic imaging, as well as hirsutism, acne, and alopecia. PCOS patients are treated according to their symptoms however, there are still several unanswered problems, particularly in relation to the ideal long-term management. Objective: In our research, we aim to identify the best markers for predicting IR in obese/overweight PCOS women. **Material and methods**: 45 patients with PCOS and 42 healthy control have a body mass andix(BMI) of more than 25kg/m^2, The consultant gynecologist diagnosed according to Rotterdan criteria, each patient done an ultrasonogram, and an elbow vein was used to take blood. Calculations were made for visceral adiposity index (VAI), lipid accumulation product (LAP), BMI, waist circumference (WC) and homeostasis model assessment index of insulin resistance(HOMA-IR). Also, Hormone levels and metabolic indicators were tested. Receiver-operating characteristic (ROC) curve was calculated. **Results:** Hormone levels in group PCOS patient have significantly different in PCOS compared to the control group. The VAI (cut-off value: 2.5) and LAP (cut-off value: 47.1). **Conclusion:** In obese/overweight PCOS, VAI and WC might predict IR more accurately than LAP. Importance of early detection of serum IR in PCOS-affected women for avoiding complications.

Keywords: Polycystic ovarian syndrome (PCOS), insulin resistance, lipid accumulation product (LAP), visceral adiposity index (VAI).

الخلاصه:

الخلفية: متلازمة المبيض المتعدد الكيسات هي حالة الغدد الصماء والتمثيل الغذائي الأكثر انتشارًا لدى النساء، وهي متلازمة معقدة تتميز بفرط الأندروجين، والعقم، وقلة الإباضة المزمنة، وعدم انتظام الدورة الشهرية،المبيض المتعدد الكيسات في التصوير بالموجات فوق الصوتية، وكذلك الشعرانية، وحب الشباب. يتم علاج مرضى متلازمة تكيس المبايض وفقًا لأعراضهم، ومع ذلك، لا تزال هناك العديد من المشكلات التي لم تتم الإجابة عليها، خاصة فيما يتعلق بالإدارة المثالية على المدى الطويل. الهدف: في بحثنا، نهدف إلى تحديد أفضل العلامات للتنبؤ بـ IR لدى النساء البدينات أو ذوات الوزن الزائد في متلازمة تكيس المبايض. المواد والطرق: 45 مريضة مصابة بمتلازمة تكيس المبايض و42 من الأصحاء لديهم مؤشر كتلة الجسم أكثر من 25 كجم/م2، وتم تشخيص استشاري أمراض النساء وفقًا لمعايير روتردان، وقام كل مريض بإجراء تصوير بالموجات فوق الصوتية، وتم استخدام وريد المرفق لسحب الدم. تم إجراء حسابات لـ LAP وVAI وBMI وWC ومؤشر تقييم نموذج التوازن لمقاومة الأنسولين (HOMA-IR). كما تم اختبار مستويات الهرمونات ومؤشرات التمثيل الغذائي. تم حساب منحنى خاصية تشغيل المستقبل (ROC). النتائج: مستويات الهرمون في مجموعة مرضى متلازمة تكيس المبايض تختلف بشكل كبير في متلازمة تكيس المبايض مقارنة بالمجموعة الضابطة. VAIقيمة القطع: 2.5 و LAPقيمة القطع 47.1. الاستنتاج: النساء مع متلازمة تكيس المبايض التي تعاني من السمنة المفرطة/زيادة الوزن، قد يتنبأ VAI وWC بـ IR بشكل أكثر دقة من LAP. أهمية الكشف المبكر عن IR في الدم لدى النساء المصابات بمتلازمة تكيس المبايض لتجنب المضاعفات.

INTRODUCTION

Polycystic ovary syndrome is the most common endocrine in premenopausal women [1], it is a complex syndrome characterized by hyperandrogenism, insulin resistance, menstrual irregularities, chronic oligo-or anovulation, and polycystic ovarian morphology [2],as well as hirsutism, acne, and alopecia [3]. The pathophysiology is still vague [4], but it is clear that predisposing factors of familiar genes interact with environmental stimuli. It is associated with a risk of cardiovascular disease [5], neuropsychological disorders [6], hypertension [7] and metabolic complications often related to obesity [8], such as insulin resistance and type 2 diabetes mellitus [9], also an increased risk of pregnancy-associated complications such as gestational diabetes mellitus [10], preterm birth, preeclampsia, and increased offspring birth weight [11]. Dyslipidemia observed in women with PCOS which total cholesterol, and triglycerides are high but high-density lipoprotein is low [12].

Obesity has a marked impact on the metabolic complications of PCOS [13]. According to Shi's study, obese individuals with PCOS have more glucose and lipid metabolism abnormalities than PCOS patients with a normal BMI. While hyperinsulinemia affected PCOS patients with normal BMI as well as obesity [14]. Obesity in the center of the abdomen is defined as fat that is present between the abdominal organs [15]. Visceral obesity causes increased adipocytokine production, increased inflammatory activity, and insulin sensitivity. Visceral obesity causes IR and, through IR, encourages the growth of hyperandrogenaemia [16] [17].For the prediction of IR in obese women with PCOS patients by calculation of VAI and LAP.

MATERIALS AND METHODS

The case-control study included 87 women with ages ranging between 18 – 40 years that has a mean age of 26.1 ± 4.7 SD collected in Kerbala teaching hospital for obstetrics and gynecology, from Nov 2022 to Aug. 2023. The individuals in the control group had normoandrogenic, regular menstrual cycles without hirsutism and ultrasounds showed morphologically normal ovaries.

The presence of at least two of the following three criteria led to the diagnosis of PCOS according to the 2003 Rotterdam ESHRE/ASRM PCOS Consensus Workshop Group criteria: Oligo/anovulation, biochemical or clinical hyperandrogenism, and ultrasound-detected polycystic ovaries (more than 12 follicles with a diameter of two to nine millimeters) [18], hormonal and biochemical tests, BMI and waist circumference measurement had been done. The researcher designed a questionnaire that was used to interview participants. Exclusion criteria included: Thyroid dysfunction, kidney or liver failure, Cushing syndrome, androgen-secreting tumors, hyperprolactinemia, non-classical congenital adrenal hyperplasia (NCAH), hypertension, diabetes mellitus, and any contraception or anti-androgen medication

STUDY PROTOCOL

The participant's height, weight, and waist circumference ere measured, the second to fourth days of the menstrual period were used to collect fasting blood from the elbow veins. Clinical hyperandrogenism-hirsutism was described by a Ferriman-Gallwey score of more than four [19]. The definition of oligo/amenorrhea was a menstrual cycle delay of more than 35 days to six months [20].

MEASUREMENTS

The chemiluminescent automated immunoassay system (Cobas e 411, Roche Diagnostic, Germany) was used to measure the levels of luteinizing hormone (LH), follicle-stimulating hormone (FSH), and prolactin hormone. The measurement of free testosterone hormone (FT) concentration (ng/mL) by Enzyme-based Competitive Immunoassay. Total cholesterol, Triglyceride, LDL, and HDL were measured by Autoanalyzer Biochemistry (smart-120). Enzyme-linked immunosorbent assay based on the sandwich principle was used for the fasting insulin assay method. The colorimetric method for using the Glucose kit was used to assess the serum glucose.

CALCULATIONS

Body mass index is calculated by taking a weight, in kilograms, divided by their height, in meters squared as follows: BMI= weight(kg) / height(m)^2 [21] .

Homeostatic Model Assessment for Insulin Resistance(HOMA-IR) = Fasting glucose (mg/dl) × Fasting insulin (µU/ml)/405 [22]. Define a routinely applicable index, based on Waist circumference (WC), body mass index (BMI), triglycerides (TG), and high density lipoprotein HDL, that is capable of estimating visceral adiposity as follows:

VAI (Female)= [WC/(39.68 + 1.88 · BMI)] · (TG/0.81) ·(1.52/HDL-C) [25].

The current era of increasing obesity, we should attempt to specifically define and measure fat accumulation in those contexts where accumulation may present a physiological risk. These contexts can be described as excessive fat accumulation

LAP (Female) = ([WC (cm) -58] · TG) [23].

STATISTICAL ANALYSIS

All participant answers to the questionnaire were entered into a data sheet. The participant's data was analyzed to descriptive statistics. Values for categorical data were represented by n (%). A result was considered statistically significant if its p-value (two-sided) was less than 0.05. The Shapiro-Wilk test was used to evaluate the distribution of the data in terms of normality. The Student's t-test was used to compare normally distributed data, whereas the Mann-Whitney U test was used for comparing nonparametric data. A correlation between two variables was tested by using Spearman's correlation analysis for non-normal distribution and Pearson's correlation analysis for normal distribution.

RESULTS

The study included 86 women, A 42 healthy women, and 45 patient's women. Whose ages ranged between 18 and 40 years old. The demographic and the assessment of anthropometric measurements were given in table.

Table 1. Demographic characteristics of study participants.

Feature	PCOS Mean± SD	Control Mean± SD	p-value
Age (years)	25.8 ± 5.0	26.5± 4.4	0.079 **(S)**
BMI(kg/m2)	32.1 ± 4.72	30.1± 2.7	0.9 **(NS)**

WHR	0.83 ± 0.05	0.81 ± 0.06	0.5 (NS)
hirsutism	38(62.3%)	0%	0.001 **(S)**
Acne	41(67.9%)	0%	0.001 **(S)**
Alopecia	52(85%)	0%	0.00 **(S)**
Oligo menorrhea	46(75.4%)	0%	0.001 **(S)**
Smoking	Active 4 (6.6%) Nonsmoking (93.4%)	Active (0%) Nonsmoking (100%)	0.05 **(S)**
Married	Married (73.8%) Single(26.2%)	Married (60%) Single(40%)	0.7 **(NS)**

Note: values are shown as mean ± SD. BMI :body mass index ; WHR : waist-to-hips ratio ; BAI: Beck anxiety inventory; S: Significant ;NS: Nonsignificant.

The results shown in table 2 the level of LH was high significant in group PCOS in comparison to control (p-value = 0.001)

The mean levels of blood sugar PCOS women had higher mean values in comparison with healthy control . Insulin level and HOMA-IR were significantly higher (P< 0.001) in both group PCOS in comparison to control. LDL, HDL and TG in PCOS in comparison to control significantly (P<0.001) but total cholesterol was not significant. The LAP and VAI were higher in the PCOS group

Table 2. Biochemical and anthropometric indexes characteristics of the studied groups.

Parameters	PCOS	Control	P-values
LH IU/l	10.9±5.2	4.2±0.6	0.001S
FSH IU/l	5.4±1.4	8.1±1.05	0.15

LH/FSH	2.2±0.9	0.6±0.1	0.001
PRL ng/mL	16.2±6.3	11.9±3.6	0.001
Free.T pg/ mL	2.9±01.5	1.2±0.36	0.001
T.C mg/dl	166±25	161±21	0.166
HDL mg/dl	55.6±6.2	76.7±12.4	0.001
LDL mg/dl	97.4±29	75.6±15	0.001
TG mg/dl	110±42	93±24	0.004
FI µU/ml	15.1±4.5	6.2±0.81	0.001
FG mg/dl	93.5±9.8	87.5±5.5	0.001
HOMA-IR	3.5±1.19	1.4±0.22	0.001
WC	85.8±13.4	78.2±9.7	0.002
VAI	3.1±1.19	2.1±0.49	0.001
LAP	59±23.6	50±11.5	0.05

Note:BMI: body mass index; LH: luteinizing hormone; FSH: follicle-stimulating hormone; PRL: prolactin; Free.T; free testosterone:CHO: total cholesterol; HDL:high-density lipoprotein cholesterol; LDL: low- density lipoprotein cholesterol; TG: triglyceride; VAI: visceral adiposity index; LAP: lipid accumulation product; FG: fasting glucose; FI: fasting insulin: HOMA-IR: homeostasis model assessment index of insulin resistance;WC: waist circumference

Figure 1 shows the receiver operator characteristic curves (ROC) curves for VAI and LAP as predictors for IR. PCOS has AUC value which was for LAP (0.589) and sensitivity (54%) and specificity (50%). And has VAI with AUC value of(0.836) ,sensitivity (74%) and specificity (84%) ,while WC sensitivity (66%) and specificity (60%) respectively as shown in tables 3. VAI is the best predictors of IR in overweight or obese patients.

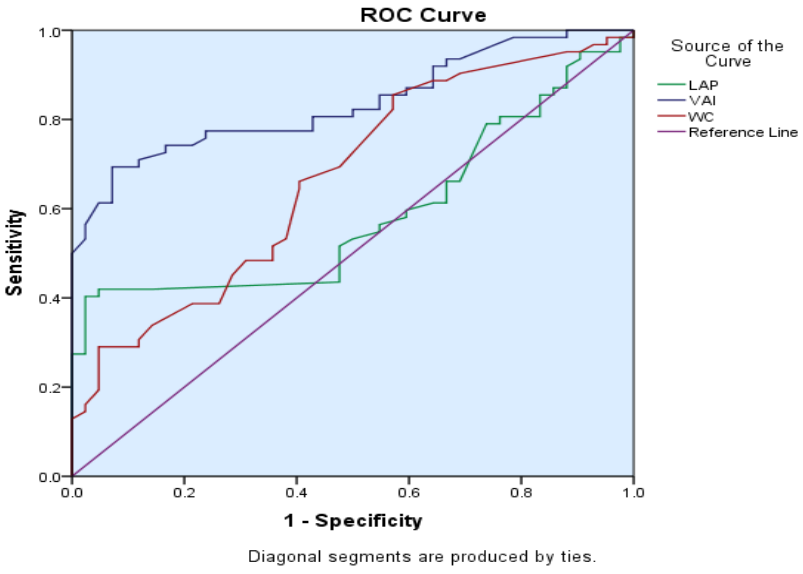

Figure1: ROC curves for PCOS patients. (b) ROC curves for PCOS patients.WC: waist circumference;VAI: visceral adiposity index; LAP: lipid accumulation product.

Table 3: Receiver operating curve analysis of anthropometric indexes and HOMA-IR for PCOS2

Variables	AUC	P-value	Cut-off values	SS%	SP%	(95% CI)

LAP	0.589	0.126	47.1	54%	50%	0.479 - 0.698
VAI	0.836	0.001	2.5	74%	84%	0.761 - 0.911
WC	0.668	0.004	78.1	66%	60%	0.563 - 0.773

AUC: area under curve; CI: confidence interval; LAP: lipid accumulation product; VAI: visceral adiposity index; SS: sensitivity; SP: specificity; WC: waist circumference.

DISCUSSION

Polycystic ovarian syndrome clinical characteristics include hormonal and reproductive problems. Anovulation-related infertility and irregular menstruation are symptoms, and increased androgen , causing hirsutism, IR, and menstrual disorders.Obesity, particularly visceral obesity, affects metabolic status causing ovulation dysfunction,IR and hyperandrogenaemia [24] . Insulin resistance (IR) is one important characteristic of PCOS and be an independent risk factor for diabetes mellitus and Cardiovascular diseases [25], and because insulin increases gonadotropin, also increases the production of ovarian steroids and pituitary LH, it can cause hyperandrogenemia. [26] [27].Patients with PCOS must detect IR early and treatment [28].Which BMI, WHR, WC, and WHtR are examples of traditional measures that are connected to IR [29].The LAP and VAI are precise in identifying visceral obesity. Additionally, research suggests they may serve as accurate indicators of IR [30] [31]. The VAI was one of the more accurate measures of adiposity and dysfunction of adipose tissue because it includes BMI, TG, HDL-C, and WC. In our study, the LAP and the VAI high significant difference between PCOS2 and control, (cut-off value:47.1;2.51, AUC:0.589;0.836) respectively, and sensitivity of LAP and VAI to predictors IR in overweight and obese individuals was 54% and 74% respectively, this agreement with the study by Wang, *et al* in 2023 [32]**,** VAI and WC are better than LAP in predicting IR.

According to the study's findings, PCOS women and the healthy control group had significantly different levels of LH, prolactin, and Free T. FSH levels between the PCOS group and the healthy control group did not differ significantly. Therefore, our results are in agreement with the study by Naina Kumar *et al* [33]**.** The prolactin level of women with PCOS has been studied for years, but no precise conclusive results have been found. Despite some studies indicated into a slight elevation [34]. This agreement with our result study.

In our study, Patients with a BMI of more than 25 kg/m2 have a connection to high insulin resistance. Insulin stimulation, both glycogenolysis and lipolysis are inhibited and increase esterified acids. However, insulin resistance enhances hepatic glycogenolysis and incorrectly accelerates up adipose tissue lipolysis, which upregulates hepatic de novo lipogenesis and leads to the development of PCOS [35]. In women with polycystic ovary syndrome, dyslipidemia is a prevalent metabolic disorder. Our results the significant difference in HDL, LDL, and TG in PCOS compared to the control and no significant differences

in total cholesterol, An abnormal situation of lipoproteins is common in women with polycystic ovary syndrome, and these disorders include: increased levels of total cholesterol, triglycerides, LDL , decreased levels of HDL , and apoprotein. this is consistent with the results of our study [36].

CONCLUSION

In obese/overweight PCOS patients, VAI and WC might predict IR more accurately than LAP. Importance of early detection of insulin resistance in PCOS-affected women for avoiding complications.

REFERENCE

1. Gu, R., & Syed, N. (2023). The Efficacy of Metformin Treatment on Insulin Resistance and Hyperandrogenism in Lean Women with Polycystic Ovary Syndrome: A Literature Review. Undergraduate Research in Natural and Clinical Science and Technology Journal, 1-1
2. Eldin, S. M. R. S., El Bohoty, S. B., Hamiesa, M. F. M., & Mahfouz, A. E. The effect of vitamin D3 supplementation in vitamin D3 deficient women with polycystic ovarian syndrome and it's relation to insulin resistance and visceral fat thickness.
3. Guo, Z., Jin, F., Chen, S., Hu, P., Hao, Y., & Yu, Q. (2023). Correlation between biochemical and clinical hyperandrogenism parameter in polycystic ovary syndrome in relation to age. BMC Endocrine Disorders, 23(1), 89.
4. Dapas, M., & Dunaif, A. (2022). Deconstructing a syndrome: genomic insights into PCOS causal mechanisms and classification. Endocrine reviews, 43(6), 927-965.
5. Osibogun, O., Ogunmoroti, O., & Michos, E. D. (2020). Polycystic ovary syndrome and cardiometabolic risk: Opportunities for cardiovascular disease prevention. Trends in cardiovascular medicine, 30(7), 399-404.
6. Wolugbom Jr, J. A., Areloegbe, S. E., & Olaniyi, K. S. (2023). Protective Role of Acetate Against Depressive-Like Behaviour Associated with Letrozole-Induced PCOS Rat Model: Involvement of HDAC2 and DNA Methylation. Molecular Neurobiology, 60(1), 355-368.
7. Kovell, L. C., Juraschek, S. P., & Michos, E. D. (2021). Hypertension in young women: implications of the polycystic ovary syndrome and opportunities for prevention and further research. The Journal of Clinical Endocrinology & Metabolism, 106(9), e3775-e3
8. Nicolaides, N. C., Matheou, A., Vlachou, F., Neocleous, V., & Skordis, N. (2020). Polycystic ovarian syndrome in adolescents: From diagnostic criteria to therapeutic management. Acta Bio Medica: Atenei Parmensis, 91(3), e2020085.
9. Armanini, D., Boscaro, M., Bordin, L., & Sabbadin, C. (2022). Controversies in the pathogenesis, diagnosis and treatment of PCOS: focus on insulin resistance, inflammation, and hyperandrogenism. *International journal of molecular sciences*, *23*(8), 4110.
10. Choudhury, A. A., & Rajeswari, V. D. (2022). Polycystic ovary syndrome (PCOS) increases the risk of subsequent gestational diabetes mellitus (GDM): A novel therapeutic perspective. Life Sciences, 121069.
11. Fougner, S. L., Vanky, E., Løvvik, T. S., & Carlsen, S. M. (2021). No impact of gestational diabetes mellitus on pregnancy complications in women with PCOS, regardless of GDM criteria used. PLoS One, 16(7), e0254895.
12. Liu, Q., Xie, Y. J., Qu, L. H., Zhang, M. X., & Mo, Z. C. (2019). Dyslipidemia involvement in the development of polycystic ovary syndrome. Taiwanese Journal of Obstetrics and Gynecology, 58(4), 447-453.
13. Bai, X., Ma, J., Wu, X., Qiu, L., Huang, R., Zhang, H., ... & Chen, X. (2023). Impact of Visceral Obesity on Structural and Functional Alterations of Gut Microbiota in Polycystic Ovary Syndrome (PCOS): A Pilot Study Using Metagenomic Analysis. Diabetes, M
14. Shi, W., Zhao, Q., Zhao, X., Xing, C., & He, B. (2021). Analysis of endocrine and metabolic indexes in non-obese patients with polycystic ovary syndrome and its compare with obese patients. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 42
15. Ritchie, S. A., & Connell, J. M. C. (2007). The link between abdominal obesity, metabolic syndrome and cardiovascular disease. Nutrition, Metabolism and cardiovascular diseases, 17(4), 319-326.
16. Beatriz Motta, A. (2012). The role of obesity in the development of polycystic ovary syndrome. Current pharmaceutical design, 18(17), 2482-2491.
17. Alalwan, T. A. (2020). Phenotypes of sarcopenic obesity: Exploring the effects on peri-muscular fat, the obesity paradox, hormone-related responses and the clinical implications. Geriatrics, 5(1), 8.
18. Geisthövel, F. (2003). A comment on the European Society of Human Reproduction and Embryology/American Society for Reproductive Medicine consensus of the polycystic ovarian syndrome. Reproductive biomedicine online, 7(6), 602-605.
19. Mumusoglu, S., & Yildiz, B. O. (2020). Polycystic ovary syndrome phenotypes and prevalence: differential impact of diagnostic criteria and clinical versus unselected population. Current Opinion in Endocrine and Metabolic Research, 12, 66-71.
20. Abulenien, M., Barghash, A., & Mohamed, S. (2004). Clinical, ultrasonographic &endocrine predictor of ovarian response to clomiphene citrate in normogonadotropic anovulatory infertility. Middle East Fertility Society Journal, 9, 242-250.
21. Chu, Y., Yang, J., Shi, J., Zhang, P., & Wang, X. (2020). Obesity is associated with increased severity of disease in COVID-19 pneumonia: a systematic review and meta-analysis. European journal of medical research, 25(1), 1-15.

22. Matthews, D. R., Hosker, J. P., Rudenski, A. S., Naylor, B. A., Treacher, D. F., & Turner, R. C. (1985). Homeostasis model assessment: insulin resistance and β-cell function from fasting plasma glucose and insulin concentrations in man. diabetologia, 28
23. Kahn, H. S. (2005). The" lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. BMC cardiovascular disorders, 5, 1-10.
24. A. Fulghesu, R. Magnini, E. Portoghese, S. Angioni, L. Minerba, and G. B. Melis, "Obesity-related lipid profile and altered insulin incretion in adolescents with polycystic ovary syndrome," Journal of Adolescent Health, vol. 46, no. 5, pp. 474–481, 2010.
25. Barber, T. M., Dimitriadis, G. K., Andreou, A., & Franks, S. (2016). Polycystic ovary syndrome: insight into pathogenesis and a common association with insulin resistance. Clinical Medicine, 16(3), 262.
26. Orbetzova, M. M. (2020). Clinical impact of insulin resistance in women with polycystic ovary syndrome. In Polycystic Ovarian Syndrome. IntechOpen.
27. Suresh, S., & Vijayakumar, T. (2015). Correlations of insulin resistance and serum testosterone levels with LH: FSH ratio and oxidative stress in women with functional ovarian hyperandrogenism. *Indian Journal of Clinical Biochemistry*, *30*, 345-350.
28. Legro, R. S., Castracane, V. D., & Kauffman, R. P. (2004). Detecting insulin resistance in polycystic ovary syndrome: purposes and pitfalls. *Obstetrical & gynecological survey*, *59*(2), 141-154.
29. Bhattacharya, K., Sengupta, P., Dutta, S., Chaudhuri, P., Das Mukhopadhyay, L., & Syamal, A. K. (2021). Waist-to-height ratio and BMI as predictive markers for insulin resistance in women with PCOS in Kolkata, India. *Endocrine*, *72*, 86-95.
30. Ramezani Tehrani, F., Minooee, S., & Azizi, F. (2014). Comparison of various adiposity indexes in women with polycystic ovary syndrome and normo-ovulatory non-hirsute women: a population-based study. *European journal of endocrinology*, *171*(2), 199-207.
31. Kavaric, N., Klisic, A., & Ninic, A. (2018). Are visceral adiposity index and lipid accumulation product reliable indices for metabolic disturbances in patients with type 2 diabetes mellitus?. Journal of Clinical Laboratory Analysis, 32(3), e22283.
32. Wang, H., Cao, H., Cao, J., & Zhang, L. (2023). The visceral adiposity index (VAI) and lipid accumulation product (LAP) are predictors of insulin resistance and hyperandrogenaemia in obesity/overweight women with polycystic ovary syndrome. BioMed Research
33. Kumar, N., & Agarwal, H. (2022). Early Clinical, Biochemical and Radiological Features in Obese and Non-Obese Young Women with Polycystic Ovarian Syndrome: A Comparative Study. Hormone and Metabolic Research, 54(09), 620-624.
34. Mahboobifard, F.; Rahmati, M.; Amiri, M.; Azizi, F.; Tehrani, F.R. To what extent does polycystic ovary syndrome influence the cut-off value of prolactin? Findings of a community-based study. Adv. Med. Sci. 2022, 67, 79–86.
35. Chao, H. W., Chao, S. W., Lin, H., Ku, H. C., & Cheng, C. F. (2019). Homeostasis of glucose and lipid in non-alcoholic fatty liver disease. International journal of molecular sciences, 20(2), 298.
36. Rashidi, H., Tafazoli, M., Jalali, M. T., & Eghbalnejad Mofrad, A. M. (2018). Serum lipid profile and insulin resistance in women with polycystic ovary syndrome (PCOS). J Diabetes Metab disord control, 5(3), 148-52.