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ORIGINAL PAPER

Evaluation of lipid profile, malondialdehyde, hemoglobin and ferritin in Iraqi women with polycystic ovarian syndrome

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ABSTRACT

Introduction and aim. The concept of polycystic ovarian syndrome (PCOS) is defined as a biochemical complex statement that affects many young and adult females (single and married). This case presents a variety of medical and biological concerns related to the reproductive system. The aim of the study was to investigate and estimate the levels of the lipid profile, malondialdehyde, hemoglobin and ferritin in women with PCOS.

Material and methods. Blood samples were collected from 180 women who were divided into 100 PCOS patients and 80 healthy women according to the variables of age and body mass index. Triglycerides (TG) levels were measured in blood sera by spectrophotometric method, total cholesterol (TC) levels were estimated using enzymatic methods and the high-density lipoprotein (HDL) was determined by the HDL-phosphotungstic acid precipitation method.

Results. Total cholesterol, triglyceride, low-density lipoproteins, and very low-density lipoproteins recorded a highly significant increase ($p<0.001$) whereas high-density lipoproteins decreased significantly ($p<0.001$) in women with PCOS women when compared to the control group depending on age and body mass index variables. The results showed that hemoglobin, ferritin and malondialdehyde levels increased significantly ($p<0.001$) in female PCOS compared to the healthy group according to age and body mass index variables.

Conclusion. The importance of thorough medical management of PCOS includes minimizing oxidative stress, metabolic function, and lipid profiles for avoidance of chronic health conditions.

Keywords. age variable, body mass index, ferritin, lipid profile, polycystic ovarian syndrome

Introduction

Polycystic ovarian syndrome (PCOS) is defined as a pathologically and biologically complex condition that takes place in the reproductive system belonging to women during their reproductive age. This syndrome leads to various biochemical disorders and clinical changes caused by many factors, such as physiological conditions and changes in the chemical systems of enzymes, hormones and vitamins.[1,2]

Many studies indicated that PCOS may increase the chance of developing certain diseases such as hypertension, diabetes, uterine cancer, and infertility. The severity of PCOS could also lead to alterations in the concentrations of enzymes, hormones, vitamins, uric acid, creatine, creatinine, malondialdehyde, lipids and trace elements.[3,4] Also, blood proteins such as hemoglobin, ferritin and albumin may differ in their levels in females affected by polycystic ovarian syndrome.[5]

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Therefore, oxidative stress, which is influenced by the balance between oxidants and antioxidants in the body, can fluctuate in response to changes in female sex hormones. This imbalance contributes to various disorders in both the clinical and biochemical systems of a woman's reproductive health. On the other hand, genetic inheritance, pathogenesis, and insulin resistance are considered distinct biochemical mechanisms that help explain the clinical abnormalities associated with PCOS. For example, insulin resistance is often a contributing factor to obesity in many women with PCOS.[6,7]

Various factors have biochemical roles in altering the clinical, physiological, and biochemical aspects of this syndrome, including age, body mass index (BMI), marital status, smoking, blood group, family history, and infection of other diseases.[8] Numerous studies have been conducted on PCOS and its etiology. While these studies have shown the pathophysiological processes associated with PCOS, the underlying causes remain unclear and require further explanation. Continuous research and investigation of the oxidant-antioxidant balance associated with PCOS shows DNA damage and genomic disorders that occur in the living cell, especially in the mitochondria. Therefore, this biochemical and clinical evidence suggests a link between oxidative stress and reduced fertility.[9,10]

Recent advances in PCOS management of PCOS include an improved understanding of its pathophysiology, the use of letrozole for infertility, and the emphasis on lifestyle changes such as diet, exercise, and weight loss that can enhance metabolic health and reproductive results.[11] The most important achievements in PCOS include the formation of the 2018 International Evidence-Based PCOS Guideline and the establishment of an early career researcher network that will improve evidence synthesis and future research which both have made breakthroughs in the current understanding of the etiology and genetics of PCOS.[12]

There have been many controversies related to PCOS, such as its distinct nature, unclear etiology, differing diagnostic standards (eg, Rotterdam criteria vs. Androgen Excess Society), and the focus on treating symptoms rather than causes, all of which result in conflicting guidelines and individual experiences influencing medical behavior.[13]

Many different biochemical parameters are necessary in polycystic ovarian syndrome such as lipid profile, various hormones and enzymatic antioxidants, vitamins, urea, trace elements, malondialdehyde, C-reactive protein, and liver enzymes according to the severity of PCOS and their correlations with some variables such as age, blood group, marital status, and BMI.[14,15]

Aim

Therefore, current research was performed to evaluate and investigate the levels of lipid profile, malondialdehyde (MDA), ferritin and hemoglobin in Iraqi female PCOS patients according to age and BMI.

Material and methods

180 women were divided into two groups. The first contains 100 women affected by PCOS, and the second is composed of 80 healthy females. These females were also divided into three categories according to their age represented by the first (14 to 24 years), the second (25 to 35 years) and the third (36 to 45 years). These women were also split into three groups according to their BMI (normal, overweight, and obese) and they were checked to make sure they had no other diseases.

Ethical approval

All ethical approval was obtained according to the official order with the number (592) on (26/4/2022) which was decided by the Basra Health Directorate Training and Human Unit - Knowledge Management Center/Research department.

Location of blood sampling

Blood samples were obtained from different women with PCOS and from healthy women at 9:00 AM at the Basra Teaching Hospital of children and women in the Basra governorate in the Republic of Iraq. The blood samples were obtained from all women by a trained nurse. Five milliliters of venous blood were withdrawn from PCOS females and control group, then the samples were placed in vacationer tubes and centrifuged at a velocity equal to 5000 RPM for six minutes. Subsequently, sera was gathered and maintained at 20°C until the day of estimation of clinical and biochemical markers. The remaining blood was kept in special tubes to separate the blood plasma. Subsequently, the red blood cells were gently rinsed with sodium chloride (9% w/v). Subsequently, the mixture underwent a lysation process using deionized water with a ratio of (1:1 w/v).[16,17]

Assessment of clinical biochemical markers

The concentrations of the lipid profile were estimated as follows:

Triglycerides (TG) levels were measured in blood sera by spectrophotometric method, where triglycerides were hydrolyzed with lipase enzyme to form glycerol and fatty acids. Then glycerol reacts with adenosine triphosphate (ATP) catalyzed by glycerol kinase to produce glycerol-3-phospate and adenosine diphosphate. Glycerol-3-phospate afterward is oxidized by oxygen catalysed by glycerol phosphate oxidase to form dihydroxyacetone phosphate and hydrogen peroxide. Finally, 4-chlorophenol and 4-aminoanti-quinonemine react with hydrogen peroxide in the presence of peroxidase enzyme to produce quinonimine complex and water. the complex has a pink color, and its absorbance is proportional to the

amount of triglycerides. This test occurs at a wavelength of 500 nm.[18]

Total cholesterol (TC) levels were estimated in the serum of the blood using enzymatic methods. In the beginning, cholesterol ester is hydrolyzed by cholesterol esterase to form cholesterol and fatty acids, free cholesterol was oxidized in the presence of cholesterol oxidase to produce cholest-4-en-3-one and hydrogen peroxide. After that hydrogen peroxide reacts with phenol and 4-amino-antipyrine catalyzed by peroxidase enzyme to produce a pink quinonimine pigment. Finally, the complex absorbance was measured at 500 nm.[19]

The high-density lipoprotein (HDL) was determined by the HDL-phosphotungstic acid precipitation method. The principle includes the precipitation of LDL, VLDL, and chylomicrons by phosphotungstic acid and $MgCL_2$. Then HDL was estimated by centrifugation depending on the total cholesterol amount.[20]

Very low-density lipoproteins (VLDL) were calculated from the following equation:[21]

$$VLDL = Triglycerides / 5$$

Low-density lipoprotein (LDL) levels were measured using the following equation:[22]

$$LDL = Total\ cholesterol - [HDL + VLDL]$$

Hemoglobin concentrations were estimated from the conversion of hemoglobin in the presence of potassium ferric cyanide and potassium cyanide. The absorbance of the colored complex was then calculated at 540 nm.[23]

MDA levels were measured spectrophotometrically by the reaction between barbituric acid and malondialdehyde, which forms a pink complex. Then its absorbance was determined at a wavelength of 535 nm.[24]

Ferritin levels were measured by the Cobas method to form a sandwich complex, then the absorbance is measured depending on the calibration curve.[25]

Statistical analysis

The concentration values in the current study were expressed by mean±standard deviation (SD) for both groups (PCOS patients and healthy group). According to the variables of age and BMI. The social science statistical program (SPSS, version 25, IBM, Armonk, NY, USA) was carried out for all data on levels belonging to lipid profile, malondialdehyde, ferritin and hemoglobin for both patients and control group using various univariate programs. Their regression coefficient values were used to differ among the means belonging to female PCOS and the control group. The *p*-value was calculated from the column 'SIG' (2-tailed) in the independent samples. This test was used to assess the equality of means between groups. Two conditions were considered: one assumed equal variances. And the other does not assume equal variances.

Results

The biochemical importance of clinical investigation into chemical markers shows the advantages of following any change that can occur in the stages of the disorder. The lipid profile is one of the clinical parameters that must be estimated.[26] Table 1 shows the concentrations of the lipid profile that is presented by TG, TC, HDL, LDL and VLDL in female patients according to the age variable.

Table 1. Activity levels of TC, TG, HDL, LDL and VLDL in PCOS patients and control group according to age variable[a]

Age category (year)	Women Groups	TC (mg/dL)	TG (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	VLDL (mg/dL)
First (14–24)	Control (n=28)	121.286 ±9.55	86.369 ±24.762	38.514 ±7.707	70.638 ±17.708	17.272 ±4.953
	PCOS (n=34)	201.058 ±26.757***	221.271 ±102.606**	26.665 ±6.41***	97.819 ±26.314***	44.448 ±20.401**
Second (25–35)	Control (n=27)	118.087 ±12.052	84.436 ±37.313	41.593 ±8.126	68.772 ±17.798	16.912 ±7.433
	PCOS (n=36)	195.747 ±18.723***	211.417 ±115.327**	26.055 ±7.799***	108.977 ±18.74***	42.28 ±23.066**
Third (36–45)	Control (n=25)	114.64 ±11.871	68.336 ±20.107	39.218 ±6.048	64.214 ±15.522	13.667 ±4.021
	PCOS (n=30)	207.783 ±26.876***	240.488 ±87.792**	26.455 ±5.309***	97.036 ±21.873***	48.094 ±17.558**

[a] The levels were expressed as mean±SD, *** – p<0.001, ** – p<0.01, * – p<0.05

The values were obtained for the activity levels of TG, TC, HDL, LDL, and VLDL. TC recorded different concentrations equal to 201.058±26.757, 195.747±18.723 and 207.783±26.876 mg/dL corresponding to the first, second and third age categories in female PCOS patients, respectively, while TG showed assorted values of concentrations represented by 221.271±102.606, 211.417±115.327 and 240.488±87.792 mg/dL for the same age categories in women with PCOS. HDL concentrations were estimated to be equal to 26.665±6.41, 26.055±7.799 and 26.455±5.309 mg/dL for the first, second and third age groups, respectively, in women with PCOS, while LDL recorded different concentrations in patients with PCOS and these levels were assessed to be equal to 97.819±26.314, 108.977±18.74 and 97.036±21.873 mg/dL at the same age categories, respectively. Regarding VLDL, the concentrations were calculated to be equal to 44.448±20.401, 42.28±23.066 and 48.094±17.558 (mg/dL) corresponding to the first, second and third age categories.

According to the results obtained, it was found that the bad cholesterols (TC, TG, LDL, VLDL) were significantly increased in the PCOS patients when compared to the control group, while HDL (good cholesterol) was noticed to be lower when comparing its levels in the same groups.

BMI is a very important variable to monitor the severity of polycystic ovarian syndrome and its correlation with biochemical markers.[27] Therefore, the lipid profile was estimated for all classes of lipids according to the body mass index, as shown in Table 2.

Table 2. TC, TG, HDL, LDL, VLDL and non-HDL activity levels in PCOS patients and control group according to the variable body mass index

BMI	Women Groups	TC (mg/dL)	TG (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	VLDL (mg/dL)
Normal	Control (n=28)	116.945 ±10.118	72.809 ±29.253	40.707 ±8.087	66.41 ±19.458	16.292 ±5.593
	PCOS (n=31)	200.262 ±25.775***	200.573 79.663**	27.168 ±5.558***	98.392 ±22.318***	43.684 ±21.23**
Overweight	Control (n=27)	117.062 ±10.175	81.403 ±28.055	39.008 ±6.968	68.978 ±14.13	14.575 ±5.837
	PCOS (n=34)	198.54 ±23.225***	218.44 ±106.152**	26.03 ±6.564***	104.897 ±25.679***	40.58 ±16.22**
Obese	Control (n=25)	120.216 ±13.427	85.444 ±30.12	39.554 ±7.275	68.478 ±17.931	17.087 ±6.025
	PCOS (n=35)	205.058 ±24.557***	251.681 ±116.84**	26.029 ±7.538***	101.609 ±20.543***	50.047 ±23.218**

[a] The levels were expressed as mean±SD, *** – p<0.001, ** – p<0.01, * – p<0.05

Table 3. Activity levels of MDA, hemoglobin, and ferritin in PCOS patients and control group according to age variable[a]

Age category (year)	Women Groups	MDA (µmol/L)	Haemoglobin (g/dL)	Ferritin (ng/mL)
First (14–24)	Control (n=28)	2.313 ±0.047	11.096 ±0.754	15.845 ±5.639
	PCOS (n=34)	3.977 ±0.603***	13.278 ±0.742**	65.891 ±13.336***
Second (25–35)	Control (n=27)	2.308 ±0.019	10.751 ±0.849	16.381 ±3.76
	PCOS (n=36)	3.672 ±0.479***	13.288 ±0.522**	62.275 ±11.875***
Third (36–45)	Control (n=25)	2.308 ±0.051	10.527 ±0.832	13.613 ±4.719
	PCOS (n=30)	3.832 ±0.588***	13.218 ±0.899**	60.754 ±11.757***

[a] The levels were expressed as mean±SD, *** – p<0.001, ** – p<0.01, * – p<0.05

TC recorded levels, according to body mass index (normal, overweight and obese) represented by 200.262±25.775, 198.54±23.225 and 205.058±24.557 mg/dL respectively, while TG showed various concentration values equal to 200.573±79.663, 218.44±106.152 and 251.681±116.84 mg/dL in PCOS patients in normal, overweight and obese categories, respectively, according to the BMI variable. HDL concentrations were recorded as equal to 27.168±5.558, 26.03±6.564 and 26.029±7.538 mg/dL for the same BMI statements, respectively, while LDL concentrations were equal to 98.392±22.318, 104.897±25.679 and 101.609±20.543 mg/dL in women with PCOS according to the same BMI categories. Concerning VLDL, the concentration values were found to be equal to 43.684±21.23, 40.58±16.22 and 50.047±23.218 mg/dL in female PCOS female patients for the same BMI statements above.

The activity levels of MDA, ferritin, and hemoglobin showed a significant correlation with different age groups. This suggests that age may influence these biochemical markers, highlighting the importance of considering age-related factors in health assessments.

MDA, hemoglobin and ferritin showed various concentration values that were equal to 3.977±0.603 µmol/L, 13.278±0.742 g/dL and 65.891±13.336 ng/mL in PCOS patients according to age factor in the first category, while the same biochemical parameters recorded different concentrations equal to 3.672±0.479 µmol/L, 13.288±0.522 g/dL and 62.275±11.875 ng/mL in the second age category, while in the third age category, the activity levels of MDA, hemoglobin and ferritin were measured equivalent to 3.832±0.588 µmol/L, 13.218±0.899 g/dL and 60.754±11.757 ng/mL respectively.

The results show a significant increase in MDA, hemoglobin, and ferritin, with ferritin showing the most significant difference between the healthy group and the control group.

There is a clinical and biochemical association between the BMI variable and the levels of MDA, ferritin, and hemoglobin. Therefore, these biochemical markers recorded various concentration values depending on the type of BMI, as indicated in Table 4.

Table 4. Activity levels of MDA, hemoglobin and ferritin in PCOS patients and control group according to body mass index variable[a]

BMI	Women Groups	MDA (µmol/L)	Hemoglobin (g/dL)	Ferritin (ng/mL)
Normal	Control (n=28)	2.304 ±0.017	10.714 ±0.78913	15.313 ±4.212
	PCOS (n=31)	3.902 ±0.616***	13.116 ±0.531**	65.049 ±13.232***
Overweight	Control (n=27)	2.317 ±0.014	10.811 ±0.818	15.524 ±5.085
	PCOS (n=34)	3.754 ±0.492***	13.28 ±0.711**	61.895 ±12.403***
Obese	Control (n=25)	2.294 ±0.069	10.868 ±0.912	15.265 ±5.259
	PCOS (n=35)	3.822 ±0.594***	13.409 ±0.91**	62.107 ±11.659***

[a] The levels were expressed as mean±SD, *** – p<0.001, ** – p<0.01, * – p<0.05

In Table 4 it was found that the levels of MDA, hemoglobin and ferritin were reported to be 3.902±0.616 µmol/L, 13.116±0.531 g/dL and 65.049±13.232 ng/mL in PCOS patients, according to the normal statement of body mass index. However, the same biochemical parameters showed various concentrations represented by 3.754±0.492 µmol/L, 13.28±0.711 g/dL and 61.895±12.403 ng/mL in female PCOS in the overweight category of BMI. In the obese category, the concentration values of MDA, hemoglobin, and ferritin were equal to 3.822±0.594 µmol/L, 13.409±0.91 g/dL and 62.107±11.659 ng/mL, respectively.

Discussion

PCOS is a complex clinical, biochemical and physiological disorder which affects many women, both single and married causing different alterations and health complications in the reproductive system of women leading to the occurrence of many biological problems in the woman's body.[28,29] In the current research, PCOS was followed and investigated clinically by the estimation of the biochemical variables represented by the lipid profile (TC, TG, HDL, LDL and VLDL), malondialdehyde, ferritin and hemoglobin in accordance with age and body mass index factors. It is known that PCOS, as a complex statement, affects most women for various reasons, therefore the severity of the biological disorder can be followed by the evaluation of many clinical markers.

From the results of the current research, it was found that the lipid profile is a very necessary marker to investigate the significant changes in the levels of TC, TG, HDL, LDL and VLDL concentrations in PCOS patients compared to healthy women which may cause some irregularities in the body of women. TC, TG, LDL and VLDL levels showed a highly significant increase ($p<0.001$), whereas HDL decreased significantly decreased ($p<0.001$) in female PCOS compared with the control group. Ibrahim et al. and Swetha et al. both reported findings consistent with these results.[30,31] An atherogenic lipid profile, an important warning sign of cardiovascular disease, could originate from PCOS, due to this analysis. Because insulin resistance, which frequently occurs in women with PCOS, increases VLDL formation and diminishes HDL levels – both of which are associated with a higher chance of atherosclerosis – it is likely that insulin resistance results in dyslipidemia.[32,33]

It was noticed that the highest concentrations of TC, TG, LDL, and VLDL according to the age variable were seen mainly in the third age categories and the lowest levels of the same markers were observed in the first and second age categories, respectively. However, HDL showed the exact opposite trend, with HDL levels decreasing as age increases. The observed trend might be caused by an increase in insulin resistance and metabolic dysfunction that often become worse with age in PCOS, which additionally results in lipid abnormalities.[34] Variations in lipid concentrations associated with the biochemical mechanisms of PCOS are linked to an atherogenic lipid profile. Therefore, diet and physical activity could be used to manage these lipid imbalances. Studies have shown that weight loss and insulin sensitivity treatments (eg, diet and exercise) can reduce the risk of cardiovascular disease in PCOS patients. It is important to treat these lipid abnormalities early in PCOS patients to prevent the development of cardiovascular disease.[35,36]

Furthermore, the correlation between lipid profile concentrations of PCOS patients and body mass index was considered. Various concentration values for TC, TG, HDL, LDL and VLDL in female PCOS females according to the state of body mass index (normal, overweight, and obese). In PCOS patients, it was observed that women with higher BMI levels had higher levels of TC, TG, LDL, and VLDL, whereas those with lower weights had the lowest amounts. However, HDL levels showed a negative correlation with body weight, decreasing as weight increased.

This pattern reveals how obesity promotes an amplification of lipid issues in PCOS. Dyslipidemia is mainly caused by insulin resistance and inflammation, both of which become worse by obesity. The correlation between worsening lipid profiles and a higher body mass index indicates the need of weight management in PCOS.[37] The clinical chemical mechanism between lipid profile and BMI was suggested by the increased prevalence of hypertension in women with PCOS which is linked to many variables such as obesity, hyperandrogenism, insulin resistance, and autonomic dysfunction. Obesity in women with PCOS increases the risk of cardiovascular disease with dysfunctional blood pressure. Additionally, androgen levels and the ongoing use of oral birth control in women with PCOS can lead to variations in lipid profile levels, possibly leading to an increase or decrease.[38,39] More specifically, excessive androgen levels found in women with PCOS could increase cardiovascular risk through changing lipid transport and liver metabolism, which can contribute to lipid abnormalities.[40]

The biochemical indicators represented by malondialdehyde, ferritin, and hemoglobin are very important variables and have medicinal correlation and biological significance with PCOS.

In PCOS, hemoglobin levels might be higher owing to some disorders such as obesity and insulin resistance, but there is still no consistent relationship between Hb levels and PCOS, and individual results can differ depending on other health factors. De Medeiros et al. reported a moderate significant increase ($p<0.001$) in hemoglobin levels in PCOS patients which was consistent with the results collected in this investigation.41 On the other hand, Alvarez-Blasco et al. obtained different results, seeing a significant decrease in patients with Hb levels in PCOS compared to the healthy group.[42] The heightened levels of hemoglobin might be related to altered metabolic pathways and chronic low-grade inflammation. Higher hemoglobin levels might result from erythropoiesis due to inflammation and insulin resistance. However, additional research is required to further clarify the relationship between hemoglobin and PCOS.[43]

The results obtained show that hemoglobin levels increase in PCOS patients as weight increases (highest levels shown in the obese category) while decreasing as patients become older (lowest levels seen in the third age category). This confirms the theory that elevated blood hemoglobin concentrations are an outcome

of metabolic dysfunction in PCOS, especially insulin resistance and obesity. Women's hemoglobin levels could decrease as a result of disturbances in their metabolic processes as they age.[41]

Furthermore, malondialdehyde levels significantly increased ($p<0.001$) in PCOS patients compared to the healthy group. Deba et al. and Sabuncu et al. both found similar results.[44,45] MDA is a marker of inflammation and oxidative stress, which has been shown to be higher among women with PCOS. Since oxidative stress damages tissues and causes metabolic dysfunctions, including insulin resistance, it plays a role in the development of PCOS.[35]

Although the results in the normal BMI group show the highest concentrations, the main trend shows a moderately significant increase in MDA levels of MDA as BMI increases. This unexpected result in the lowest BMI group could be influenced by many factors, such as underlying metabolic or hormonal conditions that can increase oxidative stress. On the contrary, the same trend is seen when looking at the results of MDA according to age, as its levels show a steady increase as age increases. Also, the first (youngest) age group displays the highest levels. This could indicate that although oxidative stress and inflammation increase with age and BMI.[46] This relationship between MDA with age and BMI should be further investigated to confirm or disprove these results.

Increased malondialdehyde in oxidative stress, especially during pregnancy, can be necessary to achieve the diagnosis of PCOS, which means that MDA is a significant indicator of following PCOS progression.[47] This reinforces how oxidative stress plays an active role in the pathophysiology of PCOS, demonstrating that high levels of MDA can lead to the development of PCOS in conjunction with its adverse effects.[48]

Ferritin, an indicator of iron storage, is usually elevated in obese and insulin resistant women and is correlated to the severity of PCOS. High levels of ferritin signify elevated inflammation and oxidative damage, which contribute to the metabolic dysfunctions observed in PCOS, similar to MDA, which is another sign of oxidative stress.[49] Since ferritin is similar in its function as a marker of oxidative stress to MDA, its levels were also significantly ($p<0.001$) in PCOS patients compared to the healthy group. Sharifi et al. and Al-Hakeim et al. both concluded that ferritin levels increased in female PCOS due to the increase of oxidative stress.[50,51]

Conclusion

In summary, the outcomes of this research highlight all the complicated metabolic and biochemical changes attributed to PCOS. Substantial changes in the lipid profile, including higher levels of TC, TG, LDL, and VLDL and decreased HDL, point to an atherogenic risk profile in women affected by PCOS. Obesity and insulin resistance worsen these lipid abnormalities, demonstrating the important role of weight management and early treatment to reduce cardiovascular risks. Furthermore, it became apparent that PCOS patients showed substantially higher levels of oxidative stress signals such as ferritin and MDA, demonstrating that inflammation and oxidative damage play an active role in the pathophysiology of the condition. Furthermore, there were significant connections involving hemoglobin levels and both BMI and metabolic dysfunction, revealing that raised hemoglobin might indicate a sign of insulin resistance and abnormal metabolic processes. With every aspect considered, these findings draw attention to the importance of thorough medical management of PCOS, with a special focus on minimizing oxidative stress, metabolic function, and lipid profiles to avoid chronic health conditions, notably cardiovascular disease.

Declarations

Funding

This study did not receive external funding.

Authors' contributions

Conceptualization, A.A.S., A.D.M. and M.K.A.; Methodology, A.A.S.; Software, A.D.M.; Validation, A.A.S., A.D.M. and M.K.A.; Formal Analysis, M.K.A.; Investigation, A.A.S.; Resources, A.A.S.; Data Curation, A.A.S.; Writing – Original Draft Preparation, A.A.S.; Writing – Review & Editing, A.D.M.; Visualization, A.D.M.; Supervision, M.K.A.; Project Administration, A.A.S.; Funding Acquisition, A.A.S.

Conflicts of interest

The authors have disclosed no conflicts of interest.

Data availability

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

In this study, the ethical approval with the number (592) on (26/4/2022) was acquired from the Basrah Health Department – Training and Human Development – Center of Knowledge Management/Research Division.

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