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Effect of Follicular Fluid and Serum Irisin on Oocyte and Embryo Quality in PCOS Women Undergoing ICSI Cycle.

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ABSTRACT

Polycystic ovarian syndrome (PCOS) is a group of clinically distinct endocrine conditions. Insulin resistance-related proteins are involved in PCOS pathogenesis. Irisin is a new myokine that functions similarly to adipokines. Irisin has been linked to insulin resistance and metabolic syndrome. There have been conflicting findings regarding irisin levels and their connection to hormonal and metabolic alterations in PCOS .This study aimed to compare the levels of irisin in follicular fluid and serum between women with PCOS and healthy women and correlate them with oocyte and embryo quality in women undergoing the ICSI cycle .Ninety infertile Iraqi women were enrolled, 46 women with PCOS and 44 weight-matched non-PCOS controls, in whom ICSI was done for them and evaluated the level of follicular fluid, serum Irisin, and insulin level with measure of Homeostasis Model of Assessment-Insulin Resistance (HOMA-IR) and correlate them to with oocyte and embryo quality. HOMA-IR, FF, and serum irisin levels in PCOS considerably increased. ($P \leq 0.01$).

In addition, there was a significant negative correlation between Irisin levels in follicular fluid and serum with MII oocyte, oocyte maturity rate, and grade 1 embryo. The serum, follicular fluid Irisin, and HOMA-IR were significantly higher in PCOS than in control cases, which may cause a reduction in oocyte maturation, embryo quality, and pregnancy outcome.

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KEYWORD

Infertility, Polycystic Ovarian Syndrome, Irisin, Oocyte and Embryo quality

1. Introduction

Infertility is one of the most common problems in the world, resulting from genetic or pathological diseases, prompting ongoing studies and research in the field of assisted reproductive technology (ART) to discover the best treatment option possible. A successful pregnancy needs high-quality oocytes and embryos, so the efforts of fertility clinics worldwide in the field of ART to obtain the best quality oocytes and embryos **(Mohammad S, et, al. 2021[1])**

Polycystic ovarian syndrome (PCOS) is a fairly frequent health issue among women of reproductive age that is related to ovulatory dysfunction and female subfertility. The identification of PCOS is constructed on Rotterdam criteria, which consists of 2 of three characteristics: polycystic ovary form on ultrasound, menstrual irregularity, and biochemical or clinical proof of excessive androgen levels **(Zhang L, et, al. 2018[2]).** The increase in insulin level and insulin resistance are a fundamental for utmost of the symptoms of PCOS which consist of an-ovulatory subfertility with skin alterations that result from hyper-androgenemia **(Wiweko B, et, al. 2018[3])**. In PCOS women premature luteinization of the granulosa cell and disturbance of the intrafollicular milieu are initiated by ovarian hyperinsulinemia and hyperandrogenism, resulting in poor development of follicular and oocyte maturation **(Sanchez-Garrido MA, and Tena-Sempere M. 2020[4]).**

Insulin resistance may be assessed in a range of ways; while some, like HOMA-IR, are straightforward and uncomplicated, others are challenging and complex, like hyper-insulinemic glycemic glucose clamp **(Basukala P, et, al. 2018[5])**

Irisin has recently been recognized as an adipokine and a myokine, a protein utilized as a biomarker to evaluate insulin

resistance. It causes white fatty tissue to transform into brown fatty tissue. It seems that irisin increase could represent the first step in the onset of PCOS **(Ibrahim M, et, al. 2018[6]).** In recent years, specialists in this subject have devoted particular consideration to this important protein. Irisin levels in PCOS individuals may rise before other metabolic and phenotypic alterations. It may be regarded as an early PCOS biomarker enabling a diagnosis of this illness. Its detection may have a significant impact on human physiology and assist in lowering long-term morbidity in this group **(Fukushima Y, et, al. 2016 [7]).**

Irisin is a myokine that was initially identified by Boström et al.1 in 2012. called according to the Greek goddess of messengers, Iris. The precursor of Irisin is Fibronectin type III domain-containing protein 5, a type I transmembrane glycoprotein coded through the FNDC5 gene; Irisin is a cleaved form of FNDC5. Exercise increases the muscle cell's peroxisome proliferator-activated receptor coactivator-1 (PGC1) activity. Causing the fibronectin type III domain containing 5(FNDC5) gene to become active lead to produces the FNDC5 protein; Irisin is produced into circulation as a consequence of FNDC5 proteolysis; Circulating irisin promotes the production of uncoupling protein 1 mRNA in subcutaneous white adipose tissue cells, a feature of brown adipose tissue cells. White adipose tissue cells develop characteristics of brown adipose tissue cells (browning).

That uncoupling protein 1, a protein found within the mitochondrial inner membrane, allows protons to move from the inter-membranous region into the matrix, resulting in heat production throughout oxidative phosphorylation 2 **(Mahgoub MO, et, al. 2018[8])**

Irisin has been reported to reduce obesity and glucose homeostasis,

consequently improving lifespan **(Mahgoub MO, et, al. 2018[8])**

Human and animal research has provided conclusive data on a link between irisin and IR. Irisin acts on the muscles, increasing cell glucose uptake. Translating the glucose transporter type 4 (GLUT4) to the plasma membrane **(Jiang S,et, al. 2021[9], Ma EB, et, al. 2019[10]).**

The definitive determination of IR as the crucial contributory factor of PCOS. The regulatory function of irisin and its role in glucose metabolism are yet unclear and remains to be clarified. Irisin is furthermore associated with a raised incidence of metabolic syndrome and cardiovascular disease in humans, and its production may be raised as a compensatory way for these people to conquer latent irisin resistance **(Mahgoub MO, et, al. 2018[8])**.

These findings support the hypothesis that metabolic imbalance induces a "vicious circle" in PCOS females. As a result, irisin may be a new participant in the interaction between adipose tissue, hyperinsulinemia, and hyperandrogenism in PCOS **(Bousmpoula A, et, al. 2019[11]).**

The purpose of this study was to investigate irisin levels in the blood and follicular fluid in individuals with PCOS and to compare these levels with non-PCOS women to understand the correlations of irisin with the oocyte and embryo characteristics in women undergoing the Intracytoplasmic Sperm Injection (ICSI) cycle.

2. Patients and Methods

This prospective comparative study was done on 90 infertile females who were undergoing intracytoplasmic sperm injection (ICSI) at the infertility center of the High Institute for Infertility Diagnosis and Assisted Reproductive Technologies, Reproductive Physiology, Al Nahrain University, Baghdad, Iraq, during the period from September 2021 until March 2023. Ethical approval of the

current study was issued by the Local Medical Ethical Committee of the Institute (code 0701-PF-2021S5). Females with chronic diseases like chronic renal disease, hypertension, diabetes, hyperprolactinemia, poor ovarian reserve, pelvic inflammatory disease, and all cases of endometriosis, except mild-type, as well as male partners with azoospermia, were omitted from this study.

Complete obstetrical, medical, and surgical histories derived from couples participating in the study.

The infertile females were extensively investigated, including gynecological and general examinations. The infertile females who enrolled in this prospective comparison study were divided into two groups based on their PCOS status:

Group 1: 46 ladies have PCOS. had to meet at least two of the three criteria set by the Rotterdam ESHRE/ASRMS criteria and

Group 2: 44 ladies do not have PCOS.

On day two of the menstrual cycle, the baseline hormonal analysis (luteinizing hormone LH, Follicle stimulating hormone FSH, Estradiol E2) and basal transvaginal ultrasound were done; Controlled Ovarian Hyperstimulation with a flexible Gonadotropin Releasing Hormone (GnRH) antagonist regimen was used for all female participants. The program included subcutaneous recombinant follicular stimulating hormone (r-FSH) (Gonaf -F®, Merk-Serono/ Switzerland). The r-FSH administration started on the 2nd day of the menstrual cycle, with or without human menopausal gonadotropin (HMG) (Menogone®, Ferring, GmbH/ Germany).

The gonadotropin starting dosage was determined according to the women's age, BMI, ovarian reserve marker (antral follicular count, anti-mulligan hormone), and previous response to ovarian stimulation in the IVF cycle. On day 5 of stimulation, transvaginal ultrasound was achieved, and additional scans were done every two

to three days as suggested. A daily subcutaneous injection of 0.25 mg of cetrorelix acetate (Cetrotide®, Merck Serono, Geneva, Switzerland) was administered as soon as the leading follicles achieved a diameter of 13-14 mm.until the trigger day.

Follicular growth was monitored by trans-vaginal ultrasonography and E2 levels till the trigger day. When 2-3 leading follicles reach an average diameter of 17-18 mm, final oocyte maturation is accomplished by giving subcutaneous recombinant human chorionic gonadotropin. (r-hCG) 500 µg (Ovitrelle® Merk-Serono/ Switzerland) or r-hCG 250 µg and Triptorelin 0.1 mg (Decapeptyl® Ferring / Germany) (dual triggering).

Oocyte retrieval was conducted under general anesthesia using transvaginal ultrasound guidance. Oocytes are extracted from follicles using a needle attached to suction equipment, commonly done 34-36 hours after the trigger injection because the oocytes are fully developed shortly before the follicle rupture. The follicular fluid was directly conducted by an embryologist to collect the retrieved "cumulus-oocyte complex." Following denudation, each oocyte was thoroughly examined, looking for the absence or presence of the germinal vesicle or first polar body. Oocytes that were morphologically normal and had extruded the 1st polar body (metaphase II) had been selected for microinjection. Intracytoplasmic sperm injection (ICSI) was done, and about 16-18 hours after ICSI, the existence of 2 pronuclei (2PN) and 2PB in injected oocytes confirmed fertilization.

Both maturation rate (MR) "(number of mature oocytes/total number of oocytes retrieved)" and Fertilization rate (FR) "(number of fertilized oocytes /total number of injected mature oocytes)" were calculated **(Magaton I, et, al. 2023[12]).**

The embryo morphology was assessed by the same embryologist, and the grading system was according to the Istanbul consensus workshop on

embryo assessment; the grading system was done based on the number of blastomeres, blastomere symmetry (equal = score 1, different = 2), and the percentage of fragmentation (≤10% = score 0; 11–20% = 1; 21–30% = 2; >30% = 3), the cleavage stage (day-3) fresh embryo transfer was done under ultrasound-guided with a soft catheter.

Luteal support was initiated on the day of oocyte retrieval with progesterone injection depot 250mg twice weekly and daily vaginal progesterone. (Crinone, ® 8% progesterone gel, MERK, Switzerland) Or (Cyclogest®400mg; Actavis, UK), B-hCG levels in the blood were evaluated 14 days following embryo transplantation **(Zhang Y, et, al. 2020[13])**

Collection of blood, follicular fluid samples, and biochemical assay:

On the day of oocyte pickup, blood samples were drawn from all female patients for measurement of Irisin, fasting glucose, and fasting insulin levels. With a disposable syringe, these blood samples (3ml) were deposited in a serum-separating tube (gel and clot activator) and allowed to coagulate for 10-15 minutes at room temperature, then centrifuged for 20 minutes at 3000 rpm. The serum was extracted and kept at -20°C in an Eppendorf tube.

The collected follicular fluid on the day of oocyte pickup was used to measure Irisin levels. Following COC isolation, the residual follicular fluid was collected in a plain tube and centrifuged for 20 minutes at 3000 rpm to isolate cellular contents and debris; the supernatant of follicular fluid was collected and kept at -20°C in a labeled collection tube.

The enzyme-linked immune assay (ELISA) technique used in the current study for the measurement of Irisin and insulin levels using a detection kit (YL Biotech Co., Ltd., Shanghai, China) and microplate reader capable of calculating absorbance at 450 nm (Huma reader HS, Human, USA) In this research, was utilized. The GOD-

PAP enzymatic colorimetric test technique with the glucose liquicolor kit was used to measure fasting glucose levels. Fasting glucose levels were measured using a semi-automatic microprocessor-controlled photometer (Humalyzer Primus, Human, USA).

Calculation of the Homeostasis Model of Assessment-Insulin Resistance (HOMA-IR) index for evaluating insulin resistance. Matthews et al. primarily defined it as HOMA in 1985. HOMA-IR can be calculated by using this equation:

HOMA-IR = [glucose (mg/dl) × insulin (mIU/ L)] /405.Normal value in adults: < 2. **(Yoon J, et, al. 2021[14])**

Ethical Consideration:

Ethical approval the study was carried out in conformity with the moral standards outlined in the Declaration of Helsinki. Before a sample was taken, it was done with the patient's verbal and analytical consent. A local Ethics Committee examined and approved the study protocol, subject information, and permission form in accordance (code 0701-PF-2021S5).

between serum INSL3 and the patient's age and body mass indices. On the other hand, there was no significant correlation between follicular fluids INSL3 with the age of patients, body mass indices, or length of infertility, as shown in Table 5. A positive significant relation between serum INSL3 with serum AMH (r= 0.578 & p= 0.001) and testosterone (r= 0.378 & p= 0.001) was recognized; nevertheless, no significant correlations were identified between both serum and follicular fluids INSL3 with serum LH, FSH, prolactin, TSH, basal E2, and E2 at the day of the trigger as presented in table 6. There were significant positive correlations involving serum INSL3 with antral follicle count, as presented in Table 7.

3. Results

Ninety females were categorized into 2 groups according to the PCOS statue

Table 1 shows there was no significant difference in the demographic characteristics between PCOS group and Non-PCOS group ($P > 0.05$) .

Table *(1):* Demographic characteristics of infertile women according to PCOS status

Characteristic	**PCOS** ***n* = 46**	**Non-PCOS** ***n* = 44**	***P***
Age (years)			
Mean ±SD	31.33 ± 5.28	31.45 ± 5.86	0.88 † NS
BMI (kg/m^2)			
Mean ±SD	27.55 ±3.61	27.16± 3.94	0.92 † NS
Range	21.67 - 35.70	21.05 -34.60	
Normal, *n* (%)	13 (14.44%)	14 (15.56 %)	
Overweight, *n* (%)	18 (20 %)	17 (18.89 %)	
obesity, *n* (%)	15 (16.67 %)	13 (14.44 %)	
Waist /Hip ratio			
Mean ±SD	0.82 ±0.05	0.83±0.05	0.59 † NS
Range	0.70- 0.92	0.73- 0.99	
Duration of infertility (years)			
Mean ±SD	4.76 ± 2.892	5.70 ± 3.613	0.17† NS
Type of infertility			
Primary, *n* (%)	38 (42.22 %)	39 (43.33 %)	0.41 € NS
Secondary, *n* (%)	8 (8.89 %)	5 (5.56 %)	

n: number of cases; SD: standard deviation; BMI: body mass index; †: Independent samples t-test; €; Chi-square test; NS: not significant at $P > 0.05$.

The oocyte and embryo characteristics are shown in Table 2 there was a significant difference in total oocyte count, MI oocyte, and oocyte maturity rate between PCOS and Non-PCOS groups ($P < 0.001$). however, there was no significant difference in MII oocyte, germinal vesicle, and grade I, II, and III embryo between groups.

Table (2): Oocyte and embryo characteristics of infertile women according to PCOS status

Characteristic	**PCOS** ***n* = 46**	**Non-PCOS** ***n* = 44**	***P***
Count of retrieved oocytes	14.20 ±3.42	10.50 ±1.93	**<0.001 †HS**
MII oocyte count	7.28± 2.41	6.75 ± 2.02	0.26 † NS
MI oocyte count	3.35± 1.63	1.80 ± 1.51	**<0.001 †HS**
Germinal vesicle	1.24 ± 0.63	0.98 ± 0.73	0.70 † NS
Abnormal oocyte	1.48 ± 0.16	0.64 ± 0.13	**<0.001 †HS**
Oocyte maturity rate	50.96 ± 10.03	65.57 ±15.12	**<0.001 † HS**
Fertilized oocyte (2 PN)	65.22 ±17.40	69.70 ±19.36	0.25 † NS
Grade I	2.33 ± 1.38	2.66 ± 1.43	0.26 † NS
Grade II	1.46 ± 0.91	1.32 ± 0.93	0.47 † NS
Grade III	0.80 ± 0.61	0.73 ± 0.58	0.54 † NS

***n*:** number of cases; SD: standard deviation; †: Independent samples t-test; **MI**: metaphase I (immature) oocytes; **MII**: metaphase II (mature) oocytes; **PN**: pro-nuclei; **NS**: not significant at $P > 0.05$; HS: highly significant at $P \leq 0.01$

in Table 3 there was significant difference in serum and follicular fluid Irisin and HOMA-IR between PCOS and Non-PCOS groups ($P < 0.05$).

Table (3): serum and follicular irisin and HOMA-IR of infertile women according to PCOS status

Characteristic	**PCOS** ***n* = 46**	**Non-PCOS** ***n* = 44**	***P***
HOMA-IR	1.61 ± 0.51	1.03 ± 0.29	**<0.001 † HS**
Serum Irisin (µg/ml)	5.20 ± 1.97	4.05 ± 1.44	**<0.002† S**
Follicular Irisin (µg/ml)	3.97 ±1.62	3.28 ± 1.14	**0.02 † S**

The correlations between follicular fluids and serum Irisin within PCOS and non-PCOS patients enrolled in the study were presented in Table 4 and the results demonstrated a Negative significant correlation between follicular fluids and serum Irisin with metaphase II oocytes, maturation rate, fertilization rate, grade 1 embryos, and pregnancy outcome ($P \leq 0.05$) in PCOS.

Table (4): Correlations between serum & follicular fluids Irisin with oocyte and embryo characteristics in PCOS and Non- PCOS group patients

		PCOS group		Non- PCOS group	
Parameters		**Serum Irisin**	**F.F Irisin**	**Serum Irisin**	**F.F Irisin**
Metaphase II oocytes	r	-0.49**	-0.048**	-0.255	-0.245
Metaphase I oocytes	r	-0.157	-0.210	0.148	0.110
GV	r	0.149	0.132	0.121	0.048
Maturation Rate	r	-0.40**	-0.38**	-0.219	-0.134
Fertilization Rate	r	-0.31*	-0.41**	0.047	0.040
Grade 1 embryos	r	-0.27*	-0.34*	-0.242	-0.180
Grade 2 embryos	r	0.240	0.201	0.275	0.192
Grade 3 embryos	r	0.122	0.053	0.186	0.064

r: Pearson's correlation coefficient; *: Significant correlation; **: highly Significant correlation

4. Discussion

1. Oocyte and Embryo characteristics of infertile women enrolled in the present study

Oocyte maturation may be hampered by the effects of both intraovarian (such as epidermal, fibroblast, insulin-like, and neurotrophin growth factors) and extra ovarian (such as LH hypersecretion, hyper-androgenemia, and hyperinsulinemia) factors **(Jassim WH, et, al. 2019[15])**

The analysis of the follicular growth, in the PCOS group, show a direct correlation between the large numbers of total numbers of the oocytes MI, with a significant difference to non PCOS oocytes as well with statically lower maturation index in PCOS group The study's findings concur with those

of other researchers who discovered that PCOS women have more total numbers of the oocytes and MI oocytes than controls do **(Uk A, et, al. 2022[16])** This study found that PCOS women had abnormal oocytes that were significantly higher than those of non-PCOS women. The suboptimal oocyte competence may be caused by abnormal folliculogenesis, which may be caused by high androgen levels and intrinsic molecular defects, lowering fertilization in PCOS women **(Jassim WH, et, al. 2019[15])**

This outcome is consistent with several studies that found PCOS had considerable negative effects on the quality of oocytes **(Jain N, et, al. 2022[17], Artini PG, et, al. 2021[18])** Embryos were categorized according to three morphological standards into three grades. (Blastomeres number and size, blastomeres regularity, and fragmentation rate). The statistical analysis showed that the embryo subtypes did not differ significantly in the PCOS group and the Non-PCOS group.

Irisin effect on oocyte and embryonic development parameters

The present work is an attempt to explore the role of Irisin on follicle development and the correlation between FF-Irisin and oocyte and embryonic development indices by measuring serum and FF levels of these molecules in patients with PCOS and control. Irisin is present in significant amounts in the FF of PCOS women undergoing IVF/ICSI. Also showed that negative correlation between serum& FF-Irisin with metaphase II oocytes, maturation rate, fertilization rate, and grade 1 embryos.

Thus, extraordinary amounts of FF-Irisin may interfere with the oocyte and follicle cells' ability to consume energy in PCOS-infertile women. Therefore, inappropriate follicle development may be influenced by unbalanced serum and FF-Irisin levels. **(Sharan B, et, al. 2021[19], Kruszewska J, et, al. 2022[20]).** Additionally, irisin conflict

in follicle cells can impair angiogenesis and mitochondrial biogenesis during follicular development. In agreement, it has been revealed that Irisin regulates oxidative metabolism and mitochondrial biogenesis in numerous cell types **(Furino VO, et, al. 2021[21]).** Irisin have proposed that may be crucial for follicle development. This may offer a novel therapeutic target for the management of metabolic disruption and subfertility caused by PCOS.

Lack of a significant association between serum and FF Irisin levels and oocyte and embryo parameters in non-PCOS patients, in contrast to PCOS cases, led to support for our hypothesis.

2. Evaluation of HOMA-IR markers, Irisin in infertile women enrolled in this study

Irisin is a novel peptide that resembles a hormone and is used to regulate certain metabolites or to promote health. It has been discovered to be associated with biochemical and anthropometric parameters, other hormones, adipokines, insulin resistance, obesity, and metabolic syndrome **(Ahmed B, et, al. 2021[22], Villareal R, et, al. 2019[23])**

Currently, a lot of research focuses on the connection between Irisin and metabolic illnesses and Irisin as a potential new target for IR and type 2 diabetes **(Mubarak SMH, and Ali HA 2020[24], Berberoğlu H, and Hacişevki A. 2021[25])** has generated a lot of attention among scientists. Yet, the current evidence for the role of Irisin on IR is scant and conflicting, and the linking between them rests indistinct.

Hence, it was proposed that that PCOS may be caused by abnormal regulation of Irisin metabolism **(Foda AA, et, al. 2018[26])**

The results of the present study showed that PCOS patients have an elevated serum and FF Irisin level when compared to controls (P = 0.002), and these changes are associated with insulin resistance (high HOMA-IR).

The inappropriate regulation of Irisin might be a clue of early PCOS development and a contribute in the metabolic symptoms **(Leustean L, et, al. 2021[27]).** The raised serum Irisin level has been proposed as a protective factor in the pre-diabetic state before DM develops in PCOS patients **(Chang CL, et, al. 2019[28]).**

Irisin's aberrant alterations may help PCOS patients develop risk factors that lead to a rise in morbidities such dyslipidemia, insulin resistance, and obesity **(Leustean L, et, al. 2021[27]).** Serum and FF Irisin levels was higher in PCOS women. Because this clinical entity is frequently accompanied by metabolic disturbances and reduced insulin sensitivity, the elevated Irisin levels may represent a compensating adaptive response. This condition is known as "Irisin resistance" when, despite increased levels, the intended effects are not obtained **(Leustean L, et, al. 2021[27], Zhang R, et, al. [29])**

It was discovered that patients with metabolic syndrome have higher Irisin levels than those of patients without the illness **Dawood, et, al. 2023 [30]).**

Insulin resistance (IR), is the furthermost widely acceptable hypothesis to account for the pathogenesis of metabolic syndrome in PCOS patients. These findings agreed with other earlier research (3,31,32). **(Wiweko B, et, al. 2018[3], Wanderley MDS, et, al. 2018[31], Kim JJ, et, al. 2019[32])**.

Although Irisin has already been linked to both muscle mass and BMI in humans, the considerable rise Irisin levels in PCOS female as compared to the control group cannot be explained by variations in either. Patients with PCOS have high amounts of Irisin, which can be clarified by Irisin resistance **(Wang C, et, al. 2017[33])** analogous to IR **(Farhan FS and Hussien SS. 2019[34])** in which excessive circulating hormone levels fail to produce the desired physiologic impact, Alternatively, the hypothesis is that Irisin functions as a protective mechanism to balance out excess

energy influx since it frequently stimulates energy expenditure in brown and beige adipose tissues or by the proposal that Irisin functions as a protective mechanism to balance out excess energy inflow because it often promotes energy expenditure in brown and beige adipose tissues **(Zhu Y, et, al. 2022[35]).**

According to earlier studies, PCOS patients had higher serum irisin levels than controls, which is consistent with our findings **(Mubarak SMH, and Ali HA 2020[24]).**

In contrast, lower Irisin levels have been reported in PCOS patients compared to controls **(Oliveira FR, et, al. [36], Jaafar ZA, et, al. [37]).**

Irisin detection methods, kits, and the patient heterogeneity with metabolic abnormalities comprised in each study are likely to be to responsible for the controversial results regarding Irisin levels **(Bousmpoula A, et, al. 2019[11]).**

5- Conclusion

The serum, follicular fluid Irisin, and HOMA- IR were substantially greater in PCOS individuals compared to controls. and can affect the oocyte and embryo quality in addition there was a negative correlation between follicular fluid and serum Irisin levels with MII oocyte count, oocyte maturity rate, and embryo grade 1.

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FAuthor Contribution

Sundus A. Dawood performed the study, Hayder A. L. Mossa, Mufeda A. Jwad supervised the work .

Conflict of Interest

The authors declare no conflict of interest .

Ethical Clearance

The study was approved by the Ethical Approval Committee.

Financial Disclosure

There is no financial disclosure.

Ethical Clearance

The study was approved by the Ethical Approval Committee

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