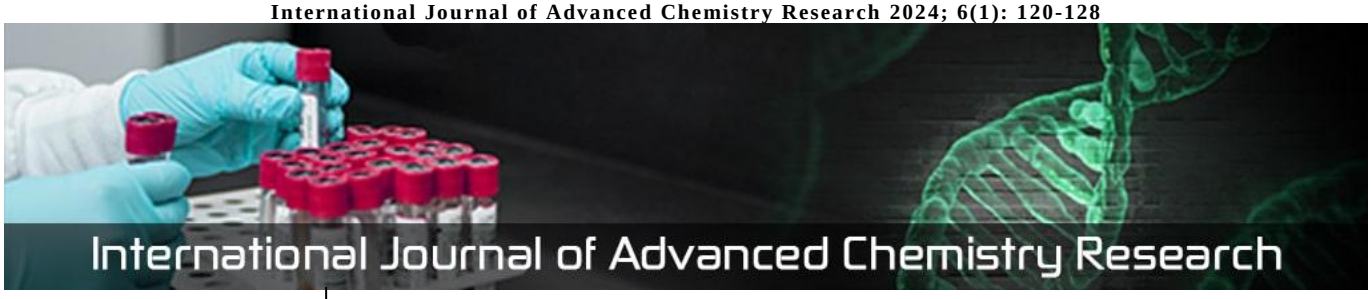

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Obesity, insulin resistance, and hormonal perturbations in Iraqi women

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Abstract
Background: Obesity and increased weight are related to Polycystic Ovarian Syndrome (PCOS) progression and exacerbate Insulin Resistance (IR).
Aims of the study: This research aimed to assess the potential impacts of BMI and IR on the functions of the pituitary-ovary and the pituitary-thyroid axis by assessing the Follicle-Stimulating Hormone (FSH), Estradiol (E2), Luteinizing Hormone (LH), Thyroid Stimulating Hormone (TSH), Triiodothyronine (T_3), Thyroxine (T_4) and prolactin serum levels in the overweight and the obese PCOS groups.
Methodology: From May to December 2023, Martyr Mohammed Baqer Al-Hakim Hospital in Baghdad City, Iraq, conducted this prospective study. The individuals were divided into three BMI groups: 40 in the normal weight control group (BMI<25 kg/m^2), 30 in the overweight group (BMI≥25 kg/m^2), and 30 in the obese PCOS group (BMI≥30 kg/m^2). On days two or three of menstruation, blood was drawn. Electrochemiluminescence measured basal hormones.
Result: Obese PCOS patients had higher levels of LH, LH/FSH, prolactin, E2, and TSH, and decreased levels of FSH, T_3, and T_4 compared to the normal weight group (p<0.05). Additionally, the overweight group had considerably (p<0.05) lower LH, FSH, and E2 levels than the normal weight group. LH/FSH, prolactin, T_3, T_4, and TSH were not significantly different (p>0.05) between groups. In the overweight group, BMI was associated with FSH (r=-0.39, P=0.03). The obese PCOS group had a comparable LH association (r=-0.52, P=0.02). Obese PCOS patients had a BMI-HOMA-IR association (r=0.42, P=0.02).
Conclusion: Our research shows that BMI decreases gonadotropin release in overweight and obese PCOS patients. However, IR does not inhibit/stimulate the pituitary-ovary or pituitary-thyroid axes.

Keywords: Polycystic ovarian syndrome, insulin resistance, obesity, body mass index, hormones

Introduction
A Body Mass Index (BMI) beyond 30 kg/m^2 indicates obesity, characterized by an abundance of body fat. BMI is frequently employed as a reliable measure of adiposity in epidemiological investigations (Deurenberg *et al*., 1991) [15]. The World Health Organization (WHO) estimated that 15% of women worldwide were obese in a report that was released in 2016 (WHO, 2016) [61]. Furthermore, 25.40% of women in the Middle East who were of childbearing age were obese (Okati-Aliabad *et al*., 2022) [44]. This troubling trend is observed in Iraq, where 35.2% of women are obese (Jasim *et al*., 2018) [31]. No matter how they conceive, obese women exhibit worse reproduction rates (Elia *et al*., 2015) [21], and rising BMI is coupled with worse fertility diagnosis (Supramaniam *et al*., 2018) [55]. The risk of several diseases is exacerbated by obesity, especially insulin resistance (IR) (Sayın *et al*., 2020) [51]. The relationship between obesity and inflammatory processes in skeletal muscles, adipose tissues, and the pancreas has been documented (Kawai *et al*., 2021) [32]. Besides this, immune cells could be active in the inflammation linked to obesity, which is significant since it may function as a biological connection between IR and obesity (Wu & Ballantyne, 2020) [63]. However, adipose tissues produce more significant glycerol, hormones, non-esterified fatty acids, and cytokines that may contribute to IR development (Wondmkun, 2020) [62]. Obese women have a poorly functioning Hypothalamic-Pituitary-Ovarian (HPO) axis (Chen *et al*., 2022) [8] and they typically experience menstrual irregularity that ends in infertility and anovulation (Mikhael *et al*., 2019) [38].

Pituitary gonadotrophs synthesize Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH), which they employ for ovulation (Choi & Smitz, 2014) [9]. One etiology for the general impaired fertility in obese women is that both LH and FSH are routinely determined to be diminished, with a related decline in progesterone and estrogen generation by the ovary following ovulation (Jain *et al*., 2007) [29]. The endocrine condition influencing females of childbearing age is Polycystic Ovarian Syndrome (PCOS) (Norman *et al*., 2007) [42]. In compliance with the clinical protocols of the Rotterdam, the incidence of PCOS in females of childbearing age in numerous countries was reported to be from 5 to 13% (Bozdag *et al*., 2016) [3]. In contrast, Iraqi women had a PCOS incidence of around 33% (Mousa & Al Joborae, 2020) [40], which is greater than in other nations. Indeed, a principal reason for PCOS, IR, is typically present in concerned PCOS women (Zhao *et al*., 2023) [65]. Fundamental processes for the pathogenesis of PCOS would include the metabolic effects of IR and hyperinsulinemia on steroidogenic and reproductive processes (Barber *et al*., 2019) [2]. Obesity and increased weight are related to the development of PCOS as they exacerbate hyperandrogenism and menstrual irregularities (Itriyeva, 2022) [28]. Between 6 and 100% of PCOS females are obese or overweight (Lim *et al*., 2012) [33]. This research aimed to assess the potential impacts of BMI and IR on the functions of the pituitary-ovary and the pituitary-thyroid axis by assessing the FSH, LH, E2, prolactin, TSH, T_3, and T_4 blood levels in the overweight and obese PCOS group.

Methodology

Women were enlisted at the Martyr Mohammed Baqer Al-Hakim Hospital, Baghdad, Iraq, from May 2023 to December 2023. According to BMI, the subjects were split into three groups: Forty in the normal weight control group (BMI<25 kg/m^2), Thirty in the overweight group (BMI≥25 kg/m^2), and Thirty in the obese PCOS group (BMI≥30 kg/m^2). Further, every woman was provided with informed consent. For the obese PCOS group, the subjects aged 19 to 45 years; for the overweight group, from 21 to 45 years; and for the normal weight group, from 18 to 44 years. PCOS females were identified employing the Rotterdam criteria (ESHRE & ASRM, 2004) [22]. Females with the following causes were eliminated from participating in the study: endometriosis, uterine fibroid, cancer, adrenal hyperplasia, Cushing syndrome, adrenal virilism, androgen-secreting tumour, hyper- and hypothyroidism, diabetes, hyperprolactinemia, smoking, and being drinking. The blood draw occurred on days two or three of the menstrual cycle. Venous blood samples (10 mL) were gathered by puncturing women's veins, converted to plain tubes, and centrifuged at 402×g to separate serum. The samples were deep-frozen till hormonal analysis at -20 °C. Serum glucose level was assessed using the kit (Glucose MR, Linear chemicals, Barcelona, SPAIN). Electrochemiluminescence was employed to quantify basal hormones (Cobas E411 Immunoassay System, ROCHE, Switzerland). The body mass index was calculated using the equation dividing the weight by the square of the height, and the HOMA-IR was also calculated using the equation by the insulin concentration multiplied by the glucose concentration divided by 405.

Statistical analysis

SPSS for Windows, version 26, was employed to evaluate the findings (SPSS Inc. Chicago, Illinois, United States). The normality distribution of all variables was analyzed. The findings were tabulated as mean and standard deviation (SD). Following the ANOVA test, the Post Hoc test was employed. Pearson correlation was implemented to investigate the relationship degree between various parameters. $p<0.05$ was designated as the threshold for significance.

Results

Socio-demographic characteristics of the study groups

In a study comparing normal-weight women, overweight women, and obese women with Polycystic Ovary Syndrome (PCOS), it was found that mean age did not show statistically significant differences between the three groups, with mean ages of 33.65±6.54 and 33.63±5.62. and 33.33±6.40, respectively, with a P value of 0.90. However, there were statistically significant differences in body mass index (BMI) with normal-weight women recording a value of 22.21±2.31, overweight women 27.32±1.39, and obese women with PCOS 35.93±6.27, with a P value equal to 0.00. Also, the HOMA-IR showed significant differences between groups with readings of 2.14±0.40, 3.91±1.73, and 7.07±2.95 for normal-weight, overweight, and obese women with PCOS with a P value of 0.00. Noting a significant increase in insulin resistance consistent with increases in body mass index.

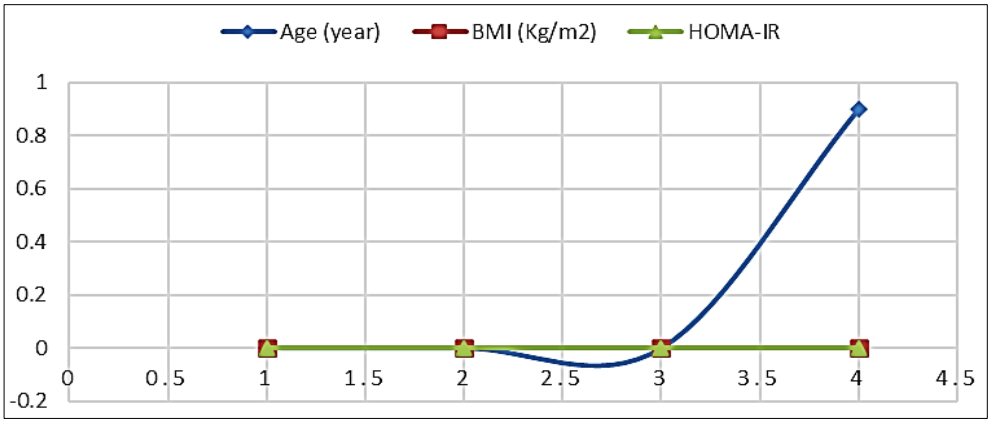

Fig 1: General characteristics of the studied groups

Table 1: General characteristics of the studied groups

	Normal-weight (N=40)	Overweight (N=30)	Obese PCOS (N=30)	*P*
Age (year)	33.65±6.54 a	33.63±5.62 a	33.33±6.40 a	0.90
BMI (Kg/m^2)	22.21±2.31 a	27.32±1.39 b	35.93±6.27 c	0.00
HOMA-IR	2.1*4* ±0.40 a	3.91 ±1.73 b	7.0*7*±2.95 c	0.00

The difference between the levels of sex hormones and thyroid hormones between the case group and the control group

The study showed highly statistically significant differences in the levels of some hormones when compared between normal-weight, overweight, and obese women with Polycystic Ovary Syndrome (PCOS). Luteinizing Hormone (LH) levels were significantly higher in obese women with PCOS (12.04±3.13 mIU/mL) compared to the other two groups (8.63±3.20 mIU/mL for normal weight and 7.00±1.95 mIU/mL for overweight). With p value < 0.001. Significant decreases in follicle-stimulating hormone (FSH) levels were also recorded in the second group (4.99±1.41 mIU/mL) compared to the first and third (7.05±1.64 mIU/mL and 6.18±2.04 mIU/mL, respectively) with a p-value < 0.001. While the ratio of Luteinizing Hormone to Follicle-Stimulating Hormone (LH/FSH ratio) was significantly higher in obese women with PCOS syndrome (2.00±0.82) compared to normal weight (1.22±0.43) and overweight (1.46±0.73) with a p-value < 0.001. Also, an increase in prolactin levels was observed with weight gain, recorded (10.37±4.85 ng/mL) in normal-weight women, (13.87±5.41 ng/mL) in overweight women, and (18.84±3.91 ng/mL) in obese women with PCOS., with p-value < 0.001. While there was a significant difference in estradiol (E2) levels, which decreased in overweight women (297.67±97.65 pMol/L) compared to normal weight (402.00±112.16 pMol/L) and obese women with PCOS (417.05±130.07 pMol/L) with a p-value < 0.001. Thyroid hormones T_3 and T_4 did not show statistically significant differences between the three groups with p at 0.52 and 0.08, respectively. However, TSH levels increased dramatically in obese PCOS patients (2.32±0.93 mIU/L) compared to the other two groups (1.40±0.72 mIU/L for normal weight and 1.74±0.51 mIU/L for overweight), the p-value was < 0.001.

Table 2: Basal serum levels of hormones in normal-weight, overweight, and obese PCOS.

	Normal-weight (N=40)	Overweight (N=30)	Obese PCOS (N=30)	*P* value
LH (mIU/mL)	8.63±3.20	7.00±1.95	12.04 ±3.13	<0.001
FSH (mIU/mL)	7.05 ±1.64	4.99 ±1.41	6.18 ±2.04	<0.001
LH/FSH	1.22±0.43	1.46±0.73	2.00 ±0.82	<0.001
Prolactin (ng/mL)	10.37±4.85	13.8*7*±5.41	18.84±3.91	<0.001
E_2 (pMol/L)	402.00±112.16	297.67 ±97.65	417.05±130.07	<0.001
T_3 (nmol/L)	1.86±0.99	1.73±0.56	1.67±0.40	0.52
T_4 (nmol/L)	95.05±23.68	87.6*7* ±22.44	81.6*6* ±26.67	0.08
TSH (mIU/L)	1.40±0.72	1.74 ±0.51	2.32 ±0.93	<0.001

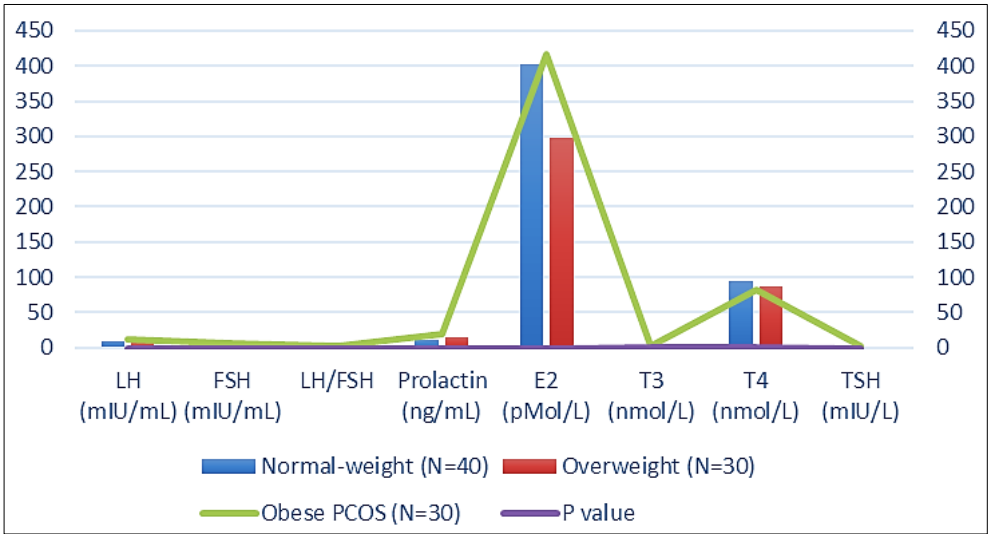

Fig 2: Serum levels of hormones in normal-weight, overweight, and obese PCOS

The person correlation coefficient analysis

In a Pearson correlation coefficient analysis for the overweight group, it was shown that there were some relationships between insulin resistance (HOMA-IR), body mass index (BMI), and several hormonal parameters. It was noted that the correlation of HOMA-IR with luteinizing hormone (LH) was weak and not significant (r=0.12, P=0.49).

The results also showed a negative and non-significant correlation between HOMA-IR and Follicle-Stimulating Hormone (FSH) levels (r=-0.22, P=0. 0.22), in contrast, a weak but significant negative correlation was recorded between BMI and FSH (r=-0.39, P=0.03). As for the LH/FSH ratio, it showed a modest positive correlation with HOMA-IR (r=0.19, P=0.23) and a non-significant negative correlation with BMI (r=-0.30, P=0.10).

For prolactin, there was no significant correlation with HOMA-IR (r=-0.07, P=0.68) or with BMI (r=0.11, P=0.54). Estradiol (E2) results revealed no significant correlation with HOMA-IR (r=-0.19, P=0.32) or BMI (r=-0.31, P=0.09). Thyroid hormones T_3 and T_4 did not show statistically significant associations in the study with HOMA-IR or BMI (r=-0.14, P=0.43 and r=-0.03, P=0.83 for T_3 respectively; r=-0.04, P=0.80 and r =-0.22, P=0.24 for T_4 respectively). Finally, no significant correlation was observed between TSH and HOMA-IR (r=-0.13, P=0.46), but there was a non-significant negative correlation with BMI (r=-0.20, P=0.27). As expected, there was a perfect correlation between self-rated HOMA-IR (r=1) and self-rated BMI (r=1), indicating that the data on both HOMA-IR and BMI were internally consistent.

Table 3: The person correlation coefficient analysis of the overweight group.

		HOMA-IR	BMI (Kg/m^2)
LH (mIU/mL)	*r*	0.12	-0.22
	P	0.49	0.22
FSH (mIU/mL)	*r*	0.13	-0.39*
	P	0.49	0.03
LH/FSH	*r*	0.19	-0.30
	P	0.23	0.10
Prolactin (ng/mL)	*r*	-0.07	0.11
	P	0.68	0.54
E_2 (pMol/L)	*r*	-0.19	-0.31
	P	0.32	0.09
T_3 (nmol/L)	*r*	-0.14	-0.03
	P	0.43	0.83
T_4 (nmol/L)	*r*	-0.04	-0.22
	P	0.80	0.24
TSH (mIU/L)	*r*	-0.13	-0.20
	P	0.46	0.27
HOMA-IR	*r* *P*	1	0.15 0.41
BMI (Kg/m^2)	*r* *P*	0.15 0.41	1

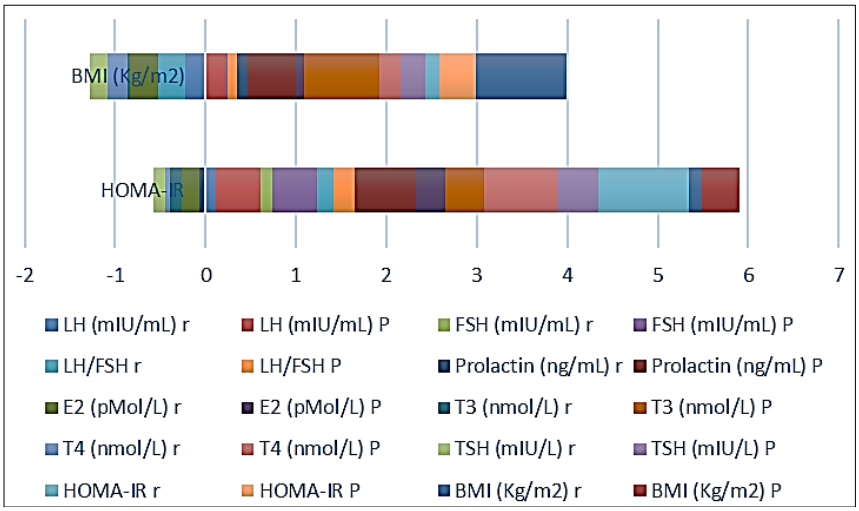

Fig 3: The person correlation coefficient analysis of the overweight group

The person correlation coefficient analysis of the obese PCOS group

In a Pearson correlation coefficient analysis of the group with Polycystic Ovary Syndrome (PCOS) and obese women, the table showed some correlations between levels of Insulin Resistance (HOMA-IR), Body Mass Index (BMI) and various hormonal indicators. The research concluded that there was no significant correlation between Luteinizing Hormone (LH) levels and HOMA-IR (r=-0.22, P=0.27), but there was a significant negative correlation between LH and BMI (r=-0.52, P=0.02). While it was found that there was no significant correlation between levels of Follicle-Stimulating Hormone (FSH) and HOMA-IR (r=0.16, P=0.39) or BMI (r=0.13, P=0.58). As for the ratio between LH and FSH, it did not show a significant effect on HOMA-IR or BMI, as the results were (r=-0.03, P=0.88) for HOMA-IR and (r=-0.03, P=0.90) for BMI, respectively. Considering prolactin levels, no significant correlation was observed with HOMA-IR (r=-0.24, P=0.19) or BMI (r=-0.18, P=0.34). While estradiol (E2) levels were non-significantly positively associated with HOMA-IR (r=0.29, P=0.12) as well as with BMI (r=0.21, P=0.25). Thyroid hormones T_3 and T_4 did not show significant correlations with HOMA-IR or BMI, as the results for T_3 were (r=0.25, P=0.17) and (r=0.06, P=0.71) and for T_4 the results were (r=-0.04, P=0. 0.80) and (r=-0.08, P=0.64) respectively. No statistical significance was found for TSH levels with any of the variables with P values (r=-0.05, P=0.76) for HOMA-IR

and (r=0.00, P=0.98) for BMI. Finally, the analysis only showed a significant association between HOMA-IR and BMI in women with obesity and PCOS (r=0.42, P=0.02), adding evidence of a relationship between insulin resistance and the increase in BMI in this group.

Table 4: The person correlation coefficient analysis of the obese PCOS group.

		HOMA-IR	BMI (Kg/m^2)
LH (mIU/mL)	*r*	-0.22	-0.52*
	P	0.27	0.02
FSH (mIU/mL)	*r*	0.16	0.13
	P	0.39	0.58
LH/FSH	*r*	-0.03	-0.03
	P	0.88	0.90
Prolactin (ng/mL)	*r*	-0.24	-0.18
	P	0.19	0.34
E_2 (pMol/L)	*r*	0.29	0.21
	P	0.12	0.25
T_3 (nmol/L)	*r*	0.25	0.06
	P	0.17	0.71
T_4 (nmol/L)	*r*	-0.04	-0.08
	P	0.80	0.64
TSH (mIU/L)	*r*	-0.05	0.00
	P	0.76	0.98
HOMA-IR	*r* *P*	1	0.42* 0.02
BMI (Kg/m^2)	*r* *P*	0.42* 0.02	1

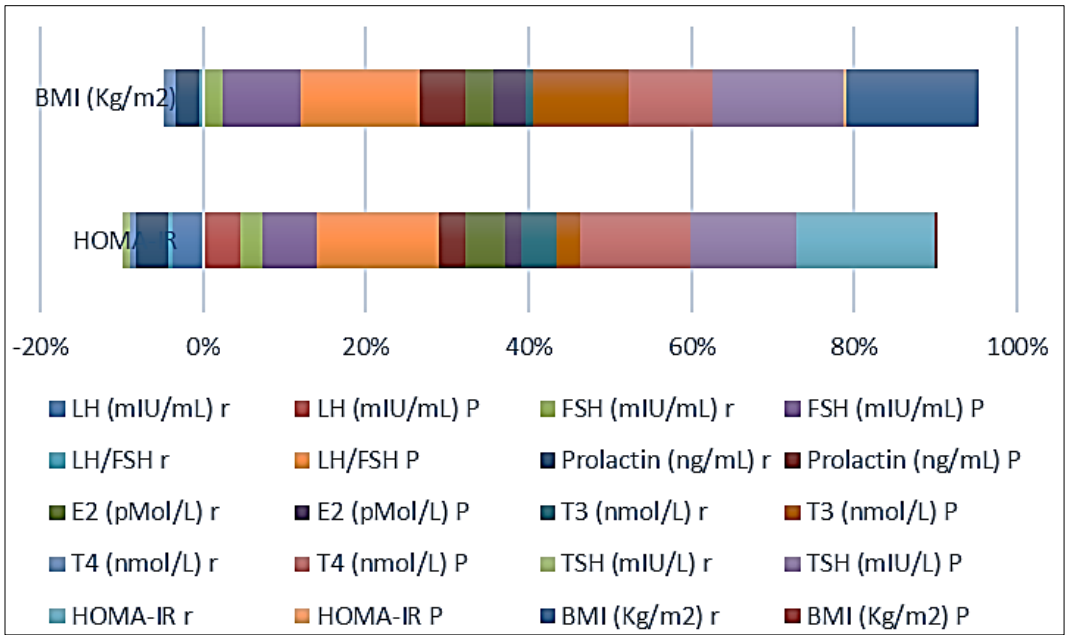

Fig 4: The person correlation coefficient analysis of the obese PCOS group

Discussion

This study compared endocrine hormones in obese PCOS patients, overweight people, and healthy weight controls. We also examined the relationship between BMI, HOMA-IR, and hormones in the overweight and obese PCOS groups. Obesity may cause insulin resistance in women with polycystic ovarian syndrome (PCOS) (Cassar *et al*., 2016) [5]. Other pathways, such as insulin dysfunction due to insulin receptor signaling, are not fat-dependent. Elevated serine residue phosphorylation on insulin receptor substrate-1 impairs usual metabolic pathways in insulin-responsive ovarian tissues, changing receptor signaling (Diamanti-Kandarakis & Dunaif, 2012) [18]. A 2016 study by Reyes-Muñoz *et al*. found insulin resistance (IR) in 60% of patients with polycystic ovarian syndrome (PCOS). These include 78.2% of obese women and 76.00% of non-obese women. The meta-analysis by Cassar *et al*. 2016 [5] indicated that 27% of women with polycystic ovarian syndrome (PCOS) worsen. A meta-analysis by Cassar *et al*. 2016 [5] indicated that 27% of PCOS women had impaired insulin sensitivity, a sign of insulin resistance. Insulin resistance was worsened by 15% of these women's higher BMIs (Cassar *et al*., 2016) [5]. This may be caused by obesity-related abdominal fat (Dumesic *et al*., 2022) [20]. Overweight and obesity in women with PCOS exacerbate insulin resistance (IR), hyperinsulinemia, metabolic abnormalities, and reproductive characteristics (Barber *et al*., 2019) [2]. The current investigation demonstrated a link between HOMA-IR and BMI in obese PCOS patients. Obesity was linked to HOMA-IR by Svensson *et al*. (2016) [56]. Weight growth

also raised insulin resistance (IR) levels. Weight gain may increase insulin resistance due to altered MAPK and PI3K pathways (Makker *et al*., 2012) [35]. The obese group with polycystic ovarian syndrome (PCOS) had higher HOMA calculator insulin resistance (IR) than the overweight and normal weight groups. This has been documented in multiple research (Dadachanji *et al*., 2021) [11]. According to research, patients who have polycystic ovary syndrome and are obese or overweight have higher hormone levels than the control group, and this is what we found (Saleh & Al-Naddawi, 2022; Raju *et al*., 2013) [50, 49]. After the ovulation period, the increase in androgen and progesterone levels may lead to a decrease in the secretion of GnRH, which leads to the secretion of FSH during the menstrual period, which leads to the growth of eggs during the second period of menstruation (Welt *et al*., 2003) [60]. If GnRH is not slowed, FSH release will be reduced to a minimum (Chaudhari *et al*., 2018) [6]. GnRH is not effectively inhibited by progesterone and estrogen, which may explain the increased LH levels and decreased FSH levels in females with PCOS (Haisenleder *et al*., 1991) [25]. Therefore, due to the higher production of LH compared to FSH, the LH/FSH ratio is elevated in PCOS, leading to distinct hormonal markers. In addition, LH stimulates several steroidogenic enzymes in the theca cells of the ovary, promoting testosterone production (Hughesdon, 1982) [27]. Testosterone inhibits the normal feedback effects of progesterone and estradiol on the GnRH pulses, preventing LH surge and ovulation (Diamanti-Kandarakis & Dunaif, 2012) [18]. This study confirms previous research by Al-Fartosy *et al*. (2020) [66] and Chen *et al*. (2015) [7] that obese females with polycystic ovary syndrome (PCOS) have higher levels of oestrogen (E2) compared to those with normal weight.

According to Shaw *et al*. (2014) [52], increased activity of aromatase in granulosa cells may cause higher levels of estradiol in women with PCOS. Pituitary lactotroph cells secrete prolactin, and the promotion of this process is facilitated by oestrogen and dopamine receptors (DeVito *et al*., 1992) [17]. Other studies have shown elevated levels of prolactin in females with PCOS compared to females without PCOS (Mahboobifard *et al*., 2022) [34], consistent with the findings of the current study. Also, women with PCOS have increased GnRH pulsation, abnormal luteinizing hormone production, and decreased hypothalamic dopamine tone which may explain the increase in prolactin levels (Robin *et al*., 2011; Delcour *et al*., 2019) [13]. Other studies that have also shown a relationship between elevated LH and prolactin secretion in females with polycystic ovary syndrome (PCOS) and the ability of estrogen to enhance prolactin synthesis include (Venturoli *et al*., 1988 and Christin-Maître *et al*., 2007; and Azziz *et al*., 2016) [59, 1, 10]. These studies concluded that elevated prolactin levels could serve as a diagnostic indicator for PCOS. Polycystic ovary syndrome patients with high male hormone levels (hyperandrogenemia) and insulin resistance could develop thyroid dysfunction.

Raj *et al*., 2021 [48] and Singh, 2020 [54] are referenced. In the current study, obese women with PCOS exhibited significantly higher TSH levels. Controlled ovarian hyperstimulation increased TSH levels in patients with adequate thyroid function, according to Noventa *et al*. 2021 [43]. The authors hypothesized that regulated ovarian hyperstimulation would enhance thyroxine-binding protein due to elevated E2. This would lower free thyroid hormones and raise serum TSH (Noventa *et al*., 2021) [43]. Thus, we might infer that higher amounts of E2 in women with PCOS may influence thyroid hormones. In addition, Cai *et al*. 2019 [4] discovered that euthyroid-overweight women with polycystic ovary syndrome (PCOS) had higher levels of thyroid-stimulating hormone (TSH) above 2.5 mU/L. This finding is associated with hyperandrogenism, regardless of body mass index (BMI) (Cai *et al*., 2019) [4]. Thyroid hormones play a role in the generation of androgens by influencing the activity of enzymes involved in steroid synthesis (Denver, 1988) [14]. Several studies have shown that the administration of a GnRH agonist is associated with changes in thyroid hormones (Du *et al*., 2019; Han *et al*., 2013) [19, 26]. Therefore, increased synthesis of GnRH in women with PCOS may have the ability to alter thyroid hormones at the pituitary gland. The results of our study support the previous findings that there is a negative correlation between LH levels and BMI in obese women with PCOS, which is in line with the data reported by Pagán *et al*. in 2006 [45]. The researchers determined that obesity alters the abnormal LH production patterns in females with PCOS specifically at the pituitary gland, rather than in the hypothalamus (GnRH) (Pagán *et al*., 2006) [45]. The findings of Wu *et al*. (2022) [64] support our results, as they demonstrate an improvement in testosterone and LH hormone levels in obese persons with PCOS who undergo weight loss. Leptin, a major regulator produced by fat cells, may account for the increased serum levels observed in women with PCOS (Peng *et al*., 2022) [46]. Several studies have demonstrated that women with polycystic ovary syndrome (PCOS) exhibit elevated levels of leptin, which are associated with Body Mass Index (BMI) and Luteinizing Hormone (LH) levels (Jalilian *et al*., 2016) [30]. However, other researchers were unable to establish a correlation between BMI and LH in persons with PCOS who are overweight or obese (Esmaeilzadeh *et al*., 2015) [23].

The current study found that overweight people have lower FSH, LH, and E2 levels than normal-weight people. In the overweight cohort, FSH levels correlated negatively with BMI. Previous research reported reduced LH, E2, FSH, and inhibin B levels in overweight women. The study also found an inverse relationship between hormone levels and BMI. Weight inhibits gonadotropin and ovarian E2 production, according to studies (De Pergola *et al*., 2006) [12]. Higher body weight increases leptin, which suppresses gonadotropin synthesis and E2 release by granulosa cells. Thus, overweight people may have higher leptin levels (Metwally *et al*., 2007) [37], which may influence pituitary FSH release in proportion to BMI (Moschos *et al*., 2002) [39]. More leptin research is needed to prove this notion.

Conclusion

In light of our research, we can deduce that BMI substantially impacts the IR pathophysiology of Iraqi PCOS women who are obese. Moreover, our findings suggest that BMI has a suppressive impact on FSH release in overweight women. Obesity impacts the irregular patterns of LH production in females with PCOS. BMI suppresses gonadotropin release across the two overweight and obese PCOS groups. A significant issue is that the study failed to find any relationship between IR and the studied hormones. As a result, we presume that IR seems to have no

inhibitory/stimulatory activity on the pituitary-ovary and pituitary-thyroid axes.

Ethical approval

Prior to the sample collection process, all patients participating in this study were duly informed and provided verbal consent. The study received approval from the Committee on Publication Ethics at the Martyr Mohammed Baqer Al-Hakim Hospital, Baghdad, Iraq.

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