The Pivotal Influence of Obesity on Body Composition and Ovarian Doppler in Different Polycystic Ovarian Syndrome Phenotypes

Shymaa A. Shalaby[1], Doaa A. Osman[2], Sondos M. Salem[3], Mahmoud Zaatar[3], Kareem El-Nahhas[3], Safenaz Y. El Sherity[4]*

[1]Radiodiagnosis department, Faculty of Medicine, Helwan University, Cairo, Egypt.
[2]Department of Physical Therapy for Woman's Health, Faculty of Physical Therapy, Cairo University, Cairo, Egypt.
[3]Obstetrics and Gynecology Department of Reproductive Health and Family Planning, Medical Research and Clinical Studies Insitute, National Research Centre, Cairo, Egypt (Affiliation ID 60014618).
[4]*Biological Anthropology Department, Medical Research and Clinical Studies Insitute, National Research Centre, Cairo, Egypt (Affiliation ID 60014618).

***Corresponding author:** Dr. Safenaz Y. El Sherity
*Assistant Professor, Biological Anthropology Department, Medical Research and Clinical Studies Insitute, National Research Centre (NRC), and A head of radiology department at Medical Research Centre of Excellence (MRCE), Dokii, Cairo, Egypt. E-mail: dr_safy_youssif@yahoo.com , Mobile: 002 – 01003980727, Postcode: 11331.

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Abstract
Aim: To investigate the effect of obesity on body composition and ovarian Doppler parameters in females with different polycystic ovarian syndrome (PCOS) phenotypes, and find the correlations between these parameters and PCOS clinical criteria.
Design: Observational cross-sectional study.
Methods: One hundred PCOS females participated in this study. We assessed the chronic anovulation (O), the hyperandrogenism (H), and polycystic ovaries (P) to classify the presence of PCOS phenotyping using the Rotterdam criteria into four types. They were classified according to their body mass index (BMI) into three groups. The normal weight group had BMI of 18.5-24.9 kg/m^2 (n = 21); the overweight group had BMI of 25-29.9 kg/m^2 (n = 39); the obese group had BMI of more than or equal to 30 kg/m^2 (n = 40). Body composition parameters were evaluated by dual-energy X-ray absorptiometry (DEXA), while ovarian Doppler parameters were evaluated by colour Doppler ultrasound for all females in the three groups.
Results: Obese PCOS females had significantly higher waist-hip ratio (WHR), total and regional fat mass, total and trunk lean mass, ovarian volume and blood flow velocities at both ovarian arteries than both normal weight and overweight PCOS females. The WHR was positively correlated to total fat and lean masses, as well as ovarian volume and blood flow velocities (P<0.05). The phenotype III and IV had significantly higher android & gynoid fat masses, total lean mass, also higher ovarian volume, PSV & EDV and significantly lower RI (P<0.05) comparing to type I and II.
Conclusion: Obesity has a pivotal role in body composition distribution and ovarian Doppler parameters in different PCOS phenotypes.

Keywords: Obesity, body composition, ovarian blood flow, polycystic ovarian syndrome, phenotypes.

INTRODUCTION
Polycystic ovarian syndrome is a complex multifactorial condition, accompanied by endocrinological, reproductive, metabolic and biochemical abnormalities, accounting for 12% to 21% of reproductive-aged females [1]. Polycystic ovary syndrome (PCOS) has become a major public health international concern. While there is a controversy between the patient selection and diagnostic criteria, to estimate its prevalence [2].
Obesity and fat distribution have a critical role in PCOS etiology [3]. More than 50% of PCOS females suffer from overweight and obesity, particularly central obesity [4]. However, both obese and non-obese females with PCOS are susceptible to insulin resistance, which is positively correlated to BMI [5]. Additionally, menstrual dysfunction, hyperandrogenaemia and infertility appear in PCOS females regardless of their weight [4].
Colour Doppler ultrasound (US) represents a non-invasive tool for ovarian morphological assessment and ovarian blood flow quantification, helping PCOS diagnosis and providing more information about its pathophysiology [6]. Several studies showed significant differences in ovarian volume and blood flow between PCOS females and their normal counterparts [7-8].
Previous studies compared ovarian volume and blood flow indices between obese and non-obese females with PCOS [9,10]. However, they used different cut-off points for identifying obese and non-obese females. Additionally, none of

them had compared ovarian volume and blood flow parameters between normal weight, overweight and obese PCOS females. Therefore, the current study aimed to investigate the effect of obesity on body composition and ovarian Doppler parameters in different PCOS phenotypes and find the correlations between these parameters and PCOS clinical criteria.

MATERIALS AND METHODS

Study Design

This study was an observational cross-sectional design. Ethical approval was obtained from the institutional review board at the Faculty of Physical Therapy, Cairo University before study commencement [No: P.T.REC/012/004609]. The study followed the Declaration of Helsinki Guidelines on the conduct of the human research.

Recruitment

A convenient sample of one hundred Egyptian females with PCOS participated in this study. They were recruited from the gynaecology and infertility clinic for Doppler sonographic examination and body composition analysis. A consent was obtained from each participating female after explaining the purpose and benefits of this study, then informed of all rights to refuse or withdraw from the study at any time, and about the confidentiality of any obtained information.

The inclusion & exclusion criteria:

To be included in the study, the participants were chosen females suffering from PCOS. They should have two of the 3 features of Rotterdam criteria for the diagnosis of PCOS which include oligo-or anovulation (O), clinical and/or biochemical signs of hyperandrogenism (H) (ie, hirsutism, acne, male pattern balding, elevated serum androgens), and polycystic ovaries on ultrasonography (P) (the ovarian volume >10 cm^3) [11]. The females' age ranged from 18 to 40 years. The participants were excluded if they had congenital adrenal hyperplasia, thyroid dysfunction, hyperprolactinemia, androgen-secreting tumors and Cushing syndrome. All females did not receive any medical therapy for PCOS treatment or weight loss.

Outcome measures

PCOS Phenotypes:

PCOS phenotypes were divided into 4 types: type (I), oligo/amenorrhea and hyperandrogenism (O+H); type (II), polycystic ovaries and hyperandrogenism (P+H); type (III), oligo/amenorrhea and polycystic ovaries (O+P); and type (IV), oligo/amenorrhea, polycystic ovaries and hyperandrogenism (O+P+H) [12].

Anthropometric parameters

Body weight, height, waist and hip circumferences were taken following the International Biological Program recommendations [13]. Weight was taken using a balance Seca Scale with light clothing and no shoes, while a Holtain anthropometer was used to assess the height. Then, BMI was calculated by dividing weight by height squared (Kg/m^2). Additionally, the WHR was calculated after measurement of both waist and hip circumferences. The waist circumference (WC) was measured when the tape measure was positioned horizontally just above the iliac crest and exactly under the umbilicus, while the hip circumference (HC) was measured by a tape measure at the largest buttocks circumference.

Body composition parameters

Dual-energy X-ray absorptiometry (Lunar encore software version 16 GE Healthcare, Madison, WI, USA) was used to measure body composition parameters for all PCOS females in the three groups. The measured body composition parameters included total fat and lean mass, as well as regional fat and lean mass (g) at the trunk, android and gynoid regions. The trunk region included the neck, chest, abdominal and pelvic areas. It extended from the inferior edge of the chin to a line intersecting the middle of the femoral necks without touching the brim of the pelvis. The android region included the area between the ribs and the pelvis that was enclosed by the trunk region. The gynoid region included the hips and upper thighs and overlapped both the leg and trunk regions [14].

Ovarian Doppler parameters

The Sonographic examination was done using (GE, HD, Volusion P 8). It was performed during the early follicular phase (between the 3^{rd} and 5^{th} days of the menstrual cycle). All females were examined at the same time of the day to avoid the circadian rhythm of the ovarian blood flow. They were examined in the supine position, for ovarian volume and ovarian artery blood flow parameters (Fig. 1), by the same sonographic specialist doctor, as the following:

<u>B mode:</u> Pelvic assessment was performed using a 4.5 MHz abdominal transducer with full bladder, while transvaginal examination was performed using a 6.5 MHz transducer after bladder evacuation. The largest longitudinal, anteroposterior and transverse diameters of each ovary were measured, and the ovarian volume was calculated using the ellipse formula (length × width × height × 0.523) [15].

<u>Colour Doppler ultrasound examination:</u> The right and left ovarian arteries were detected lateral to the superior pole of the ovaries, near the infundibulopelvic ligament or at the hilum. For ovarian blood flow measurements, colour signals

were detected in the ovarian stroma at the maximal distance from the surface of the ovary. Three waveforms were recorded on each side from the ovarian artery and the average was included in the calculations. The ovarian blood flow velocities, including peak systolic velocity (PSV) and end-diastolic velocity (EDV) were recorded. Then, the ovarian blood flow indices, including resistive index (RI) and pulsatility index (PI), were calculated. The RI was calculated as the difference between PSV and EDV divided by PSV, while the PI was calculated as the difference between PSV and EDV divided by the mean maximum flow velocity. The PSV reflects the extent of vascular filling and blood supply, while the EDV reflects the blood perfusion of the distal tissue and a numerical drop shows a shortage of the distal blood supply. Both RI and PI reflect impedance to blood flow, and lower values of RI and PI reflect higher blood flow [15-16].

Statistical Analysis:

Data were analyzed using the SPSS version 25; mean ± standard deviations (SD) for parametric data, using ANOVA test for comparison between three groups. Pearson´s Partial correlation test was used to assess the association and correlation between variables with controlling BMI effect, also scatter plots were done ($P < 0.05$ was statistical significance).

Results

This study included one hundred Egyptian females with PCOS; their age (18-40 years, mean 29.2 years ± 5.2 SD), 41% of them were 25-30 years. While their weight range (61–109 kg); height (153–169 cm); WC (78-118 cm), HC (88-138 cm) and WHR (0.47-0.94). They were classified into three groups according to BMI; normal weight (21), overweight (39) and obese (40). Age showed insignificant differences between three groups. While regarding PCO phenotypes; type I (48), type II (7), type III (29) and type IV (16) (Fig.2).

All anthropometric parameters of obese PCOS females had significantly higher BMI, WC, HC and WHR than both normal-weight and overweight PCOS females (P<0.05). Additionally, overweight PCOS females had significantly higher BMI than both normal-weight (P<0.05) (Table 1).

Body composition parameters of obese PCOS females had significantly higher total and regional fat mass at all measured sites, as well as total and trunk lean mass (P<0.05) than normal-weight PCOS females. Overweight PCOS females had significantly higher total and regional fat mass at all measured sites (P<0.05), non-significantly higher total and trunk lean mass (P>0.05) than normal weight PCOS females. Obese PCOS females had significantly higher body composition parameters (P<0.05) than overweight PCOS females (P>0.05) (Table 1).

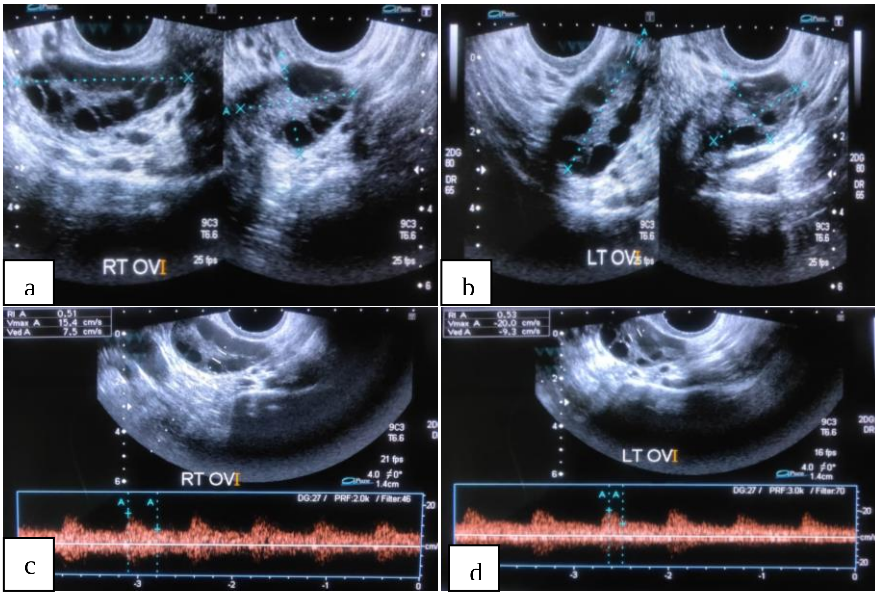

Fig. 1: Transvaginal Doppler sonography images; (a and b) longitudinal and transverse B-mode scan to estimate ovarian volume at the obese female; (Right ovarian volume is 17.4 cm^3 and left ovarian volume is 15.2 cm^3, (c & d) doppler examination images for ovarian artery, showed RI (0.51 and 0.53 for the right and left respectively).

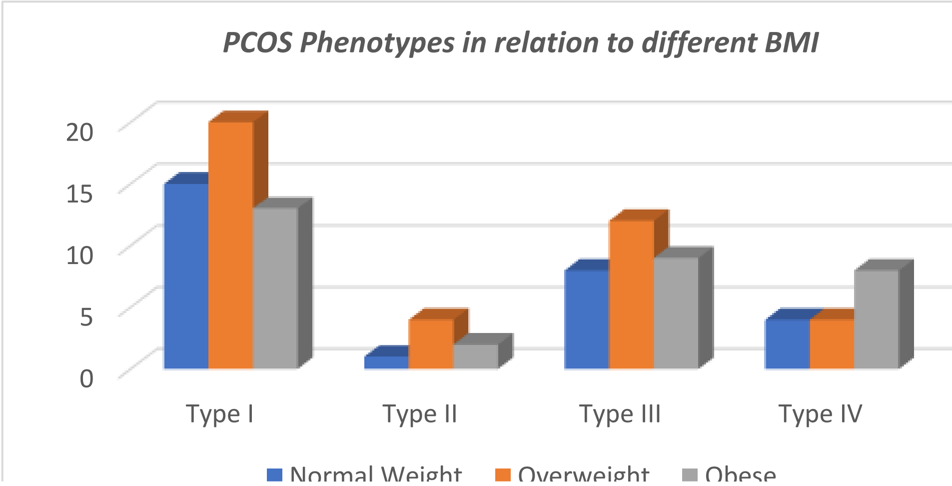

Figure 2: PCOS Phenotypes in relation to different BMI (**Type I**: oligo/amenorrhea & hyperandrogenism, **type II**: polycystic ovaries US & hyperandrogenism, **type III:** oligo/amenorrhea and polycystic ovaries US and **type IV**: oligo/amenorrhea, ultrasonography polycystic ovaries and hyperandrogenism).

Ovarian Doppler ultrasonography parameters revealed that obese PCOS females had significantly higher ovarian volume, PSV and EDV (P<0.05) than both normal-weight and overweight PCOS females and significantly lower RI and PI (P<0.05) than normal-weight PCOS females only. Overweight PCOS females had significantly lower RI and PI (P<0.05) than normal-weight PCOS females (Table 2).
Different PCOS phenotypes revealed that phenotypes III and IV had significantly higher total lean mass, android and gynoid fat masses. In addition, had significantly higher ovarian volume, PSV & EDV and significantly lower RI (P<0.05) compared to type 1 and II (Table 3).

Table 1: Anthropometric and Body composition parameters of normal weight, overweight and obese PCOS females

	Normal-Weight No. (21)	**Overweight No. (39)**	**Obese No. (40)**	**p-value**
	Mean±SD	Mean±SD	Mean±SD	
Anthropometric parameters				
BMI (kg/m^2)	22.2± 1.7[ab]	28.1± 1.3[b]	33.9± 3.8	0.00
WC (cm)	80.3±3.4[ab]	87.0± 6.9[b]	98.7± 8.9	0.00
HC (cm)	97.7±7.1[ab]	106.5± 6.6[b]	114.5± 9.0	0.00
WHR	0.824± 0.04[b]	0.818± 0.06[b]	0.862± 0.04	0.00
Body composition parameters				
Total fat (Kg)	25.6± 3.9[ab]	32.9± 3.2[b]	39.0± 4.5	0.00
Trunk fat mass (Kg)	4.1±1.8[ab]	17.1± 8.9[b]	24.2± 3.8	0.00
Total lean (Kg)	36.5± 2.9[b]	38.3± 2.5[b]	43.3± 6.2	0.00
Trunk lean mass (Kg)	22.0± 4.9[b]	23.9± 3.4[b]	29.6± 1.3	0.00
Android fat mass (Kg)	0.95± 0.6[ab]	2.60± 0.8[b]	4.4± 0.7	0.00
Gynoid fat mass (Kg)	1.9± 0.6[ab]	5.1±1.4[b]	8.3± 1.0	0.00

* $P \leq 0.05$ Significant [a] P≤0.05 relative to overweight group; [b]P≤0.05 relative to obese group.

Table 2: Ovarian Doppler sonography parameters of normal weight, overweight and obese PCOS females

	Normal-Weight No. (21)	**Overweight No. (39)**	**Obese No. (40)**	**p-value**
	Mean±SD	Mean±SD	Mean±SD	
Right ovarian volume (cm^3)	16.7±3.2[b]	16.1±4.3[b]	22.18±6.7	0.00
Right ovarian artery PSV (cm/s)	18.7±6.1[b]	18.7±6.6[b]	28.5±6.7	0.00
Right ovarian artery EDV (cm/s)	5.2±1.9[b]	6.4±2.4[b]	10.2±3.5	0.00
Right ovarian artery RI	0.80±0.08[ab]	0.64±0.08	0.63±0.09	0.00
Right ovarian artery PI	1.82±0.9[ab]	1.10±0.4	1.03±0.3	0.00

Left ovarian volume (cm^3)	13.7±3.5[b]	13.0±4.4[b]	20.7±7.1	0.03
Left ovarian artery PSV (cm/s)	18.3±5.6[b]	16.1±4.9[b]	22.6±7.4	0.00
Left ovarian artery EDV (cm/s)	4.8± 0.9[b]	5.3± 1.7[b]	8.0±2.3	0.00
Left ovarian artery RI	0.71± 0.13[ab]	0.62± 0.09	0.61±0.16	0.001
Left ovarian artery PI	1.85± 0.87[ab]	1.42± 0.33	1.32±0.40	0.00

* $P \le 0.05$ Significant [a] $P \le 0.05$ relative to overweight group; [b]$P \le 0.05$ relative to obese group.

Table 3: BMI, Body composition and Ovarian Doppler sonography parameters in different PCOS phenotypes

	Type I No. (48)	Type II No. (7)	Type III No. (29)	Type IV No. (16)	p-value
	Mean± SD	Mean± SD	Mean± SD	Mean± SD	
Anthropometric parameters					
BMI (kg/m^2)	30.1±2.7	25.2±1.6	27.2±1.5	29.2± 1.1	0.06
Body composition					
Total fat (Kg)	35.6± 2.8	32.7± 2.2	37.0 ± 6.5	36.0 ± 6.5	0.07
Total lean (Kg)	33.5± 2.9[bC]	36.3± 2.4	41.3± 5.2	41.8± 4.8	0.01
Trunk fat mass (Kg)	22.1± 3.6	25.6± 3.8	24.4± 2.7	24.1± 3.6	0.06
Android fat mass (Kg)	2.7±0.5[bC]	2.6± 0.6[bC]	3.4±0.7	3.2 ± 0.6	0.01
Gynoid fat mass (Kg)	6.1± 1.4[bC]	5.6± 1.6[bC]	8.1± 1.2	8.2± 1.0	0.00
Ovarian Doppler sonography					
Ovarian volume (cm^3)	16.5± 2.1[bC]	18.1± 3.3	22.0± 4.5	21.2± 5.7	0.00
Ovarian artery PSV (cm/s)	20.7± 6.4[bC]	18.5± 6.6	28.4± 4.6	26.5± 5.5	0.00
Ovarian artery EDV (cm/s)	5.6± 2.9[bC]	6.2±2.3[bC]	8.2± 3.2	10.3± 3.6	0.00
Ovarian artery RI	0.76±0.0 [bC]	0.62±0.08	0.64±0.09	0.63±0.08	0.00
Ovarian artery PI	1.02± 0.7	1.18± 0.6	1.13± 0.3	1.08± 0.8	0.06

* $P \le 0.05$ Significant [a] $P \le 0.05$ relative to type II phenotype; [b]$P \le 0.05$ relative to type III phenotype, [c]$P \le 0.05$ relative to type IV phenotype.

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The correlations between body composition parameters and anthropometric parameters, the fat mass at the total body, trunk and gynoid regions had significant positive correlations with BMI, WC, HC and WHR ($P<0.05$). The total lean mass also showed significant positive correlations with all anthropometric parameters ($P<0.05$) (Table 4).

Moreover, the partial correlations between body composition parameters and ovarian Doppler parameters with the controlling effect of BMI, all body composition parameters showed no significant correlations with the ovarian volume ($P>0.05$). The total fat mass showed a significant positive correlation with ovarian RI ($P<0.05$), and a significant negative correlation with ovarian EDV ($P<0.05$). For the regional fat mass, both android and gynoid fat mass were positively correlated to ovarian RI ($P<0.05$), and both trunk and gynoid fat mass were negatively correlated to ovarian PI ($P<0.05$). Concerning total lean mass, showed significant positive correlations with ovarian RI and PI ($P<0.05$) (Table 5).

Finally scatter plot (Fig. 3) was done between WHR and PSV (a), EDV (b) & ovarian volume (c), which showed statistically significant correlations (r= 0. 20, 0.12 and 0.20 respectively).

Table 4: Correlations between body composition and anthropometric parameters in PCOS females

		Total fat mass	Trunk fat mass	Total lean mass	Trunk lean mass	Android fat Mass	Gynoid fat mass
BMI	r	.897**	.764**	.803**	-.154	.685	.799**
	p	.000	.000	.000	.127	.215	.000
WC	r	.767**	.660**	.819**	-.140	.484	.687**
	p	.000	.000	.000	.165	.150	.000
HC	r	.765**	.605**	.742**	-.237	.514	.613**
	p	.000	.000	.000	.118	.125	.000
WHR	r	.229*	.303**	.356**	.088	.106	.344**
	p	.022	.002	.000	.385	.292	.000

r=Pearson correlation coefficient, *Correlation is significant at the 0.05 level.

Table 5: Correlations between body composition and ovarian Doppler sonography parameters in PCOS females

		Total fat mass	Trunk fat mass	Total lean mass	Trunk lean mass	Android fat Mass	Gynoid fat mass
Right ovarian volume	r	.278**	.002	.059	.091	.112	.070
	p	.005	.981	.563	.372	.268	.488
Right ovarian artery PSV	r	.012	-.041	.180	.275**	.318**	-.025
	p	.907	.684	.074	.006	.001	.805
Right ovarian artery EDV	r	-.305**	.100	-.103	-.069	-.016	.183*
	p	.002	.325	.310	.499	.879	.040
Right ovarian artery RI	r	.203*	.014	.080*	.168*	.240**	.136*
	p	.043	.889	.034	.046	.017	.017
Right ovarian artery PI	r	.129	-.243	.253	.337	.186	-.212
	p	.205	.015*	.012*	.001**	.066	.035*
Left ovarian volume	r	.353**	.042	.062	.096	.129	.123
	p	.000	.680	.541	.346	.204	.226
Left ovarian artery PSV	r	-.197	-.028	.115	.221*	.197*	.026
	p	.060	.781	.256	.028	.051	.799
Left ovarian artery EDV	r	-.418**	.136	-.167	-.153	-.124	.233*
	p	.000	.179	.099	.132	.222	.020
Left ovarian artery RI	r	.325**	-.170	.281**	.359**	.299**	.217*
	p	.001	.092	.005	.000	.003	.031
Left ovarian artery PI	r	-.193	-.156*	.113*	.173*	.036	-.070*
	p	.055	.012	.026	.016	.720	.049

r=Pearson correlation coefficient, *Correlation is significant at the 0.05 level

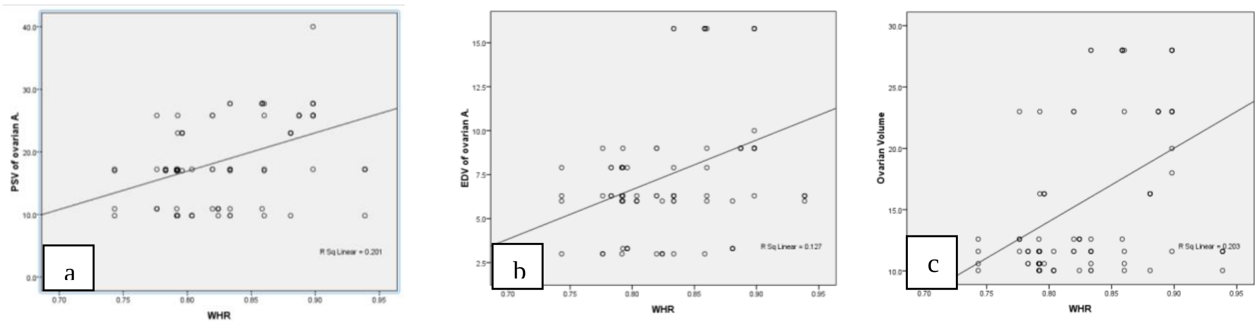

Fig. 3: Scatter plot shows the statistically significance correlation between WHR and mean PSV (a), EDV (b) and ovarian volume (c) (r= 0. 20, 0.12 and 0.20 respectively)

DISCUSSION

Polycystic ovarian syndrome is a chronic complex disorder, that significantly affects the body composition [17-18], as well as the ovarian volume and blood flow of PCOS females compared to normal [7-9]. However, little is known about body composition and ovarian Doppler parameters of obese versus overweight and normal-weight PCOS females. Therefore, this cross-sectional study aimed to evaluate body composition, as well as ovarian volume and blood flow in obese, overweight and normal-weight females with different PCOS phenotypes.

The current study showed that 21% of PCOS females had normal-weight, 39% of them had overweight and 40% of them had obesity. These findings were consistent with Hanif et al. [19] who found that 80% of PCOS females were overweight and obese, suggesting a higher incidence of PCOS in overweight and obese females. Additionally, the mean of WHR in the three groups was more than 0.8, indicating central obesity in PCOS females with different BMI [20]. These results suggested a greater central obesity in obese PCOS females when compared to the other two groups.

Both normal-weight and overweight PCOS females had significantly lower total and regional fat mass at (total body, trunk, android and gynoid regions) when compared to obese PCOS females. These findings were consistent with Kogure et al. in Brazil[21], Jin et al. in Korea[22] and Jalilian et al. in Iran[23]. While both normal-weight and overweight PCOS females had significantly lower total lean mass when compared to obese PCOS females. This result could be attributable to the greater levels of hyperandrogenism and insulin resistance in obese PCOS females.

The excess androgen and high insulin resistance could subsequently induce total lean mass increase in obese PCOS females through its anabolic effects on the skeletal muscle mass [24 -25]. Moreover, the current study showed that there was a non-significant difference between normal-weight and overweight PCOS females concerning total lean mass.

This result suggested that there was a critical threshold for BMI, beyond which hyperandrogenism and insulin resistance could affect the total lean mass.
The current study revealed that obese PCOS females had significantly increased ovarian volumes on both ovaries in comparison to overweight and normal-weight PCOS females. These results were supported by Usmani et al. [26], who found a positive correlation between BMI and ovarian volume in PCOS females, indicating that increased BMI is associated with increased ovarian volume in PCOS patients. Also, Crosignani et al. [27], reported a reduction in ovarian volume by 18% in PCOS females who lost 5% of their weight, and a reduction of 27% in PCOS females who lost 10% of their weight. They suggested that the reduction in ovarian volume could be attributed to the effect of weight loss on reducing free androgen levels, improving insulin sensitivity and reducing micro-follicles and ovarian stroma.
Regarding the PCOS phenotypes frequencies; the current study revealed that the most frequent phenotypes were I and III (48% and 29% respectively), phenotype IV was found in 16%, while type II was found in 7%. These results are supported by the study conducted by Gluszak and his colleagues [28], as the prevalence rates for phenotype were; I (60.2%), II (16.1%), III (18.3%), and IV (5.4%). Also, Pehlivanov and Orbetzova [29] demonstrated the same results in their study. The current study demonstrated that there was a statistically significant between different PCOS phenotypes with the ovarian volume and ovarian artery parameters. These findings were consistent with the study of Guraya S. [30], and Ali H. et al. [16].
The results of the current study revealed that obese PCOS females had significantly increased PSV and EDV parameters on both ovaries during the early follicular phase in comparison to overweight and normal-weight PCOS females. In addition, RI and PI on both ovaries showed a significant decrease in both obese and overweight PCOS females compared with normal weight PCOS females. These results were explained by Samy et al. [31] who reported significant positive correlations between BMI and inflammatory markers levels in PCOS, these markers caused vasodilation of blood vessels and increased blood flow, which may explain the significant increase of ovarian blood flow in PCOS females in the obese.
Moreover, there is a significant positive correlation between WHR and both ovarian blood flow velocities (PSV and EDV) indicating that the increased ovarian blood flow velocities in the obese might be attributed to the increased WHR. In contrast, Lam et al. [32] and Battaglia et al. [33] reported a non-significant difference in PSV, EDV, RI and PI of ovarian vessels between obese PCOS females and normal-weight PCOS females. Also, the increased ovarian blood flow in obese PCOS females was inconsistent with a previous study, which found non-significant differences in RI and PI between obese PCOS females and non-obese PCOS females [34]. This controversy could be related to the variations in the study design and the criteria for PCOS diagnosis.
Regarding the correlations between body composition and anthropometric parameters; the total lean mass, as well as the fat mass at the total body, trunk and gynoid regions, were positively correlated to all anthropometric parameters.
Although the correlations between body composition and ovarian Doppler parameters; the fat mass was positively correlated to ovarian RI at the total body, android and gynoid regions. Additionally, the fat mass was negatively correlated to ovarian PI at both trunk and gynoid regions. Concerning total lean mass was positively correlated to the ovarian blood flow indices (RI and PI).
In the current study, the body composition parameters weren’t correlated to both ovarian volumes. This result was consistent with Dolfing et al. [35] who reported no significant correlations between the fat measures at all sites and the ovarian volumes on both sides. Nevertheless, the results of the current study showed a positive correlation between WHR and ovarian volume in PCOS females. This finding agreed with Gharakhani et al. [36] who found the same correlation in PCOS patients.
The current study had some limitations such as the cross-sectional nature of the study. Therefore, further longitudinal studies are needed to explore the long-term effect of obesity on body composition and ovarian Doppler parameters in PCOS females. The strengths of this study included the use of Rotterdam criteria for the diagnosis of PCOS females, as well as the gold-standard assessment for body composition and ovarian Doppler parameters.

Conclusions and Clinical Implication

Clinical markers for PCOS, Body composition and ovarian Doppler parameters are affected by obesity in different PCOS phenotyping. Therefore, assessment of these parameters should be incorporated in the management of obese PCOS females undergoing weight loss protocols.

Conflict of interest

The authors state no conflict of interest.

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Author contribution

Shymaa A. Shalaby: Acquisition of the ultrasonographic data. **Doaa A. Osman:** Drafting the work and revising it critically for important intellectual content. **Sondos M. Salem:** Clinical assessment**. Mahmoud Zaatar:** Design of the work. **Kareem El- Nahhas:** Acquisition of the data and **Safenaz Y. El Sherity** (corresponding author): Analysis and interpretation of the data. All authors shared in design of the work and final approval of the version to be published.

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