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METHODS

Readdressing pathophysiology of polycystic ovary syndrome in post-COVID new normal era: A pilot study

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Background: Polycystic ovary syndrome or PCOS is a complex endocrinopathy in women of reproductive age. The diversified expression pattern of this multigenic syndrome and its complex association with modulation in nutritional status, anthropometric indices, and biochemical parameters are still in puzzle. The COVID-19 pandemic has worsened the existing crosstalk by changing lifestyle toward more home confinement as well as sedentary.
Aims and objectives: This study aimed to understand the effect of altered dietary patterns, anthropometric parameters like various adiposity indices, and biochemical parameters related to hyperandrogenism (HA) on the penetrance of PCOS in a new normal situation.
Design: PCOS individuals (n = 50) and their age and gender (18–36 years)-matched healthy control (n = 50) were recruited in this study.
Materials and methods: Food frequency questionnaire (FFQ), bioimpedance analyzer (BIA), and biochemical assays were used to estimate different indices of the participants.
Statistical analysis: IBM SPSS (Statistical Package for the Social Sciences), Version 20.0, Armonk, NY, was applied for analyzing quantitative variables ($P < 0.05$ and $P < 0.01$ indicate significance level).
Results: Consumption of dietary fat ($P < 0.01$) and carbohydrates ($P < 0.05$) were significantly higher in PCOS individuals compared to the control one; 94% of PCOS patients were found to be under oligomenorrhea+polycystic ovaries (O+PCO) category. The body fat content ($P < 0.01$ and 0.05) along with intrauterine androgen exposure (digit ratio-2D:4D, $P = 0.000$) were significantly higher and lower respectively, in PCOS individuals relative to the control group. HA was highly prevalent in the PCOS group where 100% of them manifested alopecia, and significant ($P < 0.01$) correlation between free testosterone (free T) and free sex-hormone-binding-globulin (FSHBG) was also found. Low-density lipoprotein (LDL) was strongly associated with waist-to-height ratio (WHtR, $P = 0.02$) and body mass index (BMI, $P = 0.041$) in the same way as homeostatic model assessment for insulin resistance (HOMA-IR) with visceral adiposity index (VAI, $P = 0.002$) and lipid accumulation product (LAP, $P = 0.014$) index in PCOS individuals. Additionally, the triglyceride glucose (TyG) index was normally distributed (Kolmogorov–Smirnov test = 0.20) in PCOS individuals.
Conclusion: Abnormal alternation in dietary patterns, and anthropometric and biochemical indices could be promising indicators for early detection and better prognosis of this multifaceted syndrome.

Keywords: PCOS, adiposity indices, hyperandrogenism, HOMA-IR, 2D:4D ratio, TyG index

1. Introduction

Polycystic ovary syndrome, commonly referred to as PCOS, is a multifaceted endocrine disorder vexing reproductive-aged females (1). This syndrome is found in 4–7% in world and 4–20% of women in India (2). The COVID-19 pandemic potentially exaggerates the existing complication by inducing stress and obesity (3).

The wild-type characteristics of this condition are hyperandrogenism (HA) and its cutaneous manifestation such as alopecia, acanthosis nigricans (AN), hirsutism, and acne, and menstrual irregularities (4). Abnormally altered biochemical profile, anthropometric indices like adiposity indices including VAI and LAP, and poor nutritional habit are the inducing factors in the expressivity of PCOS and are associated with other health complications such as IR, obesity, obstructive sleep apnea (OSA), and cardiovascular diseases (CVDs) (3–8). Body surface area (BSA), visceral fat (VF), BMI, body adiposity index (BAI), total adipose tissue mass (TATM), and total adipose tissue fat mass (TATFM) are some non-invasive, simple, and easy-to-handle anthropometric indices to determine obesity, which can be applied in the screening process for early and quick detection of PCOS expression (9). In human, the length of the index finger (the second digit, or 2D), divided by the ring finger (the fourth digit, or 4D), is defined as the 2D:4D ratio and shows consistent significant sexual dimorphism with the ratio being commonly <1 in male and ≥ 1 in females. Studies have shown the second-to-fourth digit ratio as a promising indicator of exposure to androgens like testosterone (T) and estrogens like estradiol (E2) in intrauterine life where it was found to have a negative correlation with prenatal T and a positive correlation with prenatal E2 (10). Reduced 2D:4D ratio was reported to be significantly correlated with PCOS expression in eastern Indian population (11). Triglyceride glucose (TyG) index (fasting triglyceride (TG) and glucose ratio) is a highly effective, simple, and low-cost method for identifying IR in patients (12, 13). In Chinese PCOS population, Zheng et al. reported a positive correlation between the TyG index and the homeostatic model assessment for insulin resistance (HOMA-IR) (13). As both the parameters TG and IR are highly variable depending on ethnicity, this study aimed to address these indices in ethnic population of West Bengal (WB). The objective of this pilot study is to assess the significance of deviated dietary patterns, altered anthropometric parameters (i.e. adiposity indices), intrauterine androgen marker (i.e. 2D:4D ratio), and easy-to-assess biochemical parameters like TyG index for predicting IR of PCOS patients in the ethnic population of WB, India.

2. Materials and methods

2.1. Study design

In this study, women with PCOS (n = 50, age 18–36 years) having complications with their menstruation and fertility and their age-matched healthy control women (n = 50) in and around Kolkata, WB, India, were recruited. The survey work got approval from the institutional ethical committees of University of Calcutta (CUIEC/04/2018-19) and Medical College and Hospital, Kolkata (MC/KOL/IEC/NON-SPON/1275/02/22) and was conducted from May 2022 to December 2022. Necessary consent was taken from all participants by predesigned and approved trilingual consent form.

2.2. Inclusion criteria

PCOS individuals were recruited based on Rotterdam criteria, 2003 [European Society of Human Reproduction and Embryology, ESHRE/American Society for Reproductive Medicine, ASRM]. PCOS patients were defined as those who met two of the following three criteria: (i) oligo-ovulation or anovulation with an intermenstrual interval of 35 days or >3 months respectively, (ii) clinical and/or biochemical HA, and (iii) polycystic ovaries (PCO, 2–9 mm in size and multiple cysts of greater than 12 in number) in gynecological ultrasound (1).

2.3. Exclusion criteria

Women having a medical history of drug ingestion such as androgens were ruled out (14). Those with physical and/or cognitive limitations and pregnant or lactating were excluded from the study (15, 16). Etiological factors including prolactinoma, virilizing tumor, Cushing syndrome, and congenital adrenal hyperplasia (CAH) simulating PCOS were also excluded (1).

2.4. Survey of nutritional status

The nutritional status was evaluated by using the food frequency questionnaire (FFQ) method (17). Food items including wheat, cereals, millets, fruits, roots, tubers, grain legumes, vegetables, nuts, oil seeds, milk, poultry, egg, animal meat, fish, and food ingredients including condiments, spice, and cooking oil were taken to be analyzed (18). Spoons and bowls of various sizes were used to estimate the weight of different food items, and the nutritional values of the raw

ingredients were estimated following the guidelines of the Indian Council of Medical Research (ICMR) (18).

2.5. Cutaneous manifestation

Phenotypes such as alopecia and hirsutism were assessed using modified Norwood and Ferriman-Gallwey (F-G) scores, respectively, (4, 19). Velvety and pigmented skin in the neck and antecubital fossa region was classified as AN, and nodules in the face, neck, and back were categorized as acne (4, 19).

2.6. Estimation of anthropometric indices

Height (cm) was estimated barefoot using ultrasonic technology-based portable stature (1). Body mass (kg), BMI (kg/m^2), VF (total), subcutaneous-whole-body fat% (SWBF%), and skeletal muscle of whole body% (SMWB%) of the participants were measured with minimum garments using a body composition monitor based on the bioelectrical impedance [bioimpedance analyzer (BIA), Model: OMRON-HBF-375]. Circumferences (cm) of the waist (WC, the midpoint between top of iliac crest and lower margin of last palpable rib), hip circumference (HC, the broadest portion of the buttock), and mid-upper arm (MUCA, the midpoint between the elbow and the tip of the shoulder (left hand), i.e. olecranon process and the acromion) were measured with or without minimum clothes using measuring tape (1, 20).

Waist-to-height ratio (WHtR), BAI, TATM, TATFM, BSA, 2D:4D ratio (left hand), VAI, and LAP were measured by the following formulae (5, 6, 9, 10, 21, 22):

$$\text{WHtR} = \frac{\text{WC (cm)}}{\text{height (cm)}}$$

$$\text{BAI (\%)} = \frac{\text{HC (cm)}}{\text{height (m)}^{1.5}} - 18$$

$$\text{TATM (kg)} = 0.789^{*}\text{weight (kg)} + 0.0786^{*}\text{age (years)} - 0.342^{*}\text{height (cm)} + 24.5$$

$$\text{TATFM} = \text{TATM}^{*}0.80$$

$$\text{BSA (m}^2\text{)} = \frac{[\text{weight (kg)}^{*}\text{height (m)}]^{0.5}}{6}$$

$$\text{2D : 4D ratio} = \frac{\text{2D length (mm)}}{\text{4D length (mm)}}$$

$$\text{VAI} = \frac{\text{WC (cm)}}{36.58 + [\text{BMI (kg/m}^2\text{)} * 1.89]} * \frac{\text{TG (mmol/l)}}{0.81} * \frac{1.52}{\text{HDL (mmol/l)}}$$

$$\text{LAP}\left(\text{cm}.\frac{\text{mmol}}{\text{l}}\right) = \{\text{WC (cm)} - 58\}^{*}\text{TG (mmol/l)}$$

2.7. Evaluation of blood parameters

Early morning blood samples were collected from PCOS patients in Scientific Clinical Laboratory Pvt. Ltd., Kolkata, after 12 h of fasting during the follicular phase (2–3 days of the menstrual cycle). The concentration of 25-hydroxy vitamin D [25-(OH)VD] and fasting insulin [system: Alinityi (Abbott), method: chemiluminescent microparticle immunoassay (CMIA)], fasting glucose (FG, Hexokinase, Automated Biochemistry Analyzer: DXC 700AU/COBAS 501), lipid profile and albumin (Automated Biochemistry Analyzer, DXC 700AU/COBAS 501), total testosterone (total T) and dehydroepiandrosterone-sulfate (DHEA-S) (System: COBAS e 411, method: electrochemiluminescence), and free T (FT, enzyme-linked immunoassay, ELISA) were estimated from the collected blood samples in the laboratory.

Estimation of the concentration of free-SHBG (FSHBG), HOMA-IR, and TyG index was done using the following standard formulae (7, 12, 13, 23):

$$\text{FSHBG} = \text{total T} - \text{FT} - \text{Albumin bound T}$$

$$\text{HOMA-IR} = \frac{[\text{glucose (mg/dl)}][\text{insulin (mU/ml)}]}{405}$$

$$\text{TyG index} = \ln \frac{\text{fasting TG}\left(\frac{\text{mg}}{\text{dl}}\right) * \text{fasting plasma glucose}\left(\frac{\text{mg}}{\text{dl}}\right)}{2}$$

2.8. Statistical analysis

In Statistical Software for the Social Sciences (SPSS, version 20, IBM Corp.), the acquired data were evaluated using independent-samples *t*-test, bar chart, Pearson correlation and histogram. The significance levels were $p < 0.01$ and $p < 0.05$. Technical errors were in limit (1).

3. Results

In this study, dietary intakes of fat, carbohydrates, energy, protein, VD, and phosphorus were found to be significantly ($P < 0.01$ and $P < 0.05$) higher in PCOS patients relative to recommended dietary allowance (RDA) of ICMR. On the contrary, total dietary fiber, calcium, iron, and magnesium consumption in the PCOS group was significantly ($P < 0.01$) lower than the RDA. Also, PCOS patients consumed considerably more carbohydrates, fat, protein, and phosphorus ($p < 0.01$ and $p < 0.05$) than the control group (**Table 1**). The majority (94%) of PCOS individuals showed oligomenorrhea+PCO (O+PCO) manifestation, whereas 2% of patients suffered from O+HA+PCO, O+HA, and HA+PCO (**Table 2**). VF, SWBF, WHR, WHtR, BMI, BAI, TATM, and TATFM ($P < 0.01$

TABLE 1 | Comparison (mean ± standard deviation) of nutritional status (per day) between recommended dietary allowance (RDA of ICMR) values, PCOS patients (n = 50), and control (n = 50) [independent-samples t-test (significance level $P < 0.01$ and $P < 0.05$)].

Nutritional parameters	RDA	PCOS	Control
Protein (g)	55	↑80.71 ± 34.46^^*	↑65.48 ± 36.95^^
Fat (g)	35	↑138.27 ± 79.73^^*	↑83.86 ± 46.78^^
Total-dietary-fiber (g)	30	↓16.74 ± 5.42^^	↓15.83 ± 5.79^^
Carbohydrates (g)	114.82 ± 11.30	↑156.88 ± 46.36^^!	↑139.66 ± 43.39^^
Energy-sedentary (kcal)	1900	↑2200.26 ± 970.23^	↓1620.84 ± 693.22^^
Vitamin D (μg)	10	↑24.58 ± 8.9^^	↑23.29 ± 10.08^^
Calcium (mg)	600	↓299 ± 164.35^^	↓278.61 ± 185.29^^
Iron (mg)	21	↓15.53 ± 6.61^^*	↓12.48 ± 7.30^^
Magnesium (mg)	310	↓222.88 ± 60.94^^	↓215.23 ± 81.56^^
Phosphorus (mg)	600	↑1112.64 ± 412.77^^!	↑932.36 ± 462.66^^

RDA ($P < 0.01$ = ^^, $P < 0.05$ = ^) vs PCOS: protein^^, fat^^, total-dietary-fiber^^, carbohydrate^^, energy-sedentary^, VD^^, calcium^^, iron^^, magnesium^^, phosphorus^^. Vs control: protein^^, fat^^, total-dietary-fiber^^, carbohydrate^^, energy-sedentary^^, VD^^, calcium^^, iron^^, magnesium^^, phosphorus^^. Control ($P < 0.01$ = *, $P < 0.05$ = !) vs PCOS: protein*, fat*, carbohydrate!, phosphorus!. ICMR (Indian Council of Medical Research), ↑=higher, ↓=lower.

and $P < 0.05$), MUAC, and BSA ($P > 0.05$) parameters were higher in PCOS individuals relative to the control group, whereas SMWB was ($P < 0.05$) lower in significant levels in the PCOS group compared to control individuals (**Table 3A**). PCOS individuals had significantly ($P < 0.01$) greater 2D:4D ratio than the control group (**Table 3B**). In **Figure 1A.a**, cutaneous manifestations were illustrated. The prevalence of the phenotypic HA such as alopecia (100%), AN (82%), hirsutism (72%), and acne (52%) was found (**Figures 1A.b**) to be very high irrespective of obese and lean PCOS patients. A positive correlation was obtained between DHEA-S and total T (P = 0.000), total T and FT (P = 0.002), and FSHBG and FT (P = 0.000) (**Figures 1B.a–c**). However, total T increased positively (P = 0.240) with albumin in the PCOS individuals (**Figures 1B.d**). FG with TG ($P < 0.05$) and LDL with HOMA-IR had positive ($P < 0.01$) association in the PCOS individuals (**Figures 2A.a, b**). It was also found that BMI ($P < 0.05$), WHtR ($P < 0.05$), and VF ($P > 0.05$) were positively associated with low-density lipoprotein (LDL), and VAI ($P = 0.002$) and LAP ($P = 0.014$) had positive interaction with HOMA-IR. (**Figures 2B.a–e**). In the PCOS group, the TyG index displayed a normal distribution pattern (Kolmogorov–Smirnov test, K-S = 0.2) and increment with obesity (**Figure 3** and **Table 4**).

TABLE 2 | Phenotypic manifestation of PCOS individuals (n = 50).

Phenotypic group	% of PCOS individuals
O+PCO	94
O+HA+PCO	2
O+HA	2
HA+PCO	2

O = oligomenorrhea, PCO = polycystic ovaries, and HA = hyperandrogenism.

4. Discussion

A sedentary lifestyle with a surplus amount of dietary intakes such as carbohydrates and fat is the key inducer of obesity, which is an alarming factor of PCOS expression (24, 25). The COVID-19 pandemic has worsened the existing intricacy by the commencement of a new normal life (3, 8). From this study, it can be reiterated that excess macronutrients ($P < 0.01$) play a crucial role in PCOS penetrance by altering metabolism (**Table 1**).

Pathophysiological alteration in the hypothalamic-pituitary-gonadal (HPG) axis causes PCO by inhibiting ovarian follicular maturation and inducing HA that often expresses as O, one of the focal characteristics of PCOS (1, 26). In our study population, the phenotypic manifestation of O+PCO (94%) was prevalently found (**Table 2**). Adiposity indices are the primary non-invasive indicators to recognize PCOS expression (1). High amounts of VF, SWBF%, MUAC, WHR, WHtR, and BMI with lowered SMWBF% indicate ectopic-sarcopenic obesity that leads to the enhancement of PCOS severity (27). Gindan et al. proposed some simple and inexpensive anthropometric indices such as TATM and TATFM, derived from age, HC, height, and weight, to determine adiposity easily in an epidemiological study (9). Reading et al. showed BSA in System International (SI) unit as a useful parameter to predict body volume (22). In this study, PCOS individuals possess higher (0.681) BSA than control participants. Also, the VF (P = 0.007), SWBF% (P = 0.031), WHR (P = 0.008), BMI (P = 0.021), WHtR (P = 0.006), TATM (P = 0.027), and TATFM (P = 0.026) were greater, and SMWB% (0.040) were lower in PCOS individuals relative to control group (**Table 3A**). In **Table 3B**, the digit ratio (2D:4D ratio), which is a reflector of uterine life androgen exposure, was found to be significantly (1.01 ± 0.100, $P < 0.000$) higher in PCOS individuals compared to the control (0.93 ± 0.06) group,

TABLE 3 | Comparison (mean ± standard deviation) of anthropometric indices between PCOS patients (n = 50) and control (n = 50) [independent-samples t-test (significance level $P < 0.01$ and $P < 0.05$)].

Determining indices	Types of anthropometric parameters		PCOS	Control	*P*
(A) Adiposity index	Base anthropometric quantities	Visceral fat (total)	↑7.23 ± 5.15	4.77 ± 3.65	0.007
		Subcutaneous whole body fat (%)	↑29.50 ± 5.98	26.79 ± 6.42	0.031
		Skeletal muscle whole body (%)	↓24.21 ± 1.98	25.55 ± 4.11	0.040
		Mid-upper arm circumference (cm)	↑31.62 ± 4.13	30.92 ± 3.37	0.356
		Body mass index (kg/m^2)	↑26.00 ± 5.46	23.62 ± 4.65	0.021
	Derived anthropometric quantities	Waist-to-hip ratio	↑0.92 ± 0.05	0.90 ± 0.05	0.008
		Waist-to-height ratio	↑0.63 ± 0.09	0.58 ± 0.08	0.006
		Body adiposity index (%)	↑36.86 ± 6.42	34.14 ± 5.48	0.025
		Total adipose tissue mass (kg)	↑21.92 ± 10.17	17.64 ± 8.88	0.027
		Total adipose tissue fat mass	↑17.60 ± 8.08	14.18 ± 7.02	0.026
		Body surface area (m^2)	↑1.66 ± 0.48	1.62 ± 0.49	0.681
(B) Androgen exposure		2D:4D ratio	↑1.01 ± 0.10	0.93 ± 0.06	0.000

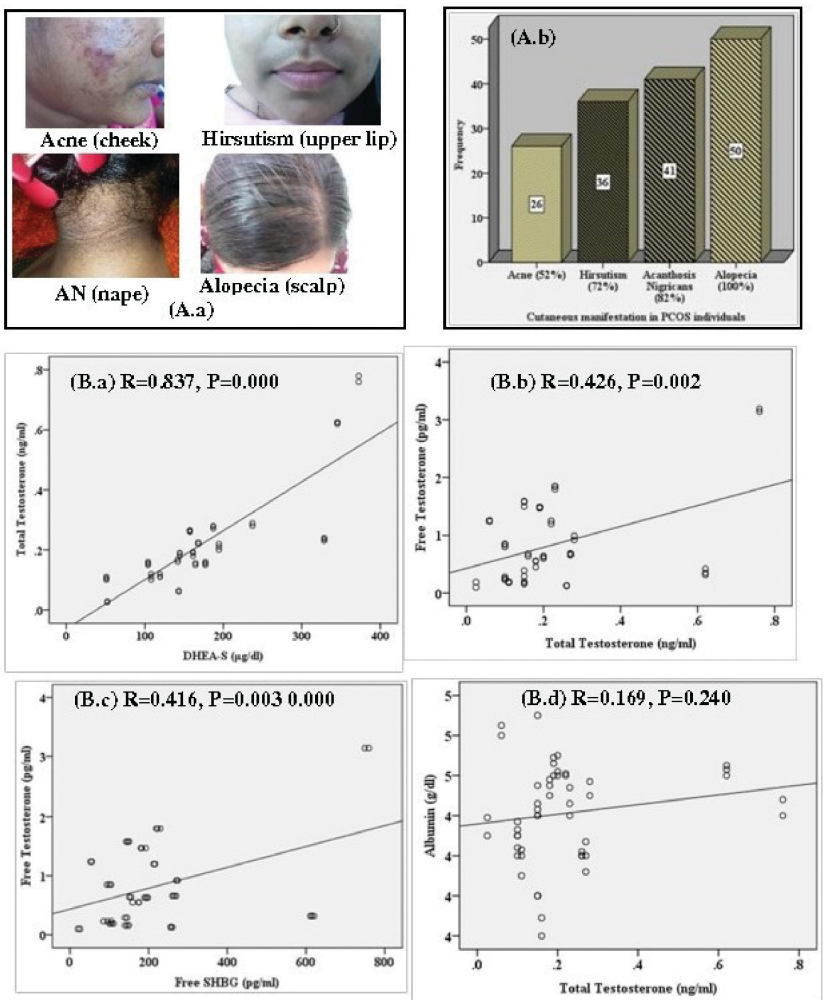


FIGURE 1 | Hyperandrogenism status of PCOS individuals (n = 50). **(A)** Cutaneous manifestation: **(A.a)** photographs of survey study and **(A.b)** % of patients having different manifestations. **(B)** Correlation between biochemical indices: **(B.a)** dehydroepiandrosterone sulfate (DHEA-S) and total testosterone (T), **(B.b)** total T and free T, **(B.c)** free-sex hormone binding globulin (free SHBG) and free testosterone (free T), and **(B.d)** total T and albumin. Significance level $P < 0.01$ and $P < 0.05$.

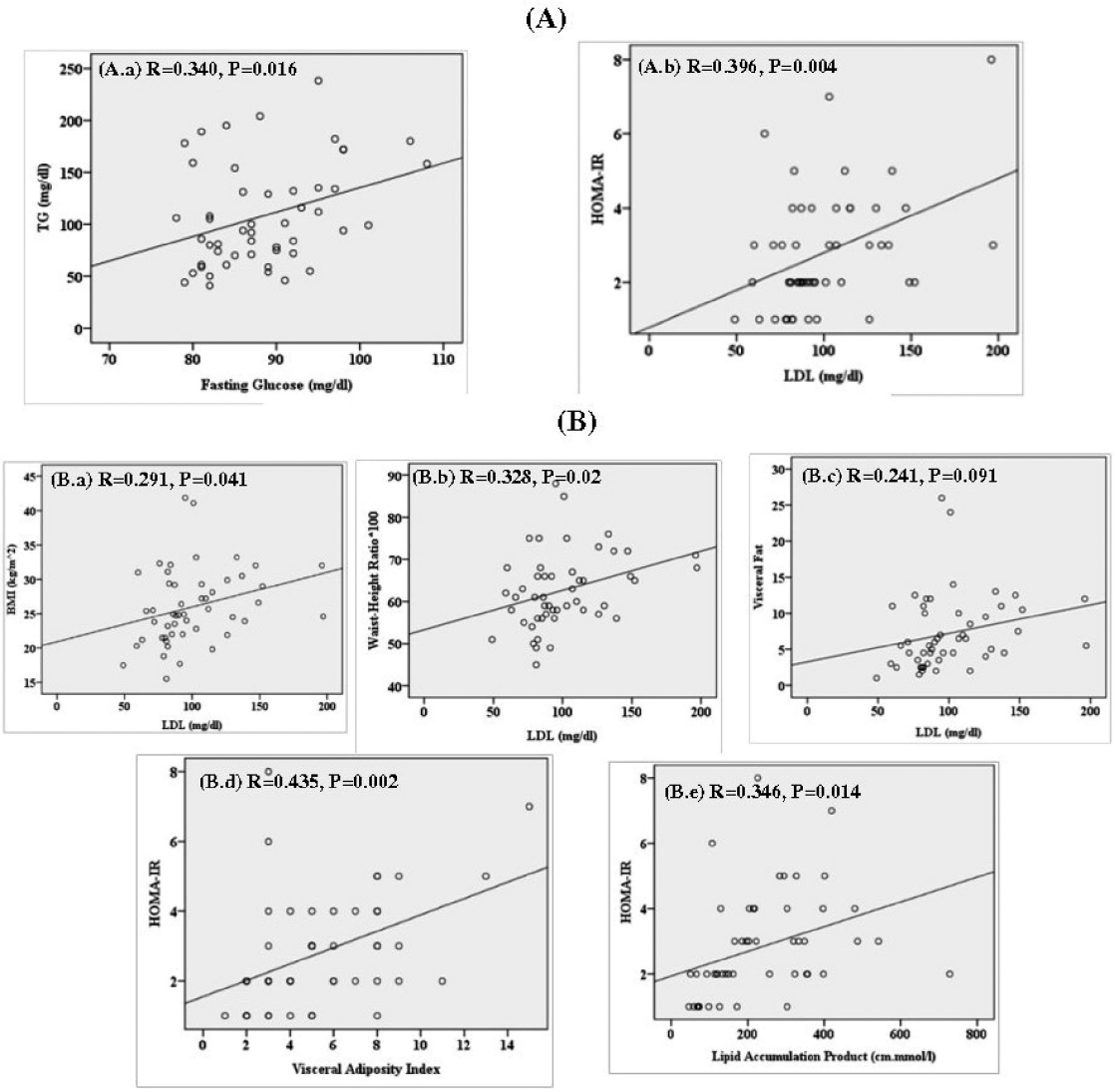
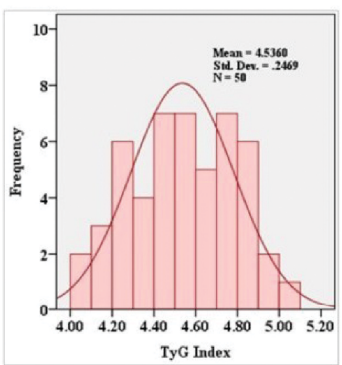


FIGURE 2 | Correlation scatter plot of PCOS patients (n = 50). **(A)** Biochemical parameters: **(A.a)** fasting glucose and triglyceride (TG) and **(A.b)** low-density lipoprotein (LDL) and homeostatic model assessment for insulin resistance (HOMA-IR). **(B)** Biochemical-anthropometric indices: **(B.a)** LDL and body mass index (BMI), **(B.b)** LDL and waist-to-height ratio (WHtR), **(B.c)** LDL and visceral fat (VF), **(B.d)** visceral adiposity index (VAI) and HOMA-IR, and **(B.e)** lipid accumulation product (LAP) and HOMA-IR. Significance level $P < 0.01$ and $P < 0.05$.



TyG index	Median	Mode	Minimum	Maximum	K-S test
	4.54	4.87	4.06	5.01	0.2

FIGURE 3 | Frequency distribution pattern of triglyceride glucose (TyG) index in PCOS participants (n = 50). K-S = Kolmogorov–Smirnov test.

which contradicts the previous observations (28). However, to establish the nature of the impact of androgen exposure during prenatal life in chosen survey population, a large sample size is required to consider under the study umbrella. HA including dihydrotestosterone (DHT, converted from T) alters hair growth pattern and pigmentation of the integumentary system by abnormally modulating activities of 5-α reductase and keratinocytes that often express as cutaneous manifestation including alopecia, AN, hirsutism, and acne (4). In this study, these cutaneous expressions and exposures including alopecia (100%), AN (82%), hirsutism (72%), and acne (52%) were prevalently found in the patients (**Figure 1A**). DHEA-S is a major precursor of T biogenesis that is primarily carried by SHBG along with albumin (29). In this study, a positive association between DHEA-S and T, and carriers (albumin) and T was also found (**Figure 1B**). However, further study with different forms of androgens is required to look for insight into the modulatory pattern of the steroid hormones across the age gradient in PCOS. Alternation in the clearance of TG and formation of LDL in association with hyperglycemia and IR lead to obesity (30). VAI and LAP are promising derived indies to determine IR and CVDs risk (5, 6, 31). Studies indicate that BMI, WHtR, and VF are essential indicators of uneven distribution of obesity-associated fat distribution pattern (1, 21). The present study found a positive correlation between FG with TG ($P = 0.016$), and LDL with HOMA-IR ($P = 0.004$), BMI ($P = 0.041$), WHtR ($P = 0.02$) and VF ($P = 0.091$). It was also found that HOMA-IR was positively associated with VAI ($P = 0.002$) and LAP ($P = 0.014$), (**Figure 2**). Zeing et al. found that TyG index with its high sensitivity and specificity is a novel, low-cost, simple, reliable, and easy-to-use biomarker along with anthropometric indices in the prognosis of CVDs and IR which crosstalk with PCOS in an ethnicity-dependent manner (11). In this study, the TyG index was found to be normally distributed in the PCOS population (**Figure 3**) but failed to attain significant variation with BMI ($P = 0.214$) and VF ($P = 0.122$) which may be due to a smaller sample size (**Table 4**). However, further analysis correlating TyG with other determinants of PCOS in a larger population needs to be addressed.

TABLE 4 | Comparison (mean ± standard deviation) of TyG index based on variation in anthropometric adiposity indices in PCOS patients ($n = 50$) using independent-samples t-test (significance level $P < 0.01$ and $P < 0.05$).

Anthropometric indices		TyG index	*P*
BMI (kg/m^2)	≥ 25 (60%)	↑4.57 ± 0.21	0.214
	< 25 (40%)	4.48 ± 0.29	
VF (total)	≥ 10 (32%)	↑4.62 ± 0.19	0.122
	< 10 (68%)	4.50 ± .26	

5. Conclusion

Anthropometric adiposity indices along with nutritional status and easy-to-assess biochemical parameters like the TyG index for determining obesity and IR are found to be promising biomarkers to screen PCOS expression among adolescents. Prediction and early detection are the key way to have a check for the escalation of an enigmatic syndrome such as PCOS. Alteration of nutritional status, adiposity indices, association between biochemical and anthropometric parameters, HA indices (cutaneous and biochemical determinants), and normal distribution pattern of TyG index, greatly related to the severity of PCOS, are the key findings of this study. These criteria might play an important role in the diagnostic protocol for the epidemiological study during screening of PCOS. A larger sample size of the study population is required for better statistical findings. To understand the PCOS expression more precisely, a study on the interactive pattern of different androgen profiles along with all other modulatory factors is also needed to be considered. These limitations trigger future research to explore the root of HA in terms of its genetic cause and epigenetic crosstalk along with other contributors of PCOS.

6. Body of the paper

- Dietary fat and carbohydrate consumption was considerably greater in PCOS patients compared to controls ($P < 0.01$ and $P < 0.05$, respectively).
- The majority (94%) of PCOS patients were found to be under the oligomenorrhea+polycystic ovaries (O+PCO) category.
- The body fat content ($P < 0.01$ and $P < 0.05$) and intrauterine androgen exposure (2D:4D ratio) ($P = 0.000$) were significantly higher and lower respectively in PCOS individuals relative to the control group.
- HA was highly prevalent in the PCOS group where 100% of them manifested alopecia, and significant ($P < 0.01$) correlation between free testosterone (free T) and free sex-hormone-binding globulin (free SHBG).
- LDL was strongly associated with body mass index (BMI, $P = 0.041$) and WHtR ($P = 0.02$) in the same way as HOMA-IR or homeostatic model assessment for insulin resistance with lipid accumulation product (LAP, $P = 0.014$) index and visceral adiposity index (VAI, $P = 0.002$) in PCOS individuals.
- Additionally, the TyG index was normally distributed (Kolmogorov–Smirnov test = 0.20) in PCOS individuals.

Author contributions

PM: experimentation, acquisition, and analysis of data, data interpretation, and preparation of the manuscript. SC: data interpretation and preparation of the manuscript. RP: concept and designing of the study, experimentation, acquisition, analysis of data, critical revision of the manuscript, and contribution to relevant intellectual content. AS: concept and designing of the study, experimentation, acquisition of data. SS: clinical examination. BB: concept and designing of the study, data interpretation, critical revision of the manuscript, contribution to relevant intellectual content, and approval of the final manuscript for submission. All authors contributed to the article and approved the submitted version.

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Conflicts of interest

The authors have no conflicts of interest.

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