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RESEARCH ARTICLE

Anthropometric, lifestyle, dietary and diabetic status of Yemeni women with polyendocrine metabolic ovarian syndrome in Taiz City: a cross-sectional study

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Objective: Exploration of risk factors for polyendocrine metabolic ovarian syndrome (PMOS) across various populations has identified obesity, poor dietary habits, and absence of physical activity as key contributing factors. This study aimed to assess the anthropometric measurements, lifestyle, dietary habits, and diabetic status of Yemeni women with PMOS in Taiz City.
Methods: A cross-sectional study was conducted to collect anthropometric measurements, lifestyle factors, dietary habits, and diabetic status among 151 women with PMOS in Taiz City, Yemen. Data were collected using a structured questionnaire between March and August 2022.
Results: The most prevalent symptoms among participants were menstrual irregularities (66.2%), mood disorders (83.4%), dysmenorrhea (74.2%), and androgenic alopecia (72.8%) ($p < 0.0001$). The prevalence of type 2 diabetes was 45.7%, whereas high glucose levels were present in only one participant. The main finding of the anthropometric measurements was the high prevalence of overweight (45%) and obesity (13.3%). In contrast to the hypothetical equal frequency of healthy diet and physical activity categories, there were higher observed frequencies of no adherence to a healthy diet (73.5%) and absence of physical activities (76.2%) in participants, which was statistically significant ($p < 0.0001$). Dietary analysis revealed high daily consumption of white flour (90.1%), sugar (49%, 1–5 teaspoons), low intake of fruits (61.6%, 2–3 times/week), dairy products (44.4%, 2–3 times/week), and water (49%, one litre daily). Postprandial blood glucose exhibited hyperglycaemia in only 0.7%, which indicates good control with antidiabetic medications.
Conclusions: The study shows that Yemeni women with PMOS often have a high body mass index, an absence of physical activity, and an unhealthy diet, which is further complicated by a high incidence of diabetic status. The frequent manifestations of menstrual irregularities, dysmenorrhea, mood disorders, and androgenic alopecia can be alleviated by adopting a healthy lifestyle involving dietary changes and exercise.

Keywords anthropometry, blood glucose, dietary, lifestyle, polyendocrine metabolic ovarian syndrome, Yemen

Introduction

Polyendocrine metabolic ovarian syndrome (PMOS), previously named polycystic ovary syndrome (PCOS), is one of the most prevalent female endocrinopathies, affecting approximately one in eight women globally. It is a complex multisystem disorder fundamentally driven by the interplay of endocrine, metabolic, and ovarian disruptions.[1]

The underlying endocrine features include hyperandrogenism, which drives hirsutism, acne and alopecia, alongside central neuroendocrine defects marked by increased gonadotropin-releasing and luteinizing hormones that stimulate excessive ovarian androgen production. This state is further compounded by insulin resistance and hyperinsulinemia, which amplify androgen secretion, and altered anti-Müllerian hormone (AMH) concentrations that complicate reproductive and metabolic outcomes and elevate pregnancy risks.[2–4]

Metabolically, this syndrome is characterised by collective action of insulin resistance, low-grade chronic inflammation and sympathetic nervous system hyperactivity to fuel systemic dysfunction.[5] Obesity, particularly central adiposity, severely aggravates clinical presentation and accelerates long-term cardiometabolic complications. These include impaired glucose tolerance, gestational diabetes, metabolic dysfunction-associated steatotic liver disease, type 2 diabetes mellitus (T2DM), dyslipidaemia, hypertension and vascular dysfunction.[5,6] Concurrently, neuroendocrine irregularities disrupt ovarian steroidogenesis and impair follicular maturation. Aggravated by hyperinsulinemia and hyperandrogenism, this disrupted folliculogenesis and elevated AMH levels manifest clinically as ovulatory dysfunction, chronic menstrual irregularity and infertility.[2,4]

A diagnosis of PMOS is crucial for proper treatment. An important diagnostic approach is the modified Rotterdam criteria, whereby patients must fulfil two of the following criteria: clinical or biochemical hyperandrogenism, evidence of oligo-anovulation, and ultrasound evidence of PMOS morphology ($\geq$ 20 follicles per ovary in either ovary and/or $\geq$ 10 cm^3 ovarian volume in at least one ovary). Other relevant disorders must be excluded, such as thyroid dysfunction, androgen-secreting tumours, hyperprolactinemia and Cushing's disease.[7]

PMOS is a multifactorial disease caused by genetic, epigenetic and environmental factors.[2] The severity of the disease depends on various anthropometric, lifestyle, dietary, genetic and medication factors, such as antipsychotics and antiepileptics. Other factors include age, diet, ethnicity, contraceptive use, adiposity and body mass index (BMI). Controlling these factors may ameliorate the condition. Dietary interventions focusing on a low glycaemic index and improved glucose control are considered a first-line approach for managing PMOS.[8]

In contrast, unhealthy dietary patterns, absence of physical activity and obesity are strongly associated with the development of T2DM in these patients.[9] Women with central obesity have been found to be more susceptible to hormonal and metabolic abnormalities than lean women diagnosed with PMOS.[10] Moreover, insulin sensitivity and hormonal balance can be improved by consuming antioxidant-rich foods and anti-inflammatory diets, as well as engaging in regular physical activity to enhance insulin sensitivity, promote weight loss and improve reproductive outcomes.[11] Alomran and Estrella, in their review of evidence on the dietary regimen of different communities' effect on PMOS outcomes, found conflicting findings. Some studies concluded that an unhealthy diet correlates with the development of PMOS, while other studies showed no disparity in dietary patterns compared with healthy controls. This leads them to recommend further investigations employing extensive cohorts.[12] The impact of healthcare professional education on lifestyle and the advice provided by dietitians offers promise for long-term sustainable changes and improvement in PMOS outcomes.[13] However, limited studies have analysed the interplay between anthropometric, lifestyle, dietary and diabetic status predisposition factors in women with PMOS in developing countries, particularly in Yemen.

According to the Global Burden of Disease (GBD) study conducted by the Institute of Health Metrics and Evaluation (IHME) at the University of Washington (USA), the burden of PMOS in Yemen was estimated to be 10.9%.[14] A local study carried out in Aden City on a specific group of girls (students at private university) reported a prevalence of 26.7%.[15] Yemen has unique cultural, dietary and lifestyle habits, and healthcare services are not widely available. Taiz City has the highest population density in Yemen. This study aimed to investigate the interplay of anthropometric, lifestyle, dietary and diabetic status factors within Yemeni women with PMOS in Taiz City in order to determine the local risk factors that could guide management and prevention strategies.

Methods

Study design and setting

This cross-sectional study was conducted across selected gynaecological clinics in public and private hospitals in Taiz City, Yemen. The two largest public hospitals (AL-Thawra and Al-Gomhury hospitals) were included in the study to ensure access to a large and diverse population of women with PMOS. Private hospitals and clinics were selected based on their willingness to collaborate and the feasibility of accessing the target participants. This use of a multicentre approach ensures sample representation of PMOS in Taiz City.

The clinical infrastructure was configured to allow consecutive recruitment of participants during their routine outpatient visits to the clinics. Data collection via interviews was conducted in a private and appropriate room in the hospitals specified to provide a clinical environment to ensure consistency. Measurements and glucose testing were carried out with the same tools and instruments to minimise inter-assay variability.

The total sample size ($n = 151$) was calculated using the following formula.[16] $n = Z^2$ (p)*(1-p)/d^2 assuming a PMOS prevalence rate of 10.9%,[14] a 95% confidence interval of 1.96 and an error margin of 0.05.

Diagnosis was performed by specialised gynaecologists and radiologists. Participants diagnosed with PMOS fulfil at least two of the three modified Rotterdam criteria: oligo-anovulation, hyperandrogenism and ultrasound evidence of polycystic ovaries. Oligo-anovulation was assessed by oligo-amenorrhea, which is characterised by menstrual cycles of > 35 days or by < 8 menses a year. Clinical hyperandrogenism was assessed by a modified Ferriman–Gallwey score of $\geq$ 4 to $\geq$ 8, and varied with ethnicity; this score evaluates and quantifies hirsutism in nine body regions of women. Ultrasound evidence of PMOS shows either $\geq$ 20 follicles per ovary or an ovarian volume of $\geq$ 10 cm^3 on either ovary.[7]

The recruitment of participants followed the systemic clinical approach of modified Rotterdam criteria under the supervision of gynaecologists at the selected clinics from 12 March to 21 August 2022. Women who met the inclusion criteria and had no exclusion criteria were informed of the study objectives clearly and invited to participate in the study. Women with PMOS who were willing to enrol and gave consent were included in the study. A convenience sampling method was employed due to the outpatient clinical flow and feasibility considerations.

Inclusion and exclusion criteria

The inclusion criteria were females with a confirmed diagnosis of PMOS according to the modified Rotterdam criteria who were willing to participate in the study. Participants were excluded if they did not meet the modified Rotterdam criteria to be diagnosed with PMOS, if they were pregnant, or if they had a history of cancer or chronic debilitating kidney, liver or heart disease.

Ethical considerations

This research protocol was approved by the Research Ethics Committee at the Faculty of Medical Sciences, Al-Janad University for Science and Technology. Participants' anonymity and confidentiality were maintained. Informed consent was obtained from each participant. All stages of this research were in accordance with international ethical standards, mainly the Helsinki Declaration on Biomedical Research, 2013.

Data collection

Data collection was conducted by researchers through direct, face-to-face interviews. A fully structured questionnaire with closed questions, guided by previous literature,[17–19] had been constructed for data collection. The questionnaire was designed to identify sociodemographic and economic characteristics, anthropometry, reproductive data, dietary habits, lifestyle and physical activities, as well as a full medical history concerning PMOS signs and symptoms and related gynaecological data.

Anthropometric measurements were taken by trained personnel using standardised techniques and calibrated equipment. All measures were taken twice, and the average was reported. The researchers took anthropometric measurements (weight, height, waist circumference and hip circumference) using a digital scale and standard measuring tape. Height and weight: height was measured to the nearest 0.5 cm without shoes using a stadiometer. Weight was measured to the nearest 0.1 kg with participants wearing light clothing and bare feet, using a calibrated scale. BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m^2) and categorised according to the World Health Organization (WHO) international cut-off points as

underweight (< 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), obese I (30–34.9 kg/m^2) and obese II (≥ 35.0 kg/m^2).[20]

Waist and hip circumferences were taken to the nearest 0.1 cm. Waist circumference was measured at the midpoint between the lower rib margin and the top of the iliac crest. Women with a waist circumference of ≥ 80 cm (cut-off point) are classed as abdominally obese. Hip circumference was measured by passing the tape in a horizontal plane across the buttocks perpendicular to the long axis of the trunk and fixing it at the greatest posterior protuberance; arms must be folded across the chest, and the gluteal muscles must be relaxed (normal range is 91–105 cm). The waist to hip ratio was further categorised by metabolic risk as low (< 0.80) moderate (0.80–0.84) and high (≥ 0.85).[21]

Clinical assessment for the common PMOS-related symptoms was carried out by the gynaecologist and documented by the research team. These features include irregular menstrual cycles (oligomenorrhea/amenorrhea), mood disorders (depression, anxiety), hirsutism (excessive hair growth), dysmenorrhea (severe pelvic pain), androgenic alopecia (scalp hair loss) and weight gain.[2]

For the dietary assessment, a validated semiquantitative food frequency questionnaire (FFQ) was developed for the Yemeni population[18,19,22] to assess the usual dietary intake of the participants diagnosed with PMOS and integrated within the main questionnaire. To ensure the scientific rigour of the newly adapted tool, it was subjected to a systematic, multistep validation and reliability process. Initially, content validity was established by the core research team through iterative review sessions focusing on data completeness, appropriateness and linguistic clarity. Following the content validity, expert validation was performed by two independent department nutritionists who formally evaluated the questionnaire items to ensure relevance, clarity and cultural appropriateness. A pilot study was subsequently conducted among 10 participants at Al-Thawra Hospital in Taiz City to evaluate instrument feasibility and ensure that respondents interpreted the questions exactly as intended. Based on the pilot feedback, minor revisions were executed to maximise comprehension of specific dietary items. Finally, the internal consistency of the finalised questionnaire was quantitatively evaluated, yielding an overall Cronbach's alpha coefficient of 0.87, which demonstrates a good internal reliability of the questionnaire for assessing this target population.

The questionnaire included an assessment of adherence to one of the most popular dietary patterns recognised for weight management and preventing complications in women living with PMOS. These patterns were defined as follows: ketogenic diet (very low-carbohydrate, high-fat [70–80% of calories] and moderate-protein); low-carbohydrate diet (reduced intake of refined sugars and grains with increased healthy fats and proteins); balanced diet (sustainable intake of nutrient-dense whole grains, fruits, vegetables and lean proteins); intermittent fasting (cycling between eating and fasting windows, such as 16:8 or 20:4); and high-carbohydrate diet (45–65% of total daily calories derived from nutrient-dense carbohydrate sources like whole grains, legumes, fruits and vegetables).[23,24]

Dietary habits were reported within the validated FFQ. Dietary cut points were adapted from international references[18,19,22] and validated for the local Yemeni context as a low-income country. Recommended dietary thresholds were defined as follows: whole grain from cereals (daily), fruit, vegetables and milk, even caffeine, are consumed daily; optimum water is 3 litres daily; meat is approximately < 2 servings/week; and sugar is 1–5 teaspoons daily. It is recommended that fast foods, soft drinks and sweets be avoided or limited to < 1 consumption/week.[25–28] Foods that were categorised by types and frequency reported for daily consumption were cereals (white flour, millet, whole grain and barley) and caffeine (peel coffee, coffee and cacao), while meat (red meat, chicken and fish) frequency was reported for weekly consumption. Fruit, vegetables and milk and dairy products were categorised into three levels of consumption (daily, 2–3 times/week and 4–5 times/week). Water daily consumption categories were 1–3 litres. Sugar daily consumption categories are in teaspoons as 1–5, 6–10 and 11–15; one teaspoon approximately equals 5 grams. Fast foods, soft drink and sweets consumption frequency categories were daily, 2–3/week and none.

Physical activity refers to all body movement that engages muscles and expends energy, such as housework, hard work, transportation, walking, cycling and other sports for at least 150 minutes of moderate to vigorous activity per week.[29] Physical activities were reported within the questionnaire as 'yes' if they do regular physical activity for at least 150 minutes/week or 'no' for the absence thereof.

The diabetic status was diagnosed clinically by a special internist using standard protocols based on clinical examination and laboratory tests using standard cut-off points: fasting blood glucose (> 126 mg/dl), 2-hour postprandial glucose (> 200 mg/dl) or haemoglobin A1c (HbA1c > 6.5%). Women with PMOS were evaluated for their postprandial blood glucose to monitor the glucose control using a glucometer via a finger-prick capillary blood sample in the middle of the day, prior to the participant's scheduled afternoon antidiabetic medication dose. Participants were categorised according to the American Diabetes Association standards: normal (80–140 mg/dl), prediabetic/slightly elevated (141–200 mg/dl), and high (> 200 mg/dl).[30]

Data analysis

Data collected were entered into a Microsoft Excel (2021) sheet file to be used for analysis (Microsoft Corp, Redmon, WA, USA). Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 21 (IBM Corp, Armonk, NY, USA). Continuous variables were presented using mean and standard deviation. Categorical variables were presented with frequency percentage. The chi-square goodness-of-fit test was used to determine whether the observed frequencies of variable categories differed (alternative hypothesis) from the expected equal frequencies (null hypothesis). Results were considered statistically significant at a p-value < 0.05.

Results

The participants diagnosed with PMOS in this study numbered 151. The majority of the recruited participants were aged between 20 and 25 years (56.3%), and they were from families with a monthly household income of either $100–500 or > $500 (67.5% and 23.8%, respectively). The majority of participants had a graduate level of education (62.9%) as listed in Table 1. The study showed similar proportions of married and single women (49% vs. 51%, respectively).

Table 1: Sociodemographic characteristics of Yemeni women with PMOS in Taiz City

Characteristic	*n*	%
Age in years		
15–20	28	18.5
21–25	85	56.3
26–30	27	17.9
Above 30	11	7.3
Marital status		
Single	77	51
Married	74	49
Education level		
Primary	14	9.3
Secondary	42	27.8
University	95	62.9
Monthly household income		
< $100	13	8.6
$100–500	102	67.6
> $500	36	23.8

Table 2: PMOS signs and symptoms frequency among Yemeni women diagnosed with PMOS in Taiz City, Yemen

Signs		*n*	%	X^2	*p*-value*
Acne	Yes	82	54.3	1.12	0.290
	No	69	45.7		
Irregular menstrual cycle	Yes	100	66.2	15.90	0.0001
	No	51	33.8		
Mood disorders	Yes	126	83.4	67.56	0.0001
	No	25	16.6		
Hirsutism	Yes	82	54.3	1.12	0.290
	No	69	45.7		
Dysmenorrhea	Yes	112	74.2	35.29	0.0001
	No	39	25.8		
Androgenic alopecia	Yes	110	72.8	31.53	0.0001
	No	41	27.2		
Weight gain	Yes	77	51.0	0.06	0.807
	No	74	49.0		

*$p \leq 0.05$ was considered significant.

Clinical features, including irregular menstrual cycle, mood disorders, dysmenorrhea and androgenic alopecia, were more prevalent among the study cohort than would be expected under the hypothetical equal distribution ($p < 0.0001$). This confirms that these symptoms did not appear by chance in the participants (Table 2).

Basic anthropometric measurements of the participants are depicted in Table 3. They had a mean weight of 60.04 ± 14 kg, a mean height of 155.77 ± 6.82 cm, a mean waist circumference of 81.84 ± 14.86 cm and a mean hip circumference of 99.86 ± 12.56 cm.

Based on BMI classification, the majority of the participants exhibited abnormal bodyweight; specifically, 45% were categorised as overweight, while 13.3% presented with clinical obesity (class I and II) (Table 4). Underweight Yemeni women with PMOS represented 12.6%. Based on the WHO (2011)

Table 3: Mean basic anthropometric measurements of Yemeni women with PMOS

Measurement	Mean ± SD
Weight (kg)	60.04 ± 14
Height (cm)	155.77 ± 6.82
Waist circumference (cm)	81.84 ± 14.86
Hip circumference (cm)	99.86 ± 12.56

Table 4: Distribution of the studied Yemeni women with PMOS in Taiz City according to their BMI, waist-to-hip ratio, diabetic status, postprandial blood glucose level, engagement in regular physical activity and adherence to a healthy diet

Factor	*n*	%	χ^2	*p*-values*
BMI (kg/m^2)				
Underweight (> 18.5)	19	12.6	88.04	0.0001
Normal weight (18.5–24.9)	44	29.1		
Overweight (25–29.9)	68	45.0		
Obese I (30–34.9)	17	11.3		
Obese II (≥ 35)	3	2.0		
Waist to hip ratio				
Low metabolic risk (< 0.80)	68	45.0	9.55	0.008
Moderate metabolic risk (0.80–0.84)	39	25.8		
High metabolic risk(≥ 0.85)	44	29.2		
Diabetes mellitus type 2				
Yes	69	45.7	1.12	0.290
No	82	54.3		
Postprandial blood glucose (mg/dl)				
Normal (80–140)	120	79.4	152.99	0.0001
Slight elevation (141–200)	30	19.9		
High (> 200)	1	0.7		
Physical activity (≥ 150 minutes/week)				
Yes	36	23.8	40.56	0.0001
No	115	76.2		
Healthy diet				
Yes	40	26.5	33.4	0.0001
No	111	73.5		
Type of healthy diet				
Ketogenic diet	6	4.0	49.1	0.0001
Low-carbohydrate	25	16.5		
Balance diet	3	2.0		
Intermittent fasting	3	2.0		
High-carbohydrate	3	2.0		

Note: Cut-off points for BMI, waist-to-hip ratio and physical activity are based on WHO standards. Postprandial blood sugar cut-off points follow the American Association of Diabetes guidelines. *$p \leq 0.05$ was considered significant.

metabolic risk stratification, the waist to hip ratio indicates high metabolic risk (> 0.85) in 44 participants, moderate risk (0.80–0.84) in 39 participants and low metabolic risk (< 0.80) in 68 participants.

Diabetic status was reported in 69 participants. Meanwhile, high postprandial blood glucose (> 200 mg/dl) was observed in one participant, and a slight elevation (141–200 mg/dl) was observed in 30 participants, while the rest (120 participants) had a normal blood glucose level (80–140 mg/dl). Additionally, the majority of participants failed to meet the WHO (2010) recommendation of physical activity (≥ 150 minutes of moderate

to vigorous activity/week) and did not adhere to any healthy diet, with proportions of 76.3% and 73.5%, respectively. There were 40 participants who had adhered to one healthy diet in decreasing frequencies: low-carbohydrate, ketogenic, balanced, intermittent fasting and high-carbohydrate diets.

Table 5: Detailed dietary pattern of the Yemeni women with PMOS in Taiz City

Food consumption	*n*	%	χ^2	*p*-value*
Cereals (daily)				
White flour	136	90.1	298.79	0.0001
Millet	23	15.2		
Whole grain	21	13.9		
Barley	5	3.3		
Fruits				
Daily	23	15.2	115.36	0.0001
2–3/week	93	61.6		
4–5/week	29	19.2		
Vegetables				
Daily	69	45.7	103.6	0.0001
2–3/week	68	45.0		
4–5/week	11	7.3		
Milk and dairy products				
Daily	27	17.9	38.64	0.0001
2–3/week	67	44.4		
4–5/week	16	10.6		
Meat (< 2 servings/week)				
Red meat	46	30.5	40.81	0.0001
Chicken	132	87.4		
Fish	97	64.2		
Water (daily)				
1 l	74	49.0	31.80	0.0001
2 l	58	38.4		
3 l	19	12.6		
Sugar (daily)				
1–5 teaspoons	74	49.0	83.09	0.0001
6–10 teaspoons	56	37.1		
11–15 teaspoons	12	7.9		
Caffeine (daily)				
Peel coffee	41	27.2	51.13	0.0001
Coffee	86	57.0		
Cacao	17	11.3		
Fast foods				
Daily	30	19.9	14	0.001
2–3/week	67	44.4		
No	54	35.8		
Soft drinks				
Daily	14	9.3	45.56	0.0001
2–3/week	56	37.1		
No	81	53.6		
Sweets				
Daily	33	21.9	21.83	0.0001
2–3/week	77	51.0		
No	41	27.2		

Note: Recommended consumption levels based on the international guidelines: cereals; whole grains daily, fruits, vegetables, and milk and dairy products are consumed daily, meats < 2 servings weekly, sugar 1–5 teaspoons daily, water 3 l daily. Fast foods, soft drinks and sweets avoided or < once/week. *$p \leq 0.05$ was considered significant.

Table 5 details the daily dietary habits of Yemeni women with PMOS. For the cereal types, the most consumed by the participants daily were white flour, brown millet, whole grains and barley, with percentages of 90.1%, 15.2%, 13.9% and 3.3%, respectively. It has been shown that the highest consumption of fruits ranges between 2 and 3 times/week by 61.6% of participants, while the highest consumption of vegetables reported was daily by 45.7% of participants. The most consumption of milk and dairy products within participants was 2–3 times/week with a percentage of 44.4%, one litre of water daily by 49%, and 1–5 teaspoons of sugar by the same proportion of participants. The frequency of meat consumption of < 2 servings/week includes chicken (87.4%), fish (64.2%) and red meat (30.5%). Coffee was the most prevalent daily consumed caffeinated beverage (57%), followed by peel coffee (27.2%) and cacao (11.3%), as detailed in Table 5. Fast food and sweets at a rate of 2–3 times/week were reported within 44.4% and 51% of participants, respectively. Regarding soft drinks, about 53.6% of participants did not consume any of them.

Discussion

This study explored the anthropometric, lifestyle, dietary and diabetic status in Yemeni women diagnosed with PMOS. Within this cohort, prominent clinical features included high prevalence of overweight, low waist to hip ratio, diabetic status, consumption of an unhealthy diet and absence of physical activity. The high prevalence of diabetic status alongside predominantly normal postprandial glucose levels among the participants is explained by their adherent use of antidiabetic medications, which successfully controlled their blood glucose levels.

PMOS affects women at any age after puberty. The majority of the participants were aged between 20 and 25 years; this timeline differs from the reported global peak incidence at younger ages (10–19 years), which represents the vast majority of women with PMOS cases worldwide.[31] This variation may be attributed to the low and poor health services and constrained health education, which collectively delayed diagnosis in Yemen. In the neighbouring country, Saudi Arabia, the most reported age group was those younger than 25 years old, in agreement with our results.[32] However, there is a considerable disparity in disease awareness between Yemeni and Saudi women[33] due to high illiteracy in Yemen. Higher educational attainment serves as a positive driver that prompts individuals to seek timely clinical diagnosis and intervention. Notably, these educated individuals belonged to families with a monthly household income of $100–500 or exceeding $500; this category of people represents the majority of attendees at public hospitals.[34]

The most prevalent clinical manifestations observed among participants included irregular menstrual cycles, mood disorders, dysmenorrhea and androgenic alopecia. The frequency of mood disorders is similar to that reported previously among the local cohort.[15] Less prevalent signs are the appearance of acne and hirsutism, both of which are classically induced by androgen overproduction in this syndrome.[35] The prevalence rate of each manifestation agrees with the prevalence among Saudi and Egyptian women diagnosed with PMOS.[33,36] Furthermore, the high prevalence of acne and hirsutism reported here matches the pattern observed in the Indian population.[37] This may be pointing to the shared sociocultural and environmental factors. PMOS signs and symptoms not merely affect women's health but also impact their quality of

life and social behaviour, resulting in diminished self-esteem and social withdrawal. Similarly, mood disorders and stress affect emotional and social well-being.[38]

Anthropometric measurements were utilised to evaluate BMI, waist circumference and waist to hip ratio. Participants were then classified as underweight, normal, overweight and obese according to the BMI. The majority of participants displayed a distinct metabolic abnormality, characterised by central obesity (elevated waist circumference) and diabetic status. In the context of PMOS pathophysiology, excess adipose tissue, particularly in the abdomen, produces proinflammatory cytokines that trigger systemic inflammation, which interferes with insulin signalling, leading to insulin resistance. Insulin resistance, in turn, leads to hyperinsulinemia, which promotes weight gain and obesity by accelerating the conversion of blood glucose into stored lipids, inhibiting lipolysis and increasing dietary craving, especially for carbohydrates.[39]

In the present study, 58.3% of the participants were categorised as overweight and obese, in concordance with many studies in Yemen and in different countries (Egypt, India and Poland)[15,36,37,40] and aligns with the well-established consensus that obesity is a primary risk factor for the development of PMOS.[41] Additionally, PMOS may drive obesity through a series of metabolic and hormonal events; individuals with insulin resistance develop hyperinsulinemia and increased ovarian androgens, both of which lead to changes in energy expenditure and physical activity, and increased weight gain.[42] Notably, 76.2% of the cohort reported an absence of regular physical activity. On the other hand, physical activity enhances glucose transport and skeletal muscle metabolism to augment the effects of insulin sensitivity. A prior meta-analysis demonstrated that improvements in health outcomes depend more on exercise intensity than dose, recommending a minimum of 120 minutes of aerobic exercise per week.[43] The mean waist circumference among participants exceeded the WHO cut-off point (> 80 cm) and indicates a high prevalence of abdominal obesity among them.[21]

The findings indicate that 45.7% of the participants had developed T2DM. Crucially, 55% of them exhibited normal postprandial blood glucose levels according to American Diabetes Association standards,[30] indicating effective glycamic control with antidiabetic medications. These findings are in accordance with those reported in Egypt.[44] The prevalence of insulin resistance was reported to be 40.2% in the Czech Republic.[45] In contrast, T2DM was prevalent in only 9% in Denmark.[46] Meanwhile, slightly elevated postprandial blood glucose was reported in about 20% of the current participants, identifying them with poor blood glucose control. The high rate of diabetic status observed here is attributed to the poor health services in Yemen, which lead to delayed clinical detection and deterioration of long-term follow-up care. The progression toward the development of type 2 diabetes can be prevented by early treatment.[47]

Clinical guidelines for women with PMOS include adopting a 'balanced diet', which is defined by sustainable intake of nutrient-dense whole grains, fruits, vegetables and lean proteins, especially at breakfast and lunch, to lessen the raised plasma glucose levels after meals. Kale, spinach, watercress and chard are examples of dark green leafy vegetables that can be eaten. However, few participants adhered to this balanced diet (2%). About 16.5% of the participants followed a low-carbohydrate diet, which is known to support flexible weight management by reducing intake of refined sugars and grains and increasing intake of healthy fats and proteins. Moreover, those who did not adhere to any healthy diet regimen consumed higher amounts of simple carbohydrates and lower levels of complex carbohydrates, monounsaturated fatty acids and fibres. This poor diet exacerbates the underlying inflammatory environment and hyperandrogenism found in women diagnosed with PMOS.[48] The main reasons behind non-adherence to healthy diets and other dietary problems in Yemen are poverty, prevalence of malnutrition, poor health education programmes and low awareness levels.[49,50]

Dietary habits exploration among participants reveals a high daily consumption of white flour (90%), a refined cereal product characterised by a high glycaemic index and low nutritional density.[48] Daily consumption of white (refined) bread is also prevalent among women diagnosed with PMOS as well as among healthy controls in the United States.[51] Regarding the recommended daily intake of fruits and vegetables, normal daily consumption was reported among 15% and 45% of the participants, respectively, in contrast to 75% and 78% of Polish women with PMOS.[52] Daily fruit and vegetable consumption has a significant impact on reducing symptoms, improving insulin sensitivity and aiding weight management,[9] because its high fibre content has a good effect on insulin resistance by reducing both blood sugar and haemoglobin A1c.[53] Furthermore, fruits and vegetables are rich in dietary antioxidants and can alleviate inflammation and oxidative stress.[54]

Milk and dairy products such as cheese, yogurt and buttermilk contain important nutrients such as calcium, vitamin D and high-quality proteins, which have better effects on overall human health. It is believed that daily dairy consumption may reduce the risk of insulin resistance in women diagnosed with PMOS. Despite limited evidence on the direct relationship, some review analysis studies showed no effect of low-fat milk. This may suggest a beneficial effect of high-fat milk consumption in this population.[55,56] Notably, only 15% of the current Yemeni participants consumed milk daily, a rate comparable with cohorts in Iran (88%)[57] and Poland (84%).[52]

Similarly, participants' consumption of water was lower than the recommended threshold (< 3 litres daily). Although water consumption does not exert a direct biochemical effect on lipolysis, maintaining an optimal hydration status is crucial to prevent metabolic deceleration, support standard energy expenditure and facilitate the renal clearance of metabolic waste products, including ketones, through increased urine output.[58]

International nutritional guidelines recommend limiting red meat consumption to fewer than 2 servings/week.[59] Fewer participants consumed red meat compared with chicken and fish (30.5%, 87.4% and 64.2%, respectively). Polish women reported daily consumption of red meat, chicken and fish of 80%, 77.8% and 80%, respectively.[40] This marked disparity in red meat consumption between Yemeni and Polish women with PMOS is primarily attributed to the low economic state in Yemen. Consequently, red meat may act as a less prominent risk factor in Yemen. Nonetheless, it has been established that red meat may alter hormonal balance and is associated with a high risk of PMOS, as concluded in previous case-control literature.[60]

Another risk factor is the high consumption of refined sugar. Approximately 49% of the participants reported consuming

1–5 teaspoons of sugar daily, which is close to that reported in the United States.[51] Additionally, about 37% of the participants reported consuming 6–10 teaspoons of sugar daily. High sugar consumption can worsen insulin resistance and contribute to weight gain. The same effect was observed with sweet consumption, reported by 72.9% of participants. Furthermore, a study found that the consumption of sweets with a high glycaemic index and glycaemic load along with a low-fibre diet is associated with the development of PMOS and exacerbates insulin resistance in these patients.[61]

In term of beverage habits, the high daily consumption of coffee across the cohort is deeply rooted in Yemen's historical production of premium coffee. Culturally, coffee consumption was found to correlate negatively with PMOS symptom severity, aligning with the conclusions of Meliani-Rodríguez et al.[62] Fast food and soft drinks were also proved to be other risk factors despite the low consumption rate reported among participants compared with that in Saudi individuals.[63] Meanwhile, a majority of an Iranian cohort reported consumption of fast foods at least twice a week alongside soft drinks.[64] The low consumption of fast foods and soft drinks among participants is attributed to the low economic status of the Yemeni population. However, it was found previously that nutritional and lifestyle modifications, which are complementary non-pharmacological strategies, were effective in alleviating symptoms and improving the overall health of Yemeni women diagnosed with PMOS.[15]

The limitations of this study include funding constraints, incomplete health record-keeping systems in Yemen, and limited resources for conducting additional biomedical investigations, such as severity markers (anti-Mullerian hormone), adipose tissue dysfunction markers (leptin and adiponectin) and inflammatory markers (Interleukin-6). An intervention study should be performed to draw more robust conclusions regarding variable effects. Finally, cultural and habitual constraints present challenges in conducting research involving Yemeni women with PMOS.

Conclusion

This study provides insights into the anthropometric, dietary and lifestyle profiles of a cohort of women with PMOS in Taiz City, Yemen. The findings indicate that the most common age group in this study sample is 20–25 years old. Several modifiable risk factors were identified, including increased BMI, waist circumference, waist-to-hip ratio and absence of physical activity. Common manifestations include menstrual irregularities, dysmenorrhea, mood disorders and androgenic alopecia. Participants' dietary patterns were characterised by high consumption of refined carbohydrates and sugars, alongside inadequate intake of water, milk and fruits. The development of diabetic status was identified as a notable complication among the participants. The observations suggest that a well-managed diet, combined with structured physical activity and improvement of lifestyle, can help reduce PMOS symptoms. Further prospective, multicentre and interventional studies are needed to validate these findings and assess the impact of dietary interventions.

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Ethics statement — This study was conducted under the approval of the Research Ethics Committee at the Faculty of Medical Sciences, Al-Janad University for Science and Technology (ethical code: JustMed12/2021). Anonymity of participants was maintained for confidentiality. Informed consent was obtained from all participants diagnosed with PCOS. All stages of this research were in accordance with international ethical standards, mainly the Helsinki Declaration on Biomedical Research, 2013.

Data availability statement — Data supporting the findings of this study are available within the paper.

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