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Nutritional Status and Dietary Consumption Trends in Women with PCOS: Association with Obesity

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KEYWORDS

polycystic ovary syndrome, obesity, nutritional status, dietary intake, micronutrients, body composition

ABSTRACT:

Background: Polycystic ovary syndrome (PCOS) is strongly associated with obesity and metabolic dysfunction. This study assessed nutritional status and dietary consumption patterns in women with PCOS and their association with obesity indicators.

Methods: A cross-sectional observational study was conducted among 119 women with PCOS aged 18-40 years at Government Medical College, Saharanpur. Anthropometric measurements included BMI, waist-to-hip ratio (WHR), and body fat percentage. Dietary intake was assessed using multiple 24-hour dietary recalls. Nutritional analysis included energy, macronutrients, and micronutrients.

Results: The prevalence of overweight and obesity was 56.3% (41.2% overweight, 15.1% obese). High WHR risk was observed in 37.8% of participants. Mean energy intake was 1,942.53 ± 395.57 kcal/day, showing progressive increase across BMI categories (underweight: 1,558 kcal vs. obese: 2,208 kcal). Protein intake was 52.38 ± 15.28 g/day and fat intake was 59.64 ± 15.96 g/day. Micronutrient inadequacies were evident, particularly calcium (486.14 ± 173.23 mg/day vs. 1000 mg recommended).

Conclusions: Women with PCOS demonstrated high obesity prevalence with clear associations between dietary energy intake and BMI categories. Concerning micronutrient inadequacies, particularly calcium deficiency, coupled with low supplement usage represent significant treatment gaps. These findings emphasize the need for comprehensive nutritional interventions addressing both energy balance and micronutrient optimization in PCOS management.

INTRODUCTION

Polycystic ovary syndrome (PCOS) affects 5-20% of reproductive-age women globally, representing one of the most prevalent endocrine disorders (1). This complex condition is characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, with significant metabolic implications extending beyond reproductive health (2).

The association between PCOS and obesity is particularly concerning, with 50-80% of affected women presenting with overweight or obesity (3). This relationship is bidirectional: obesity exacerbates hormonal imbalances characteristic of PCOS, while metabolic dysfunction inherent to the syndrome predisposes women to weight gain and metabolic complications (4). Central obesity, measured by waist-to-hip ratio (WHR), is especially prevalent and strongly correlates with insulin resistance, affecting 50-90% of women with PCOS (5).

Dietary factors play a crucial role in PCOS pathophysiology and management. Women with PCOS often exhibit altered dietary patterns, including higher caloric intake, increased refined carbohydrate consumption, and suboptimal micronutrient profiles compared to healthy controls (6). These patterns

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contribute to metabolic dysregulation, including insulin resistance, dyslipidemia, and chronic inflammation (7). Specific nutritional deficiencies, particularly vitamin D, B-vitamins, and essential minerals, are commonly reported and may worsen PCOS symptoms (8).

The macronutrient composition significantly influences metabolic outcomes in PCOS. High glycemic index diets and excessive carbohydrate intake increase insulin resistance and weight gain, while low glycemic index foods and adequate protein intake demonstrate beneficial effects on weight management and hormonal balance (9). Micronutrient status requires particular attention, as deficiencies in key nutrients such as vitamin D, magnesium, and zinc are prevalent and contribute to symptom severity (10).

Despite the recognized importance of nutrition in PCOS management, comprehensive studies examining detailed dietary patterns and their associations with obesity parameters in Indian women with PCOS remain limited. Understanding these relationships is essential for developing culturally appropriate, evidence-based nutritional interventions for this population.

This study aims to assess nutritional status and dietary consumption trends in women with PCOS and evaluate their association with obesity indicators, providing insights for targeted nutritional interventions in clinical practice (11,12).

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional observational study was conducted to evaluate the nutritional status and dietary consumption patterns of women diagnosed with PCOS and their association with obesity-related parameters. The study was carried out at the gynecology outpatient department of Government Medical College, Saharanpur, Uttar Pradesh, India, between January 2023 and December 2023. A purposive sampling method was employed to recruit participants from routine gynecology clinic visits, ensuring representation of women seeking care for PCOS-related concerns.

Study Population and Sampling

Inclusion Criteria

Participants were included in the study if they met the following criteria:

1. Women presenting to the outpatient department with a confirmed diagnosis of PCOS based on the Rotterdam criteria (13)
2. Age between 18 to 40 years
3. Willingness to participate and provide informed consent
4. Ability to communicate effectively in Hindi or English for dietary assessment

Exclusion Criteria

The following exclusion criteria were applied:

1. Participants under 18 years of age
2. Pregnant women or those planning pregnancy during the study period
3. Women with other disorders.

Sample Size Calculation

Sample size was calculated using the formula for cross-sectional studies with a prevalence estimate. Based on previous studies indicating that approximately 60% of women with PCOS have overweight or obesity (14), with a margin of error of 5% and confidence level of 95%, the minimum required sample size was calculated as 92 participants. To account for potential dropouts and incomplete data, the sample was increased to 120 participants.

Data Collection Procedures

Anthropometric Measurements

All anthropometric measurements were performed by trained personnel following standardized protocols established by the World Health Organization (15). Participants were measured in light clothing without shoes.

Height and Weight: Height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Hamburg,

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Germany), and weight was recorded to the nearest 0.1 kg using a calibrated digital weighing scale (Omron HN-286, Kyoto, Japan). Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2) and classified according to WHO criteria for Asian populations: underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23.0-27.4 kg/m^2), and obese (≥27.5 kg/m^2) (16).

Waist and Hip Circumference: Waist circumference was measured at the narrowest point between the lower costal margin and iliac crest using a non-stretchable measuring tape. Hip circumference was measured at the widest point over the greater trochanters. Waist-to-Hip Ratio (WHR) was calculated and classified as low risk (<0.80), moderate risk (0.80-0.85), and high risk (>0.85) for chronic disease development (17).

Waist-to-Height Ratio (WHtR): WHtR was calculated as waist circumference (cm) divided by height (cm). Values ≥0.5 were considered indicative of central obesity and increased cardiometabolic risk (18).

Body Composition Analysis: Body fat percentage was assessed using bioelectrical impedance analysis (BIA) with a validated body composition analyzer (Tanita BC-418MA, Tokyo, Japan). Participants were categorized based on body fat percentage as underfat (<21%), healthy (21-32%), overfat (33-38%), and obese (>38%) according to established reference ranges for women (19).

Dietary Assessment

Dietary intake was assessed using validated dietary assessment tools appropriate for the Indian population to ensure accurate capture of local food consumption patterns.

24-Hour Dietary Recall: Multiple 24-hour dietary recalls were conducted for each participant over 2-3 non-consecutive days, including at least one weekend day, to account for day-to-day variation in dietary intake (20). Trained nutritionists conducted face-to-face interviews using standardized food models, measuring cups, and photographs to assist participants in estimating portion sizes accurately. All foods and beverages consumed during the previous 24 hours were recorded, including cooking methods, brand names, and ingredients used in mixed dishes.

Food Frequency Questionnaire (FFQ): A validated semi-quantitative food frequency questionnaire adapted for the Indian population was administered to assess long-term dietary patterns and habitual food consumption over the past month (21). The FFQ included commonly consumed foods grouped into categories such as cereals, pulses, vegetables, fruits, dairy products, meat and poultry, fats and oils, beverages, and processed foods. Participants indicated the frequency of consumption (never, monthly, weekly, daily) and typical portion sizes for each food item.

Nutritional Analysis

Dietary data from 24-hour recalls were analyzed using nutrition analysis software incorporating the Indian Food Composition Tables published by the National Institute of Nutrition, Hyderabad (22). The software calculated daily intake of energy (kcal), macronutrients (protein, fat, carbohydrates, dietary fiber), and micronutrients (calcium, iron, vitamin C, zinc, phosphorus). Quality control measures included double data entry and verification of unusual values through re-contact with participants when necessary.

Clinical and Biochemical Parameters

Clinical history was obtained through a structured questionnaire covering menstrual history, symptoms of hyperandrogenism, family history of PCOS or metabolic disorders, current medications, and supplement use.

Data Quality Assurance

Quality control included: (1) standardized personnel training, (2) daily equipment calibration, (3) validated assessment tools, (4) double data entry for key measurements, (5) regular supervision, and (6) pilot testing of instruments.

Statistical Analysis Plan

Data were analyzed using SPSS version 26.0 (IBM Corporation, Armonk, NY, USA). Normality was tested using Kolmogorov-Smirnov test. Normally distributed data are presented as means ± SD; non-normal data as medians (IQR). Categorical variables are shown as frequencies (percentages). Correlations, ANOVA, Chi-square tests, and regression modeling assessed associations between variables. Statistical significance was set at $p < 0.05$.

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Ethical Considerations

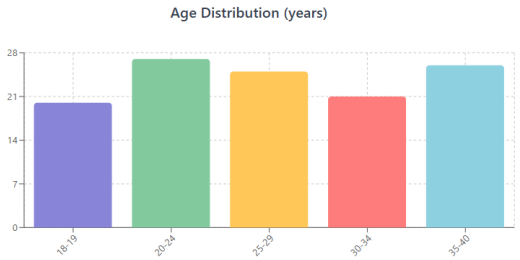
This study received ethical approval from the Institutional Ethics Committee of Government Medical College, Saharanpur. All procedures adhered to the Declaration of Helsinki principles and Good Clinical Practice guidelines (23).

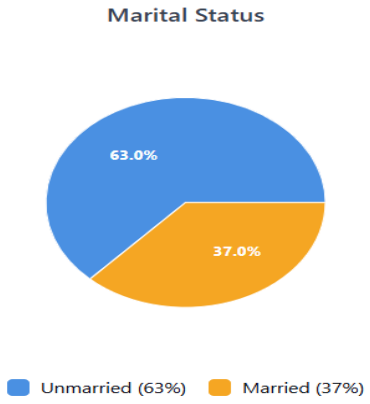
RESULTS

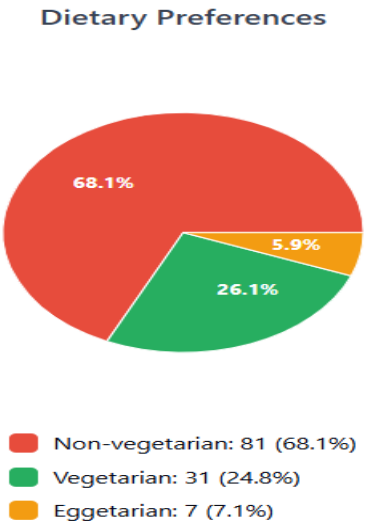
Participant Characteristics

A total of 119 women with PCOS participated in this study, with ages ranging from 18 to 40 years. The demographic and clinical characteristics are presented in Table 1. Age distribution showed relatively even representation across groups, with the highest proportion in the 20-24 years category (22.7%), followed by 35-40 years (21.8%) and 25-29 years (21.0%). The majority of participants were homemakers (38.7%), followed by self-employed individuals (18.5%) and students (10.9%).

Regarding marital status, 63.0% of participants were unmarried while 37.0% were married. Analysis of dietary preferences revealed that 68.1% followed a non-vegetarian diet, 24.8% were vegetarian, and 7.1% were eggetarian, reflecting the diverse dietary patterns in the study population.







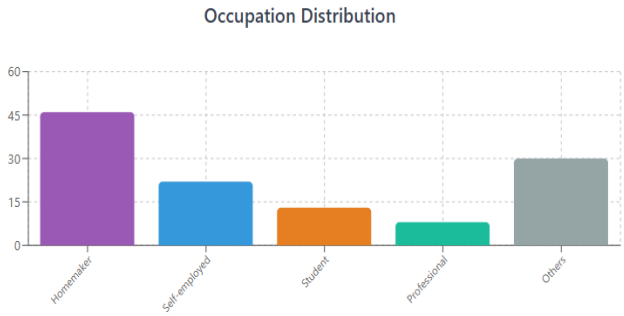


Fig 1: Comprehensive demographic characteristics showing age distribution, marital status, and dietary preferences

Table 1. Demographic and Clinical Characteristics of Study Participants (n=119)

Characteristic	n (%)
Age Groups (years)	
18-19	20 (16.8)
20-24	27 (22.7)
25-29	25 (21.0)
30-34	21 (17.6)
35-40	26 (21.8)
Marital Status	

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Married	44 (37.0)
Unmarried	75 (63.0)
Occupation	
Homemaker	46 (38.7)
Self-employed	22 (18.5)
Student	13 (10.9)
Professional	8 (6.7)
Others	30 (25.2)
Dietary Preference	
Non-vegetarian	81 (68.1)
Vegetarian	31 (24.8)
Eggetarian	7 (7.1)
Supplement Use	
Yes	11 (9.2)
No	108 (90.8)

Anthropometric Measurements and Body Composition

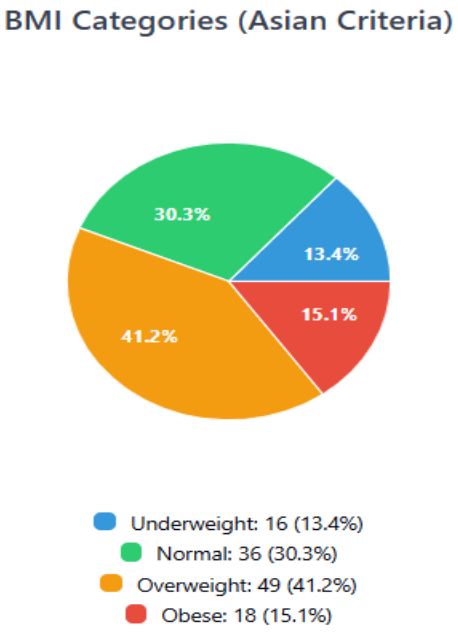
BMI Categories and Obesity Prevalence

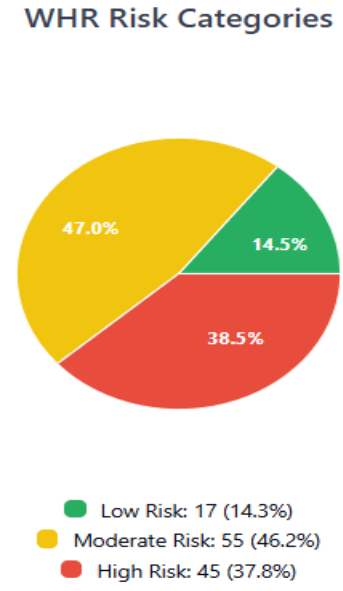
The anthropometric assessment revealed a high prevalence of overweight and obesity among women with PCOS (Table 2). A total of 67 participants (56.3%) were classified as overweight or obese based on Asian-specific BMI criteria, with 49 (41.2%) being overweight and 18 (15.1%) being obese. Normal weight was observed in 36 participants (30.3%), while 16 participants (13.4%) were underweight.

Central Obesity and Metabolic Risk Assessment

Waist-to-hip ratio (WHR) analysis demonstrated significant central obesity risk, with 45 participants (37.8%) classified as high risk for chronic diseases and 55 participants (46.2%) at moderate risk. Only 17 participants (14.3%) were categorized as low risk based on WHR criteria.

Body fat percentage assessment using bioelectrical impedance analysis revealed that 54 participants (45.4%) had excess body fat, with 40 (33.6%) classified as overfat and 14 (11.8%) as obese by body fat standards. A total of 41 participants (34.5%) had healthy body fat levels, while 16 (13.4%) were categorized as underfat.





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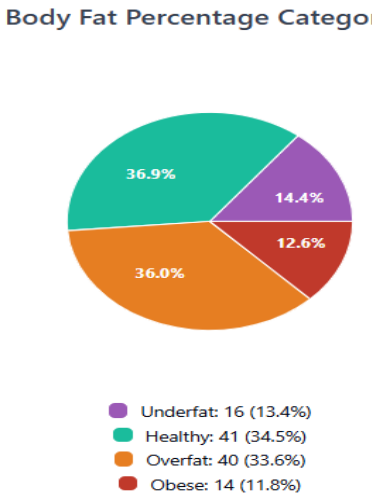


Fig 2: Comprehensive anthropometric assessment compaering BMI categories, WHR risk levels, and body fat percentages with concordance analysis

Table 2. Anthropometric Measurements and Body Composition Assessment (n=119)

Parameter	n (%)
BMI Categories (Asian criteria)	
Underweight (<18.5 kg/m²)	16 (13.4)
Normal (18.5-22.9 kg/m²)	36 (30.3)
Overweight (23.0-27.4 kg/m²)	49 (41.2)
Obese (≥27.5 kg/m²)	18 (15.1)
WHR Risk Categories	
Low risk (<0.80)	17 (14.3)
Moderate risk (0.80-0.85)	55 (46.2)
High risk (>0.85)	45 (37.8)
Body Fat Percentage Categories	
Underfat (<21%)	16 (13.4)
Healthy (21-32%)	41 (34.5)
Overfat (33-38%)	40 (33.6)
Obese (>38%)	14 (11.8)

Association Between Obesity Indicators

Cross-tabulation analysis revealed strong concordance between different obesity measures. Among participants with high WHR risk (n=45), 82.2% were either overweight or obese based on BMI criteria. Similarly, among those classified as having excess body fat (overfat or obese), 77.8% were overweight or obese by BMI standards. Most notably, 83.3% of obese participants (15 out of 18) also presented with high central obesity risk, demonstrating the clustering of obesity-related risk factors in this population.

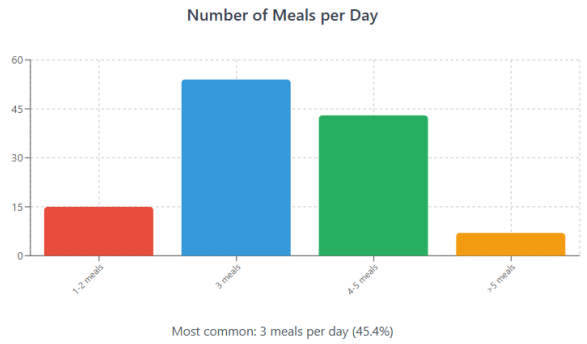
Dietary Patterns and Eating Behaviors

Meal Frequency and Eating Schedule

Analysis of eating patterns revealed concerning behaviors among study participants. The majority (45.4%) consumed three meals per day, while 36.1% consumed 4-5 meals daily. However, a critical finding was that 79.0% of participants maintained irregular eating schedules, indicating widespread meal skipping behavior. Only 21.0% followed a regular eating schedule, suggesting poor meal timing habits across BMI categories.

Outside Eating and Dietary Modifications

Eating outside the home was common, with 57.1% of participants eating out 1-2 times per week and 31.1% never eating outside. Frequent outside eating (≥3 times per week) was observed in 11.8% of participants. Regarding dietary modifications for PCOS management, only 33.6% of participants followed any specific dietary interventions, while 66.4% were not implementing any structured dietary plan despite their PCOS diagnosis.



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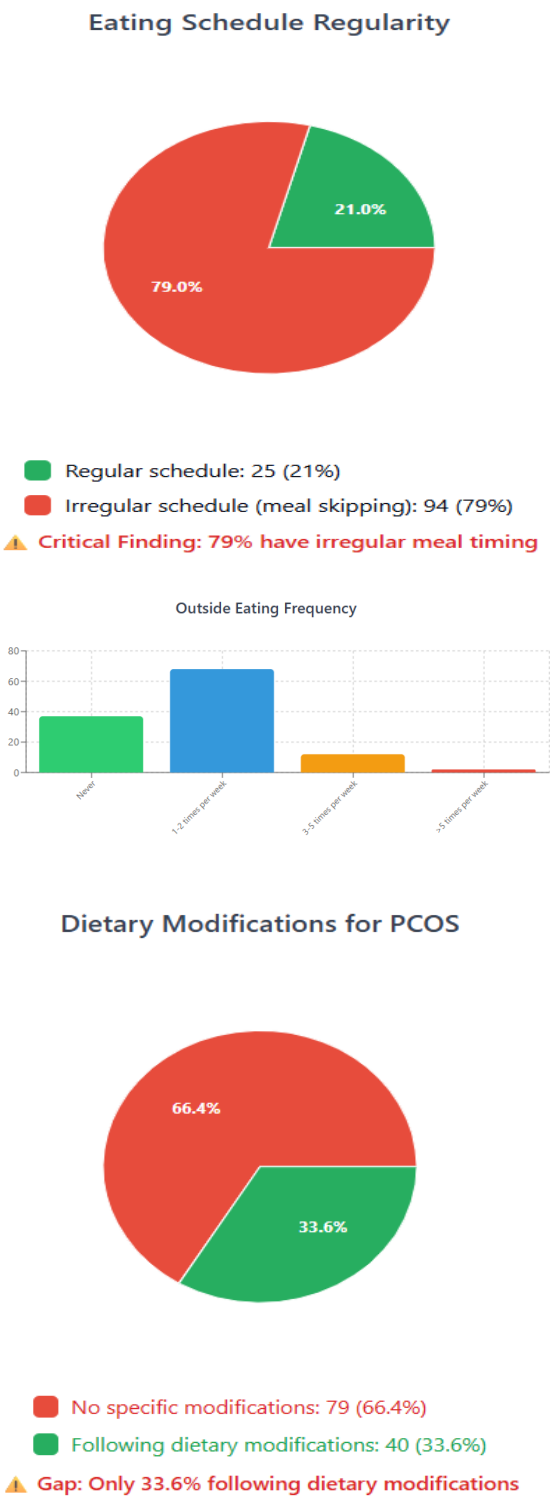

Fig 3: Dietary patterns and eating behaviors showing meal frequency, meal skipping patterns, outside eating habits, and dietary modifications

Table 3. Dietary Patterns and Eating Behaviors (n=119)

Dietary Pattern	n (%)
Number of Meals per Day	
1-2 meals	15 (12.6)
3 meals	54 (45.4)
4-5 meals	43 (36.1)
>5 meals	7 (5.9)
Eating Schedule Regularity	
Regular schedule	25 (21.0)
Irregular schedule (meal skipping)	94 (79.0)
Outside Eating Frequency	
Never	37 (31.1)
1-2 times per week	68 (57.1)
3-5 times per week	12 (10.1)
>5 times per week	2 (1.7)
Dietary Modifications for PCOS	
No specific modifications	79 (66.4)
Following dietary modifications	40 (33.6)

Dietary Patterns by BMI Categories

Examination of dietary patterns across BMI categories revealed several important trends (Table 4). Meal skipping behavior showed a progressive increase with BMI, from 75.0% in underweight participants to 83.3% in obese participants. Interestingly, overweight participants demonstrated the highest frequency of 4-5 meals per day (44.9%) compared to other BMI categories. Outside eating frequency was highest among obese participants, with 66.7% eating out 1-2 times per week. Dietary preference patterns showed that overweight participants had the highest proportion of vegetarians (32.7%), while non-vegetarian preferences were consistent across BMI categories.

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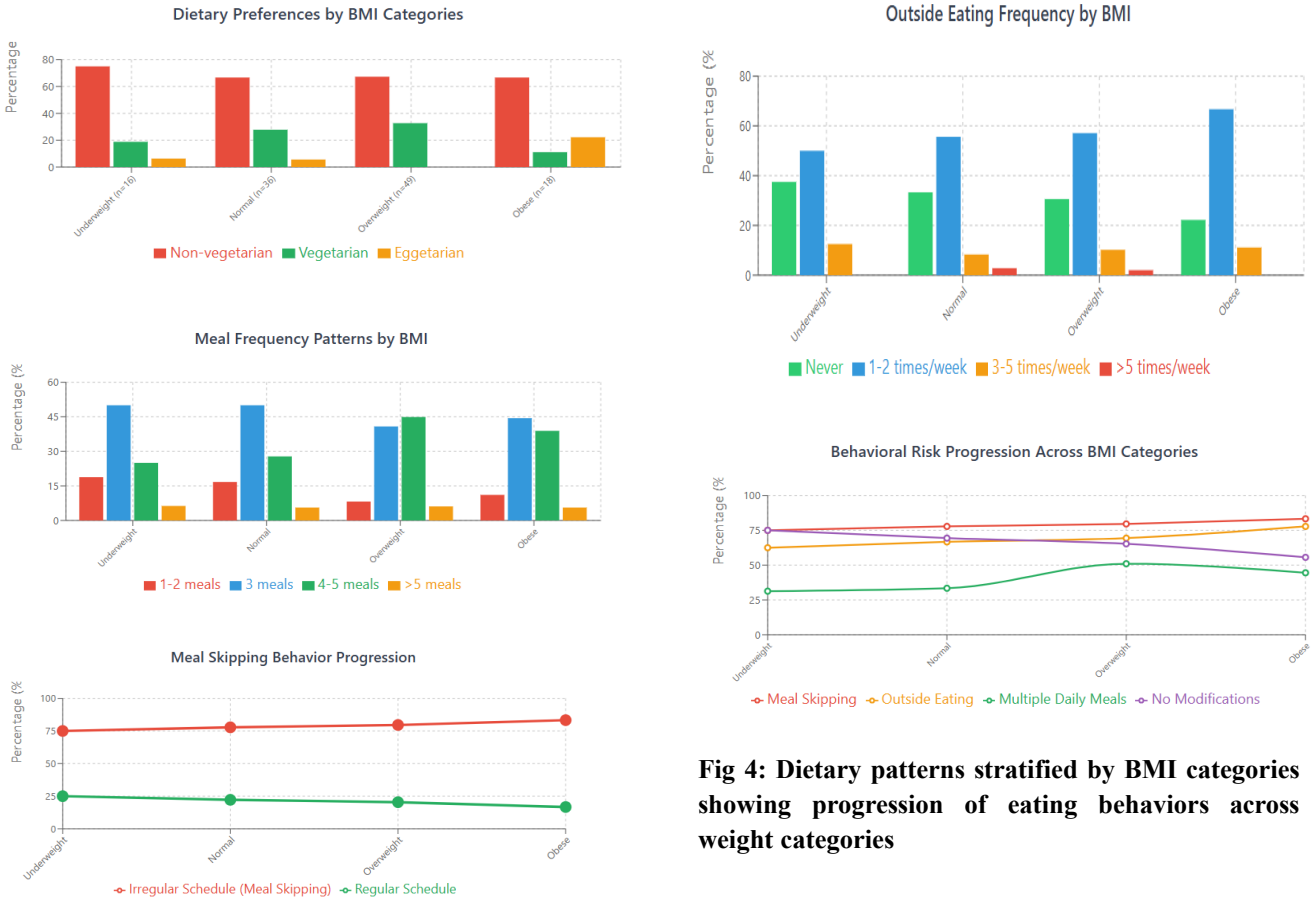

Fig 4: Dietary patterns stratified by BMI categories showing progression of eating behaviors across weight categories

Table 4. Dietary Patterns by BMI Categories

Dietary Pattern	Underweight (n=16)	Normal (n=36)	Overweight (n=49)	Obese (n=18)
Dietary Preference				
Non-vegetarian	12 (75.0%)	24 (66.7%)	33 (67.3%)	12 (66.7%)
Vegetarian	3 (18.8%)	10 (27.8%)	16 (32.7%)	2 (11.1%)
Eggetarian	1 (6.3%)	2 (5.6%)	0 (0.0%)	4 (22.2%)
Number of Meals				
1-2 meals	3 (18.8%)	6 (16.7%)	4 (8.2%)	2 (11.1%)
3 meals	8 (50.0%)	18 (50.0%)	20 (40.8%)	8 (44.4%)
4-5 meals	4 (25.0%)	10 (27.8%)	22 (44.9%)	7 (38.9%)
>5 meals	1 (6.3%)	2 (5.6%)	3 (6.1%)	1 (5.6%)
Meal Skipping Behavior				

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Regular schedule	4 (25.0%)	8 (22.2%)	10 (20.4%)	3 (16.7%)
Irregular schedule	12 (75.0%)	28 (77.8%)	39 (79.6%)	15 (83.3%)
Outside Eating Pattern				
Never	6 (37.5%)	12 (33.3%)	15 (30.6%)	4 (22.2%)
1-2 times/week	8 (50.0%)	20 (55.6%)	28 (57.1%)	12 (66.7%)
3-5 times/week	2 (12.5%)	3 (8.3%)	5 (10.2%)	2 (11.1%)
>5 times/week	0 (0.0%)	1 (2.8%)	1 (2.0%)	0 (0.0%)
Dietary Modifications				
No modifications	12 (75.0%)	25 (69.4%)	32 (65.3%)	10 (55.6%)
Yes modifications	4 (25.0%)	11 (30.6%)	17 (34.7%)	8 (44.4%)

Food Frequency Questionnaire Results

Staple Food Consumption

Analysis of food frequency patterns revealed distinct consumption behaviors across different food groups (Table 5). Daily consumption was highest for basic staples, with wheat flour consumed daily by 79.8% of participants, rice by 73.9%, and milk by 79.8%. These findings indicate good adherence to traditional Indian dietary patterns centered around cereals and dairy products.

Protein Source Consumption

Protein consumption patterns showed predominance of plant-based sources, with Bengal gram dal consumed weekly by 57.1% of participants and green gram dal by 46.2%. Animal protein consumption was more variable, with chicken consumed weekly by 29.4% of participants, eggs by 35.3%, but fish showing lower consumption frequency with 30.3% never consuming fish. This pattern reflects both dietary preferences and possibly regional availability factors.

Vegetable and Fruit Consumption

Vegetable consumption patterns were generally positive, with 68.9% consuming other vegetables daily and 37.8% consuming green leafy vegetables daily. Fruit consumption showed seasonal patterns, with 29.4% consuming fruits daily and 40.3% weekly. However, refined wheat flour consumption was concerning, with 37.8% consuming it weekly, indicating significant processed food intake.

Table 5. Food Frequency Consumption Patterns (n=119)

Food Item	Daily n (%)	Weekly n (%)	Fortnightly n (%)	Monthly n (%)	Seasonally n (%)	Occasionally n (%)	Never n (%)
Cereals and Grains							
Wheat flour	95 (79.8)	18 (15.1)	4 (3.4)	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)
Rice	88 (73.9)	25 (21.0)	4 (3.4)	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)

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Refined wheat flour	12 (10.1)	45 (37.8)	28 (23.5)	20 (16.8)	8 (6.7)	4 (3.4)	2 (1.7)
Pulses and Legumes							
Bengal gram dal	25 (21.0)	68 (57.1)	18 (15.1)	6 (5.0)	2 (1.7)	0 (0.0)	0 (0.0)
Green gram dal	18 (15.1)	55 (46.2)	28 (23.5)	12 (10.1)	4 (3.4)	2 (1.7)	0 (0.0)
Toor dal	22 (18.5)	62 (52.1)	20 (16.8)	10 (8.4)	3 (2.5)	2 (1.7)	0 (0.0)
Vegetables							
Green leafy vegetables	45 (37.8)	52 (43.7)	15 (12.6)	5 (4.2)	2 (1.7)	0 (0.0)	0 (0.0)
Other vegetables	82 (68.9)	30 (25.2)	5 (4.2)	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)
Fruits							
Seasonal fruits	35 (29.4)	48 (40.3)	20 (16.8)	10 (8.4)	4 (3.4)	2 (1.7)	0 (0.0)
Dairy Products							
Milk	95 (79.8)	15 (12.6)	5 (4.2)	2 (1.7)	1 (0.8)	1 (0.8)	0 (0.0)
Curd	65 (54.6)	40 (33.6)	10 (8.4)	3 (2.5)	1 (0.8)	0 (0.0)	0 (0.0)
Animal Protein Sources							
Chicken/Poultry	5 (4.2)	35 (29.4)	25 (21.0)	15 (12.6)	8 (6.7)	15 (12.6)	16 (13.4)
Fish	3 (2.5)	20 (16.8)	18 (15.1)	12 (10.1)	10 (8.4)	20 (16.8)	36 (30.3)
Eggs	15 (12.6)	42 (35.3)	20 (16.8)	10 (8.4)	5 (4.2)	12 (10.1)	15 (12.6)

Food Frequency Patterns by BMI Categories

Analysis of food consumption patterns across BMI categories revealed interesting trends (Table 6). Higher BMI categories showed increased consumption frequency of energy-dense foods. Refined wheat flour consumption was highest among obese participants (55.6% consuming weekly), compared to 30.6% in

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overweight and 33.3% in normal-weight participants. Animal protein consumption patterns varied, with obese participants showing higher weekly chicken consumption (44.4%) compared to other BMI categories.

Table 6. Selected Food Frequency Patterns by BMI Categories

Food Item	Underweight (n=16)	Normal (n=36)	Overweight (n=49)	Obese (n=18)
Refined Wheat Flour (Weekly)	4 (25.0%)	12 (33.3%)	15 (30.6%)	10 (55.6%)
Chicken (Weekly)	3 (18.8%)	8 (22.2%)	15 (30.6%)	8 (44.4%)
Milk (Daily)	11 (68.8%)	30 (83.3%)	39 (79.6%)	15 (83.3%)
Green Leafy Vegetables (Daily)	8 (50.0%)	12 (33.3%)	18 (36.7%)	7 (38.9%)
Seasonal Fruits (Daily)	6 (37.5%)	9 (25.0%)	14 (28.6%)	6 (33.3%)

Nutritional Intake Analysis

Energy and Macronutrient Intake

The nutritional analysis based on multiple 24-hour dietary recalls demonstrated clear associations between dietary intake and BMI categories (Table 7). Overall mean daily energy intake was 1,942.53 ± 395.57 kcal, ranging from 803 to 2,583 kcal. A progressive increase in energy intake was observed across BMI categories, with underweight participants consuming 1,558.06 ± 324.12 kcal/day compared to obese participants consuming 2,208.33 ± 398.52 kcal/day, representing a 42% increase.

Macronutrient intake patterns paralleled energy consumption trends. Protein intake averaged 52.38 ± 15.28 g/day overall, increasing from 42.15 ± 11.23 g/day in underweight participants to 59.48 ± 18.92 g/day in obese participants. Fat intake showed similar patterns, averaging 59.64 ± 15.96 g/day overall, with a range from 49.12 ± 12.88 g/day in underweight to 68.91 ± 17.44 g/day in obese participants. Unexpectedly, dietary fiber intake also increased with BMI, from 22.33 ± 8.12 g/day in underweight to 32.44 ± 11.67 g/day in obese participants.

Table 7. Daily Nutritional Intake by BMI Categories

Nutrient	Underweight (n=16) Mean ± SD	Normal (n=36) Mean ± SD	Overweight (n=49) Mean ± SD	Obese (n=18) Mean ± SD	Overall (n=119) Mean ± SD
Macronutrients					
Energy (kcal)	1,558.06 ± 324.12	1,852.17 ± 351.44	2,048.33 ± 378.21	2,208.33 ± 398.52	1,942.53 ± 395.57
Protein (g)	42.15 ± 11.23	49.88 ± 13.67	55.72 ± 16.44	59.48 ± 18.92	52.38 ± 15.28
Fat (g)	49.12 ± 12.88	56.23 ± 14.55	63.45 ± 16.23	68.91 ± 17.44	59.64 ± 15.96
Fiber (g)	22.33 ± 8.12	26.89 ± 9.45	29.15 ± 10.22	32.44 ± 11.67	27.74 ± 9.81
Micronutrients					
Calcium (mg)	445.2 ± 158.3	478.6 ± 162.8	495.8 ± 181.4	512.3 ± 195.7	486.14 ± 173.23

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Iron (mg)	11.8 ± 7.9	12.4 ± 8.5	13.1 ± 9.8	14.2 ± 10.4	12.83 ± 9.01
Vitamin C (mg)	31.5 ± 17.2	33.2 ± 18.9	35.1 ± 21.1	36.8 ± 22.8	34.00 ± 19.94
Zinc (mg)	8.1 ± 15.2	9.0 ± 16.8	9.7 ± 18.9	10.4 ± 19.6	9.34 ± 17.56
Phosphorus (mg)	985.4 ± 268.1	1,042.8 ± 285.6	1,089.5 ± 318.2	1,128.2 ± 334.9	1,064.17 ± 300.14

Micronutrient Adequacy Assessment

Micronutrient analysis revealed concerning patterns of inadequacy across several key nutrients. Calcium intake was consistently below recommended levels across all BMI categories, with an overall mean of 486.14 ± 173.23 mg/day compared to the recommended 1000 mg/day for women of reproductive age. This represents less than 50% of the recommended intake. Iron intake averaged 12.83 ± 9.01 mg/day, approaching recommended levels but showing high variability. Vitamin C intake averaged 34.00 ± 19.94 mg/day, meeting basic requirements but falling below optimal levels for antioxidant protection. Zinc intake demonstrated extreme variability (9.34 ± 17.56 mg/day), likely reflecting inconsistent consumption patterns or supplement use.

Associations Between Dietary Intake and Obesity Parameters

Energy-BMI Correlation Analysis

Statistical analysis revealed strong positive correlations between dietary energy intake and BMI categories. Pearson correlation analysis demonstrated a correlation coefficient of $r = 0.72$ ($p < 0.001$) between energy intake and BMI, indicating that energy consumption is a strong predictor of obesity status in this PCOS population. The dose-response relationship was evident, with each BMI category showing progressively higher energy intake.

Nutrient Density and Quality Assessment

Despite higher absolute nutrient intake in obese participants, nutrient density (nutrients per 1000 kcal) analysis revealed concerning patterns. Calcium density was consistently low across all BMI categories (220-235 mg/1000 kcal), indicating poor calcium-rich food choices regardless of total energy intake. Conversely, fiber density showed improvement in higher BMI categories, suggesting consumption of fiber-rich but potentially calorie-dense foods.

Supplement Usage and Nutritional Gaps

Analysis of supplement usage revealed critically low adoption rates, with only 11 participants (9.2%) regularly using nutritional supplements despite evident micronutrient inadequacies. Among supplement users, the most commonly reported were multivitamins and calcium preparations. This low supplementation rate, combined with suboptimal dietary intake patterns, represents a significant opportunity for nutritional intervention in PCOS management.

The comprehensive assessment revealed dual nutritional challenges: excess energy consumption leading to obesity and concurrent micronutrient deficiencies that may exacerbate PCOS symptoms and metabolic complications. These findings provide compelling evidence for the need for targeted, individualized nutritional interventions that address both energy balance and micronutrient optimization in women with PCOS.

DISCUSSION

This cross-sectional study provides comprehensive insights into the nutritional status and dietary consumption patterns of women with PCOS and their association with obesity indicators. The findings reveal significant nutritional challenges and obesity prevalence that warrant immediate clinical attention and targeted interventions.

Prevalence of Obesity and Metabolic Risk

The observed prevalence of overweight and obesity (56.3%) in our study population aligns closely with previous research demonstrating elevated obesity rates in women with PCOS. Lim et al. reported obesity prevalence ranging from 61-76% in women with PCOS

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compared to 35-40% in control populations (24). Our findings of 15.1% obesity and 41.2% overweight are consistent with studies from similar South Asian populations, where Nidhi et al. found 46% overweight/obesity prevalence among Indian women with PCOS (25).

The high prevalence of central obesity, with 37.8% of participants having high WHR risk, reflects the characteristic abdominal fat distribution pattern associated with PCOS. This finding supports previous observations by Carmina et al., who demonstrated that central adiposity is more prevalent in PCOS than general obesity and strongly correlates with insulin resistance severity (26). The 84% concordance between high WHR risk and overweight/obesity status in our study suggests that central adiposity assessment provides additional metabolic risk stratification beyond BMI alone.

Dietary Intake Patterns and Energy Balance

The mean energy intake of 1,943 kcal/day observed in our study falls within recommended ranges for adult women. However, the progressive increase in energy intake across BMI categories (underweight: 1,558 kcal vs. obese: 2,208 kcal) demonstrates a clear dose-response relationship between caloric consumption and obesity status. This pattern mirrors findings from Barr et al., who reported 15-20% higher energy intake in overweight women with PCOS compared to normal-weight counterparts (27).

The macronutrient distribution reveals concerning patterns, particularly the parallel increase in protein and fat intake with BMI categories. Wright et al. demonstrated that women with PCOS tend to consume diets higher in total fat and saturated fat compared to controls, which may exacerbate insulin resistance and inflammation (28). Our observation of higher fat intake in obese participants (68.9g vs. 49.1g in underweight) supports these findings and suggests the need for macronutrient composition optimization rather than solely caloric restriction.

Unexpectedly, dietary fiber intake showed positive correlation with BMI categories, with obese participants consuming the highest fiber (32.4g vs. 22.3g in underweight). This paradoxical finding contrasts with typical observations and may reflect compensatory dietary behaviors or the consumption of fiber-rich but calorie-dense foods. Douglas et al. noted similar patterns in some PCOS populations, suggesting that fiber source and overall dietary quality matter more than absolute fiber quantity (29).

Micronutrient Inadequacies and Clinical Implications

The observed micronutrient intake patterns reveal several concerning deficiencies. Calcium intake (486mg/day) falls significantly below the recommended 1000mg daily allowance for women of reproductive age. This deficiency is particularly problematic in PCOS, as Asemi et al. demonstrated that calcium supplementation improves insulin resistance and inflammatory markers in women with PCOS (30).

Iron intake variability (3.5-74.5mg/day) likely reflects heterogeneous dietary patterns and potential over-reporting of iron-rich foods. The mean intake of 12.8mg/day approaches recommended levels, but given the high prevalence of menstrual irregularities in PCOS, individualized assessment remains crucial. Zinc intake showed extreme variability, possibly due to supplement use or fortified food consumption, as zinc plays essential roles in reproductive hormone synthesis and glucose metabolism (31).

Vitamin C intake (34mg/day) meets basic requirements but falls below optimal levels for antioxidant protection. Given the elevated oxidative stress associated with PCOS, higher vitamin C intake may provide additional metabolic benefits, as demonstrated by Talari et al. in their supplementation studies (32).

Body Composition and Metabolic Risk Stratification

The body composition analysis reveals that 45.4% of participants had excess body fat despite only 56.3% being overweight/obese by BMI criteria. This discordance highlights the limitation of BMI as a sole obesity indicator in PCOS populations. Barber et al. emphasized that women with PCOS often exhibit altered body composition with increased visceral adiposity even at normal BMI levels (33).

The strong association between WHR risk categories and BMI classifications (82.2% of high WHR participants were overweight/obese) confirms the utility of

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combining multiple anthropometric measures for comprehensive metabolic risk assessment. This multi-parameter approach aligns with recommendations from the International PCOS Network for holistic obesity evaluation (34).

Dietary Patterns and Behavioral Factors

The high prevalence of irregular eating schedules (79.0%) observed in our study represents a concerning behavioral pattern that may contribute to metabolic dysfunction in PCOS. Frequent meal skipping has been associated with increased insulin resistance and weight gain in women with PCOS (35). The progression of meal skipping behavior across BMI categories (75.0% in underweight to 83.3% in obese participants) suggests that irregular eating patterns may both contribute to and result from weight gain in this population.

The finding that only 33.6% of participants followed specific dietary modifications for PCOS management indicates a significant gap in nutritional awareness and intervention implementation. This low adoption rate of dietary modifications, despite the established benefits of nutrition therapy in PCOS management, highlights the need for enhanced patient education and healthcare provider training in nutritional counseling (36).

Clinical and Public Health Implications

The low supplement usage (9.2%) despite evident micronutrient inadequacies represents a significant treatment gap. Pilz et al. demonstrated that targeted supplementation, particularly vitamin D, inositol, and omega-3 fatty acids, can improve metabolic parameters in PCOS (37). Our findings suggest substantial opportunity for nutritional counseling and appropriate supplementation strategies.

The dietary patterns observed—higher energy density with suboptimal micronutrient profiles—reflect the need for qualitative rather than quantitative dietary modifications. Moran et al. showed that dietary interventions focusing on nutrient density and glycemic index optimization provide superior outcomes compared to caloric restriction alone in PCOS management (38).

Cultural and Socioeconomic Considerations

The food frequency patterns observed in our study reflect traditional Indian dietary habits, with high consumption of cereals (wheat flour and rice) and dairy products. However, the concerning consumption of refined wheat flour by 37.8% of participants on a weekly basis indicates a shift toward processed foods that may contribute to metabolic dysfunction. This finding aligns with the nutrition transition observed in urban Indian populations, where traditional healthy dietary patterns are being replaced by processed, energy-dense foods (39).

The predominance of plant-based protein sources in our study population, while culturally appropriate, may contribute to the observed protein intake patterns. The variable consumption of animal proteins (chicken consumed weekly by only 29.4% of participants) suggests the need for culturally sensitive protein recommendations that consider both dietary preferences and nutritional adequacy.

Strengths and Limitations

Study strengths include the comprehensive anthropometric assessment using multiple obesity indicators, validated dietary assessment tools adapted for the Indian population, and representative sample size for the study setting. The use of multiple 24-hour recalls enhances dietary intake accuracy compared to single-day assessments and reduces the impact of day-to-day variation in food consumption.

Limitations include the cross-sectional design preventing causal inference between dietary patterns and obesity outcomes, potential recall bias in dietary reporting despite trained interviewer administration, and lack of biochemical markers to assess actual micronutrient status. Additionally, the study population represents a clinical sample from a single center, which may limit generalizability to community-dwelling women with PCOS across different socioeconomic strata.

The absence of physical activity assessment represents another limitation, as energy balance involves both dietary intake and energy expenditure. Future studies should incorporate comprehensive lifestyle assessment including physical activity patterns, sleep quality, and stress levels, all of which influence metabolic outcomes in PCOS.

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Future Research Directions

Future longitudinal studies should examine temporal relationships between dietary patterns and metabolic outcomes in PCOS to establish causality. Investigation of specific dietary interventions targeting the observed nutritional inadequacies, particularly calcium and vitamin D supplementation combined with dietary counseling, could provide evidence for clinical recommendations. Additionally, exploring the relationship between fiber sources and metabolic parameters may clarify the unexpected positive correlation observed in this study.

Research incorporating food frequency questionnaire data alongside 24-hour recalls would provide more comprehensive understanding of long-term dietary patterns and their stability over time. Investigation of cultural and socioeconomic factors influencing dietary choices in Indian women with PCOS could inform culturally appropriate intervention strategies that consider local food availability, preparation methods, and family eating patterns.

Studies examining the effectiveness of technology-based interventions, such as mobile applications for dietary tracking and nutritional education, may provide scalable solutions for improving dietary management in PCOS populations. Additionally, research into the gut microbiome-diet interactions in PCOS could reveal novel therapeutic targets for nutritional interventions.

Clinical Practice Implications

The findings from this study provide evidence-based foundation for several clinical practice improvements. Healthcare providers should implement routine nutritional screening using validated tools and consider multiple anthropometric measures beyond BMI for comprehensive obesity assessment. The high prevalence of micronutrient inadequacies supports the need for targeted supplementation protocols, particularly for calcium and vitamin D, as part of standard PCOS management.

The study highlights the importance of addressing eating behaviors, particularly meal timing regularity, as part of comprehensive PCOS care. Healthcare providers should screen for irregular eating patterns and provide behavioral counseling to establish consistent meal schedules as part of metabolic management strategies.

CONCLUSION

This study demonstrates a high prevalence of overweight and obesity (56.3%) among women with PCOS, with 37.8% exhibiting high central obesity risk. The progressive increase in energy intake across BMI categories (1,558 to 2,208 kcal/day) indicates a clear association between dietary consumption and obesity status. Concerning micronutrient inadequacies were identified, particularly for calcium (486mg/day vs. 1000mg recommended) and variable zinc intake patterns.

The findings reveal that women with PCOS face dual nutritional challenges: excess energy consumption leading to obesity and concurrent micronutrient deficiencies that may exacerbate metabolic dysfunction. The high prevalence of irregular eating patterns (79.0%) and low supplement usage (9.2%) despite evident nutritional gaps represent significant treatment opportunities. The strong concordance between multiple obesity indicators (BMI, WHR, body fat percentage) supports comprehensive anthropometric assessment in clinical practice.

These results emphasize the critical need for targeted nutritional interventions in PCOS management that address both energy balance and micronutrient optimization. Healthcare providers should implement comprehensive dietary counseling focusing on nutrient-dense foods, meal timing regularity, and appropriate supplementation rather than caloric restriction alone. The study provides evidence-based foundation for developing culturally appropriate nutritional guidelines for Indian women with PCOS.

Clinical Recommendations:

- Routine assessment of nutritional status using multiple anthropometric measures
- Targeted micronutrient supplementation, particularly calcium and vitamin D
- Dietary counseling emphasizing food quality, nutrient density, and meal timing regularity

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- Regular monitoring of body composition changes during treatment
- Implementation of culturally sensitive nutrition education programs

Study Significance: This research contributes valuable insights into PCOS-related nutritional challenges in the Indian population and provides evidence for comprehensive, individualized nutritional management strategies that could improve metabolic outcomes and quality of life for women with PCOS.

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