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Effectiveness of dietary interventions on metabolic and hormonal profiles in women with polycystic ovary syndrome

Mamta Gupta[1], Anuradha Yadav[2]

[1]Ph.D. Scholar, [2]Senior Professor, Department of Physiology, SMS Medical College, Jaipur, Rajasthan, India

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) affects women globally and is rising in urban areas due to sedentary lifestyles and unhealthy dietary patterns. It involves hormonal and metabolic disturbances such as insulin resistance and obesity. Lifestyle changes can improve the pathophysiology and symptoms through dietary modifications. However, optimal strategies remain unclear. **Aims and Objectives:** The present study evaluates the effectiveness of a 12-week dietary intervention on metabolic and hormonal outcomes in women with PCOS. **Materials and Methods:** This open-label, randomized controlled interventional study was conducted on 59 diagnosed PCOS women after obtaining ethical clearance and written consent. Participants underwent a 12-week dietary intervention based on the Indian Council of Medical Research and National Institute of Nutrition's Recommended Dietary Allowances. Metabolic and hormonal parameters were recorded at baseline, 6 weeks, and 12 weeks. Results were expressed as mean ± standard deviation. Data were analyzed using repeated measures analysis of variance, with Bonferroni *post hoc* tests for pairwise comparisons, and a $P < 0.05$ was considered statistically significant. **Results:** Most participants were young, urban, educated, and from higher socioeconomic backgrounds. Dietary modification led to significant reductions in hemoglobinA1c, lipid parameters (triglycerides, total cholesterol, and low-density lipoprotein), and an increase in high-density lipoprotein levels, reflecting improved metabolic health. Hormonal profiles also improved significantly, with reductions in LH, insulin, dehydroepiandrosterone, estradiol, prolactin, and testosterone, and increases in sex hormone binding globulin and progesterone. **Conclusions:** The findings indicate that structured dietary interventions are effective in improving both metabolic and hormonal parameters in women with PCOS. This highlights the potential of dietary modification as a valuable non-pharmacological approach to managing PCOS-related health issues.

Key words: Dehydroepiandrosterone; Dietary patterns; Insulin resistance; Obesity; Prolactin; Recommended dietary allowances; Sedentary behavior

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INTRODUCTION

Polycystic ovary syndrome (PCOS) is a prevalent endocrine disorder affecting 5–10% of women of reproductive age globally, with a rising trend observed, particularly in urban populations due to sedentary lifestyles and unhealthy dietary patterns.[1] Characterized by chronic anovulation, hyperandrogenism, and polycystic ovarian morphology, PCOS is also closely associated with a spectrum of metabolic disturbances, including insulin resistance (IR), dyslipidemia, obesity, and an increased risk of type 2 diabetes mellitus and cardiovascular disease.[2] The underlying pathophysiology of PCOS is complex, involving a bidirectional relationship between hormonal imbalance and metabolic dysfunction.[3]

Address of Correspondence:
Dr. Anuradha Yadav, Senior Professor, Department of Physiology, SMS Medical College, Jaipur - 302004, Rajasthan, India.
Mobile: +91-9414638469. **E-mail:** dr.anuradhayadav@yahoo.co.in

Lifestyle modification, especially dietary intervention, has been widely recommended as the first-line management strategy in PCOS, particularly for overweight and obese individuals.[4] Evidence suggests that even a modest weight loss of 5–10% can lead to significant improvement in menstrual regularity, insulin sensitivity, and androgen levels.[5] Diet plays a pivotal role in modulating the hormonal and metabolic milieu in PCOS. Low glycemic index diets, calorie-restricted regimens, and anti-inflammatory nutritional plans have shown promise in improving IR and lipid profiles in affected women.[6] However, there remains a lack of consensus regarding the most effective dietary strategy and the duration of intervention needed to achieve clinically meaningful outcomes.

Recent clinical trials and systematic reviews have highlighted the beneficial effects of structured dietary interventions in restoring hormonal balance, reducing circulating androgens, and improving ovulatory function.[7] Despite these advances, regional data, especially from South Asia, where dietary patterns and genetic predispositions differ, remain limited. Therefore, evaluating the efficacy of dietary modifications in improving metabolic and hormonal parameters among women with PCOS in specific populations is crucial for tailoring interventions that are both culturally acceptable and clinically effective.

The present study aims to assess the impact of diet-based lifestyle interventions over 12 weeks on metabolic and hormonal outcomes in women diagnosed with PCOS. This study seeks to contribute to the growing body of evidence supporting dietary management as a non-pharmacological, cost-effective strategy for managing PCOS and its associated comorbidities.

Aims and objectives

The present study evaluates the effectiveness of a 12-week dietary intervention on metabolic and hormonal outcomes in women with PCOS.

MATERIALS AND METHODS

This interventional study was conducted in the Department of Physiology in collaboration with the Department of Gynecology, using a randomized controlled open-label design. The intervention was a structured lifestyle modification, specifically dietary changes, among women diagnosed with PCOS attending the gynecology outpatient department. A total of 59 participants completed the diet change intervention and were included in the final analysis.

The sample size was calculated based on previous research,[8] which indicated a mean change in free testosterone levels of 0.1±0.2 pg/mL after 6 months of a low-glycemic load dietary intervention. Using a statistical power of 80% and a significance level of 0.05, the minimum required sample size was calculated to be 34, factoring in a 10% dropout rate. Thus, 65 participants were initially recruited using Primer software version 6.

Participants were selected through purposive sampling. Pre-menopausal women aged 18–40 years who met the 2003 Rotterdam Criteria for PCOS[9] and provided written informed consent were included. Exclusion criteria comprised a history of smoking, alcohol use, recent hormonal therapy, cardiovascular disease, diabetes, thyroid or adrenal disorders, hyperprolactinemia, pregnancy, breastfeeding within the past 6 months, participation in yoga or exercise programs in the last 6 months, and non-cooperative behavior or loss to follow-up.

Study procedure

The study began after receiving approval from the Departmental Research Committee and the Institutional Ethics Committee. Eligible women were diagnosed using the Rotterdam Criteria and completed a structured proforma collecting sociodemographic data, medical and gynecological history, psychiatric history, lifestyle habits, and physical parameters such as blood pressure, heart rate, height, and weight. A detailed gynecological assessment focused on symptoms such as menstrual irregularities, infertility, weight gain, and acne.

All participants were informed about the study objectives and were asked to adhere to the lifestyle interventions for 12 weeks. Written informed consent was obtained before baseline data collection. Follow-up assessments were conducted at the 6th and 12th weeks, evaluating both metabolic and hormonal parameters.

Dietary intervention

Participants received comprehensive dietary counseling and followed a structured diet plan designed according to the recommended dietary allowances (RDA),[10] a guideline from the Indian Council of Medical Research (ICMR), and the National Institute of Nutrition. The diet provided 1600–2000 kilocalories daily, including approximately 130 g of carbohydrates, 45.7 g of protein, and 25 g of fat. Adherence was encouraged through weekly follow-ups through phone calls and WhatsApp messages.

Initially, 65 participants were enrolled, but six were unable to complete the study due to personal reasons or failure to adhere to the protocol, resulting in 59 participants completing all follow-ups.

Data collection tools included a general information schedule for sociodemographic and medical history and

a dietary intake evaluation based on ICMR's RDA. Diet quality and caloric intake were monitored regularly.

Statistical analysis involved presenting categorical variables as frequencies and percentages, compared using the Chi-square test. Continuous variables were summarized as mean and standard deviation, and repeated measures analysis of variance was used to analyze differences over time. *Post hoc* Bonferroni t-tests were used for pairwise comparisons. A $P<0.05$ was considered statistically significant.

RESULTS

The sociodemographic profile of the 59 participants showed that 54.23% were aged ≤25 years, and 64.40% were from urban areas. Most participants were graduates (54.23%), belonged to the upper socioeconomic class (91.52%), and were unemployed (69.49%). The distribution of family type was nearly equal, with 50.84% from nuclear families and 49.15% from joint families (Table 1).

After 6 and 12 weeks of physical activity, the number of participants with standard BMI increased from 4 to 13, whereas the number of obese participants reduced from 39 to 32. Overweight cases showed a slight fluctuation. The change was not statistically significant (P=0.189). No participants were underweight throughout the study (Table 2).

Table 1: Sociodemographic profile of study participants with the intervention of physical activity (n=59)

Sociodemographic variables	Number	Percentage
Age group (years)		
≤25	32	54.23
>25	27	45.76
Locality		
Urban	38	64.40
Rural	21	35.59
Education		
Up to higher secondary	7	11.86
Graduate	32	54.23
Postgraduate	20	33.89
Socio economic status		
Upper class	54	91.52
Upper middle class	5	8.47
Middle class	0	0
Lower middle class	0	0
Lower class	0	0
Occupation		
Employed	18	30.58
Unemployed	41	69.49
Family type		
Nuclear	30	50.84
Joint	29	49.15

The dietary intervention led to a gradual decrease in fasting blood sugar (FBS) levels from baseline to 12 weeks; however, the change was not statistically significant (P=0.079). In contrast, hemoglobin A1c (HbA1c) levels showed a significant reduction over time ($P<0.001$), with *post hoc* analysis confirming a significant decrease at both 6 and 12 weeks compared to baseline. This indicates improved glycemic control following dietary modification in PCOS women (Figure 1).

The dietary intervention significantly improved metabolic parameters in PCOS women over 12 weeks. Triglycerides (TG), total cholesterol (TC), and low-density lipoprotein (LDL) levels showed a significant reduction from baseline to 6 and 12 weeks ($P<0.001$), whereas high-density lipoprotein (HDL) levels increased significantly over the same period ($P<0.001$). *Post hoc* analysis confirmed significant differences from baseline to both follow-up points for all parameters, indicating enhanced lipid profile and metabolic health following dietary changes (Figure 2).

The dietary intervention led to significant improvements in hormonal profiles among PCOS women over 12 weeks. Levels of LH, insulin, dehydroepiandrosterone (DHEA), estradiol, prolactin, and testosterone significantly decreased ($P<0.001$), whereas sex hormone binding globulin (SHBG) and progesterone levels significantly increased ($P<0.001$). Follicle-stimulating hormone (FSH) and thyroid-stimulating hormone also showed statistically significant changes ($P<0.001$ and P=0.003, respectively). *Post hoc* analysis confirmed significant differences between baseline and both follow-up intervals for most parameters, indicating favorable hormonal modulation with diet (Table 3).

The study observed significant improvements in key metabolic indices among women with PCOS following a 12-week dietary intervention. The LH/FSH ratio decreased from 3.16 at baseline to 2.48 ($P<0.001$), indicating improved hormonal balance. The free androgen index (FAI) dropped from 83.47 to 44.50, reflecting reduced androgen levels. In addition, homeostatic model assessment

Table 2: Change in BMI categories after 6 and 12 weeks of physical activity intervention (n=61)

BMI category (kg/m²)	Baseline n (%)	6 Weeks n (%)	12 Weeks N (%)	P-value (Chi-square)
Standard weight (18.5–22.9)	4	9	13	P=0.189
Overweight (23–24.9)	16	18	14	
Obese (≥25)	39	32	32	

No participants had a BMI <18.5 during the study. BMI: Body mass index

for IR (HOMA-IR) values declined from 4.63 to 2.31, suggesting enhanced insulin sensitivity, as shown in Table 4.

DISCUSSION

The present study assessed the effects of a structured dietary intervention on metabolic and hormonal parameters in women with PCOS. Most participants were young (≤25 years), urban residents, graduates, from higher socioeconomic backgrounds, and predominantly unemployed. The intervention over 12 weeks led to notable improvements in metabolic health, lipid profiles, glycemic control, and hormonal balance, although BMI reduction was not statistically significant.

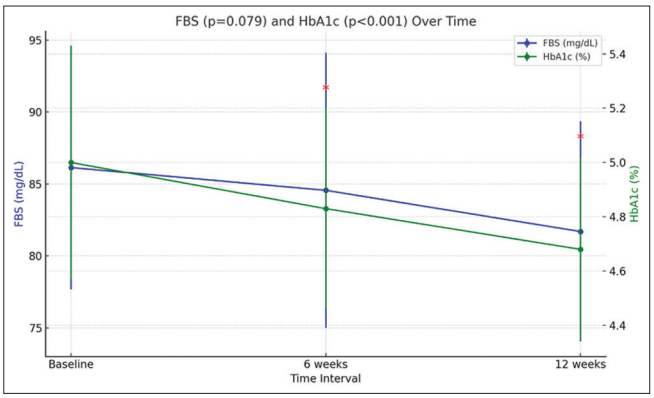

Figure 1: Effect of diet intervention on fasting blood sugar and hemoglobin A1c outcomes at different time intervals (6 and 12 weeks) in women with polycystic ovary syndrome

Following dietary modification and physical activity, an increase in the number of participants with normal BMI was observed, though the change did not reach statistical significance. This finding partially aligns with the study by Hoover et al., (2021)[11] conducted in Boston, where a low-glycemic index diet led to significant reductions in body mass index (BMI), TC, and increases in HDL levels. However, in the present study, although BMI decreased, it was not statistically significant.

Our findings regarding lipid profile improvements mirror those reported by Pandurevic et al. (2023)[12] in Italy, where a ketogenic diet over 16 weeks resulted in decreased BMI, insulin, HOMA-IR, TC, and an increase in HDL. Similarly, Paoli et al. (2020)[13] also reported significant improvements in lipid profiles and hormonal parameters, including

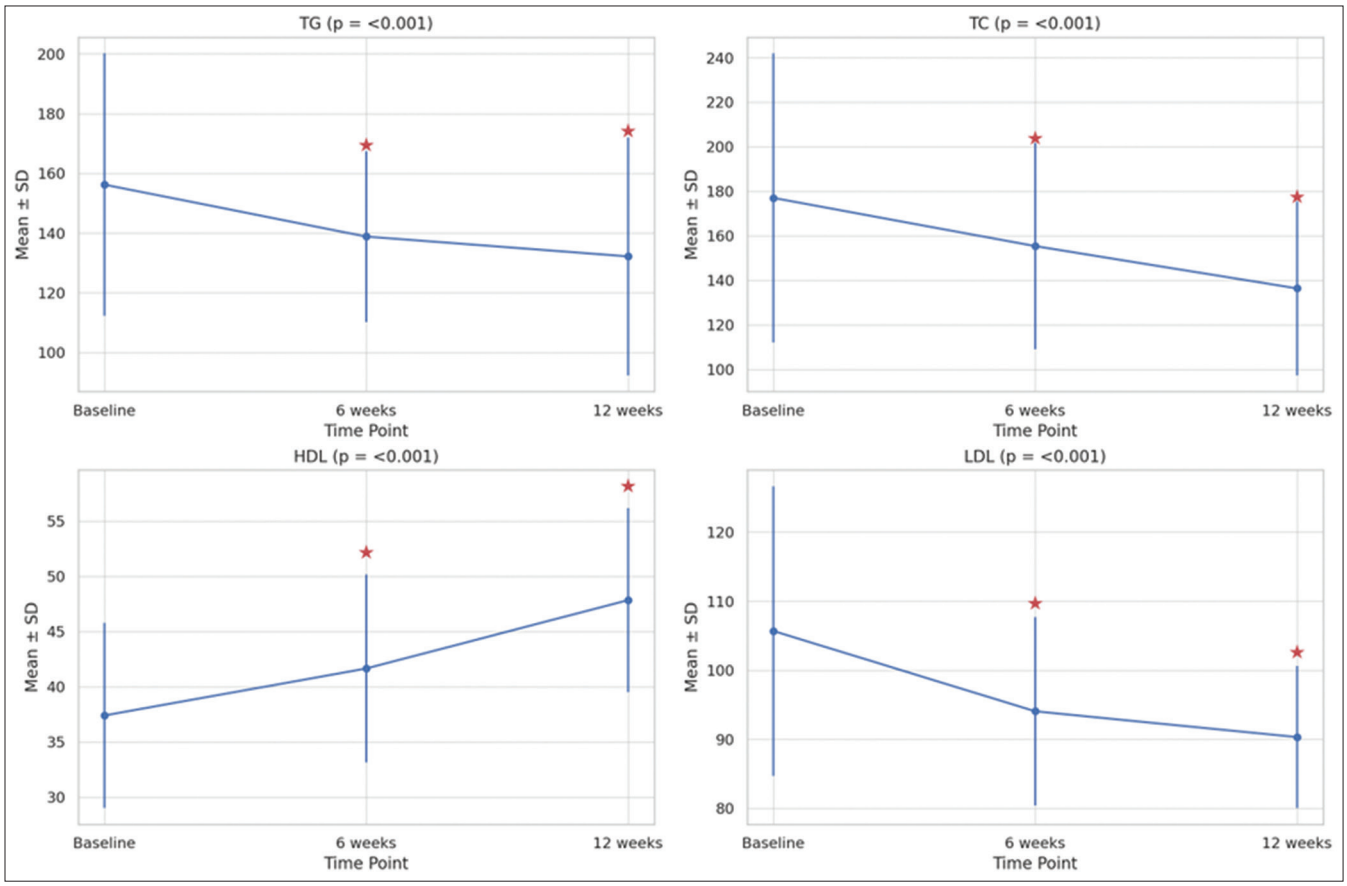

Figure 2: Effect of diet intervention on metabolic parameters in polycystic ovary syndrome. Women at the different time intervals (6 and 12 weeks). Red asterisks (*) mark time points with statistically significant change (Bonferroni *post hoc* test). TG: Triglyceride, TC: Total cholesterol, HDL: High-density lipoprotein, LDL: Low-density lipoprotein

Table 3: Effect of dietary intervention on various metabolic outcomes at different time intervals on PCOS women (n=59)

Parameter unit	Time interval	Mean	SD	"P" value*	"P"<0.05 from#
LH (mIU/mL)	Baseline (1)	17.86	4.48	<0.001	2,3
	6 weeks (2)	14.95	2.84		1
	12 weeks (3)	13.34	2.33		1
FSH (mIU/mL)	Baseline (1)	5.65	0.78	<0.001	2,3
	6 weeks (2)	5.80	0.79		1
	12 weeks (3)	5.39	0.63		1
Estradiol (pg/mL)	Baseline (1)	146.44	26.69	<0.001	2,3
	6 weeks (2)	124.41	21.45		1
	12 weeks (3)	102.18	18.84		1
Progesterone (ng/mL)	Baseline (1)	0.75	0.46	<0.001	3
	6 weeks (2)	0.92	0.44		3
	12 weeks (3)	1.33	0.38		1,2
Prolactin (ng/dL)	Baseline (1)	19.40	4.67	<0.001	3
	6 weeks (2)	16.42	3.94		3
	12 weeks (3)	13.59	3.06		1,2
DHEA (ng/dL)	Baseline (1)	335.76	75.07	<0.001	2,3
	6 weeks (2)	303.17	70.09		1
	12 weeks (3)	273.51	61.49		1
Testosterone (ng/dL)	Baseline (1)	49.57	25.72	<0.001	2,3
	6 weeks (2)	37.80	19.09		1
	12 weeks (3)	30.68	14.03		1
SHBG (nmol/dL)	Baseline (1)	61.34	10.53	<0.001	2,3
	6 weeks (2)	65.73	10.25		1
	12 weeks (3)	71.69	10.22		1
Insulin (μIU/mL)	Baseline (1)	21.75	12.08	<0.001	2,3
	6 weeks (2)	16.27	5.62		1
	12 weeks (3)	11.46	2.57		1
TSH (μIU/mL)	Baseline (1)	3.71	3.25	0.003	3
	6 weeks (2)	2.80	1.70		
	12 weeks (3)	2.68	1.02		1

*Repeated measures ANOVA, #*Post hoc* Bonferroni t-tests. TSH: Thyroid-stimulating hormone, SHBG: Sex hormone binding globulin, DHEA: Dehydroepiandrosterone, FSH: Follicle-stimulating hormone, PCOS: Polycystic ovary syndrome, ANOVA: Analysis of variance

Table 4: Effect of dietary intervention on various metabolic indices at different time intervals on PCOS women (n=59)

Metabolic indices	Time interval	Mean	SD	"P" value*	"P'<0.05 from#
LH/FSH ratio	Baseline (1)	3.16	5.72	<0.001	2, 3
	6 weeks (2)	2.58	3.62		1
	12 weeks (3)	2.48	0.57		1
Free androgen index (FAI)	Baseline (1)	83.47	45.25	<0.001	2,3
	6 weeks (2)	60.11	34.63		1,3
	12 weeks (3)	44.50	23.77		1,2
HOMA-IR	Baseline (1)	4.63	0.25	<0.001	2,3
	6 weeks (2)	3.40	0.13		1,3
	12 weeks (3)	2.31	0.05		1,2

*Repeated measures ANOVA. #*Post hoc* Bonferroni t-tests. ANOVA: Analysis of variance, FSH: Follicle-stimulating hormone, HOMA-IR: Homeostatic model assessment for insulin resistance, PCOS: Polycystic ovary syndrome

decreases in TG, TC, LDL, and increases in HDL and SHBG, comparable to the present study.

Significant hormonal changes were observed in our study, including reductions in LH, insulin, DHEA, prolactin, estradiol, and testosterone levels, with increases in SHBG and progesterone. These findings are consistent with those of Haidari et al. (2020)[14] who demonstrated reductions in BMI, fasting blood glucose (FBG), HOMA-IR, TG, and FAI, along with improved menstrual regularity in PCOS women. Kazemi et al. (2021)[15] also observed significant reductions in FBG, I, TC, TG, LDL, and prolactin, which align with our findings. Similarly, Izadi et al. (2019)[16] reported a decrease in total testosterone and HOMA-IR and an increase in SHBG among PCOS women, further supporting our results. Moreover, the significant rise in FSH levels observed in our study is consistent with findings by Qorbani et al., (2020).[17]

Another interesting comparison comes from the study by Esmaeilinezhad et al., (2020),[18] who evaluated the effects of

symbiotic pomegranate juice and found improvements in lipid profiles, oxidative stress, and inflammation, highlighting the impact of dietary interventions on metabolic health.

Paoli et al. (2020)[13] also demonstrated significant improvements in anthropometric measures, glucose-insulin metabolism, lipid profiles, and hormonal markers after 12 weeks of dietary intervention. Their observations of reduced LH/FSH ratio, testosterone, and DHEAS levels, along with increased SHBG and progesterone, closely resemble the trends noted in our study.

Overall, the findings from the present study are in strong agreement with existing literature, underscoring the effectiveness of dietary interventions in improving metabolic and hormonal outcomes in women with PCOS. Despite minor differences in BMI outcomes, the improvements in glycemic control, lipid profiles, and hormonal regulation highlight the critical role of structured lifestyle and dietary management in PCOS treatment.

Limitations of the study

This pioneering study at our institute assessed the impact of dietary interventions on metabolic and hormonal outcomes in women with PCOS. However, it has some limitations. Self-reported dietary data may be subject to recall bias. The 12-week duration was relatively short, limiting insights into long-term effects. A small sample size and participant variability in demographic, socioeconomic, and educational backgrounds may affect the validity and generalizability of results. Future studies with larger cohorts and extended follow-up are needed to confirm and build on these findings.

CONCLUSIONS

The 12-week structured dietary intervention resulted in significant improvements in metabolic, glycemic, lipid, and hormonal profiles among women with PCOS. Although changes in BMI and FBS were not statistically significant, HbA1c levels, lipid parameters (TG, TC, LDL, and HDL), and key hormonal markers (LH, insulin, DHEA, estradiol, prolactin, testosterone, SHBG, and progesterone) showed significant improvements. These findings highlight the effectiveness of dietary modification as a non-pharmacological strategy for improving metabolic and hormonal health in PCOS women.

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A**uthors' Contributions:**
AY- Played a key role in the conception and design of the study. She also contributed significantly to the literature review, data, and statistical analysis, and interpretation of results, and was actively involved in preparing and editing the manuscript; **MG-** Involved in planning the research work, literature search, data acquisition, data collection, analysis, and interpretation, and contributed to the manuscript preparation.

Work attributed to:
Department of Physiology, SMS Medical College, Jaipur - 302004, Rajasthan, India.

Orcid ID:
Mamta Gupta - https://orcid.org/0009-0002-3284-9167
Anuradha Yadav - https://orcid.org/0000-0002-9573-0545

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