

**Original Research Article** 

# IMPACT OF PHYSICAL ACTIVITY ON METABOLIC AND HORMONAL OUTCOMES IN WOMEN WITH POLYCYSTIC OVARY SYNDROME: A RANDOMIZED CONTROLLED STUDY

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 Received
 : 19/03/2025

 Received in revised form : 03/04/2025
 Accepted

 Accepted
 : 28/04/2025

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**DOI:** 10.70034/ijmedph.2025.2.226

Source of Support: Nil, Conflict of Interest: None declared

**Int J Med Pub Health** 2025; 15 (2); 1254-1259

## ABSTRACT

**Background:** Polycystic Ovary Syndrome (PCOS) is a common endocrine disorder affecting women of reproductive age, characterized by hyperandrogenism, ovarian dysfunction, and is a major cause of anovulatory infertility. This study aimed to assess the impact of structured physical activity on metabolic and hormonal parameters in women with PCOS, contributing to evidence-based recommendations for lifestyle management.

**Materials and Methods:** A randomized controlled interventional study was conducted on 61 women diagnosed with PCOS, following approval from the Institutional Ethical Committee and informed consent from participants. A structured physical activity program was implemented using the Rossmax PA-S20 pedometer. Participants were instructed to complete 9,000 steps per day, five days per week, over 12 weeks. Metabolic and hormonal parameters were measured at baseline, 6 weeks, and 12 weeks. Categorical data were expressed as percentages and analysed using the chi-square test, while continuous variables were presented as mean  $\pm$  SD and analysed using ANOVA with post-hoc testing. A p-value of <0.05 was considered statistically significant.

**Results:** Most participants were young, urban, educated, unemployed, and unmarried. After 12 weeks of intervention, there were significant improvements in metabolic and hormonal markers. HbA1c, lipid profile, LH, testosterone, and insulin levels showed notable improvement (p < 0.001). Additionally, FAI and HOMA-IR significantly decreased, indicating enhanced insulin sensitivity and hormonal regulation.

**Conclusion**: The findings demonstrate that structured physical activity is an effective non-pharmacological intervention for improving metabolic and hormonal health in women with PCOS.

**Keywords:** Exercise, Hyperandrogenism, Infertility, Lifestyle, Polycystic Ovary Syndrome.

## **INTRODUCTION**

Polycystic ovary syndrome (PCOS) is one of the most prevalent endocrine disorders affecting women of reproductive age, with a global prevalence ranging from 4% to 20% depending on diagnostic criteria and population studied.<sup>[1]</sup> Characterised by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, and a major cause of anovulatory infertility in women. PCOS is also strongly associated with insulin resistance, dyslipidaemia, and increased risk for type 2 diabetes and cardiovascular disease.<sup>[2,3]</sup> Given its complex metabolic and reproductive manifestations, PCOS imposes a significant burden on women's health and quality of life.4 The complex aetiology of PCOS involves many factors like genetic, environmental, and lifestyle factors, obesity, and gut dysbiosis making its management challenging.<sup>[5,6]</sup> Physical activity is widely recognized as a nonpharmacological strategy to improve insulin sensitivity, reduce androgen levels & visceral adiposity and promote weight management in women with PCOS.<sup>[7-9]</sup> Studies have shown that moderate-intensity exercise can positively influence menstrual regularity and ovulatory function, even in the absence of significant weight loss.<sup>[10-12]</sup> Additionally, structured exercise interventions have demonstrated favourable effects on lipid profiles and inflammatory markers in this population.<sup>[13,14]</sup>

Despite growing evidence supporting the role of physical activity, there remains a need for a highquality randomised controlled study to establish clarity on specific metabolic and hormonal benefits in women with PCOS. This study aims to assess the impact of a structured physical activity intervention on key metabolic and hormonal outcomes in women with PCOS, thereby contributing to evidence-based recommendations for lifestyle management in this condition.

# **MATERIALS AND METHODS**

The present randomised controlled study was conducted in the Department of Physiology in collaboration with the Department of Gynaecology at our institution. The study aimed to assess the effects of lifestyle modifications, specifically a physical activity intervention, in women with polycystic ovarian syndrome (PCOS). Participants were recruited from the Gynaecological OPD and were randomly assigned a unique sequential number for enrollment. The study followed an open-label design and involved 61 diagnosed PCOS cases, selected based on the 2003 Rotterdam criteria.

Sample size calculation was based on a previous study15 that evaluated changes in free testosterone levels following a 12-week physical activity program. Assuming a detectable mean change of  $1 \pm 2.66$  pg/ml, with  $\alpha = 0.05$  and power of 80%, a minimum of 58 participants was required. Considering a 10% attrition rate, 65 participants were recruited in each group using Primer software version 6.

Inclusion criteria included premenopausal women aged 18–40 years diagnosed with PCOS, who gave informed written consent. Exclusion criteria involved recent hormonal or pharmacological treatment, diagnosed endocrine or cardiovascular disorders, recent pregnancy or lactation, ongoing lifestyle interventions (such as yoga or diet), substance abuse, or inability to maintain a daily step count over 9000.

The study protocol was approved by the Departmental Research Committee and Ethics Committee. After obtaining informed consent, participants completed a structured proforma capturing demographic data, medical and personal history, gynaecological symptoms, lifestyle factors, and physical measurements such as BMI. Detailed menstrual histories were also recorded.

Participants underwent blood sampling at baseline, 6 weeks, and 12 weeks to assess hormonal and

metabolic outcomes. A structured physical activity protocol was implemented using the Rossmax PA-S20 pedometer16. Participants received training on device usage and were instructed to record daily step counts in a diary. Data was shared with researchers regularly, who monitored progress and provided individualized targets and weekly motivational feedback via phone and WhatsApp.

The physical activity protocol included a gradual increase in daily step count based on each participant's baseline activity level. Those taking fewer than 6,000 steps per day were advised to increase their steps by 3,000 per day. Participants with a baseline of 6,000–8,999 steps were encouraged to reach at least 9,000 steps, while those already exceeding 9,000 steps were instructed to maintain or further increase their activity. The goal was to achieve and sustain a daily step count of over 9,000 within the first week, continued for 5 days per week over 12 weeks.

Energy expenditure was calculated using MET scores

# Energy Expenditure (kcal/min) = METs $\times$ body weight (kg) $\div$ 60.

Dropouts were defined as participants who did not complete follow-up at 6 and 12 weeks or withdrew consent. A total of four participants dropped out due to personal constraints, leaving 61 participants who completed the study.

**Statistical Analysis:** Included mean and standard deviation for continuous variables and percentages for categorical data. The chi-square test was used to analysed the categorical variables. The repeated measures ANOVA assessed changes over time, with post-hoc Bonferroni tests identifying significant pairwise differences. A p-value <0.05 was considered statistically significant.

## RESULTS

Among the 61 study participants receiving a physical activity intervention, the majority (70.49%) were aged  $\leq 25$  years. Most belonged to urban areas (72.13%) and were graduates (67.21%). A larger proportion were unemployed (73.77%) and unmarried (72.13%). Participants were almost evenly distributed between joint (52.45%) and nuclear (47.54%) families. These findings highlight a predominantly young, educated, and urban population with a higher prevalence of unemployment and unmarried status. [Table 1]

Figure 1 shows that the majority of participants (93.44%) belonged to the upper class, while 6.55% were from the upper middle class. No participants were reported from the middle, lower middle, or lower socioeconomic classes.

The BMI categories was changed after 12 weeks of physical activity intervention, the proportion of participants with standard BMI increased from 8% to 20%, while obesity reduced from 77% to 69%. Overweight cases showed minor fluctuations.

However, the changes were not statistically significant (p = 0.296). [Table 2]

The physical activity intervention resulted in significant improvements in most metabolic parameters in PCOS women over 12 weeks. HbA1c, TG, TC, HDL, LDL, and VLDL levels showed statistically significant changes (p < 0.001), with post hoc tests confirming improvement from baseline at both 6 and 12 weeks. Notably, HbA1c reduced from 5.14 to 4.79, and HDL increased from 37.05 to 46.26 mg/dL. While FBS showed a decreasing trend, the change was not statistically significant (p = 0.079). These findings suggest a positive metabolic impact of sustained physical activity in women with PCOS, as shown in Table 3. The physical activity intervention led to statistically significant improvements in hormonal profiles among PCOS women over 12 weeks (p < 0.001 for most parameters). Levels of LH, estradiol, prolactin, DHEA, testosterone, insulin, and TSH significantly decreased, while FSH, progesterone, and SHBG levels increased. For example, testosterone levels reduced from 51.30 to 28.68 ng/dL, and SHBG increased 61.82 to 71.54 from nmol/L. Improvements were consistent and sustained across 6 and 12 weeks, indicating beneficial hormonal regulation through lifestyle modification. TSH also showed significant decline (p = 0.003), further supporting endocrine balance improvement. [Table 4]

The physical activity intervention significantly improved key markers of endocrine and metabolic dysfunction in PCOS women. The LH/FSH ratio decreased from 4.03 to 2.18, the Free Androgen Index (FAI) dropped from 86.67 to 41.04, and HOMA-IR reduced from 5.43 to 2.97 over 12 weeks (p < 0.001 for all). These reductions indicate enhanced hormonal balance, lowered androgen levels, and improved insulin sensitivity, reflecting the beneficial impact of sustained physical activity on PCOS-related hormonal and metabolic abnormalities. [Figure 2]



Figure 1: Distribution of Socioeconomic status of study participants with the intervention of physical activity (N=61)

Table 1: Socio-demographic profile of study participants with the intervention of physical activity (N=61)						
Sociodemographic variables	Number	Percentage (%)				
Age group (years)						
≤25	43	70.49				
>25	18	29.50				
Locality						
Urban	44	7.13				
Rural	17	27.86				
Education						
Up to higher secondary	13	21.31				
Graduate	41	67.21				
Postgraduate	7	11.47				
Occupation						
Employed	16	26.22				
Unemployed	45	73.77				
Family Type						
Nuclear	29	47.54				
Joint	32	52.45				
Marital status						
Married	17	27.87				
Unmarried	44	72.13				

Table 2: Change in BMI Categories After 6 and 12 Weeks of Physical Activity Intervention (N = 61)								
BMI Category	Baseline	6 Weeks	12 Weeks	p-value				
(Kg/m2)	N (%)	N (%)	N (%)	(Chi-square)				
Standard weight (18.5–22.9)	5 (8%)	6 (10%)	12 (20%)					
Overweight (23–24.9)	9 (15%)	11 (18%)	7 (11%)	0.296				
Obese (≥25)	47 (77%)	44 (72%)	42 (69%)					

Note: No participant was underweight (<18.5 BMI) during the study

Table 3:	Effect	of	Physical	Intervention	on	Various	Metabolic	Outcomes	at	Different	Time	Intervals	on	PCOS
Women (	N=61)													

Parameters	Time Interval	Mean	SD	p-value*	p<0.05 from#
FBS (mg/dL)	Baseline (1)	85.39	9.72	0.079	-
_	6 wks (2)	83.71	8.10		-
	12 wks (3)	83.31	6.83		-
HbA1c (%)	Baseline (1)	5.14	0.50	< 0.001	2,3
	6 wks (2)	4.95	0.47		1
	12 wks (3)	4.79	0.43		1
TG (mg/dL)	Baseline (1)	151.34	45.30	< 0.001	2,3
	6 wks (2)	135.95	28.63		1
	12 wks (3)	131.15	40.37		1
TC (mg/dL)	Baseline (1)	186.38	71.17	< 0.001	2,3
	6 wks (2)	164.00	59.91		1
	12 wks (3)	148.34	47.88		1
HDL (mg/dL)	Baseline (1)	37.05	7.46	< 0.001	2,3
	6 wks (2)	40.90	7.97		1
	12 wks (3)	46.26	8.42		1
LDL (mg/dL)	Baseline (1)	100.33	14.67	< 0.001	2,3
	6 wks (2)	94.00	10.93		1
	12 wks (3)	88.82	11.64		1
VLDL (mg/dL)	Baseline (1)	24.43	3.70	0.001	3
	6 wks (2)	24.62	2.85		3
	12 wks (3)	22.74	3.80		1,2
*Repeated Measures ANOVA	#Post hoc Bonferroni t-	tests			

Table 4: Effect of Physical Intervention on Various Metabolic Outcomes at Different Time Intervals on PCOS Women (N=61)

Parameter unit	Time Interval	Mean	SD	'p' value*	'p'<0.05 from#
LH (mIU/ml)	Baseline (1)	19.75	10.44	< 0.001	2,3
	6 wks (2)	15.41	4.27		1
	12 wks (3)	13.55	3.06		1
FSH (mIU/ml)	Baseline (1)	5.23	0.92	< 0.001	2,3
	6 wks (2)	5.78	0.82		1
	12 wks (3)	6.29	0.67		1
Estradiol (pg/ml)	Baseline (1)	149.91	31.78	< 0.001	2,3
	6 wks (2)	123.81	24.62		1
	12 wks (3)	98.56	19.88		1
Progesterone (ng/ml)	Baseline (1)	0.92	0.82	< 0.001	3
	6 wks (2)	1.10	0.81		3
	12 wks (3)	1.41	0.80		1,2
Prolactin (ng/dl)	Baseline (1)	18.67	5.03	< 0.001	2,3
	6 wks (2)	15.84	4.10		1
	12 wks (3)	13.40	3.87		1
DHEA (ng/dl)	Baseline (1)	347.79	96.37	< 0.001	2,3
	6 wks (2)	300.79	73.71		1
	12 wks (3)	267.84	61.26		1
Testosterone (ng/dl)	Baseline (1)	51.30	24.70	< 0.001	2,3
	6 wks (2)	37.12	15.32		1
	12 wks (3)	28.68	10.74		1
SHBG (nmol/dl)	Baseline (1)	61.82	10.21	< 0.001	2,3
	6 wks (2)	66.24	10.24		1
	12 wks (3)	71.54	10.31		1
Insulin (µIU/ml)	Baseline (1)	25.68	15.40	< 0.001	2,3
	6 wks (2)	19.39	9.60		1
	12 wks (3)	14.38	6.68		1
TSH (µIU/ml)	Baseline (1)	3.40	2.84	0.003	3
	6 wks (2)	2.71	1.83		
	12 wks (3)	2.42	0.95		1

\*Repeated Measures ANOVA #Post hoc Bonferroni t-tests



Figure 2: Effect of Physical Activity Intervention on LH/FSH Ratio, Free Androgen Index, HOMA-IR at Different Time Intervals on PCOS Women (N=61)

Note: Asterisks (\*) mark time points with statistically significant changes (Bonferroni post hoc test)

# DISCUSSION

In this study of 61 PCOS women, most participants were young, urban, educated, unemployed, and unmarried. After 12 weeks of physical activity, improvements were observed in BMI and significant changes occurred in metabolic and hormonal parameters. HbA1c, lipid profile, LH, testosterone, and insulin levels showed marked improvement (p < 0.001), while FAI and HOMA-IR significantly decreased, indicating better insulin sensitivity and hormonal balance. Although BMI changes were not statistically significant (p = 0.296), overall findings support the positive impact of physical activity on metabolic and endocrine health in PCOS women, highlighting its role as a beneficial non-pharmacological intervention.

Multiple studies have demonstrated the significant benefits of physical activity interventions for women with polycystic ovary syndrome (PCOS). Moderate-intensity exercise, even without accompanying weight loss, has been shown to improve lipoprotein profiles by reducing large VLDL particles, triglycerides, and medium/small HDL, while increasing large HDL particles and average HDL size.<sup>[17]</sup> Similarly, aerobic exercise over a 12-week period led to notable reductions in BMI, waist-to-hip ratio (WHR), body fat, and triglyceride levels, along with an increase in HDL among overweight and obese women with PCOS.<sup>[18]</sup> Importantly, vigorous-intensity exercise has been linked to superior metabolic outcomes, such as lower BMI, reduced insulin resistance (HOMA-IR). and a decreased risk of metabolic syndrome, independent of total energy expenditure.<sup>[19]</sup> Haqq et al. found that Lifestyle interventions combining physical activity and dietary changes have led to favourable hormonal adjustments, including elevated levels of follicle-stimulating hormone (FSH) and sex hormone-binding globulin (SHBG), as well as reduced levels of total testosterone and androstenedione.<sup>[20]</sup> Although the ideal exercise regimen for PCOS is yet to be clearly defined, consistent benefits have been observed across a range of exercise modalities, frequencies, and durations. These include improved ovulation, reductions in insulin resistance (by 9-30%), and weight loss ranging from 4.5% to 10%.<sup>[21]</sup> Samadi, Z. et al. reported that physical activity leads to a decrease in LH, FAI, DHEA-S, and HOMA-IR, along with an increase in FSH, SHBG.<sup>[22]</sup> These findings support the results of our study. Almenning, I. et al. concluded that in women with PCOS, high-intensity interval training (HIIT) resulted in a reduction in HOMA-IR and DHEA-S, while strength training (ST) led to a decrease in FAI and AMH and an increase in SHBG. This highlights the positive impact of different exercise modalities on hormonal and metabolic parameters. Scott, D. et al., in their study exploring the effects of a 12-week exercise intervention in overweight and obese women with and without polycystic ovary syndrome, observed a decrease in LDL. triglycerides, cholesterol, fasting insulin, and fasting glucose, along with an increase in HDL and SHBG.<sup>[24]</sup> These findings further confirm the beneficial effects of exercise on metabolic and endocrine health.

### **CONCLUSION**

The 12-week physical activity intervention demonstrated significant improvements in metabolic and hormonal parameters among women with PCOS. While BMI changes were not statistically significant, key indicators such as Hba1c, lipid profile, LH/FSH ratio, testosterone, insulin levels, FAI, and HOMA-IR showed marked improvement, indicating enhanced insulin sensitivity, reduced androgen excess, and overall endocrine balance. These findings highlighted the efficacy of structured physical activity as a non-pharmacological strategy in managing PCOS-related metabolic and hormonal dysfunction, particularly in a predominantly young, urban, and educated female population.

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