



Effects of high-intensity interval training and strength training on levels of testosterone and physical activity among women with polycystic ovary syndrome

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Objective

Polycystic ovary syndrome is a diverse endocrine disorder characterized by hyperandrogenism and ovulatory dysfunction. Hyperandrogenism affects body morphology, resulting in excess weight (overweight or obesity). This study aimed to evaluate the efficacy of high-intensity interval training on serum testosterone levels, body fat percentage, and level of physical activity among women with polycystic ovary syndrome.

Methods

Fifty participants were enrolled in the study and randomly allocated into two groups. Group A performed high-intensity interval training on alternate days per week (total of 12 weeks) and group B performed strength training on alternate days per week (total of 12 weeks). Baseline and 12th-week assessments included serum testosterone levels, body fat percentage using the skinfold method, and level of physical activity assessed using the International Physical Activity Questionnaire.

Results

After 12 weeks of intervention, both groups showed significant improvements in all the outcomes. However, group A (high intensity interval training) showed statistically significant results compared to group B (strength training) in lowering serum testosterone levels ($P=0.049$) and body fat percentage ($P=0.001$) and increasing physical activity levels ($P=0.006$).

Conclusion

After 12 weeks of exercise, both exercises benefited the participants; however, high-intensity interval training specifically was found to be a more effective exercise regimen than strength training in reducing serum testosterone levels and body fat percentage and enhancing levels of physical activity in women with polycystic ovary syndrome.

Keywords: Exercise; Exercise training; High-intensity interval training; Polycystic ovary syndrome

Introduction

Polycystic ovary syndrome (PCOS) is a multifactorial disorder and common endocrinopathy of hyperandrogenism (HA) that affects 5.5% to 19.9% of women of reproductive age. It is associated with higher morbidity, thus increasing the economic burden. It is also a complex disorder in which anovulation, infertility, hirsutism, oligomenorrhea, insulin resistance, and obesity are frequent clinical complaints and spectrums [1,2]. HA is the most common manifestation and characterized by the elevated production of luteinizing hormone (LH). LH, along with insulin, synergistically elevates androgen pro-

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duction (testosterone level), which can lead to obesity [3,4]. According to several studies conducted worldwide, the prevalence of PCOS is rapidly increasing [5]. In Pakistan alone, its prevalence accounts for 20.7% of women of reproductive age [6]. Oral contraceptives have been known to be given to PCOS patients which lowers anti-müllerian hormone and morphology of polycystic ovaries [7].

According to the recommendation of the National Health and Medical Research Council, optimizing physical therapy interventional strategies is effective in managing complications and reducing the financial burden of patients with PCOS [8]. PCOS is a sequence of endocrine system feedback loops that makes it difficult to differentiate a single factor for the management of PCOS [9]. Exercise targeted at improving insulin sensitivity and weight loss in obese patients with PCOS are essential for improving the different manifestations of PCOS [10]. Strength training (ST) improves body composition among women with PCOS and insulin sensitivity in overweight and obese sedentary populations [11]. It has also been reported that ST improves the menstrual cycle and HA by decreasing central adiposity and increasing lean muscle mass, resulting in the alteration of body composition [12].

Recently, high-intensity interval training (HIIT) has been considered as a secure and popular fitness program. It consists of short segments of high-intensity exercise, followed directly by an active recovery phase. After a strenuous workout, this recovery cycle helps the individual continue performing high-intensity exercises that would have otherwise been difficult to follow through with continuous training [13-15]. HIIT improves insulin resistance, body morphology, and the reproductive hormone profile [11]. Current evidence regarding HIIT and other intensity exercises is lacking, and the health benefits for the PCOS population remain unclear.

Physical therapy plays a paramount role in managing PCOS; however, the current literature is scarce. Therefore, the authors of this study designed an exercise-based management strategy using HIIT. This exercise strategy aims to help control the three primary complaints of PCOS: increased serum testosterone levels, body fat percentage (BF%), and reduced physical activity levels. Results from our study would fill the gap for the lack of evidence regarding the effectiveness of exercise-based intervention strategies for PCOS.

Materials and methods

The sample size was calculated based off a previous study conducted by Almenning et al. [11] (body mass index [BMI]) with the following parameters: a confidence interval of 95%, power of test set at 80%, standard deviation of 6.3, and mean difference of 5.2. A sample size of 50 was calculated by using the following formula: $n = \frac{Z_{(1-\alpha)} Z_{(1-\beta)} (\sigma)^2}{\Delta^2}$, where $Z_{(1-\alpha)}$ is the confidence interval at 95%, $Z_{(1-\beta)}$ is the power of test at 80%, $(\sigma)^2$ is the standard deviation, Δ^2 is the square of mean difference.

This is randomized clinical trial. Data collection occurred at an obstetric and gynecological setup at the Shamim Clinic in Karachi starting from April 12, 2021 and ending on September 26, 2021. Women diagnosed with PCOS (based on the Rotterdam criteria) and referred to the rehabilitation unit were selected and enrolled in the study. The envelope method was used for sample randomization. A total of 50 envelopes were made, with 25 envelopes with group A marked on them and 25 envelopes with group B. The randomization and participation of subjects in the study is demonstrated in Fig. 1. Informed consent was obtained from the participants before inclusion in the study, and baseline assessment was performed before the start of the first session. Group A performed HIIT and group B performed ST. These exercise regimens were followed over 36 sessions over 12 weeks. For baseline assessment, a laboratory test for total serum testosterone levels was performed by taking the participants' blood samples, the chief examiner took skinfold measurements for BF% using a body caliper, and an international physical activity questionnaire for physical activity measurement was filled out by the participants [16]. All outcome measures were reassessed at the end of the last intervention session (post intervention). A physical therapist supervised all activities.

1. Inclusion criteria

- BMI (Asian-Pacific classification)
- Overweight: 23-24.9 kg/m²
- Obese: greater than or equal to 25 kg/m² [17]
- Diagnosed (using Rotterdam criteria) and referred patients with PCOS to the rehabilitation unit were selected for the study [11]
- Female patients within the age of 20 to 40 years [18]
- High serum testosterone level: normal range 0.52-2.43 nmol/L [19]



CONSORT 2010 Flow Diagram

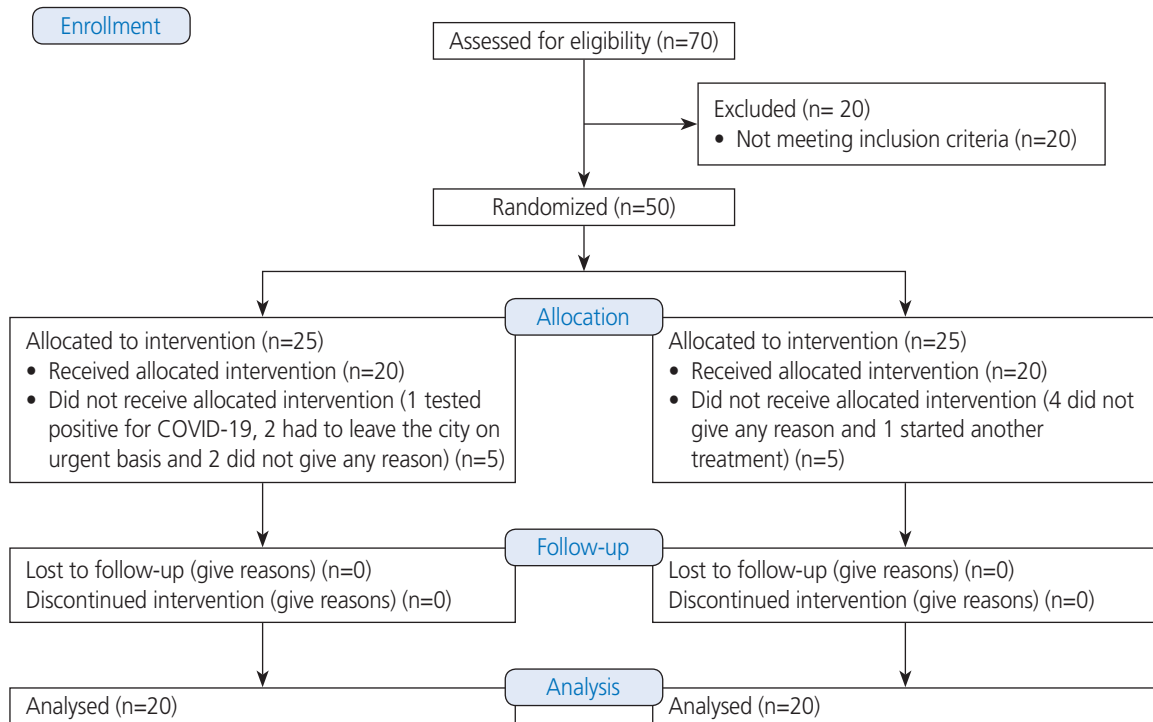


Fig. 1. Consolidated standards of reporting trials flow diagram showing randomization and participation in study.

2. Exclusion criteria

- On-going pregnancy [18]
- Any cardiovascular complication [18]
- Any other endocrine disorder
- Any musculoskeletal condition that may hinder the exercise training protocol [15]

3. Exercise protocol

For HIIT, group A went through 10-minute warm-up consisting of light- to moderate-intensity cardiorespiratory activity. Participants used a treadmill for the warm-up, starting at a low speed (<55% of maximum heart rate [MHR]). For ST, group B performed stretching and flexing of the arms and legs to warm up the muscles [20].

4. High-intensity interval training

HIIT for group A was performed three times per week using a treadmill. The protocol of each session was four sets of 4-minute interval sessions (at 90-95% of the individual heart

rate [HR] max calculated by the Karvonen method), and each set was followed by 3 minutes of moderate-intensity exercise (at 70% of the individual HR max calculated by the Karvonen method). The Karvonen method is a formula used to calculate the target HR, which is 220 subtracted from the participant's age [20]. Each session lasted 45 minutes, including a warm-up and cool-down period. The total duration of HIIT was 25 minutes. To ensure that the correct exercise intensity was performed, participants wore HR monitors during the training sessions [11].

5. Strength training

ST for group B was performed three times per week. Each session comprised of eight dynamic drills (with a resistance of 60-70% of one repetition maximum [RM]). Eight exercises involving the major muscle groups were included in this session (squats, deadlift, lunge, standing bent rowing, shoulder press, bench press, push-ups, and abdominal crunches). Each drill consisted of three sets of 10-12 repetitions. Each set was

followed by a 1-minute rest. Equipment such as dumbbells was provided. Progression of ST was defined as an increase in weight (kg) according to the 1 RM method assessed every week. The 1 RM method is the gold standard for dynamic strength assessment. The 1 RM is the maximum weight that can be moved in a single repetition. The 1 RM is determined through four trials that gradually increases the resistance from 2.5 to 20 kg until the participant can no longer complete repetitions. The final weight achieved was selected as the absolute 1 RM [20]. Strength training was performed for approximately 32 minutes in each session; each set was given 60 seconds, followed by a 2-minute rest.

6. Cool down

A 10 minutes cool-down of light- to moderate-intensity cardiorespiratory activity was performed for HIIT in group A. The participant used a treadmill for warm-up, starting at low speed (<55% of MHR). For ST in group B, stretching and flexing of the arms and legs were performed to cool down [20].

7. Exercise termination criteria

Exercise-based interventions were prematurely terminated when any one of the following occurred, as per the American College of Sports Medicine Criteria [20].

- Modified Borg dyspnea scale is at level 8 or higher
- Decrease in oxygen saturation at less than 90%
- At the request of the patient

8. Data analysis

Data were entered and analyzed using MedCalc software version 19.0.5. Descriptive statistics were performed for demographic information, and the data were presented in terms of frequency and percentage. The Shapiro-Wilk test was used to determine data normality. The data were normally distributed for BMI and serum testosterone levels; therefore, a paired t-test was performed for within-group analysis. For BF% and international physical activity questionnaire (IPAQ), the data were not normally distributed; therefore, the Wilcoxon signed-rank test was performed for within-group analysis. An independent t-test was performed to compare the two groups for all the outcome measures.

9. Ethical consideration

This study was approved by the Ethical Review Committee of Ziauddin University, Karachi, Pakistan (ERC No:

3100121MRRS). This study was conducted per the Declaration of Helsinki. Informed consent was obtained from all participants to ensure that they were not exposed to any harm. Participant confidentiality was maintained, and participant

Table 1. Demographic data of participants

Variable	Value
Age (yr)	
HIIT	28.1±4.92
20-24	4
25-29	9
30-34	4
35-40	3
ST	30.5±4.80
20-24	2
25-29	7
30-34	7
35-40	4
Marital status	
HIIT	
Married	10
Single	10
ST	
Married	14
Single	6
Gravida	
HIIT	
0-2	-
ST	
0-2	-
Months since diagnosis of PCOS	
HIIT	18.6±12.5
7-48	-
ST	42.5±32.3
7-120	-
Overweight	
HIIT	11
ST	6
Obese	
HIIT	9
ST	14

Values are presented as mean±standard deviation or frequency. HIIT, high-intensity interval training; ST, strength training; PCOS, polycystic ovary syndrome.

identity was not disclosed. Participants were enrolled only after they signed the consent form.

Results

No adverse events were reported during the study period. The demographic data of the participants are presented in Table 1. The baseline and post-intervention assessments of BMI, serum testosterone levels, BF%, and IPAQ for groups A and B are listed in Table 2. Group A showed improvements in BMI ($P<0.001$), serum testosterone levels ($P<0.001$), BF% ($P<0.001$), and IPAQ (0.001) from pre-to post-intervention. Group B showed improvements in BMI ($P<0.001$), serum testosterone ($P<0.001$), BF% ($P<0.001$), and IPAQ (0.001) pre and post-intervention.

The group analysis for groups A and B showed that for BMI, group A had no statistically significant results compared to group B ($P=0.135$), indicating that HIIT and ST were both influential in lowering BMI among women with PCOS (Table 2). For serum testosterone levels, group A had statistically significant results compared to group B ($P=0.049$), indicating that HIIT was proven to be more effective in lowering serum testosterone levels than ST among women with PCOS. For BF%, group A had more significant results than group B ($P=0.001$), indicating that HIIT efficiently lowered BF% compared to ST. For IPAQ, group A had a more significant result than group B ($P=0.006$), indicating that HIIT effectively improved the IPAQ score compared to ST.

Discussion

The aim of this study was to compare the effectiveness of 12 weeks of structured HIIT on the serum testosterone levels, BF%, and physical activity levels among women with PCOS to 12 weeks of ST. The ultimate goal was to provide data for an exercise regimen that is beneficial in managing PCOS symptoms. This study reported statistically significant differences in the pre- and post-intervention outcomes for both groups. However, 12 weeks of HIIT was more effective in lowering serum testosterone levels and BF% and enhancing physical activity levels among overweight/obese women with PCOS than 12 weeks of ST. The exercise protocol in this study was established according to the ACSM and international guidelines for the evaluation and management of PCOS [20,21].

In recent years, the focus has been on confirming HIIT as the most beneficial exercise regimen in managing the long-lasting symptoms of PCOS. Several studies support HIIT as the most beneficial exercise regimen. Vizza et al. [22] studied the effect of progressive resistance training on PCOS symptoms. They reported no significant change in the levels of testosterone or other endocrine variables after exercise. Similarly, Wu et al. [23] reported that exercise did not improve the levels of testosterone and other metabolic variables. Our study completely contradicted these findings, as our results showed significant results in the lowering of serum testosterone levels in women with PCOS. Almenning et al. [11] reported that while 10 weeks of HIIT improved several PCOS parameters (HOMA-IR and BF%), many of the other parameters did not change, such as testosterone levels. These results

Table 2. The between-group analysis for body mass index, serum testosterone, body fat percentage, and international physical activity questionnaire

Variable	F	t	Df	Pre-intervention	Post-intervention	Mean difference	95% CI of the difference	P-value
BMI (kg/m ²)	3.94	-1.52	38	25.3±1.96 (HIIT) 26.5±3.09 (ST)	23.26±1.87 (HIIT) 24.47± 3.00 (ST)	-1.21	-2.81 (lower) 0.39 (upper)	0.135
Serum testosterone (nmol/L)	0.07	-2.03	38	2.54±0.07 (HIIT) 2.54±0.09 (ST)	2.39±2.42 (HIIT) 2.47±0.09 (ST)	-0.07	-0.15 (lower) -0.00 (upper)	0.049
BF%	2.58	-3.79	38	31.6±1.79 (HIIT) 34.1±2.70 (ST)	29.62±1.76 (HIIT) 32.48±2.87 (ST)	-2.86	-4.39 (lower) -1.33 (upper)	0.001
IPAQ (min/wk)	0.00	2.94	38	3,491.15±211.99 (HIIT) 3,439.60±243.76 (ST)	3,928.10±220.04 (HIIT) 3,716.60±234.45 (ST)	211.5	65.94 (lower) 357.05 (upper)	0.006

Values are presented as mean±standard deviation unless otherwise indicated.

F, test statistic of Levene's test; t, test statistics; Df, degrees of freedom; CI, confidence interval; BMI, body mass index; HIIT, high-intensity interval training; ST, strength training; BF%, body fat percentage; IPAQ, international physical activity questionnaire.

differ from our findings, as the BF% and serum testosterone levels decreased among women with PCOS. Kirthika et al. [24] reported that if women with PCOS undergo aerobic exercise as an early intervention, it significantly lowers free testosterone levels. Similarly, Vigorito et al. [25] reported that 12 weeks of two different exercise regimens decreased testosterone levels in women with PCOS. These findings are similar to the outcomes of our study, in which serum testosterone was reduced after 12 weeks of HIIT and ST; however, HIIT was more significant than ST in lowering serum testosterone levels. In the future, there should be more high-quality RCTS (randomized control trials and randomized clinical trials) with a larger sample size spanning different cities to establish more concrete evidence regarding PCOS prevalence, evaluation, and management in Pakistan.

The study's greatest strength is using the gold standard study type, the RCT. To the best of our knowledge, this study is only one to examine exercise efficiency and record positive outcomes on serum testosterone levels, BF%, and physical activity levels among the PCOS population in Pakistan. Moreover, no adverse events were observed throughout the study period. A limitation of this study was that we could not meet the calculated sample size. The study was conducted in a single private clinic in Karachi, meaning that the participants were not from different cities and were limited to one area in Karachi. In addition, participation in the study was limited because of the country's pandemic (COVID-19) situation.

This study focused on determining the effectiveness of HIIT over ST for the management of serum testosterone levels, BF%, and physical activity levels in the PCOS population. After completing the 12-week exercise regimen, a post-intervention assessment of outcomes was performed and analyzed. The study determined that while both HIIT and ST improved the outcomes, HIIT was found to be statistically more beneficial than ST in the PCOS population.

Conflict of interest

The authors declare no potential conflicts of interest concerning the research, authorship, or publication of this manuscript.

Ethical approval

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Patient consent

Informed consent was obtained from all participants to ensure that they were not exposed to any harm. Participant confidentiality was maintained, and participant identity was not disclosed. Participants were enrolled only after they signed the consent form.

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