Original Article

The Effect of High Intensity Intermittent and Combined (Resistant and Endurance) Trainings on Some Anthropometric Indices and Aerobic Performance in Women with Polycystic Ovary Syndrome: A Randomized Controlled Clinical Trial Study

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Abstract

Background: Overweight and obesity are associated with cardiometabolic risk in polycystic ovary syndrome (PCOS). Lifestyle adjustment, such as increasing physical activity, is a first-line strategy to treat PCOS. The current study aims to compare and examine the effect of high intensity intermittent training (HIIT) and combined (COM) training on some anthropometric indices and aerobic performance in PCOS females.

Materials and Methods: This randomized controlled clinical trial was conducted on 45 women with PCOS divided into three groups receiving HIIT (n=15), COM interventions (n=15) or control group (n=15) for eight weeks. Some anthropometric indices factors including weight, body mass index (BMI), waist to hip ratio (WHR), body fat percent (FP), and visceral adipose tissue (VAT) as well as VO_{2max} were measured at the baseline at the eighth week. Data were analyzed by one-way ANOVA test. Tukey post hoc tests were used to compare the pair differences.

Results: After eight-week intervention, weight, BMI, WHR, FP, and VAT decreased significantly in both groups of COM and HIIT ($P<0.05$) relative to the control group. There were no differences between HIIT group and COM group in terms of these variables ($P>0.05$). VO_{2max} increased significantly after COM and HIIT interventions relative to the control group ($P=0.001$); however, HIIT was statically more effective than COM ($P=0.011$).

Conclusion: The current study revealed that both HIIT and COM trainings could be beneficial in improving some anthropometric indices in addition to aerobic capacity, although HIIT was more effective on aerobic performance (registration number: IRCT20130812014333N143).

Keywords: Body Composition, Endurance Training, High Intensity Intermittent Training, Polycystic Ovary Syndrome, Resistance Training

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Introduction

Polycystic ovary syndrome (PCOS) is distinguished as the most frequent endocrine disease with 5 to 10 percent patient among females in reproductive age (1). Multiple factors have been reported to be involved in its pathogenesis in which the main one is long-standing lack of ovulation results from hyperandrogenism. Its clinical appearance is various and may exist in anovulation, oligoovulation as well as hyperandrogenism (2). Diverse elements like dysregulation of mitochondria, inflammatory pathways, oxidative stress and change in hormones, are seen in PCOS (3). Furthermore, abdominal obesity, abnormal lipid and glucose metabolism, insulin resistance (IR), and hypertension (4, 5) are related to PCOS development which increase the danger of cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) incidence (5).

In addition to genetic involvement (6), environmental aspects such as obesity are found to affect the progression of PCOS or even to make patients' clinical condition worse. Diet (7) or physical activity (8) are recommended as the first treatments for PCOS cure (9). Metabolic comorbidities and hyperandrogenism have been reported to be ameliorated by regular physical activity leading to the treatment of anovulation and in turn fertility restoration.

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The aerobic training with the intensity of moderate or high benefits PCOS via ameliorating metabolic and fertility related expressions in PCOS individuals. This type of exercise can also positively affect anovulation, IR, obesity and cardio metabolic indices (10).

Nate less, the literature is restricted to sparse randomized controlled trials (RCTs) limiting to some general advise of training instead of developing a clear exercise guideline for PCOS ameliorating (11). For instance, diet and exercise interconnection, duration, appropriate intensity, or modality of exercise have not been clear yet. Also training has positive functions on elevating energy consumption, hormones like cortisol, growth related, insulin, sex related catecholamine, etc. as well as lowering fat accumulation (12). Previous works have indicated that high-intensity interval training (HIIT), containing alternative phases of intensity, may increase the total metabolic capacity and ameliorate metabolic diseases such as diabetes mellitus and obesity which are both important in PCOS progression (13). Sprung et al. (14) revealed that, aerobic exercise interferences, three times a week, 30-60% heart rate reserve, 20-45 minutes, improve endothelial function and an adaptation associated with reduced CVD risk independent of changes in body weight and body composition. Besides, it has been reported that resistance training improves insulin resistance, obesity and metabolic factors (15). Thus, it could be reasonable to prescribe resistance exercise to patients with PCOS. Resistance training inhibits osteoporosis and benefits of the musculoskeletal system. Additionally, resting metabolic rate, glucose homeostasis and insulin resistance, as well as body fat could be positively affected by this form of exercise (16).

Moreover, fat hypertrophy, as an increase in cell size resulting in a reduction in blood perfusion, eventually causes hypoxia. This additionally leads to cell apoptosis, resulting in a greater macrophage cell infiltration and improves the secretion of pro-inflammatory cytokines. Consequently, extra fat tissue can reflect an etiological issue in the pathogenesis of PCOS (17).

To our knowledge, there is no evidence comparing the effects of HIIT and combined (COM) (resistance and endurance) training concerning the improvement of cardiopulmonary fitness, body composition or weight loss in women with PCOS. Moreover, there is a wide variety of training structures used in previous studies. Thus, it is not feasible to advise a favorable type of training in PCOS patients. Therefore, the purpose of study was to evaluate the effects of these two well-known types of exercises on improving PCOS.

Materials and Methods

Study design

This study was carried out as a randomized clinical trial from April 2020 to December 2020 on the patients referring to the gynecological clinic of Imam Reza Hospital, Kermanshah, Iran. Rotterdam criteria was applied for PCOS diagnosis (18). Patients were between the ages of 18 and 40. The exclusion criteria included taking oral contraceptives, taking hormone drugs affecting total testosterone levels over the past three months. As the flowing diagram in (Fig.1) illustrates, 51 women with PCOS joined in this study; however, 6 individuals were not eligible based on the inclusion criteria. Finally, 45 participants were randomly allocated in 3 groups called HIIT training group; COM training group; and the control group 15 in each group for eight weeks. All of the patients completed the study. Randomization was done from a computer-generated sequence, concealed in sequentially numbered, sealed, opaque envelopes, and kept by the gynecological clinic physician.

At the beginning of this study, all individuals were asked to sustain a normal diet during the project. To increase the cooperation of patients, a short message was sent on their mobile phone to confirm the time to attend the gym.

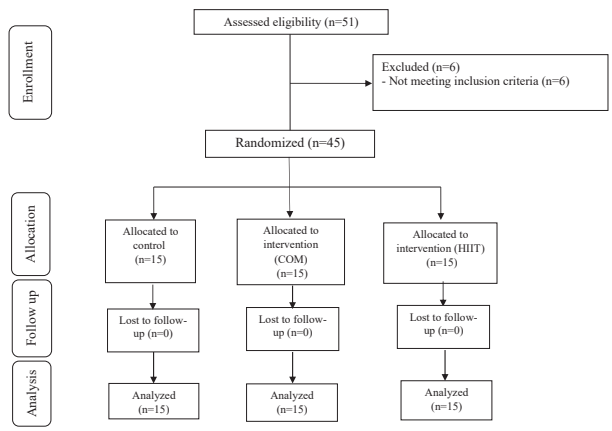

Fig.1: Summary of patients' flow diagram.

Exercise protocols

Combined (RT+MICT) and high intensity intermittent training protocols

In the COM training group, the resistance training program consisted 24 sessions of selected resistance exercises during eight weeks holding 3 sessions each week. The subjects performed different exercises including, Bench press, Barbell curl, lying triceps press, lat pull down, leg press، leg extension, lying leg curl, and standing calf raise (19-23). Each training session included a warming-up phase (5 minutes), a resistance training phase [3 sets, 50-70% of one maximum repetition (1 RM), 10-16 repetitions] and the cooling-down phase (5 minutes). The whole training session lasted 30 to 40 minutes. Brzycki formula was applied to measure 1RM as follow:

$$1\ RM = \frac{\text{Weight of displaced}}{[1.0278 - (\text{Repeat to fatigue} * 0.278)]}$$

Table 1: Combined training program (endurance and strength training) in eight weeks

Training programs	Weeks of training							
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Endurance training								
Intensity (HRR), %	60	60	65	65	60	65	70	70
Duration (minutes)	25	30	35	30	35	40	35	40
Strength training								
Intensity (1 RM), %	50	50	60	50	60	70	60	70
SET	2	3	3	3	3	3	3	3
Repetition	16	16	14	16	14	10	14	10
Rest (minutes)	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3

HRR; Heart rate reserve and RM; Repetition maximum.

The duration and intensity of training program was 30 minutes and 50% in the first week and reached to 40 minutes and 70% in the eighth week (Table 1). Immediately after resistance training, the subjects were asked to perform endurance training which consisted 24 sessions of running on treadmill with 60 to 70% of the target heart rate (THR), which was measured using the Carvonen formula as below:

Reserve heart rate=resting heart rate-maximum heart rate

Target heart rate=resting heart rate+(60-70% reserve heart rate)

A Beurer pulse digital monitoring were used for monitoring subject's heart rate (made in Germany, model PM80) during training. The duration and intensity of training was 25 minutes and 60% in the first week and reached to 40 minutes and 70% in the eighth week (Table 2).

The subjects in the control group were also enquired to do only their normal daily routines and avoid doing any physical activities throughout the training program (19-23).

The high-intensity interval training program included warming up for each session (including 15 minutes of standard warm-up), starting with a low-intensity run (50% of maximum aerobic speed) and then 3 repetitions of sprint running for 30 seconds followed by 30. Seconds of slow running and 5 minutes of dynamic stretching were performed. The high-intensity interval training program for the first week included intermittent running for 30 seconds with intensity of 100% maximum aerobic speed (MAV),4×30-seconds HIIT interspersed with 4×30-seconds of active recovery with 5 minutes of passive recovery between the repetitions. The number of sets and laps for HIIT program changed according to Table 2 for the following weeks.

Outcomes measurements

At baseline and the eight weeks, participants were tested for 1 RM to determine muscle strength in the COM and control groups. In the COM training group, the resistance training was performed with (50-70% 1 RM) and aerobic training (running, 60-70% HRR) programs were performed three times weekly for eight consecutive weeks.

Multi stage fitness test (MSFT) was carried out to determine aerobic power on the treadmill. The speed of the subjects started from 8.5 km/h for one minute. In each stage the patients' speed increased by 0.5 km/h. Aerobic power was calculated applying the following formula:

$$VO_{2max}=6[\text{measured speed (km/h)}]-22.4$$

This speed was considered as maximum aerobic velocity (MAV). HIIT program included intermittent running with 100% MAV and 50% MAV. The patients in the control group was asked not to do any exercises during the program and do only their normal activities (19-23).

Table 2: HIIT Training program

Training program	Weeks of training			
	First, Second	Third, Fourth	Fifth, Sixth	Seventh, Eighth
Repetitions	4	4	4	4
Intervals	4	6	6	6
Exercise/rest (seconds)	30:30	30:30	30:30	30:30
Exercise: rest intensity (MAV%)	100:50	100:50	110:50	110:50
Rest (minutes)	5	5	5	5

HIIT; High Intensity intermittent and MAV; Maximum aerobic velocity.

Anthropometric quantities were weighed via a professional technician at the clinic at the starting point and the end of the trial. Height was measured by automatic stadiometer (Aneascale, Iran). Weight, body fat percent (FP), visceral adipose tissue (VAT) and body mass index (BMI) were determined by 3D body scanner (Anea 3D, Iran) (24). To measure the waist to hip ratio (WHR), waist circumference and pelvic circumference (cm) were calculated from the lateral view.

Statistical analysis

The shapiro-wilk test was used to define the normality of data. Two-way ANOVA and Bonferroni post hoc tests were applied to compare the differences in each group. One-way ANOVA test was used to assess treatment effects (pre-test and post-test in terms of Delta, Δ changes) on study outcomes and comparison among groups. Tukey post hoc tests were used to compare the pair differences.

Calculations were performed by SPSS software version 23 (SPSS Inc., Chicago, Illinois, USA) and the significance level of the tests was considered as P<0.05.

Ethical considerations

The current study has been approved by the Iranian website of clinical trials registration with IRCT number: IRCT20130812014333N143. The protocol of this work was validated by the Ethics committee of Kermanshah University of Medical Sciences, Kermanshah, Iran (IR.KUMS.REC.1398.1186). Paper-based illuminated consent was also attained from all participants.

Results

The general characteristics of patients have been presented in Table 3. As shown, there were no significant variances among the participants in terms of age (P=0.64), height (P=0.91), BMI (P=0.66) and weight (P=0.42) at baseline.

Table 3: General characteristics of the participants

Variables	Control group	COM group	HIIT group	P value*
Age (Y)	23.1 ± 5.1	24.4 ± 5.7	24.9 ± 5.4	0.64
Height (m)	162.6 ± 5.5	163.1 ± 4.5	162.3 ± 5.3	0.91
Weight-baseline (kg)	84.1 ± 6.3	80.7 ± 12.1	78.6 ± 13.9	0.42
BMI-baseline (kg/m^2)	30.7 ± 3.7	29.9 ± 4.3	29.3 ± 4.3	0.66

*; Obtained from Anova test, COM; Combined Training, HIIT; High intensity intermittent training, and BMI; Body mass index.

After eight weeks of COM intervention, weight (80.7 ± 12.1 to77.8 ± 12.2, P<0.001), BMI (29.9 ± 4.3 to 28.8 ± 4.2, P<0.001), WHR (0.93 ± 0.02 to 0.91 ± 0.03, P<0.001), FP (29.7 ± 2.1 to 28.6 ± 2.1, P<0.001), VAT (120.4 ± 17.8 to 117.9 ± 18.2, P=0.014) significantly decreased compared with pre-test. The result also revealed that after eight weeks of HIIT intervention, weight (78.6 ± 13.9 to 74.8 ± 13.9, P<0.001), BMI (29.3 ± 4.3 to 28.2 ± 4.3, P<0.001), WHR (0.91 ± 0.04 to 0.89 ± 0.04, P=0.005), FP (29.4 ± 2.4 to 27.7 ± 2.1, P<0.001), and VAT (121.5 ± 16.1 to 118.8 ± 16.7, P=0.007) significantly decreased compared with pre-test .VO2max significantly increased in COM (30.3 ± 1.9 to 31.8 ± 1.8, P<0.001) and HIIT (30.8 ± 2.3 to 34.1 ± 2.4, P<0.001) interventions after eight weeks compared with pre-test (Fig.2). The result of delta change (Δ) through one-way ANOVA revealed that weight, BMI, WHR, FP, and VAT significantly decreased in both groups of COM and HIIT compared with the control (P<0.05). The post-hoc tukey test indicated that there were no differences between HIIT group and COM group in terms of these variables (P>0.05, Fig.2). VO2max increased significantly after COM and HIIT interventions compared with control group (P<0.001). Moreover, the data from tukey test showed there was statistically significant difference between two groups of COM and HIIT as HIIT was more effective than COM (P<0.001, Fig.2).

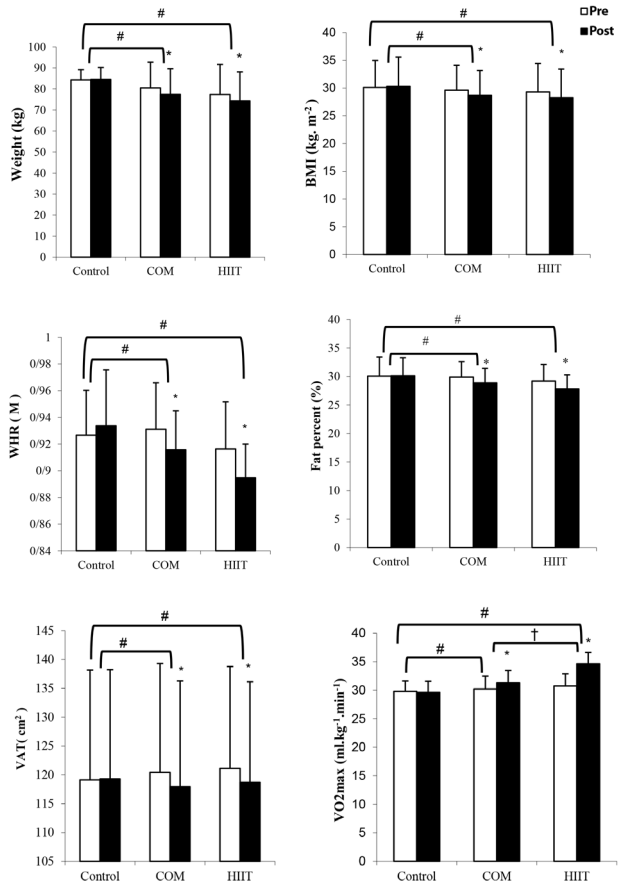

Fig.2: Anthropometrics and fitness variables at baseline and after 8-week intervention in patients with PCOS used Paired t test, One-way ANOVA and Tukey post hoc tests. BMI; Body mass index, WHR; Waist to hip ratio, VAT; Visceral adipose tissue, VO_{2max}; Maximal oxygen consumption, *; Compare to pre-test (P<0.05), #; Compare with the change (Δ) of the control group (P<0.05), and †; Compare with the combined training group (P<0.05).

Discussion

This trial aimed to indicate a comparison between the efficacy of two various exercise training programs in the treatment of PCOS. In this trial, we analyzed the effects of two different exercise protocols on anthropometrics and fitness variables including weight, BMI, FP, WHR, VAT, and VO_{2max} in women with PCOS. The findings revealed that both training programs had beneficial effects on these variables in the patients during eight weeks. There was no statistically significant difference among COM and HIIT groups in BMI, FP, WHR, and VAT, although HIIT was more operative only in VO_{2max} compared to COM group.

In current study, it was reported that COM (resistant and endurance) training could get VO_{2max} significantly increased. Two recent works on overweight and PCOS women reported significant decreased amounts of VO_{2max} than healthy controls. A study by patten et al. (9), suggested that exercises can improve VO_{2max} in this population. In addition, recent evidence showed that the resistance training in young and elderly individuals led to an elevation in VO_{2max} (25, 26).

Decreased VO_{2max} seems to be caused naturally by age; however, inactivity is its main reason. An elevation

in VO_{2max} can improve oxygen consumption, leading to a 15% reduction in the risk of CVD related mortality (25, 26) . Moreover, Low VO_{2max} has been related with elevated risk and mortality of chronic diseases. More consequences of decreased VO_{2max} are impaired capability to exercise, impairment in daily activity and quality of life. Sabag et al. (27) also proved an association between cardiopulmonary fitness (CRF) and cardiometabolic health indices in type 2 diabetic patient. Thus, enhancing VO_{2max} of patients may be beneficial for the treatment of PCOS.

We also found reductions in weight, FP, VAT, WHR and BMI in COM group, telling that resistant workout in combination with aerobic training can lead to advantages in some anthropometric indices in women with PCOS. WAT is thought to be a superior free predictor of obesity-associated disorders than BMI (28). Indeed, central adiposity plays a main role in the progression IR and T2DM, even in the individuals with standard BMI. Similar to our work, Miranda-Furtado et al. (8), indicated that in PCOS patients, WHR decreased after 4 months of strength training. Moreover, Zhang et al. (29) investigation observed that daily physical activities can improve weight and BMI dramatically in addition to metformin. In contrast, an investigation reported that resistance training (three times weekly for 1 month) did not change BMI or metabolic parameters, although it can ameliorate hyperandrogenism and reproduction in PCOS patients (30).

In a recent study (30) examined WAT as an operative sense for central adiposity, while Almenning et al. (31) employed FP to determine overall body fat quantity. As FP is the greatest assessment for total obesity, although central adiposity can estimate the risk for chronic disease more efficiently, we measured both FP and WAT that were measured in the present study. Kogure et al. (30) reported that visceral fat in overweight women with sedentary life decreased after a resistance training intervention. This point should be considered that resistance training programs have been different in details such as repetition, administration, and intensity leading to different results. However, each of these resistance training protocols has led to decreased amounts of body fat in women with PCOS basically owing to decreased abdominal adiposity.

Based on recent data, endurance training with moderate intensity diminishes the risk factors of cardio-metabolism in PCOS (7). In a recent work, endurance training improved symptoms in PCOS women by decreasing total testosterone level and WAT. Aerobic training could reduce heart rate, the levels of total cholesterol and LDL, and WHR. Yilmaz et al. (6) indicated regular endurance training ameliorated anthropometric variables as well as hyperandrogenism in PCOS cases.

Literature evaluating the effects of combination of resistance and endurance trainings in PCOS women is very limited. A 20-week investigation evaluated the impact of endurance and endurance-resistance training programs joined with an energy-controlled high protein diet on metabolic as well as reproductive parameters in overweight/obese women with PCOS. The findings from this study reveal that weight and FP reduced in both groups, but had no effect on cardiometabolic, hormonal, and reproductive factors compared to diet alone (32).

Aerobic training benefits some anthropometric indices and several cardiometabolic risk factors free of weight reduction in obese people (32). Resistance training is also efficacious for ameliorating insulin sensitivity and body composition as well as reserving lean tissue in energy-controlled diet, improving declines in resting metabolic rate after weight loss. Combining endurance and resistance exercise training programs has been observed to be more effective in insulin sensitivity reduction, glycemic management, and abdominal fat loss in obese population. Reduced BMI, and particularly abdominal fat in PCOS patients, has a key involvement in lowering risk factors for infertility leading to amelioration of hormonal and clinical outcomes. Decreased body fat can also result in improved insulin sensitivity and total cholesterol in these patients (33).

In current study, it was reported that eight-week intervention with HIIT led to an improvement in VO_{2max} in PCOS women which was greater than the effect of COM intervention. Previous studies suggested significant improvements in VO_{2max} following HIIT interventions in obesity, cardiometabolic disease and PCOS (34). Likewise, a cross-over study evaluated the effect of HIIT along with group counselling periods on anthropometry and cardio-respiratory health in women with PCOS (35). The result showed a decline in waist circumference and BMI as well as an elevation in VO_{2max}. Previously, Daussin et al. (35) observed elevated maximal stroke volume and cardiac variables result from 2 months of interval training, but not aerobic exercise, in low-active individuals. Moreover, Perry et al. (36), indicated the effect of HIIT training on fat and carbohydrate metabolism capacity. They showed that these types of training resulted in an 18 to 29% increase in the content of several mitochondrial proteins and an increase in fatty acid transporters. They resulted that HIIT training increased not only mitochondrial enzymes and fatty acid transporters in the short period but also lipid oxidation also.

Decreased amounts of body fat percentage and visceral adipose index were observed after HIIT intervention for eight weeks. Similar to our study, a recent trial found a decrease in body FP after high intensity training. This was similarly stated in other previous studies. For illustration, in a recent randomized controlled trial PCOS women were divided to take high intensity interval training, or strength training, for three times per week. The results showed that HIIT for ten weeks enhanced body FP and deprived weight loss in women with PCOS (31). In consistent to our results, Hutchison et al. (37) showed decreased visceral fat after HIIT in obese women with PCOS. A meta-analysis study indicated that HIIT was more productive in lowering total body

adiposity, whereas lower intensities had a better impact on abdominal and visceral fat bulk (38).

Recent evaluations demonstrated that HIIT is potential to elevate cardiopulmonary fitness and ameliorate insulin sensitivity. Moreover, multiple works have indicated no significant weight decline after HIIT compared with continuous exercises (39, 40).

In a recent meta-analysis study seven trials with training intensity among 90% and 95% of the maximum heart rate, 3 times/week, no less than 10 weeks, were included. Results indicated that HIIT alone is beneficial for lowering weight and BMI in females with PCOS (39). In another human study, obese patients with PCOS received AHIIT+ metformin, or metformin (control group). The exercises were performed in three sessions for 12 weeks. After 12 weeks, no significant changes were seen in parameter of WHR, but BMI and fat mass remarkably lowered and clinical parameters were improved (40). Finally, the use of an expert instructor to design and monitor the training program and habitual physical activity changes in all training sessions and monitoring the dietary change of the subjects are considered as the strengths of this research. Indirect meausres of VO_{2max} and non-gold standard measures of body composition are the limitations of the study that might have affected the results.

Conclusion

The findings from the clinical trial showed that both HIIT, COM aerobic and resistant training are successful in improving some anthropometric indices parameters including weight, BMI, WHR, FP, and VAT as well as VO_{2max}, as a cardiorespiratory element, in females with PCOS. Further investigations involving large clinical trials are needed to further determine health benefits and establish optimal therapeutic exercise dose in PCOS. Finally, if these two types of exercises are considered suitable and advantageous as a treatment policy for women with PCOS, additional trials with the aim of facilitating and removing the obstacles to exercise especial to women with PCOS is pivotal.

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Authors' Contributions

M.N., S.A.M.; Study concept and design. A.A.M., Z.A.; Analysis and interpretation of data. A.A.M.; Drafting of the manuscript, critical revision of the manuscript for important intellectual content, and statistical analysis. All authors read and approved the final manuscript.

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