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ORIGINAL RESEARCH

Bioelectric Impedance Analysis of Visceral Fat in Women with Polycystic Ovarian Syndrome and the Effect of Exercise: A Pilot Study

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ABSTRACT

Aims: To determine the body fat distribution in 30 women with polycystic ovarian syndrome (PCOS) using bioelectric impedance analysis (BIA) and assess the effect of a 2-month structured exercise on body fat, menstrual function and fertility outcomes.

Materials and methods: Thirty women with PCOS underwent assessment of body composition with BIA. Their body mass index (BMI), total body fat (TBF), visceral fat (VF) and subcutaneous fat were analyzed. Two-month structured exercises were advised based on individual exercise tolerance. The post-exercise parameters were reassessed. Outcome measures studied were improvement in BMI, TBF, VF, subcutaneous fat, menstrual functions, and fertility outcomes.

Results: A significant reduction in BMI, VF and subcutaneous fat was found in these women after exercise. Results were further analyzed after dividing them into three groups based on their BMI (normal, overweight, and obese). There was a significant reduction in all parameters (BMI, TBF, visceral and subcutaneous fat) in the overweight group. In the obese group, there was a significant drop in BMI and VF and to a lesser extent in the TBF. In women with normal BMI, a significant drop was noted in TBF only. On follow-up, five women reported regularization of their menstrual cycles and four others managed to conceive.

Conclusion: Total body fat and VF can be cost-effectively measured by a simple tool called BIA. Tailor-made exercises based on individual tolerance are effective in improving these parameters even when done over a short duration. These improvements do positively impact the menstrual dysfunctions and subfertility.

Clinical significance: These findings will help in better management of women with PCOS and ensure optimal improvement in menstrual dysfunction and fertility outcomes.

Keywords: Bioelectric impedance analysis, Polycystic ovarian syndrome, Visceral fat.

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INTRODUCTION

Polycystic ovarian syndrome (PCOS) affects 5 to 10% of women of reproductive age group.[1,2] Approximately 40 to 50% of women with PCOS are overweight or obese compared with their age-matched controls.[3]

Obesity in women with PCOS causes interaction between the pituitary gland, pancreas, and ovary, resulting in a changed hormonal milieu including insulin resistance. This impairs ovulation and adversely affects endometrial development and implantation. It also impairs the response of women to assisted reproductive treatment such as *in vitro* fertilization. Weight loss of as less as 5% appears to improve the endocrine profile and increase the likelihood of ovulation, thus improving menstrual dysfunction in women with PCOS.[4]

When one talks about weight loss, it is important that the weight, i.e., lost fat rather than lean mass. There are studies correlating central obesity/android fat with insulin resistance and hyperandrogenism.[3] Body mass index, though a convenient marker of obesity, relies on the assumption that adipose tissue is evenly distributed in the body and does not show heterogeneity in distribution. Several excellent papers have established the importance of total body fat and in particular visceral fat in assessing obesity and associated sequelae.[5]

Body composition can be measured using various tools including hydro densitometry (underwater weighing), dual-energy X-ray absorptiometry (DEXA), magnetic resonance imaging (MRI), computed tomography (CT) and bioelectric impedance analysis (BIA). Though MRI and CT are the most accurate modalities, the cost and exposure to radiation are their significant side effects.

Bioelectric impedance analysis is a machine which has body composition monitor with a scale. It measures the impedance to the flow of a safe low-level electric current through the body fluids and determines the amount of TBF, VF, and subcutaneous fat. Bioelectric impedance analysis is simple, easy, fast, noninvasive and reasonably accurate measure of body fat.

To the best of our knowledge, this is the first study assessing VF distribution by BIA and correlating the effect of structured exercise on this parameter in an Indian population.

MATERIALS AND METHODS

It is a prospective exercise interventional study over a period of 9 months (July 2014–March 2015) conducted at the Department of Obstetrics and Gynecology along with Department of Physiotherapy of a teaching hospital. All women who presented to the gynecology clinic with oligo-ovulation underwent an ultrasound scan (transvaginal or transabdominal, if unmarried) to look for ovarian morphology. Women with polycystic ovarian morphology (more than 12 follicles <10 mm in one or both ovaries or ovarian volume >10 mL in one or both ovaries) had their blood sugar and thyroid status tested. Anyone with glucose intolerance and thyroid dysfunction were excluded from the study. Women who were already on dietary restrictions or were using medications for weight loss were also excluded from the study. This way, 30 women were recruited into our study. We used recently recommended NIH workshop criteria[6] to classify our subjects into four phenotypic groups as given below:

1. Androgen excess + Ovulatory Dysfunction
2. Androgen Excess + Polycystic Ovarian Morphology
3. Ovulatory Dysfunction + Polycystic Ovarian Morphology
4. Androgen Excess + Ovulatory Dysfunction + Polycystic Ovarian morphology.

Only those women who presented with features of clinical hyperandrogenism were to be screened with androgen levels (with a view to reducing costs). Incidentally, all 30 women who were recruited for the study belonged to NIH group.[3]

After recruitment, the subjects were referred to the Department of Physiotherapy. Here, the baseline characteristics were measured, which included height, weight, BMI, TBF, VF and subcutaneous fat, using the BIA machine. After this, each subject's exercise tolerance was tested using Bruce protocol*. The subjects were advised to do these exercises three times a week. Data was collected at baseline and again after 2 months of exercise. Ethics approval was taken from the Institutional Research Committee.

Statistical Analysis

Data was analyzed using Statistical Package for the Social Science (SPSS) (version 20). Women were divided based on their BMI (WHO classification 2004) into three groups: Normal (18.5–24.9), overweight (25.0–29.9), and obese (30.0–39.9). Normality t-test indicated that the fat distribution showed normality as per Bell's curve and hence, parity test was used to test the differences in pre- and postintervention parameters. All data are presented as mean ± SD. Paired sample t-test was performed. A p-value of <0.05 was considered significant.

RESULTS

Tables 1 and 2 look at parameters in all 30 women as a single group. Tables 3 and 4 analyze the parameters after

Table 1: Pre- and postexercise BMI, VF, and TBF

				Paired t-test	
n = 30	*Preexercise values (Mean ± SD)*	*Postexercise values (Mean ± SD)*	*Differences in mean*	*t-value*	*Significance*
BMI	28.1 ± 3.48	26.8 ± 2.8	1.37↓	5.5	0
Total body fat	33.1 ± 3.58	30.3 ± 6.06	2.9↓	2.7	0.058
Visceral fat	8.67 ± 3.45	7.83 ± 2.92	0.83↓	4.3	0

Table 2: Pre- and postexercise subcutaneous fat

				Paired t-test	
n = 30	*Preexercise values (Mean ± SD)*	*Postexercise values (Mean ± SD)*	*Differences in mean*	*t-value*	*Significance*
Trunk	28.0 ± 4	26.0 ± 3.54	1.12↓	3.7	0
Arms	46 ± 4.55	41.6 ± 5.89	4.37↓	4.47	0.005
Legs	44.6 ± 6.05	41 ± 5.09	3.55↓	4.73	0

*Bruce protocol is an exercise tolerance test, used to monitor cardiac function in exercising subjects. In this, the subject is asked to walk on treadmill while cardiac function is monitored in the form of heart rate and blood pressure. The measurements continue while speed and inclination is increased every 3 minutes till the subject works to complete exhaustion. This estimates the maximal oxygen uptake of the subject calculated as a score known as VO_2 Max. VO_2 Max = 4.38 × T–3.9 where T is the total time of exercise completed (expressed in minutes and fractions, e.g., 5 minutes 30 seconds = 5.5 minutes). Based on this score, exercises are given for 2 months to each subject, which include warm up of 5 to 10 minutes, aerobic exercises for 30 to 45 minutes, and cool down or relaxation exercises for 5 to 10 minutes.

Table 3: Pre- and postexercise BMI, TBF, and VF

Categories *Normal (n = 4)* *Overweight (n = 19)* *Obese (n = 7)*		*Preexercise values (Mean ± SD)*	*Postexercise values (Mean ± SD)*	*Differences in mean*	*Paired t-test* *t-test*	 *Significance*
BMI (kg/m^2)	Normal	22.95 ± 1.57	22.85 ± 0.59	0.1↓	0.19	0.066
	Overweight	27.34 ± 1.59	26.17 ± 1.24	1.19↓	4.94	0
	Obese	32.9 ± 2.47	30.4 ± 2.77	2.5↓	4.03	0.007
Total body fat (%)	Normal	28.47 ± 2.77	27.3 ± 1.16	1.1↓	1.37	0.047
	Overweight	32.5 ± 2.64	31.02 ± 2.5	1.47↓	4.49	0
	Obese	37.15 ± 3.19	29.62 ± 12.3	7.5↓	1.76	0.127
Visceral fat	Normal	4.75 ± 0.95	4.75 ± 0.95			
	Overweight	7.74 ± 1.4	7 ± 1.1	0.737↓	3.44	0.003
	Obese	13.43 ± 3.41	11.86 ± 3.1	1.57↓	3.26	0.017

Table 4: Pre- and postexercise subcutaneous fat

Categories *Normal (n = 4)* *Overweight (n = 19)* *Obese (n = 7)*		*Preexercise values (Mean ± SD)*	*Postexercise values (Mean ± SD)*	*Differences in mean*	*Paired t-test* *t-test*	 *Significance*
Trunk	Normal	22.4 ± 2.3	22.32 ± 2.54	0.1↓	0.146	0.155
	Overweight	27.76 ± 2.99	26.88 ± 2.4	0.88↓	2.42	0.026
	Obese	31.72 ± 3.46	29.38 ± 4.45	2.34↓	4.57	0.004
Arms	Normal	41.08 ± 2.27	35.97 ± 6.01	5.1↓	1.44	0.68
	Overweight	44.90 ± 2.94	42.34 ± 2.4	2.56↓	5.15	0
	Obese	50.67 ± 5.64	42.42 ± 10.38	8.24↓	2.5	0.204
Legs	Normal	37.94 ± 2.08	35.65 ± 1.87	2.3↓	1.72	0.90
	Overweight	42.81 ± 3.99	40.63 ± 3.42	2.17↓	6.18	0
	Obese	52.1 ± 6.02	44.62 ± 7.67	7.47↓	2.85	0.241

dividing women into three groups based on their BMI as explained earlier.

Table 1 illustrates the effect of exercise on BMI (expressed as kg/m^2), VF (expressed as an absolute number), and TBF (expressed in %) in all the 30 subjects. Body mass index and VF showed significant difference, whereas reduction in TBF was not significant. The lowest BMI in the study was 21.1 kg/m^2 and the highest BMI was 36.6 kg/m^2.

Table 2 analyses the effect of exercise on subcutaneous fat (expressed as an absolute number) measurement at three sites: Trunk, arms, and legs.

Table 3 correlates BMI, TBF, and VF before and after exercise in the three BMI groups. There were 4 women in normal BMI group (21.1–24.9), 19 in overweight group (25.0–29.2), and 7 in obese group (30.0–36.6). The mean age in all the three groups was similar.

Table 3 shows that the overweight and obese groups showed significant drop in BMI after exercise, but this was not the case in women with normal BMI. Total body fat showed a significant drop in the overweight group ($p < 0.05$) and to a lesser extent in the normal BMI group ($p = 0.047$). The drop in obese group, though present, did not reach statistical significance. Visceral fat, on the contrary, showed a statistically significant improvement in both the overweight and obese groups.

Table 4 showed that exercise decreased the subcutaneous fat in all three groups. Overweight women appear to have fared the best, losing significant amount at all three sites. Obese women had a significant drop at the trunk but not at the other two sites. Normal BMI women also showed a drop but not reaching significance.

On follow-up, five of the subjects reported regularization of their menstrual cycles. All the five women belonged to the overweight group and had shown reduction in their BMI, TBF and VF. Four other women managed to become pregnant, three from the overweight group and one from the normal BMI group. (Of the overweight group, two subjects had reduction in BMI, TBF, and VF, one subject had reduction in VF only. One subject from normal group showed drop in subcutaneous fat at trunk only).

DISCUSSION

The association of PCOS with obesity is well established. There are various studies reiterating the effect of weight loss on menstrual dysfunction and fertility outcome.[4]

However, in our experience, women find it difficult to lose weight despite the advice about lifestyle changes. They often request medications to help with the weight loss. A systematic review[7] looked at 10 studies reporting dropout rates in lifestyle intervention programs for obese and overweight infertile women. They found a 24% dropout rate. One of the reasons suggested for this is that most of these programs include a fixed or personalized hypocaloric diet that is combined with an exercise regime, which the women may find difficult to adhere to.[8] We therefore decided to steer clear of any dietary advice for our subjects.

We analyzed the body composition of 30 subjects and gave each of them tailor-made exercises based on their exercise tolerance. The mean TBF in normal, overweight, and obese groups was 28.5, 32.6 and 37.2% respectively. The normal range of TBF for women is between 21 and 33%.[9] As illustrated in Table 3, both overweight and obese groups had fat content in the higher range (32.6 and 37.6% respectively). After exercise the overweight group was more successful in reducing the TBF as compared with obese group. This may be explained by the fact that this group of women have a lower VO_2 Max because of which they cannot be given very rigorous exercises. The solution may perhaps be to advise then to continue the same exercises for a longer duration. In a similar study[10] where PCOS and non-PCOS subjects were given a 12-week structured exercise, the authors concluded that insulin resistance, VF, and triglyceride levels showed improvement despite the absence of significant weight loss. They hence suggested that weight loss should not be the sole focus in an exercise regime for PCOS women.

We found that VF showed a statistically significant improvement in both the overweight and obese groups. The ideal VF in men and women differs. It also depends on the age and ethnicity. Hence, a cut-off figure is difficult to find in the literature. A Romanian study[11] used VF to identify metabolic syndrome in women with and without PCOS. They found that a VF (measured by BIA) of 7 had the best sensitivity (79.31%) and specificity (70.339%) for prediction for metabolic syndrome with a negative predictive value of 90%. In our study, the mean VF in the overweight group was 7.7 and in the obese group it was 13.4. Though we are not comparing like for like (Romanian ethnicity *vs* Indian), the values in our women appear to be high. The encouraging aspect was that even a short individualized exercise regimen was able to influence this in a positive way.

The subcutaneous fat also showed a decrease in all groups in all three sites after exercise. However, we did not find a consistent relationship between any group and any particular site. This is similar to the findings of a cross-sectional study[12] where VF (assessed by CT) was found to be most strongly correlated with markers of metabolic dysfunction. Though some correlation was found with subcutaneous fat too, it was quite weak.

The limitations of this study are the small sample size and a short span of exercise regime.

CONCLUSION

This pilot study shows that TBF and VF can be cost-effectively measured by a simple tool called BIA. They tend to be abnormal in the overweight and obese segment of women with PCOS. Tailor-made exercises based on individual tolerance are effective in improving these parameters even when done over a short duration. These improvements do positively impact the menstrual dysfunction.

CLINICAL SIGNIFICANCE

These findings will help in better management of women with PCOS and ensure optimal improvement in menstrual dysfunction and fertility outcomes.

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