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A Comparative Study of Metformin versus Metformin + Myo - Inositol Combination and Effect of Lifestyle Intervention in Polycystic Ovarian Disease Patients

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ABSTRACT

Background: Polycystic ovary disease is an endocrine disease associated with increased amounts of androgens in females, increased insulin resistance and obesity. The drugs metformin and metformin with myo-inositol combination which are insulin sensitizers are very helpful in taking care of one of the key components of PCOD which is insulin resistance. The study was done to compare the effect and safety of metformin and metformin with Myo-inositol combination and the effect of lifestyle intervention in PCOD patients. **Methods:** A prospective, randomized, observational study was conducted on 80 patients. The patient was randomly assigned group A metformin and group B metformin + myo-inositol combination. The patients were assessed by BMI, menstrual cycle, TG, HbA1C, FBS, LDL, HDL, Hirsutism score (Ferriman-Gallwey) for pharmacotherapy treatment and validated PCOSQ-50 scale used for assessment of lifestyle intervention. **Results:** In both the groups there was a significant improvement in all the above-mentioned parameters, however the group with combination of metformin + myo-inositol had statically significant improvement over the metformin group. Lifestyle interventions have the great impact in physical and mental state of PCOD woman. **Conclusion:** Combination of metformin + myo–inositol has greater effect in reducing TG and FBS than metformin alone. In case of BMI, Hirsutism, HbA1C, HDL, RBS both drug groups have similar efficacy.

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INTRODUCTION

Polycystic ovarian disease (PCOD) is a common endocrinopathy, affecting approximately 6–20% of women of reproductive age. The hallmarks of PCOD/PCOS are facial hirsutism, acne, elevated testosterone, anovulation or oligo-ovulation. In most cases, androgen overproduction by the ovary, Insulin resistance and adrenal simultaneously contribute to the disease progress.

Hyperinsulinemia and insulin resistance (IR) occurs in approximately 80% of women with PCOS/PCOD. IR is considered as the key to the pathophysiology of PCOS/PCOD and it determines hyperandrogenism by acting synergically with LH on ovarian steroidogenic enzymes and altering sex hormones binding globulin (SHBG) production by the liver. Management includes diet, lifestyle modifications and drugs. Insulin sensitizers are widely used. Inositols are secondary messengers which are responsible for glucose transport intracellularly and FSH signaling. Metformin helps to overcome the insulin resistance in PCOD conditions. Myo - inositol which are responsible for the glucose transport intracellularly and TSH signaling.

This study aimed to improve health-related quality of life. The primary objective was to study the effect of lifestyle interventions and the secondary objective was to compare the effect of metformin and metformin + myo–inositol combination in PCOD patients. As both the drugs have different mechanisms of action in improving insulin resistance, it has been postulated that both the drugs in combination may have additive effect in management of PCOD. The focus of our study is to provide with comprehensive approach which includes nutritional therapy, physical activity and behavioral modification. To compare the safety and effectiveness of metformin and a combination of metformin with myo-inositol.

MATERIALS AND METHODS

Study design:

This study was conducted as a prospective, observational and randomized study, over a period of 3 months in Department of Endocrinology and Department of Obstetrics and gynecology, PSG Hospitals, Coimbatore. Permission was obtained from Institutional Human Ethics Committee (IHEC, PSG IMSR) (Project no. 23/024).

Inclusion criteria:

Females of reproductive age group, patients diagnosed PCOD with irregular menstruation, infertility, weight gain or not able to lose weight, hirsutism, acne; who are willing to give consent for the study and follow up.

Exclusion criteria:

For drug therapy: Less than 18 years of age. Patients with Liver disorders, renal disorders, thyroid disorders, bleeding disorders, gastrointestinal diseases, type 1 and 2 diabetes mellitus. Special population - pregnancy and lactating women. Patients with neoplastic conditions. Patients with a history of drug intake of anti-diabetic, anti-lipidemic, hormonal pills in the last 3 months. Patients with social habits (smoking and alcohol).

For lifestyle interventions: The antenatal women, postpartum women with symptoms of PCOS/PCOD up to one-year, surgical conditions which contraindicate exercises, women with medical conditions such as thyroid and metabolic disorders, and those who already engaged in exercise schedule.

Sample size calculation:

Population size, N = 100 with margin of error 5%, confidence level 95%, response distribution 50% the sample size is calculated as n = 80.

Study tools:

Patient data collection forms, informed consent forms, Lifestyle interventions leaflet, HRQOL Questionnaire.

Statistical analysis:

Data was expressed as mean ± SEM unless specified otherwise both intra and intergroup statistical analysis was done. The SPSS version 24.0 software was used to perform the statistical test. Intra group analysis for repeated measures was done using paired “t” test and Inter group analysis was done using unpaired “t” test. A p value <0.05 was considered as statistically significant.

RESULTS

Out of 80 patients enrolled in the study, 10 patients were allocated in Group A (treatment with Metformin alone), 10 patients were allocated in Group B (treatment with Metformin + Myo-inositol), and the remaining 60 patients were enrolled in treatment with lifestyle modifications alone. The baseline characteristics of the patients are tabulated in Table 1.

Table 1: Study population characteristics in the Pharmacotherapy group

	GROUP A (n = 10)	**GROUP B (n = 10)**
Age (in years)	24.4 ± 3.02	25.1 ± 3.02
BMI	27.22 ±3.20	28.60 ± 4.42
Age in menarche	12 ± 1	12 ± 1
H/O Drug allergy	0	0

Table 2 and 3 show the BMI, Hemoglobin A1C, Triglycerides, HDL, RBS, FBS, Ferriman Gallwey scores in patients treated with Metformin alone and patients treated with Metformin and Myo-inositol respectively, at different periods in this study.

Table 2: Study Parameters in Group A (Metformin alone)

PARAMETERS	**BASELINE**	**12 WEEKS**	**p Value**
BMI	27.22 ± 3.2	26.05 ± 2.6	< 0.05
HbA1C	5.75 ± 0.43	5.48 ± 0.41	<0.05
TRIGLYCERIDES	148 ± 5.39	147.4 ± 5.14	<0.05
HDL	30.30 ± 3.12	30.80 ± 2.97	<0.05
RBS	95.00 ± 9.04	94.20 ± 8.24	<0.05
FBS	89.50 ± 6.39	88.60 ± 5.73	<0.05
FG SCORE	10.80 ± 1.75	10.30 ± 1.65	<0.05

Table 3: Study Parameters in Group B (Metformin + Myo-inositol)

PARAMETERS	BASELINE	12 WEEKS	p Value
BMI	28.60 ± 4.42	27.07 ± 4.75	< 0.05
HbA1C	5.93 ± 0.51	5.49 ± 0.43	<0.05
TRIGLYCERIDES	148.20 ± 6.23	145.30 ± 4.57	<0.05
HDL	27.80 ± 4.10	28.50 ± 3.80	<0.05
RBS	96.30 ± 8.71	93.40 ± 7.13	<0.05
FBS	88.90 ± 7.97	88.70 ± 8.17	<0.05
FG SCORE	12.10 ± 2.13	9.40 ± 1.50	<0.05

There was significant improvement in the above parameters at the end of 12 weeks in both the groups as compared to baseline values. In the Metformin group, the BMI decreased by 1.17, HbA1C decreased by 0.27, triglycerides decreased by 0.6, HDL increased by 0.50, RBS decreased by 0.8, FBS decreased by 0.9, and FG Score decreased by 0.5, at the end of 12 weeks as compared to baseline values. In Metformin + Myo-inositol group, the BMI decreased by 1.53, HbA1C decreased by 0.44, Triglycerides decreased by 2.9, HDL increased by 0.7, RBS decreased by 2.9, FBS decreased by 0.20 and FG Score decreased by 2.7, at the end of 12 weeks as compared to baseline values.

Intergroup analysis was performed by comparing Group A and Group B, about the above parameters, and was found to be statistically significant. Table 4 shows the significance value of different parameters after the treatment in both the groups respectively.

Table 4: Intergroup analysis between Group A and Group B at the end of 12 weeks

PARAMETERS	GROUP A	GROUP B	p Value
BMI	1.170 ± 0.70	1.530 ± 0.53	>0.05
HbA1C	0.260 ± 0.12	0.440 ± 0.18	>0.05
TRIGLYCERIDES	0.60 ± 0.51	2.90 ± 1.91	>0.05
HDL	- 0.50 ± 0.52	- 0.70 ± 0.67	<0.05
RBS	0.80 ± 1.03	2.90 ± 2.13	>0.05
FBS	0.90 ± 0.73	4.50 ± 2.83	<0.05
FG SCORE	0.50 ± 0.52	2.70 ± 0.94	>0.05

In the results of intergroup analysis, the BMI, HbA1C, FG score, HDL, and RBS were found to be not statistically Significant ($p > 0.05$). Metformin as well as Metformin + Myo – inositol combination may have equal effect in the above-mentioned parameters. The results of TG and FBS were found to be statistically significant ($p < 0.05$), hence comparing the mean and standard deviation of those parameters in both the groups. It showed Metformin + Myo – inositol combination may have higher effects while compared to metformin alone.

Out of 80 patients, 60 patients were enrolled in the study. To measure health related quality of life (HRQoL), validated questioner in reference with PCOSQ50 tool was used. The patient's demographics were collected and the patient's opinion on health-related quality of life was collected using a questionnaire before the lifestyle interventions, leaflets were use to provide lifestyle modification counseling and after a period of 3 months, the patient's Demographics were collected and the patient's opinion on health-related quality of life was collected again and the data were described. The baseline characteristics of patients are tabulated in Table 5. Assessment of Quality of Life were collected and tabulated in Table 6.

Table 5: Study population characteristics in lifestyle modification group

	LIFESTYLE MODIFICATIONS (n = 60)
Age (in years)	26.7
BMI	26.65 ±3.97
Age in menarche	12 ± 1
H/O Drug allergy	0

Table 6: Assessment of Quality of Life

S NO	QUESTIONS	BASELINE		12 WEEKS		p VALUE
		YES	N0	YES	NO	
1	Suffered from bad mood due to PCOD	72%	28%	17%	83%	<0.05
2	Experienced impatience due to PCOD	75%	25%	12%	88%	<0.05
3	Felt easily tired	55%	45%	22%	78%	<0.05
4	Experienced aggressiveness due to PCOD	60%	40%	22%	78%	<0.05
5	Felt concerned about being overweight	62%	38%	12%	88%	<0.05
6	Felt the need to decrease the weight to control PCOD Status	62%	38%	7%	93%	<0.05
7	Concerned about fast returned of previous weight after weight loss	62%	38%	5%	95%	<0.05
8	Felt embarrassment of facial hair	62%	38%	7%	93%	<0.05
9	Felt desperate need for use	50%	50%	5%	95%	<0.05
10	Felt difficult communicating others about PCOD	63%	37%	5%	95%	<0.05
11	Felt lack of satisfaction of appearance	65%	35%	5%	95%	<0.05
12	Experienced concerns about infertility	57%	43%	3%	97%	<0.05
13	Blamed yourself for having PCOD	45%	55%	5%	95%	<0.05
14	Felt lack of control of emotions	67%	33%	5%	95%	<0.05
15	Experienced fear of cancer	22%	78%	0%	100%	<0.05

The statistical analysis was performed for lifestyle interventions and the result was found to be statistically significant ($p < 0.05$). Hence, lifestyle interventions have positive effect in PCOD patients.

DISCUSSION

Out of 80 patients, 20 patients were enrolled for the pharmacotherapy study (25%). Of these, 10 patients were in Group 1, (Metformin) and 10 patients were in Group 2, (Metformin + Myo-inositol). Out of 80 patients, 60 patients were enrolled for the study (75%). Based on our study it is found that the greatest number of patients belong to the age group of 21-36 years (60 %). The patients in our study had mean age of 25 years. This syndrome affects women during their reproductive age and being observed frequently in adolescent girls and young women due to hormonal changes caused by lifestyle changes, diet and poor sleep cycle. In our study most of the participants belonged to the category of abnormal BMI concludes that patient who are overweight or obese significantly have higher risk of PCOD compared with to those who are normal weight. It was observed that PCOD is more common in obese and overweight patients. From the results that were obtained from our study, we found majority of the patients had Ferriman Galloway score of 8-15 (100%) before the treatment with the drugs. After the treatment the Ferriman Gallwey score of majorities of the patients were observed to be 8-15 (100%), but in terms of mean values the drug had a positive effect in reducing Hirsutism and improving the patient quality of life. In our study, observed that the HbA1C and RBS were found to be increased above the normal level in 11 (55%) patients and 7 (35%) and before the treatment respectively. After the treatment most of the patients 6 (25%) were observed to have normal level HbA1C and RBS 5 (25%) thus reducing the risk of diabetes mellitus and other metabolic disorder. The FBS levels were found to be increased in 2 (10%) patients before the treatment. After the treatment, it remains unchanged in terms of category, but in terms of mean and standard deviation the drug has positive effect in reducing the FBS. Lipid profiles which include TG were found to be increased above the normal level in 5 (25%) patients before the treatment.

After the treatment 2 (10 %) of patients were observed to have normal level. Lifestyle intervention was given to 60 patients and observed that most of the patients BMI were found to be 30 (55%) overweight and 11 (18%) were obese before the intervention. After the lifestyle intervention 7 (12%) patients were observed to have normal weight. The health-

related quality of life (HRQoL) of PCOD patients was analyzed using questionnaire validated in reference with PCOSQ-50. There was a clear association between PCOD and worsened quality of life before the intervention. After the intervention there was a significant improvement in the physical and mental state of PCOD patients. In general, the lack of data of pharmacotherapy was because most of the patients received hormonal medicines to regulate the menstrual cycle. Some patients had co morbidities like hypothyroidism, diabetes mellitus and other metabolic disorder. Those patients were excluded from our study as per criteria and study plan. Lack of adherence and follow up was also observed.

CONCLUSION

This study concludes that metformin and metformin + myo – inositol individually has positive effect in various lab parameters and when compared metformin + myo – inositol has greater effect in reducing TG and FBS than metformin alone. In case of BMI, Hirsutism, HbA1C, HDL, RBS both drug groups have similar efficacy. In terms of adverse effects, Metformin + myo – inositol seems to be lesser when compared to metformin. The key message here was the importance of identifying and effectively managing PCOD patients and maintaining to enhance their well-being. Metformin + myo–inositol is marginally more efficacious than metformin alone. Hence, the combination can be a new addition in the armamentarium for the treatment of PCOD. Lifestyle interventions have the great impact in the physical and mental state of PCOD woman. With proper counseling and guidance, lifestyle interventions can be initiated as the first line therapy if possible. Insulin sensitizers along with lifestyle modification should be considered as an integrative strategy which can lead to weight reduction and improvement in PCOD patients.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Nazirudeen, R., Sridhar, S., Priyanka, R., Sumathi, B., Natarajan, V., Subbiah, E., Raghavan, K. S., & Sangumani, J. (2023). A randomized controlled trial comparing myoinositol with metformin versus metformin monotherapy in polycystic ovary syndrome. Clinical endocrinology, 99(2), 198–205.
2. Agrawal, A., Mahey, R., Kachhawa, G., Khadgawat, R., Vanamail, P., & Kriplani, A. (2019). Comparison of metformin plus myoinositol vs metformin alone in PCOS women undergoing ovulation induction cycles: randomized controlled trial. Gynecological endocrinology: the official journal of the International Society of Gynecological Endocrinology, 35(6), 511–514.
3. Jamilian, M., Farhat, P., Foroozanfard, F., Afshar Ebrahimi, F., Aghadavod, E., Bahmani, F., Badehnoosh, B., Jamilian, H., & Asemi, Z. (2017). Comparison of myo-inositol and metformin on clinical, metabolic and genetic parameters in polycystic ovary syndrome: A randomized controlled clinical trial. Clinical endocrinology, 87(2), 194–200.
4. Nas, K., & Tűű, L. (2017). A comparative study between Myo-inositol and metformin in the treatment of insulin-resistant women. European review for medical and pharmacological sciences, 21(2 Suppl), 77–82.
5. Azizi Kutenaei, M., Hosseini Teshnizi, S., Ghaemmaghami, P., Eini, F., & Roozbeh, N. (2021). The effects of myo-inositol vs. metformin on the ovarian function in the polycystic ovary syndrome: a systematic review and meta-analysis. European review for medical and pharmacological sciences, 25(7), 3105–3115.
6. Fatima, K., Jamil, Z., Faheem, S., Adnan, A., Javaid, S. S., Naeem, H., Mohiuddin, N., Sajid, A., & Ochani, S. (2023). Effects of myo-inositol vs. metformin on hormonal and metabolic parameters in women with PCOS: a meta-analysis. Irish journal of medical science, 10.1007/s11845-023-03388-5.
7. Ravn, P., Gram, F., Andersen, M. S., & Glintborg, D. (2022). Myoinositol vs. Metformin in Women with Polycystic Ovary Syndrome: A Randomized Controlled Clinical Trial. Metabolites, 12(12), 1183.
8. Bahadur, A., Arora, H., Ravi, A. K., Naithani, M., Bahurupi, Y., Chaturvedi, J., Ajmani, M., & Mundhra, R. (2021). Comparison of Clinical, Metabolic and Hormonal Effects of Metformin Versus Combined Therapy of Metformin with Myoinositol Plus DChiro-Inositol in Women with Polycystic Ovary Syndrome (PCOS): A Randomized Controlled Trial. Cureus, 13(6), e15510.
9. Unanyan, A., Pivazyan, L., Krylova, E., Eskin, A., Zakaryan, A., Sarkisova, A., & Ishchenko, A. (2022). Effectiveness of inositol, metformin and their combination in women with PCOS undergoing assisted reproduction: systematic review and metaanalysis. Gynecological endocrinology: the official journal of the International Society of Gynecological Endocrinology, 38(12), 1035–1046.
10. Bodepudi, R., Seher, S., Khan, S. A., Emmanuel, S., Shantha Kumar, V., Nerella, R., Shaman Ameen, B., Patel, D., David John, J., & Khan, S. (2023). Myoinositol Versus Metformin in the Treatment of Polycystic Ovarian Syndrome: A Systematic Review. Cureus, 15(7), e41748.
11. Shokrpour, M., Foroozanfard, F., Afshar Ebrahimi, F., Vahedpoor, Z., Aghadavod, E., Ghaderi, A., & Asemi, Z. (2019). Comparison of myo-inositol and metformin on glycemic control, lipid profiles, and gene expression related to insulin and lipid metabolism in women with polycystic ovary syndrome: a randomized controlled clinical trial. Gynecological endocrinology: the official journal of the International Society of Gynecological Endocrinology, 35(5), 406–411.
12. Greff, D., Juhász, A. E., Váncsa, S., Váradi, A., Sipos, Z., Szinte, J., Park, S., Hegyi, P., Nyirády, P., Ács, N., Várbíró, S., & Horváth, E. M. (2023). Inositol is an effective and safe treatment in polycystic ovary syndrome: a systematic review and meta-analysis of randomized controlled trials. Reproductive biology and endocrinology: RB&E, 21(1), 10.
13. Fruzzetti, F., Perini, D., Russo, M., Bucci, F., & Gadducci, A. (2017). Comparison of two insulin sensitizers, metformin and myo-inositol, in women with polycystic ovary Bibliography Page 91 syndrome (PCOS). Gynecological endocrinology: the official journal of the International Society of Gynecological Endocrinology, 33(1), 39–42.
14. Prabhakar, P., Mahey, R., Gupta, M., Khadgawat, R., Kachhawa, G., Sharma, J. B., Vanamail, P., Kumari, R., & Bhatla, N. (2021). Impact of myoinositol with metformin and myoinositol alone in infertile PCOS women undergoing ovulation induction cycles - randomized controlled trial. Gynecological endocrinology: the official journal of the International Society of Gynecological Endocrinology, 37(4), 332–336.

15. Zhang, J. Q., Xing, C., & He, B. (2022). Short period-administration of myoinositol and metformin on hormonal and glycolipid profiles in patients with polycystic ovary syndrome: a systematic review and updated meta-analysis of randomized controlled trials. European review for medical and pharmacological sciences, 26(6), 1792–1802.
16. Singh J, Khan S, Kumari N, Rao P. Comparative study of metformin versus myoinositol in the treatment of insulin-resistant poly cystic ovarian syndrome in women. International Journal of Contemporary Medical Research 2022;9(2):B13-B16.
17. Lim, S. S., Hutchison, S. K., Van Ryswyk, E., Norman, R. J., Teede, H. J., & Moran, L. J. (2019). Lifestyle changes in women with polycystic ovary syndrome. The Cochrane database of systematic reviews, 3(3), CD007506.
18. Moran, L. J., Hutchison, S. K., Norman, R. J., &Teede, H. J. (2011). Lifestyle changes in women with polycystic ovary syndrome. The Cochrane database of systematic reviews, (7), CD007506.
19. Legro, R. S., Hansen, K. R., Diamond, M. P., Steiner, A. Z., Coutifaris, C., Cedars, M. I., Hoeger, K. M., Usadi, R., Johnstone, E. B., Haisenleder, D. J., Wild, R. A., Barnhart, K. T., Mersereau, J., Trussell, J. C., Krawetz, S. A., Kris-Etherton, P. M., Sarwer, D. B., Santoro, N., Eisenberg, E., Huang, H., … Reproductive Medicine Network (2022). Effects of preconception lifestyle intervention in infertile women with obesity: The FIT-PLESE randomized controlled trial. PLoS medicine, 19(1), e1003883.
20. Cowan, S., Lim, S., Alycia, C., Pirotta, S., Thomson, R., Gibson-Helm, M., Blackmore, R., Naderpoor, N., Bennett, C., Ee, C., Rao, V., Mousa, A., Alesi, S., & Moran, L. (2023). Lifestyle management in polycystic ovary syndrome - beyond diet and physical activity. BMC endocrine disorders, 23(1), 14.
21. Liu, C., Zhang, L., Zheng, W., Liang, X., Zhang, L., Tian, Z., & Li, G. (2021). Lifestyle Intervention for Overweight/Obese Pregnant Women with Polycystic Ovarian Syndrome: Lessons and Challenges. Obesity facts, 14(4), 405–414
22. Kazemi, M., McBreairty, L. E., Chizen, D. R., Pierson, R. A., Chilibeck, P. D., & Zello, G. A. (2018). A Comparison of a Pulse-Based Diet and the Therapeutic Lifestyle Changes Diet in Combination with Exercise and Health Counselling on the Cardio-Metabolic Risk Profile in Women with Polycystic Ovary Syndrome: A Randomized Controlled Trial. Nutrients, 10(10), 1387.
23. Awoke, M. A., Earnest, A., Joham, A. E., Hodge, A. M., Teede, H. J., Brown, W. J., & Moran, L. J. (2021). Weight gain and lifestyle factors in women with and without polycystic ovary syndrome. Human reproduction (Oxford, England), 37(1), 129–141.
24. Jiskoot, G., Dietz de Loos, A., Beerthuizen, A., Timman, R., Busschbach, J., & Laven, J. (2020). Long-term effects of a three-component lifestyle intervention on emotional well-being in women with Polycystic Ovary Syndrome (PCOS): A secondary analysis of a randomized controlled trial. PloS one, 15(6), e0233876.
25. Moran, L. J., Noakes, M., Clifton, P., Buckley, J., Brinkworth, G., Thomson, R., & Norman, R. J. (2019). Predictors of Lifestyle Intervention Attrition or Weight Loss Success in Women with Polycystic Ovary Syndrome Who Are Overweight or Obese. Nutrients, 11(3), 492.
26. Benham, J. L., Booth, J. E., Corenblum, B., Doucette, S., Friedenreich, C. M., Rabi, D. M., & Sigal, R. J. (2021). Exercise training and reproductive outcomes in women with polycystic ovary syndrome: A pilot randomized controlled trial. Clinical endocrinology, 95(2), 332–343.
27. Arentz, S., Smith, C. A., Abbott, J., & Bensoussan, A. (2021). Perceptions and experiences of lifestyle interventions in women with polycystic ovary syndrome (PCOS), as a management strategy for symptoms of PCOS. BMC women's health, 21(1), 107.
28. Jiskoot, G., Dietz de Loos, A., Timman, R., Beerthuizen, A., Laven, J., &Busschbach, J. (2022). Lifestyle treatment in women with polycystic ovary syndrome: predictors of weight loss and dropout. Brain and behavior, 12(7), e2621.
29. Young, C. C., Monge, M., Minami, H., Rew, L., Conroy, H., Peretz, C., & Tan, L. (2022). Outcomes of a Mindfulness-Based Healthy Lifestyle Intervention for Adolescents and Young Adults with Polycystic Ovary Syndrome. Journal of pediatric and adolescent gynecology, 35(3), 305–313.
30. Moran, L. J., Brown, W. J., McNaughton, S. A., Joham, A. E., &Teede, H. J. (2017). Weight management practices associated with PCOS and their relationships with diet and physical activity. Human reproduction (Oxford, England), 32(3), 669–678.

31. Tay, C. T., Moran, L. J., Harrison, C. L., Brown, W. J., &Joham, A. E. (2020). Physical activity and sedentary behavior in women with and without polycystic ovary syndrome: An Australian population-based cross-sectional study. Clinical endocrinology, 93(2), 154–162.