E-ISSN: 2706-8927
P-ISSN: 2706-8919
www.allstudyjournal.com
IJAAS 2024; 6(5): 104-109
Received: 02-04-2024
Accepted: 05-05-2024

Shaymaa Talal Abdul Razzaq
Baghdad Teaching Hospital, Medical City Directorate, Ministry of Health, Iraq

Jawad Kadhim Al-Diwan
Baghdad College of Medicine, Ministry of Higher Education, Iraq

Nada Dheyaa Hasan
Baghdad Teaching Hospital, Medical City Directorate, Ministry of Health, Iraq

Rasha Jaber Hameed
Baghdad-Al Rusafa Health Directorate, Ministry of Health, Iraq

Corresponding Author:
Shaymaa Talal Abdul Razzaq
Baghdad Teaching Hospital, Medical City Directorate, Ministry of Health, Iraq

The role of vitamin E in the management of polycystic ovarian syndrome

Shaymaa Talal Abdul Razzaq, Jawad Kadhim Al-Diwan, Nada Dheyaa Hasan and Rasha Jaber Hameed

DOI: https://doi.org/10.33545/27068919.2024.v6.i5b.1178

Abstract
Background: Polycystic ovary syndrome (PCOS) is a common hormonal disorder in women that causes irregular periods and excess male hormones (androgens) leading to symptoms such as acne and unwanted hair growth. Although previous research hinted at the potential of vitamin E to improve PCOS, this study aimed to explore its effectiveness in managing symptoms among Iraqi women.
Methods: A cross-sectional study was conducted and 73 women with PCOS from two hospitals in Baghdad were recruited between April and October 2023. They collected data through interviews, questionnaires, and physical measurements to assess the characteristics of the participants, the symptoms of PCOS, and the body composition (BMI). Medical records provided information on the duration of symptoms and lifestyle changes. Blood tests evaluated hormone levels, blood sugar control (HbA1c), and cholesterol profiles. Finally, they compared the health outcomes of women taking vitamin E supplements with those who did not.
Results: More than 30% of the participants incorporated vitamin E into their PCOS management. In particular, most were overweight or obese. Interestingly, vitamin E supplementation was associated with a significant decrease in androgenic symptoms such as hair loss ($p=0.017$), weight gain ($p = 0.04$), and acne ($p=0.016$). Furthermore, women taking vitamin E had lower levels of hormones associated with PCOS, including luteinizing hormone (LH, $p<0.001$), prolactin ($p<0.001$), and testosterone ($p=0.015$). This suggests potential benefits for hormonal regulation. Furthermore, HbA1c, a marker of long-term blood sugar control, was significantly lower in the vitamin E group ($p=0.005$). However, no significant impact on cholesterol, triglycerides, or fasting blood sugar levels was observed.
Conclusion: This study found promising evidence for vitamin E supplementation to manage PCOS symptoms. Women taking vitamin E reported less frequent androgenic symptoms such as hair loss, weight gain, and acne. Furthermore, their blood work showed improved hormonal profiles and better long-term blood sugar control. However, no significant effects were observed on blood cholesterol, triglycerides, or immediate blood sugar levels.

Keywords: PCOS, vitamin E, androgenic effects, hormonal balance, and blood sugar control

Introduction
Polycystic ovary syndrome (PCOS) is the most prevalent endocrine and metabolic disorder that affects women of childbearing age. Characterized by its heterogeneous nature, PCOS presents with signs and symptoms of androgen excess, including acne, hirsutism, and androgen-dependent alopecia. Ovarian dysfunction, manifested by chronic oligo-anovulation and elevated serum levels of luteinizing hormone (LH), is another hallmark feature of the syndrome [1].

The etiology of PCOS remains elusive, although strong evidence suggests epigenetic and environmental influences, such as diet and lifestyle factors. Importantly, PCOS is frequently associated with abdominal adiposity, insulin resistance, metabolic disorders, obesity, and increased cardiovascular risk factors [1, 2]. With a prevalence that reaches up to 18% according to Rotterdam criteria [3], PCOS represents a significant public health concern.

Conventional treatment approaches for PCOS are not without limitations, highlighting the need to explore complementary and alternative therapies [4]. These include traditional Chinese medicine, medicinal foods, immunotherapy, diet therapy, vitamin therapy, spa therapy, psychotherapy, and oxygen therapy [4]. Lifestyle modifications are well established as the cornerstone of PCOS management, particularly for women seeking to improve their quality of life [5].

In recent years, the use of nutritional supplements to treat PCOS has gained significant traction [6, 7].

Vitamin E, a well-known antioxidant, emerges as a promising nutritional supplement with potential benefits in the management of PCOS. It plays a crucial role in various aspects of reproduction, acting as a scavenger of oxygen-free radicals and promoting a balanced antioxidant state essential for normal physiological function within the reproductive system [8]. Emerging evidence suggests that vitamin E supplementation can significantly reduce serum total cholesterol and triglyceride levels, improve insulin resistance, and lower the free testosterone index [9]. Furthermore, recent research indicates its potential to improve endometrial thickness in women with unexplained infertility [10].

Animal studies have demonstrated the restorative potential of vitamin E in ovarian tissue in PCOS. The presence of follicles in various stages of development, a normal granulosa layer, different thecal layers, and corpora lutea within the ovaries of vitamin E-treated animals suggests its ability to promote normal oogenesis and restore a healthy estrous cycle [11]. Furthermore, higher levels of vitamin E have been linked to a lower risk of developing PCOS or a reduced susceptibility to key pathways involved in its onset [12].

Objective

The present study aims to investigate the role of vitamin E in the management of polycystic ovary syndrome.

Methods

Study design: This study used a cross-sectional design to investigate the role of vitamin E in the management of polycystic ovarian syndrome (PCOS).

Setting and study time: The research was carried out from April to October 2023 in gynecological and obstetric outpatient clinics of the Baghdad Teaching Hospital and the Al-Yarmouk Teaching Hospital.

Sampling Technique: A convenience sampling approach was used. All women diagnosed with PCOS during the study period in these facilities were invited to participate.

Study Population: The inclusion criteria included women diagnosed with PCOS by a qualified physician. A total of 73 patients completed the study after providing informed consent and meeting all data collection requirements.

Data Collection Instruments

- **Structured Questionnaire:** A questionnaire developed by the researcher evaluated demographic details (age, education, occupation, social status). The reliability and validity of the questionnaire were established by reviewing by nutrition, community medicine, and family medicine specialists.
- **Anthropometric measurements:** Weight (kg) using a Uniscale, height (cm), and waist circumference (cm) were measured during the first visit. Body mass index (BMI) was calculated using the formula BMI = weight (kg) / height (m^2). BMI categories were defined as underweight (<18.5 kg/ m^2), normal (18.5-24.9 kg/ m^2), overweight (25-29.9 kg /m^2), and obese (≥ 30 kg/ m^2).
- **Review of medical records:** Data on PCOS symptoms, duration of symptoms, and lifestyle modifications implemented to manage symptoms were extracted from patient medical records.
- **Laboratory Investigations:** The hormone profile, glycemic index, and lipid profile were assessed by blood tests.

Data Analysis: Data entry and analysis were performed using SPSS version 26 software. Categorical variables were presented as frequencies and percentages. Associations between categorical variables were analyzed using Pearson's chi-square independence test. The numerical variables were presented as means and standard deviations. Independent t-tests were used to compare mean laboratory test levels between women taking vitamin E supplements and those not taking them. A significance level of alpha < 0.05 was applied.

Ethical Considerations & Approval: The study protocol was approved by the Iraqi Ministry of Health and the Supervisory Committee of the Arab Board of Health Specializations. Communication was carried out with both the Baghdad Teaching Hospital and the Al-Yarmouk Teaching Hospital to conduct the study in the selected hospitals. Informed consent was obtained verbally from all participants before starting data collection. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

Data availability: Due to ethical considerations and privacy concerns, the data of individual participants cannot be publicly shared.

Results

An analysis of the baseline demographic characteristics in Table 1 revealed a high degree of comparability between women taking vitamin E supplements (N=22) and those who did not take them (N=51). There are no statistically significant differences in age (p-value = 0.93), educational level (p-value = 0.936), occupation (p-value = 0.964) or social status (p-value = 0.964). The majority of participants fell within the 30-45-year age range (around 64%), with similar proportions across education levels (one-third each for secondary, college, and higher degrees). Employed individuals formed the largest occupational group (around 74%), followed by housewives (around 16%) and students (around 10%). Social status also mirrored these trends, with roughly equal proportions of single (38%), married with children (27%), and married without children (34%).

Interestingly, while the BMI categories did not show significant differences (p-value = 0.966), a noteworthy finding emerged. Most of the participants in both groups fell outside the normal weight range. Approximately 37% were classified as normal weight, with similar proportions classified as overweight (29%) and obese (34%). Waist circumference also did not show significant differences (p-value = 0.384), with an average of around 95-97 cm for both groups.

This high degree of baseline comparability strengthens the internal validity of the study. Since no significant demographic differences were observed, any changes in outcomes after intervention (vitamin E supplementation) can be more confidently attributed to the treatment itself, assuming that appropriate randomization procedures were implemented.

Table 1: Demographic characteristics of the included women, N=73.

Variables	Patients on Vit. E N=22	Not on Vit. E N=51	Total N=73	P-value [a]
	N (row %)	N (row %)	N (col. %)	
Age groups				
<30 years	8 (36.4)	18 (35.3)	26 (35.6)	0.93
30 - 45 years	14 (63.6)	33 (64.7)	47 (64.4)	
Education				
Secondary	8 (36.4)	17 (33.3)	25 (34.2)	0.936
College	8 (36.4)	18 (35.3)	26 (35.6)	
Higher degree	6 (27.3)	16 (31.4)	22 (30.1)	
Occupation				
Employee	16 (72.7)	38 (74.5)	54 (74)	0.964
Housewife	4 (18.2)	8 (15.7)	12 (16.4)	
Student	2 (9.1)	5 (9.8)	7 (9.6)	
Social status				
Single	8 (36.4)	20 (39.2)	28 (38.4)	0.964
Married with children	6 (27.3)	14 (27.5)	20 (27.4)	
Married with no children	8 (36.4)	17 (33.3)	25 (34.2)	
Body mass index classes				
Normal	8 (29.6)	19 (70.4)	27 (37)	0.966
Overweight	6 (28.6)	15 (71.4)	21 (28.8)	
Obese	8 (32)	17 (68)	25 (34.2)	
	Mean ± SD	Mean ± SD	Mean ± SD	P-value [b]
Waist circumference (cm)	94.8±12.2	97.5±11.8	96.6±11.8	0.384

[a] Pearson's Chi-square test, [b] Independent t-test, SD: standard deviation

Table 2 sheds light on the characteristics of the study participants with PCOS, classified according to their vitamin E supplementation status. This information provides valuable information on the baseline presentation of PCOS in the study sample.

More than half of the participants in both groups (around 53%) reported experiencing PCOS symptoms for more than five years, suggesting a chronic condition for a substantial part of the population. Interestingly, the duration of symptoms did not differ significantly between the groups (p-value = 0.945). Although most of the participants in both groups experienced various symptoms of PCOS, some notable differences emerged. The group without vitamin E exhibited a higher prevalence of irregular menstrual cycles (74.5% vs. 54.5%), although this difference did not reach statistical significance (p-value = 0.092). However, statistically significant differences were observed for specific symptoms. Hair loss/thinning (p-value = 0.017), weight gain (p-value = 0.04), and acne/oily skin (p-value = 0.016) were more prevalent in the nonvitamin E group compared to the vitamin E group. This pattern suggests that vitamin E supplementation might be associated with a lower prevalence of these particular symptoms. The difficulty of getting pregnant also showed a trend toward being more common in the nonvitamin E group (87.1% vs. 64.3%), but more research is needed to confirm this potential association (p-value = 0.077).

Interestingly, both groups adopted similar lifestyle modification approaches to manage their symptoms, regardless of vitamin E supplementation. Weight loss was a common strategy used by a large proportion of participants in both groups (around 72%). No statistically significant differences (p-value > 0.05) were observed between the groups in weight loss efforts, adherence to a balanced diet, regular exercise, or current level of physical activity. Similarly, no significant differences were found in eating habits (processed food/sugar beverage consumption, portion control, or stress management techniques).

A significant proportion of participants in both groups (around 36%) reported experiencing insufficient sleep regularly. No statistically significant differences (p-value > 0.05) were also observed between the groups regarding sleep patterns or the use of medications, hormonal therapy, or supplements for the management of symptoms.

Table 2: Symptoms and lifestyle of the included women, N=73.

Symptoms	Patients on Vit. E N=22	Not on Vit. E N=51	Total N=73	P-value
	N (col. %)	N (col. %)	N (col. %)	
Duration of PCOS symptoms				
<2 years	8 (36.4)	18 (35.3)	26 (35.6)	0.945
2-5 years	2 (9.1)	6 (11.8)	8 (11)	
>5 Years	12 (54.5)	27 (52.9)	39 (53.4)	
Symptoms				
Irregular menstrual cycle	12 (54.5)	38 (74.5)	50 (68.5)	0.092
Excessive hair growth	11 (50)	37 (72.5)	48 (65.8)	0.062
Hair loss or thinning	9 (40.9)	36 (70.6)	45 (61.6)	0.017*
Weight gain	9 (40.9)	34 (66.7)	43 (58.9)	0.04*
Acne or oily skin	8 (36.4)	34 (66.7)	42 (57.5)	0.016*
Difficulty getting pregnant (from married women)	9/14 (64.3)	27/31 (87.1)	36/45 (80)	0.077
Lifestyle changes to manage symptoms				
Weight loss efforts	16 (72.7)	37 (72.5)	53 (72.6)	0.987

Regular exercise	10 (45.5)	25 (49)	35 (47.9)	0.78
Balanced diet	9 (40.9)	26 (51)	35 (47.9)	0.429
The current level of physical activity				
Sedentary (little to no physical activity)	14 (63.6)	31 (60.8)	45 (61.6)	0.941
Lightly active (occasional exercise)	6 (27.3)	14 (27.5)	20 (27.4)	
Moderately active (exercise 2- 3 times/week)	2 (9.1)	6 (11.8)	8 (11)	
Consumption of processed or sugary foods and beverages				
Regularly	6 (27.3)	14 (27.5)	20 (27.4)	0.998
Frequently	6 (27.3)	13 (25.5)	19 (26)	
Occasionally	6 (27.3)	14 (27.5)	20 (27.4)	
Rarely	4 (18.2)	10 (19.6)	14 (19.2)	
Monitor of portion sizes during meals	8 (36.4)	20 (39.2)	28 (38.4)	0.818
Engagement in stress reducing activities. (Hobbies, yoga, meditation)				
Once/week	2 (9.1)	5 (9.8)	7 (9.6)	0.924
Rarely	20 (90.9)	46 (90.2)	66 (90.4)	
Getting enough sleep on a regular basis (7-9) hours per night				
No	8 (36.4)	18 (35.3)	26 (35.6)	0.938
Occasionally	8 (36.4)	18 (35.3)	26 (35.6)	
Yes	6 (27.3)	15 (29.4)	21 (28.8)	
Taking medication, hormonal therapy or supplement to manage your symptoms	16 (72.7)	36 (70.6)	52 (71.2)	0.835

*Significant by Pearson's Chi-square test

Table 3 examines key health markers in women with PCOS who received vitamin E supplementation (N=22) compared to those who did not (N=51). The findings suggest potential benefits for vitamin E in the management of PCOS symptoms, particularly about hormonal imbalances and blood sugar control.

The hormonal profile revealed significant reductions in the levels of luteinizing hormone (LH) ($p<0.001$) and Prolactin ($p<0.001$) levels in the vitamin E group compared to the control group. Since elevated LH is associated with PCOS, its decrease suggests a possible advantage of vitamin E in the regulation of ovarian androgen production, a hallmark of PCOS. Similarly, lower levels of prolactin can contribute to improved menstrual regularity, which is often disrupted in PCOS.

Furthermore, the vitamin E group showed statistically significant reductions in serum testosterone (p = 0.015). However, the magnitude of this decrease is relatively small, warranting further investigation of its clinical significance and possible dose-dependent effects. Interestingly, follicle stimulating hormone (FSH) levels did not show significant differences between the groups (p = 0.375).

Although fasting blood glucose levels were lower in the vitamin E group (p=0.075), this difference did not reach statistical significance. However, glycated hemoglobin (HbA1c), a marker of long-term blood sugar control, showed a statistically significant difference (p=0.005). Women taking vitamin E had lower HbA1c levels, suggesting a potential benefit in the of management chronic blood sugar levels.

The analysis of the lipid profile did not reveal significant differences in cholesterol, triglycerides, or HDL levels between the groups. This suggests that vitamin E supplementation, in the dose used in this study, may not significantly affect lipid profiles in women with PCOS.

Table 3: Comparison of hormones, glycemic indices, and lipid profile for women, according to their taking of vitamin E, n=73.

Variables	Patients on Vit. E N=22	Not on Vit. E N=51	P-value
	Mean ± SD	Mean ± SD	
Hormones			
Luteinizing Hormone (mIU/ml)	6.1±3.2	12.3±7.1	<0.001**
Follicular Stimulating Hormone (mIU/ml)	8.3±2.4	9.1±3.6	0.353
Serum Prolactin (ng/ml)	13.8±6.7	27.4±10.8	<0.001**
Serum Testosterone (ng/ml)	0.7±0.2	0.8±0.2	0.015*
Glycemic indices			
Fasting blood glucose (mg/dl)	86.4±8	100.1±35.2	0.075
Glycated hemoglobin (HbA1c) (%)	4.9±0.4	5.4±0.6	0.005**
Lipid profiles			
Serum Cholesterol mg/dL	135.3±20.2	146.7±39	0.2
Serum Triglyceride mg/dL	130.5±70.7	143.2±81.9	0.508
Serum high density lipoprotein mg/dL	43.6±7.2	43.4±6.9	0.886

SD: standard deviation, *Significant at 0.05 level, ** Significant at 0.01 level by Independent t-test

Discussion

Previous research suggests that vitamin E supplementation can improve insulin resistance, reduce cardiovascular risk, and positively impact lipid profiles in women with PCOS [13, 14]. However, the current study did not observe significant weight changes, body mass index (BMI), or waist circumference after supplementation. These findings are consistent with several studies conducted in Iran [15-17] and China [18]. On the contrary, Ebrahimi *et al*. reported a small but statistically significant decrease in BMI for patients taking vitamin E supplements [19].

Regarding the antiandrogenic effects of vitamin E, Yalle-Vásquez *et al*. discussed its potential, which is consistent with the present study [20]. Androgenic symptoms such as

hair loss, weight gain, and acne were significantly less prevalent in the vitamin E group compared to the control group. However, the studies by Shokrpour *et al*. and Sadeghi *et al*. did not find a significant association between vitamin E and these symptoms [21, 22].

Vitamin E exhibits some hormone-like properties. It is proposed to mitigate the negative effects of elevated testosterone by mimicking progesterone actions [23]. The double-blind placebo-controlled trial by Izadi *et al*. demonstrated the positive effects of vitamin E supplementation on sexual hormone levels in PCOS patients [15]. Similarly, the current study observed significantly lower levels of LH, prolactin, and testosterone in the vitamin E group, but no significant differences in FSH levels.

The antioxidant properties of vitamin E have been associated with improved glycemic control by potentially hindering glucose oxidation and reducing the risk of diabetes and hyperglycemia [24]. However, some randomized controlled trials contradict this notion [15, 17, 25]. Although fasting blood glucose in the current study remained unaffected by vitamin E, glycated hemoglobin (HbA1c), a marker of long-term blood sugar control, was significantly lower in the vitamin E group. These findings are supported by other randomized trials that demonstrate the positive impact of vitamin E on HbA1c in patients with PCOS [26].

The current study did not reveal significant differences in lipid profiles between the vitamin E and control groups. This aligns with the findings of Izadi *et al*. and Zhang *et al*. [27, 28]. However, it contradicts several Iranian studies in which the antioxidant effects of vitamin E significantly improved lipid profiles in patients with PCOS [24- 26, 29]. This inconsistency could be attributed to differences in study settings, including the duration of vitamin E intake and the lack of longitudinal data on women's health parameters in the current study.

Conclusion

The study explored the potential of vitamin E potential for PCOS management, revealing promising benefits. Vitamin E supplementation was associated with less hair loss, weight gain, and acne, possibly due to its anti-androgenic effects. Furthermore, women taking these supplements showed significantly lower levels of hormones such as LH, prolactin, and testosterone, which could improve menstrual regularity and reduce androgen production. Importantly, vitamin E supplementation significantly reduced HbA1c, indicating potential benefits for long-term control of blood sugar in patients with PCOS. However, the study did not find a significant impact on body weight, BMI, waist circumference, lipid profile, or fasting blood sugar levels.

This study suggests that vitamin E may help to manage some symptoms of PCOS, but more evidence is needed. Future well-designed randomized controlled trials are crucial to confirm these initial findings. More research should explore the ideal dosage and duration of vitamin E supplementation for PCOS patients. Furthermore, it is essential to investigate how vitamin E affects androgenic symptoms, hormone levels, and blood sugar control. Finally, longitudinal studies are needed to understand the long-term impact of vitamin E on various markers of PCOS. Overall, this study provides a promising starting point, but more robust research is needed before definitive recommendations can be made for clinical practice.

Acknowledgment

This research is indebted to the invaluable contributions of Dr. Jawad Kadhim Al-Diwan for his mentorship and guidance, shaping the research design and execution. We extend sincere appreciation to the staff of the gynecological and obstetric outpatient clinics at Baghdad Teaching Hospital and Al-Yarmouk Teaching Hospital for facilitating participant recruitment. Our deepest gratitude goes to the participating women, whose willingness to share their experiences and health information is the foundation of this study.

Conflict of interest: The authors of Shaymaa Talal AbdulRazzaq, Jawad Kadhim Al-Diwan, Nada Dheyaa Hasan, and Rasha Jaber Hameed declare that there is no conflict of interest in the publication of this article.

Financial support: The study was self-funded by the researchers and there is no funding from any institution or organization.

References

1. Escobar-Morreale HF. Polycystic ovary syndrome: Definition, aetiology, diagnosis and treatment. Nature Reviews Endocrinology. Nature Publishing Group. 2018;14:270-84.
2. Shahrokhi SA, Naeini AA. The association between dietary antioxidants, oxidative stress markers, abdominal obesity and poly-cystic ovary syndrome: A case control study. J Obstet Gynaecol (Lahore); c2020, 40(1).
3. Teede HJ, Misso ML, Costello MF, *et al*. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Human Reproduction. 2018 Sep 1;33(9):1602-18.
4. Jia LY, Feng JX, Li JL, *et al*. The Complementary and Alternative Medicine for Polycystic Ovary Syndrome: A Review of Clinical Application and Mechanism. Vol. 2021, Evidence-based Complementary and Alternative Medicine. Hindawi Limited; c2021.
5. Teede HJ, Misso ML, Costello MF, *et al*. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Fertil Steril. 2018 Aug 1;110(3):364-79.
6. Menichini D, Ughetti C, Monari F, *et al*. Nutraceuticals and polycystic ovary syndrome: a systematic review of the literature. Gynecological Endocrinology. Gynecol Endocrinol. 2022;38:623-31.
7. Heidari H, Hajhashemy Z, Saneei P. A meta-analysis of effects of vitamin E supplementation alone and in combination with omega-3 or magnesium on polycystic ovary syndrome. Sci Rep; c2022, 12(1).
8. Chen J, Guo Q, Pei YH, *et al*. Effect of a short-term Vitamin E supplementation on oxidative stress in infertile PCOS women under ovulation induction: A retrospective cohort study. BMC Womens Health; c2020 Apr 6, 20(1).
9. Morsy AA, Sabri NA, Mourad AM, *et al*. Randomized controlled open-label study of the effect of vitamin E supplementation on fertility in clomiphene citrate-resistant polycystic ovary syndrome. Journal of Obstetrics and Gynaecology Research. 2020 Nov 1;46(11):2375-82.

10. Amini L, Tehranian N, Movahedin M, *et al*. Antioxidants and management of polycystic ovary syndrome in Iran: A systematic review of clinical trials. Vol. 13, Iranian Journal of Reproductive Medicine; c2015.
11. Aburawi SM, Treesh SA, El Jaafari HA, Benmahmoud O, *et al*. Effect of Vitamin E on Polycystic Ovary Syndrome Induced by Dehydroepiandrosterone in Female Albino Mice: Histological Study. Malaysian Journal of Pharmaceutical Sciences. 2021;19 (2):111-30.
12. Shen JY, Xu L, Ding Y, Wu XY. Effect of vitamin supplementation on polycystic ovary syndrome and key pathways implicated in its development: A Mendelian randomization study. http://www.wjgnet.com/. 2023 Aug 16;11(23):5468-78.
13. Rahmani E, Samimi M, Ebrahimi FA, *et al*. The effects of omega-3 fatty acids and vitamin E co-supplementation on gene expression of lipoprotein(a) and oxidized low-density lipoprotein, lipid profiles and biomarkers of oxidative stress in patients with polycystic ovary syndrome. Mol Cell Endocrinol [Internet]. 2017 Jan 5;439:247-55. https://pubmed.ncbi.nlm.nih.gov/27619403/
14. Omer W, Al-Hadithi T. Developing a socioeconomic index for health research in Iraq. East Mediterr Health J [Internet]. 2017 Oct 1;23(10):670-7. https://pubmed.ncbi.nlm.nih.gov/29270967/
15. Izadi A, Shirazi S, Taghizadeh S, Gargari BP. Independent and Additive Effects of Coenzyme Q10 and Vitamin E on Cardiometabolic Outcomes and Visceral Adiposity in Women With Polycystic Ovary Syndrome. Arch Med Res [Internet]. 2019 Feb 1;50(2):1-10. https://pubmed.ncbi.nlm.nih.gov/31349945/
16. Izadi A, Ebrahimi S, Shirazi S, *et al*. Hormonal and Metabolic Effects of Coenzyme Q10 and/or Vitamin E in Patients With Polycystic Ovary Syndrome. J Clin Endocrinol Metab [Internet]. 2019 Nov 9;104(2):319-27. https://pubmed.ncbi.nlm.nih.gov/30202998/
17. Jamilian M, Sabzevar NK, Asemi Z. The Effect of Magnesium and Vitamin E Co-Supplementation on Glycemic Control and Markers of Cardio-Metabolic Risk in Women with Polycystic Ovary Syndrome: A Randomized, Double-Blind, Placebo-Controlled Trial. Horm Metab Res [Internet]. 2019;51(2):100-5. https://pubmed.ncbi.nlm.nih.gov/30286483/
18. Chen J, Guo Q, Pei YH, *et al*. Effect of a short-term Vitamin E supplementation on oxidative stress in infertile PCOS women under ovulation induction: A retrospective cohort study. BMC Womens Health [Internet]. 2020 Apr 6;20(1):1-9. https://bmcwomenshealth.biomedcentral.com/articles/10.1186/s12905-020-00930-w
19. Ebrahimi FA, Samimi M, Foroozanfard F, *et al*. The Effects of Omega-3 Fatty Acids and Vitamin E Co-Supplementation on Indices of Insulin Resistance and Hormonal Parameters in Patients with Polycystic Ovary Syndrome: A Randomized, Double-Blind, Placebo-Controlled Trial. Exp Clin Endocrinol Diabetes [Internet]. 2017 Jun 1;125(6):353-9. https://pubmed.ncbi.nlm.nih.gov/28407657/
20. Yalle-Vásquez S, Osco-Rosales K, Nieto-Gutierrez W, Benites-Zapata V, Pérez-López FR, Alarcon-Ruiz CA. Vitamin E supplementation improves testosterone, glucose- and lipid-related metabolism in women with polycystic ovary syndrome: a meta-analysis of randomized clinical trials. Gynecological Endocrinology [Internet]. 2022;38(7):548-57. https://www.tandfonline.com/doi/abs/10.1080/09513590.2022.2079629
21. Shokrpour M, Asemi Z. The Effects of Magnesium and Vitamin E Co-Supplementation on Hormonal Status and Biomarkers of Inflammation and Oxidative Stress in Women with Polycystic Ovary Syndrome. Biol Trace Elem Res [Internet]. 2019 Sep 15;191(1):54-60. https://pubmed.ncbi.nlm.nih.gov/30565017/
22. Sadeghi F, Alavi-Naeini A, Mardanian F, Ghazvini MR, Mahaki B. Omega-3 and vitamin E co-supplementation can improve antioxidant markers in obese/overweight women with polycystic ovary syndrome. Int. J Vitam Nutr Res [Internet]. 2020 Oct 1;90(5-6):477-83. https://pubmed.ncbi.nlm.nih.gov/30961460/
23. Cicek N, Eryilmaz OG, Sarikaya E, *et al*. Vitamin E effect on controlled ovarian stimulation of unexplained infertile women. J Assist Reprod Genet [Internet]. 2012 Apr;29(4):325-8. https://pubmed.ncbi.nlm.nih.gov/22302530/
24. Asbaghi O, Nazarian B, Yousefi M, *et al*. Effect of vitamin E intake on glycemic control and insulin resistance in diabetic patients: an updated systematic review and meta-analysis of randomized controlled trials. Nutr J [Internet]. 2023 Dec 1, 22(1). https://pubmed.ncbi.nlm.nih.gov/36800965/
25. Heidari H, Hajhashemy Z, Saneei P. A meta-analysis of effects of vitamin E supplementation alone and in combination with omega-3 or magnesium on polycystic ovary syndrome. Sci Rep [Internet]; c2022 Dec 1, 12(1). Available from: /pmc/articles/PMC9675810/
26. Gharaei R, Mahdavinezhad F, Samadian E, *et al*. Antioxidant supplementations ameliorate PCOS complications: a review of RCTs and insights into the underlying mechanisms. Journal of Assisted Reproduction and Genetics 2021 38:11 [Internet]. 2021 Oct 24;38(11):2817-31. https://link.springer.com/article/10.1007/s10815-021-02342-7
27. Izadi A, Ebrahimi S, Shirazi S, Taghizadeh S, Parizad M, Farzadi L, *et al*. Hormonal and Metabolic Effects of Coenzyme Q10 and/or Vitamin E in Patients With Polycystic Ovary Syndrome. J Clin Endocrinol Metab [Internet]. 2019 Nov 9;104(2):319-27. https://pubmed.ncbi.nlm.nih.gov/30202998/
28. Zhang J, Xing C, Zhao H, He B. The effectiveness of coenzyme Q10, vitamin E, inositols, and vitamin D in improving the endocrine and metabolic profiles in women with polycystic ovary syndrome: a network Meta-analysis. Gynecological Endocrinology [Internet]. 2021;37(12):1063-71. https://www.tandfonline.com/doi/abs/10.1080/09513590.2021.1926975
29. Tefagh G, Payab M, Qorbani M, Sharifi F, Sharifi Y, Ebrahimnegad Shirvani MS, *et al*. Effect of vitamin E supplementation on cardiometabolic risk factors, inflammatory and oxidative markers and hormonal functions in PCOS (polycystic ovary syndrome): A systematic review and meta-analysis. Scientific Reports 2022 12:1 [Internet]. 2022 Apr 6;12(1):1-16. https://www.nature.com/articles/s41598-022-09082-3