Section: Obstetrics & Gynaecology

Research

CORRELATION OF VITAMIN D WITH AMH IN PCOS FEMALES

Deeba Khanam[1], Bhoomika Singh[2], Tamkin Khan[3], Tabassum Nawab[4]

[1]Assistant Professor, Department of Obstetrics and Gynaecology, Jawahar Lal Nehru medical college and hospital, AMU, Aligarh, Uttar Pradesh, India
[2]Junior Resident, Department of Obstetrics and Gynaecology, Jawahar Lal Nehru medical college and hospital, AMU, Aligarh, Uttar Pradesh, India
[3]Professor, Department of Obstetrics and Gynaecology, Jawahar Lal Nehru medical college and hospital, AMU, Aligarh, Uttar Pradesh, India

Received : 24/12/2022
Received in revised form : 21/01/2023
Accepted : 02/02/2023

Keywords:
PCOS, vitamin D, AMH

Corresponding Author:
Dr. Deeba Khanam
Email: khanamdeeba@gmail.com
ORCID: 0000-0001-9732-0702

DOI: 10.47009/jamp.2023.5.1.162

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (1); 778-783

Abstract

Background: To find the correlation between Vitamin D (25 OH) and AMH levels in patients of PCOS. Study design Cross-sectional observational study. **Materials and Methods:** Hundred PCOS patients satisfying inclusion criteria were enrolled for the study. Vitamin-D and AMH levels were assessed in all the patients using ELISA kit and Its correlation with various, anthropometrical, biochemical parameters and AMH levels was evaluated. Pearson product moment co-relation analysis was used to see correlation among different variables. **Result:** The results of 100 PCOS patients were analyzed. Anthropometric. Parameters including BMI and waist to hip ratio were inversely correlated with Vit-D levels ($r = 0.297$; $P < 0.01$, $r = \_0.282$; $P < 0.01$) and the result was statistically significant. AMH correlated negatively with Vitamin D levels in PCOS ($r = \_0.169$; $P > 0.05$) and after Vitamin-D supplementation AMH levels reduced from 7.57 ± 3.31 to 5.78 ± 2.35($P < 0.001$) which was highly significant. **Conclusion:** Present study showed inverse correlation of Vitamin D with AMH levels in PCOS population. Its supplementation in vitamin D deficient individuals can lower AMH levels in PCOS and thereby may improve ovarian function and address infertility issues.

INTRODUCTION

PCOS is a heterogeneous disease characterized by confluence of symptoms including menstrual irregularity, an ovulatory infertility, hirsutism as well as other metabolic manifestations including hyperandrogenaemia, dyslipidemia, and insulin resistance.[1] It is multifactorial disease which encompasses modifiable and non-modifiable risk factors. Its pathophysiology is complex and is an area where contributions can propose greater benefits. Recently role of Vit D in its pathophysiology was analyzed. Studies found that women with PCOS may also be at elevated risk of vitamin D deficiency.[2] Prevalence of vitamin D deficiency in general population is 20-48% but is relatively higher in women with PCOS (approximately 67-85%).[3]
Insulin resistance in PCOS is caused by defect in post receptor insulin signaling pathway as a result there is compensatory hyperinsulinemia which directly or indirectly results in hyperandrogenism and aggravates PCOS.[4] This insulin resistance is selective; the hyperinsulinemia affects the ovary because it remains insulin sensitive, despite insulin resistance in skeletal muscle and liver.
The pathogenesis of PCOS remains largely unexplained. According to the literature, abnormal anti-Müllerian hormone (AMH) levels and significant vitamin D deficiency are responsible for a number of different abnormalities observed in PCOS patients5.Vitamin D may stimulate insulin synthesis and increases insulin receptor expression or suppression of pro-inflammatory cytokines that possibly contribute to the development of insulin resistance.[5] The effect of vitamin D on metabolic and reproductive dysfunction in PCOS may be mediated by insulin resistance. A significant correlation between vitamin D and the LH/FSH ratio has suggested that vitamin D status might contribute to hormone deregulation in PCOS.[6] AMH is one of the most reliable markers of ovarian reserve.[7] Circulating levels of AMH in Women with PCOS are 2-3 times higher than healthy controls; it also correlates with severity of the syndrome.[8] It lowers the follicle sensitivity to circulating FSH thus preventing follicle selection resulting in follicle arrest at the small antral phase. It also inhibits granulosa cell aromatase which increases

intrafollicular androgen levels that affects follicular maturation and ovulation process thereby predisposes an individual to develop PCOS.[9]

It has been suggested that vitamin D can modulate AMH expression as there is a functional vitamin D response element in the promoter region of the human AMH gene12.[10] It has been hypothesized that vitamin D may directly affect AMH production; thereby patients with higher concentrations of vitamin D can maintain their ovarian reserve for longer time.[11] To date, there have been numerous observational studies and a few interventional studies aimed at viewing the relationship between serum AMH and vitamin D levels, yielding largely conflicting results, therefore the purpose of this clinical study was to further find the correlation between the two parameters in PCOS as improved reproductive outcomes may be the postulated benefit. There by reducing the burden of infertility. Vitamin D may act as an inexpensive and effective alternative/adjunct to the management of symptomatology in PCOS.

MATERIALS AND METHODS

Study Population

This was an observational study conducted on 100 patients of PCOS in the Department of Obstetrics and Gynaecology, Jawaharlal Nehru Medical College and Hospital (JNMCH), A.M.U., Aligarh from November 2018 to December 2020.Study inclusion criteria consisted of women aged between 18-35 years diagnosed with PCOS according to the Rotterdam criteria (Rotterdam ESHRE/ASRM-sponsored PCOS Consensus Workshop Group, 2004). Exclusion criteria included women who were consuming supplemental vitamin D > 500 IU/ day, pregnant women, and women having endocrine diseases including DM, thyroid disorder, elevated prolactin levels and women with a potential iatrogenic (e.g. ovarian surgery, gonadotoxic therapy).

Sample Size

For a study with α error 5% and power of study 80%, sample size was calculated using formula,

N = (Z1-α/2)2 p (1-p)/ L2 Where:

Z1-α/2 = 1.96 (for α error 5% and β 20%)

P = expected prevalence of vitamin D deficiency in females with PCOS = 67% = 0.67 L = allowable absolute error = 10% = (1.96)2×0.67×0.33/ (0.1)2 = 85 (approx. 100) Adding 10% non-response rate, final sample size = 85 + 10 = 95

Procedure

Standard anthropometric data [height, weight (using Omron HBF- 375 Body Composition Monitor), waist (Waist circumference was measured in standing posture at the midpoint between the lower border of the rib cage and the iliac crest) and hip circumference (at the maximum circumference of the buttocks)] were obtained from each subject. The body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in metres (kg/m2).Waist to hip ratio(waist /hip circumference) was also evaluated which is an index of abdominal fat. Hirsutism was clinically evaluated using the modified Ferriman Galway scoring system. The scoring included evaluating nine body areas including the upper lip, chin, chest, upper back, lower back, upper arm, upper and lower abdomen, thighs.

Vitamin D levels

Serum was separated by centrifuging the blood at 3000 rpm for 20 minutes at 40C and stored at -200C until assayed. Estimation of 25-OH vitamin D levels was performed by using ELISA kit

Serum AMH

Anti-mullerian hormone assay was used to determine AMH levels using ultra-sensitive AMH/MIS ELISA AL-105-i A kit

Plasma LH, FSH, PRL

The hormonal parameters LH, FSH and Prolactin levels were assessed from the sample collected from subjects on day 2 or 3 of cycle. The samples were collected and analyzed in endocrinology lab. The kit used for analysis is based on immune radiometric assay. In the kit, mouse monoclonal antibodies present are directed against two different epitopes.

Methodology

In the study population vitamin D levels were assessed and the study population was divided in to Vitamin D deficient and non-deficient groups. Baseline serum AMH levels were obtained in both the groups. Vitamin D deficient group received vitamin D tablets 60,000 IU once weekly for 12 weeks. Repeat S.AMH and vitamin D levels were tested in vitamin D deficient group to assess any change in vitamin D and AMH levels. Correlation between Vitamin D and AMH levels was evaluated. Further correlation of Vitamin D with BMI was also assessed

Statistical Analysis

Paired sample t-test was used to assess changes in quantitative variables. Pearson Product Moment Correlation analysis was used to see correlation among different variables. All the statistical tests were performed using computer program SPSS version 25.

RESULTS

Characteristics of Study Population

Mean age of study participants was 23.86 ± 4.4 years. More than half of the study subjects were graduate (60%) and only 2% were illiterate. More than half of the patients were unmarried (53%).

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Around one-third of the patients were working (35%) while more than one-third were students (38%).

In our study, 52% patients were having normal BMI, 32% patients were overweight and 16% patients were obese. Mean BMI of study subjects was 24.5±4.51 kg/m^2. Mean waist circumference of study subjects was 86.1±9.35 cm and 51% subjects were centrally obese.

Vitamin D and AMH levels

Vitamin D deficiency was found in 74% of PCOS subjects and AMH levels were compared in Vitamin D deficient and non-deficient groups as shown in [Table 3]

Table 1: Socio-demographic characteristics of study subjects (N=100)

S. No.	Variables		No. of subjects (n)	%
1	Age	15-20 Years	23	23
		21-25 Years	40	40
		26-30 Years	29	29
		31-35 Years	8	8
2	Educational Status	Uneducated	2	2
		Primary	0	0
		Secondary	13	13
		Intermediate	25	25
		Graduate or more	60	60
3	Marital Status	Unmarried	53	53
		Married	47	47
4	Working Status	Working	35	35
		House Work	27	27
		Student	38	38

Table 2: Anthropometric and biochemical parameters of study subjects

	Variables	Mean ± SD
1	Age (years)	23.86 ± 4.38
2	BMI (kg/m^2)	24.58 ± 4.51
3	WC (cm)	86.10 ± 9.35
4	WHR	0.85 ± 0.06
5	S. TSH (mIU/L)	2.65 ± 0.88
6	LH (IU/L)	11.16 ± 6.16
7	FSH (IU/L)	5.04 ± 2.22
8	PRL (ng/ml)	13.23 ± 7.22
9	Vitamin D (ng/ml)	17.27 ± 5.46
10	AMH (ng/ml)	7.47 ± 3.21

Table 3: Mean AMH levels in vitamin D deficient and non-deficient PCOS subjects

Vitamin D Status	AMH level (mean ± S.D.)	Test of significance (Independent sample test)
Vit D Deficient (n=74)	7.57±3.14	t (df 98) =0.582, p value = 0.533, not significant
Vit D non-deficient (n=26)	7.13±3.40	

It was found that mean AMH levels in vitamin D deficient PCOS patients was 7.57±3.14 ng/ml while in vitamin D non- deficient subjects was found to be 7.13±3.40 ng/ml. The difference in baseline mean AMH levels was not found to be statistically significant (t= 0.582, p>0.05) after application of independent sample t-test.

Table 4: Correlation between Vitamin D and AMH levels before supplementation (N=100)

	Vitamin D	AMH (initial) (n=100)
Correlation coefficient		-0.101
p value		>0.05

The correlation of Vitamin D with AMH levels was analyzed by using Pearson product moment correlation analysis. It was observed that Vitamin D and AMH levels were inversely correlated (r = -0.101, p>0.05) but the result was not statistically significant as shown in [Table 4 and Figure 1].

Table 5: Vitamin D levels before and after supplementation

S. No.		Vitamin D	t- Value	P- Value
1	Initial	14.68 ± 2.84	-20.776	P < 0.001
2	After Supplementation	36.98 ± 8.84		

Table 6: Effect of vitamin D supplementation on AMH levels in vitamin D deficient PCOS subjects

Vitamin D Status	Mean ± SD of AMH		t- Value	P- Value
	Initial	After Supplementation		
Deficiency (n= 74)	7.57 ± 3.14	5.60 ± 2.15	4.477	<0.001

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 7: Mean ± SD of Vitamin D and AMH levels in centrally obese PCOS patients

Vit D	Central obesity by WC	N	Mean	Std. Deviation
	No	63	18.42	5.45
	Yes	37	15.33	4.95
AMH	No	63	7.54	3.01
	Yes	37	7.35	3.55

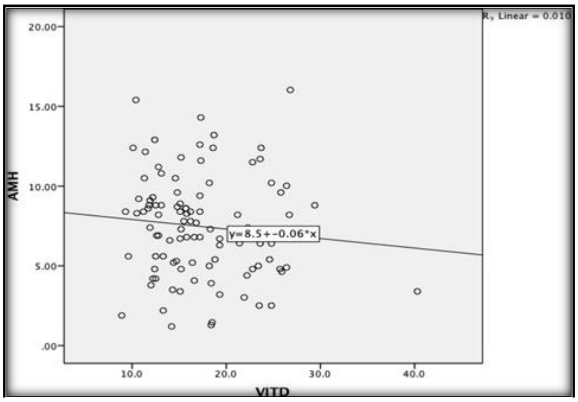

Figure 1: Correlation between vitamin D and AMH

Vitamin D and AMH levels after supplementation

Vitamin D deficient PCOS subjects were supplemented with 60000IU of Vitamin D for three months following which vitamin D levels and AMH levels were re-valuated. We found significant difference in mean Vitamin D levels after supplementation(p value-<0.001).as shown in [Table 5]

Further AMH levels were compared in vitamin D deficient groups before and after Vitamin D supplementation and statistically significant reduction in mean AMH levels was found after supplementation of vitamin D on application of Paired t-test (t=4.477, p<0.001) as shown in [Table 6].

Vitamin D and AMH levels in centrally obese PCOS

Vitamin D and AMH levels were also compared in PCOS group with central obesity (WC>85cm) and without central obesity and it was found that Vitamin D levels were significantly lower in centrally obese group (MSD1 18.42±5.45, MSD2 15.33±4.95) on application of chi2 test, however AMH levels were not affected by waist circumference as shown in table.[7]

DISCUSSION

Vitamin D is believed to play a crucial role in maintenance of biological equilibrium, and its contribution in pathophysiology of complex PCOS disorder is well established. Its deficiency alters the metabolic pathways in PCOS and its prevalence is found to be more in PCOS population.[12]

In our study the frequency of Vitamin D deficiency was found to be 74% which is in alliance with other studies.[13-16] That reported increased prevalence of vitamin D deficiency in PCOS, however as it was not a case control study true prevalence could not be estimated. It was postulated that Vitamin D receptor gene polymorphism predisposes an individual to develop PCOS and specifically CDX2 gene mutation increases the susceptibility to insulin resistance and therefore prevalence of Vitamin D deficiency is found to be more in PCOS population.[17]

Correlation of vitamin D with AMH levels in PCOS

The relationship of vitamin D with AMH is complex. Data in the current study presents an inverse correlation between vitamin D and AMH levels in patients of PCOS (r= -0.101, p>0.005), it was seen that as the Vitamin D levels increased, AMH levels declined however the correlation was not statistically significant. The mean AMH levels in VDD group were higher than non VDD group but the difference was statistically insignificant.

Studies have demonstrated that AMH gene is up regulated by vitamin D via functional vitamin D response elements that bind to vitamin D receptor (VDR) present within the AMH promoter site and therefore the deficiency may affect AMH gene expression and modulates its level not necessarily in one direction.[18]

Jukic and coworkers found evidence that low vitamin D levels were associated with low AMH levels and other biomarkers of ovarian reserve however study population was not on PCOS females.[19] Similarly, Merhi and coworkers observed a positive correlation between serum concentrations of vitamin D and AMH in late reproductive age group.[20] The association between vitamin D and AMH levels was also confirmed by Dennis and coworkers, who demonstrated a significant positive seasonal correlation of vitamin D and AMH levels.[21] According to the study, higher vitamin D levels observed in the summer season were associated with higher AMH concentrations. Results of Drakopoulos and coworkers showed no correlations between serum vitamin D levels and ovarian reserve in infertile women.[22] Monica and coworkers showed no correlation between Vitamin D levels and AMH levels and also demonstrated that AMH levels were affected by expression of VDR gene, Fok1 and Apa1 SNPs within the AMH promoter site which leads to the enhancement of AMH synthesis in PCOS women.[23] The findings of Kim and coworkers were likewise.[24]

Further AMH levels were evaluated following supplementation with vitamin D supplements for three months and we found that there was significant reduction in AMH levels (t=4.477, p<0.001).

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Raised AMH levels in PCOS cause decreased sensitivity of follicles to gonadotropins and as result growth is halted at pre antral stages, also it causes high LH levels and impaired follicular maturation which affects reproductive potential,[25] and therefore reducing AMH levels through supplementation improves reproductive outcome. Similar results were reported by Irani and coworkers who demonstrated improved folliculogenesis after vitamin D supplementation.[26] Dastorani et al conducted their study on 40 infertile women in which 20 were having PCOS. They also showed that vitamin D supplementations significantly reduced serum AMH levels in PCOS women.[27] Naderi and coworkers suggested that vitamin D supplementation leads to increased serum AMH levels.[28] A systemic review proposed decrease in AMH levels following supplementationr.[29] In contrast to our study, Cappy et al. were unable to demonstrate any significant correlation between vitamin D supplementation and AMH levels in women with PCOS diagnosed with vitamin D deficiency.[30] Similarly, Pearce and coworkers conducted their study on 340 PCOS women, and did not find any changes in AMH levels following changes in vitamin D levels.[31] Thus a complex relationship exists between Vitamin D and AMH, and the variations in AMH levels are directed with a purpose to improve reproductive outcome.

Correlation of Vitamin D with Obesity

Vitamin deficiency was more pronounced in PCOS subjects who were centrally obese with waist circumference greater than 85cm (MSD1 18.42±5.45VDD grp, MSD2 15.33±4.95 non VDD grp) and the difference in waist circumference was statistically significant. Obesity can lower 25(OH) in circulation by trapping vitamin D on adipose tissue. Similar results were also observed in studies conducted by Recep Yildizhan et al,[32] Hahn et al,[33] Li Wang et al,[34] E Wehr et al,[35] Khosravi et al,[36] and Jin Ju Kim et al.[37]

CONCLUSION

At present, there is a considerable debate in the field regarding whether Vitamin has the capacity to influence ovarian folliculogenesis, as indicated by the AMH level, and what direction that influence may take. Numerous observational studies and a few interventional studies aimed at viewing the relationship between serum AMH and vitamin D levels, yielding largely conflicting results. In most of the studies Vitamin D had positive correlation with AMH levels particularly in non PCOS population while in PCOS the result was opposite suggesting the role of vitamin D as an optimizer of AMH levels for improved reproductive outcomes. This study specifically targets the correlation in PCOS and concludes that AMH has inverse correlation with vitamin D levels and it declines with correction of Vitamin D deficiency thereby better reproductive profile is anticipated. Therefore vitamin D screening and treatment is suggested in PCOS for improvement in all the aspects of PCOS profile.

Strength of the Study

The study was pre designed and well planned. Patients were thoroughly evaluated and followed

Limitation of the Study

Sample size was small and it was not a case control study

REFERENCES

1. Sirmans SM, Pate KA. Epidemiology, diagnosis, and management of polycystic ovary syndrome. Clin Epidemiol. 2013;6:1-13
2. S. Mazloomi, F. Sharifi, R. Hajihosseini, S. Kalantari, S. Mazloomzadeh, Association between hypoadiponectinemia and low serum concentrations of calcium and vitamin D in women with polycystic ovary syndrome, ISRN Endocrinol. (2012).
3. Lin MW, Wu MH. The role of vitamin D in polycystic ovary syndrome. Indian J MedRes. 2015;142(3):238-240.
4. Micic D, Popovic V, Nesovic M et al. Androgen levels during sequential insulin euglycemic cla mp studies in patients with polycystic ovary disease. J Steroid Biochem. 1988;31(6):995–999.
5. Poel YH, Snackey C, Louwers Y, Lips P, Lambalk CB, Laven JS, et al. The role of vitamin D in metabolic disturbances in polycystic ovary syndrome: a systematic review. Eur J Endocrinol. 2013;169(6):853–65
6. Yildizhan R, Kurdoglu M., Adali E. et al., Serum 25-hydroxyvitamin D concentrations in obese and non-obese women with polycystic ovary syndrome, Arch. Gynecol. Obstet. 280 (2009) 559–563
7. Moolhuijsen LME, Visser JA. Anti-Müllerian Hormone and Ovarian Reserve: Update on Assessing Ovarian Function. J Clin Endocrinol Metab. 2020.
8. Laven J.S.Mulders A.G.Visser J.A.Themmen A.P De Jong F.H.FauserB.C.Anti-Mullerian hormone serum concentrations in normo ovulatory and anovulatory women of reproductive age.J. Clin. Endocrinol. Metab. 2004; 89: 318-32
9. Pellatt L.R.S.Brincat M. Galea R.Mason H.Anti-Müllerian hormone (AMH) inhibits aromatase expression in granulosa cells from human ovaries.2007
10. Malloy P.J., Peng L., Wang J., Feldman D. Interaction of the vitamin D receptor with a vitamin D response element in the Mullerian-inhibiting substance (MIS) promoter: Regulation of MIS expression by calcitriol in prostate cancer cells. Endocrinology. 2009; 150:1580–1587. doi: 10.1210/en.2008-1555
11. Xu J., Hennebold J.D., Seifer D.B. Direct vitamin D3 actions on rhesus macaque follicles in three-dimensional culture: Assessment of follicle survival, growth, steroid, and antimullerian hormone production. Fertil. Steril. 2016;106:1815–1820. doi: 10.1016/j.fertnstert.2016.08.037
12. He C, Lin Z, Robb SW, Ezeamama AE. Serum vitamin D levels and polycystic ovary syndrome: a systematic review and meta-analysis. Nutrients. 2015;7(6):4555–77.
13. Van Schoor N.M., Lips P. Worldwide Vitamin D Status. Best Pract. Res. Clin. Endocrinol. Metab. 2011;25:671–680. doi: 10.1016/j.beem.2011.06.007
14. M. Irani, H. Minkoff, D.B. Seifer, Z. Merhi, Vitamin D increases serum levels of the solublereceptor for advanced glycation end products in women with PCOS, J. Clin.Endocrinol. Metab. 99 (2014) E886–E890.
15. Alvarez JA, Ashraf A. Role of vitamin D in insulin secretion and insulin sensitivity for glucose homeostasis. International Journal of Endocrinology.2010;351385.
16. R.L. Thomson, S. Spedding, J.D. Buckley, Vitamin D in theaetiology and management of polycystic ovary syndrome, Clin.Endocrinol. (Oxf) 2012;77.

17. Al-Daghri NM, Al-Attas OS, Alkharfy KM, Khan N, Mohammed AK, Vinodson B, et al. Association of VDR-gene variants with factors related to the metabolic syndrome, type 2 diabetes and vitamin D deficiency. Gene. 2014;542:129–33.
18. Malloy PJ, Peng L, Wang J, Feldman D. Interaction of the vitamin D receptor with a vitamin D response element in the Mullerianinhibiting substance (MIS) promoter: regulation of MIS expression by calcitriol in prostate cancer cells. Endocrinology. 2009;150(4): 1580–7.
19. Jukic AMZ, Baird DD, Wilcox AJ, Weinberg CR, Steiner AZ. 25-Hydroxyvitamin D (25(OH)D) and biomarkers of ovarian reserve. Menopause. 2018;25(7):811–816
20. Merhi ZO, Seifer DB, Weedon J, Adeyemi O, Holman S, Anastos K, Golub ET, Young M, Karim R, Greenblatt R, Minkoff H. Circulating vitamin D correlates with serum antimullerian hormone levels in late-reproductive-aged women: women’s interagency HIV study. Fertil Steril. 2012;98(1):228–234.
21. Dennis NA, Houghton LA, Pankhurst MW, Harper MJ, McLennan IS. Acute supplementation with high dose vitamin D3 increases serum anti-Mullerin hormone in young women. Nutrients. 2017;9(7).
22. Drakopoulos P, van de Vijver A, Schutyser V, Milatovic S, Anckaert E, Schiettecatte J, et al. The effect of serum vitamin D 1288 J Assist Reprod Genet (2019) 36:1281–1289 Content courtesy of Springer Nature, terms of use apply. Rights reserved. levels on ovarian reserve markers: a prospective cross-sectional study. Hum Reprod. 2017;32(1):208–14.
23. MONICA ET LSzafarowska M, Dziech E, Kaleta B, Kniotek M, Rogowski A, Segiet-Święcicka A, Jerzak M. Anti-Müllerian hormone level is associated with vitamin D receptor polymorphisms in women with polycystic ovary syndrome. J Assist Reprod Genet. 2019 Jun;36(6):1281-1289.
24. Kim S, Kim JJ, Kim MJ, Han KH, Lee JR, Suh CS, Choi YM, Kim SH. Relationship between serum anti-Mullerian hormone with vitamin D and metabolic syndrome risk factors in late reproductive-age women. Gynecol Endocrinol : the official journal of the International Society of Gynecological Endocrinology. 2018;34(4):327–331.
25. Almeida FRCL, Costermans NGJ, Soede NM, et al. Presence of anti- Müllerian hormone (AMH) during follicular development in the porcine ovary. PLoS One. 2018;13(7):e0197894 Association of hypovitaminosis D with metabolic disturbances in polycystic ovary syndrome
26. M. Irani, H. Minkoff, D.B. Seifer, Z. Merhi, Vitamin D increases serum levels of the soluble receptor for advanced glycation end products in women with PCOS, J. Clin.Endocrinol. Metab. 99 (2014) E886–E890.
27. Dastorani M, Aghadavod E, Mirhosseini N, Foroozanfard F, Zadeh Modarres S, Amiri Siavashani M, Asemi Z. The effects of vitamin D supplementation on Metabolic profiles and gene expression of insulin and lipid metabolism in infertile polycystic ovary syndrome candidates for in vitro fertilization. Reprod Biol Endocrinol. 2018;16(94)
28. Naderi Z, Kashanian M, Chenari L, Sheikhansari N. Evaluating the effects of administration of 25-hydroxyvitamin D supplement on serum anti-mullerian hormone (AMH) levels in infertile women. Gynecol Endocrinol : the official journal of the International Society of Gynecological Endocrinology. 2018;34(5):409–412.
29. Moridi I, Chen A, Tal O, Tal R. The Association between Vitamin D and Anti-Müllerian Hormone: A Systematic Review and Meta- Analysis. Nutrients. 2020; 12(6):1567.
30. Cappy H, Giacobini P, Pigny P, Bruyneel A, Leroy-Billard M, Dewally D, Catteau-Jonard S. Low vitamin D3 and high anti- Mullerian hormone serum levels in the polycystic ovary syndrome (PCOS): is there a link? Ann Endocrinol. 2016;77(5):5939
31. Pearce K, Gleeson K, Tremellen K. Serum anti-Mullerian hormone production is not correlated with seasonal fluctuations of vitamin D status in ovulatory or PCOS women. Hum Reprod. 2015;30(9):2171–7.
32. Yildizhan R, Kurdoglu M., Adali E. et al., Serum 25-hydroxyvitamin D concentrations in obese and non-obese women with polycystic ovary syndrome, Arch. Gynecol. Obstet. 280 (2009) 559–563.
33. S Hahn, U. Haselhorst, S. Tan, B. Quadbeck, M. Schmidt, S. Roesler, et al., Low serum 25-hydroxyvitamin D concentrations are association with insulin resistance and obesity in women with polycystic ovary syndrome, Exp. Clin. Endocrinol. Diabetes Off. Journal, Ger. Soc. Endocrinol. Ger. Diabetes Assoc. 114 (2006) 577–583
34. Wong HYQ, Li HWR, Lam KSL, Tam S, Shek CC, Lee CYV, Yeung WSB, Ho PC, Ng EHY. Independent association of serum vitamin D with anti-Mullerian hormone levels in women with polycystic ovary syndrome. Clin Endocrinol (Oxf). 2018 Nov;89(5):634-641.
35. Wehr, S. Pilz, N. Schweighofer, A. Giuliani, D. Kopera, T. R. Pieber, B. Obermayer-Pietsch European Journal of Endocrinology, 161: 575-582, 2009
36. Khosravi ZS, Kafeshani M, Tavasoli P, Hassan Zadeh A, Entezari MH. Effect of vitamin D supplementation on weight loss, glycemic indices, and lipid profile in obese and overweight women: A clinical trial study. Int J Prev Med. 2018;9:63.
37. Kim JJ, Choi YM, Chae SJ, Hwang KR, Yoon SH, Kim MJ, Kim SM, Ku SY, Kim SH, Kim JG. Vitamin D deficiency in women with polycystic ovary syndrome. Clin Exp Reprod Med. 2014 Jun;41(2):80.

ISSN (O): 2687-5365; ISSN (P): 2753-6556