***Original Research Article***

**Vitamin D status of infertile women in Abidjan, Côte d'Ivoire**

**ABSTRACT**

**Background:** Long known for its role in phosphocalcic metabolism, vitamin D has been attracting growing interest in recent years for its involvement in numerous physiological processes, including its essential role in reproductive health.

According to many authors, vitamin D is involved in biological processes crucial to fertility, such as the production of sex hormones (progesterone and estrogen), promoting oocyte maturation and increasing endometrial receptivity for successful implantation. Inadequate vitamin D levels would therefore have a negative impact on fertility. This study determined the vitamin D status of infertile women in Abidjan.

**Methods:** This was a descriptive cross-sectional study conducted from June 2023 to September 2024. It included 102 infertile women, aged 21-50 years, consulting a specialized clinic in Abidjan and having given their consent to participate in the study. Serum vitamin D [25(OH)D] levels were measured on the Vidas PC®, and the prevalence of hypovitaminosis D (levels < 30 ng/ml) was determined.

**Results:**

The mean age of the patients was 37±6 years. The mean vitamin D level in the infertile population was 24.07 ± 7.69 ng/ml.

The prevalence of hypovitaminosis D (level < 30 ng/ml) was 81.37%.

Only 18.63% of women had optimal serum vitamin D levels (30-100 ng/ml).

**Conclusion:** The prevalence of hypovitaminosis D in infertile women in Abidjan is high (81.37%). These results highlight the need to monitor and correct vitamin D levels in infertile women for better management of fertility disorders.

*KEYWORDS : Vitamin D, Prevalence, Hypovitaminosis D, infertility*

**Introduction**

According to the World Health Organization (WHO), over 17% of the world's population of childbearing age suffers from infertility (1,2), with an estimated prevalence of 13.1% in Africa (3). In Côte d'Ivoire, according to some studies, the prevalence of infertility integrating all parameters is around 15.1%, with female infertility estimated at 58.6% (4,5).

Infertility, defined as the inability to achieve pregnancy after 12 months or more of regular unprotected sexual intercourse without contraception (3,6), has become a major public health problem and a matter of great importance for many couples wishing to start a family.

Among the many factors influencing the ability to conceive, one nutrient, vitamin D, is attracting increasing interest due to its potential effects on reproductive health (7-16).

In recent years, a number of authors have focused on the effects of vitamin D on the female reproductive system, given the presence of vitamin D receptors and metabolizing enzymes in certain organs such as the ovaries, endometrium, fallopian tube epithelium, placenta, decidual cells, hypothalamus and pituitary gland (17,18). These authors have shown that adequate levels of vitamin D could help improve fertility in both men and women, notably by stimulating the synthesis of female hormones involved in reproduction and in maintaining pregnancy in women (7-16,19-28).

The action of vitamin D in endometrial activity is due to its various biological effects, in particular its involvement in phospho-calcium metabolism, as well as its anti-inflammatory and anti-proliferative effects [29].

Vitamin D also acts on the female reproductive system, particularly in ovarian tissue, by increasing the production of progesterone and estradiol, thus stimulating folliculogenesis (30). In the field of Medically Assisted Reproduction (MAP), vitamin D could modulate the pregnancy rates obtained in IVF (14,15).

Its deficiency or hypovitaminosis D is therefore likely to lead to bone metabolism pathologies as well as infertility-related disorders (31-36).

In sub-Saharan Africa, and particularly in Côte d'Ivoire, there are few data available on vitamin D levels in the population of women who consult a physician because they want to have children or because they are infertile.

The aim of this study was to describe the vitamin D status of patients who consult us to the clinic because they want to have children or because they are infertile, in order to optimize their treatment under medically assisted procreation (MAP).

**Materials and methods**

**Framework and study topics**

This was a descriptive cross-sectional study initiated by the Biochemistry Laboratory of the Pharmaceutical and Biological Sciences UFR, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire, in collaboration with a center specializing in assisted reproduction for patient recruitment and the laboratory of the Abidjan Heart Institute for assays. It included 102 female patients aged between 21 and 50, who came to the said center for maternity consultations, during the period from June 2023 to September 2024. Each patient gave her consent to participate in the study.

**Method**

Each patient was asked to complete a questionnaire concerning age, medical and surgical history, duration of infertility and whether she had ever been treated for infertility.

Blood samples were taken by venipuncture at the patient's elbow, in anticoagulant-free tubes for vitamin D assay. The assay was performed using the Enzyme Linked Fluorescent Assay (ELFA), a competitive enzyme-linked immunosorbent assay with final fluorescence detection, on the Vidas PC®.

Sociodemographic (age, weight, body mass index), clinical and biological data were recorded using an Excel file. Statistical processing was performed using XLStat software. The variable measured was serum 25(OH) vitamin D concentration.

**Results**

The mean age of the patients was 37±6 years, with extremes ranging from 21 to 50 years. This population is representative of women of childbearing age, and the average duration of infertility was 5 years.

Analysis of the various vitamin D assays showed a general trend towards hypovitaminosis D in this population of infertile women. Vitamin D concentrations ranged from 8.1 ng/ml to 44.4 ng/ml, with a mean of 24.07 ± 7.69 ng/ml.

The breakdown of serum vitamin D concentrations into two categories: hypovitaminosis (deficiency and insufficiency) and optimal vitamin D levels, identified eighty-three (83) women with hypovitaminosis D (ITV D < 30 ng/ml) and 19 women with optimal vitamin D levels (ITV D ≥ 30-100 ng/ml) (Table 1).

Table 1 : Distribution of women according to vitamin D status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serum 25(OH) Vit D (ng/ml)** | **Number of women**  **(n=102)** | **Prevalence (%)** | **Mean (ng/ml)** | **Standard deviation** |
| < 10 ng/ml (deficiency) | 4 | 3,92 | 8,62 | 0,86 |
| 10-30 ng/ml (Insufficiency) | 79 | 77,45 | 22,17 | 5,05 |
| 30-100 ng/ml (Optimal) | 19 | 18,63 | 35,22 | 4,67 |

Use of the SPEARMAN matrix showed that there was no correlation between age and vitamin D levels in these infertile womena montré qu’il n’y avait aucune corrélation entre l’âge et le taux de vitamine D chez ces femmes infertiles (Table2).

Table 2 : Statistical analysis using the SPEARMAN correlation matrix

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter to be correlated | P-value | T-student | Determination coefficient |
| Age | 0,626 | 0,489 | 0,002 |
| Vitamine D levels |
| Reference | <0,01 | >0,05 | >5 |

**Discussion**

The avarage age of the patients was 37, with extremes ranging from 21 to 50 years, corresponding to the age at which ovarian reserve begins to decline. These data are similar to those reported in the literature: in fact, Kannamannadiar et al. in 2008 (37) in a study in Nottingham (UK) of patients undergoing MAP found an average age of 33.7 years. In 2012, ML Hauhouot-Attoungbré et al. reported an average age of 35 years in a study carried out in Abidjan (38). Trably C. et al (39) found an average age of 33.7 years in France in 2012. In contrast, Moreira et al. (40) found an average age of just 24 years infertile women undergoing MAP in Dakar. These results show that women turn to MAP relatively late in life. Giulia Ranzanici et al (41) have shown that socio-cultural factors such as education, professional ambition and idealization of the family have a predominant effect on the tendency to delay the age of first pregnancy until the third decade. These factors would constitute a poor prognosis for a desire for motherhood́. In fact, according to Philippe Merviet et al (42), the follicular population falls by 75% between the ages of 30 and 40, with a drop in fertilitý at 35 from 25% to 12%.

Women with severe vitamin D deficiency had a mean age of 38 ± 5 years, slightly higher than that of women with vitamin D insufficiency (37 ± 6 years). This difference was not statistically significant. These results suggest that hypovitaminosis D uniformly affects women of childbearing age, regardless of their age group.

Consideration of age alone as a demographic factor is not sufficient, and it is necessary to extend investigations to other socio-demographic factors for a complete assessment of hypovitaminosis D.

**Prevalence of hypovitaminosis D**

Hypovitaminosis D (vitamin D deficiency and insufficiency) affects many populations worldwide and has been reported in the healthy population of all age groups and both sexes [30,43]. Its prevalence in women of childbearing age appears to be increasing worldwide in recent decades [44,45].

Of particular concern is the 81.37% prevalence of hypovitaminosis D (vitamin D levels <30 ng/ml) observed in infertile women in our study. These results confirm observations made in similar studies around the world, notably those by Majid et al. in 2023 in Iraq and Nassar and Rached. 2021 in Morocco, who found prevalences of hypovitaminosis D of 85% and 76.3% respectively in infertile women [46,47]. Similarly, Balci et al. 2019 also found 71.15% deficiency and insufficiency in their population in Turkey [48].

Numerous studies highlight the involvement of socio-demographic factors such as sun exposure, dietary habits, socio-economic status and even body mass index (BMI) in the prevalence of hypovitaminosis D. Thus, comparing the profiles of infertile women in sunny regions; a study conducted in Egypt showed a prevalence of hypovitaminosis D in infertile women of 64.7% [49], while research in South Asia, an equally sunny region, reported a prevalence of up to 85%, largely due to the cultural use of covering clothing that limits exposure to the sun [50]. In Europe, where there is less sunshine, studies also show high rates of hypovitaminosis D, particularly in winter. However, the situation there is generally better managed thanks to systematic vitamin D supplementation, especially in the Nordic countries [51].

In West Africa, a study by Fadupin et al. 2018 has shown that skin pigmentation, often associated with low vitamin D synthesis under UVB radiation, is a major contributor to vitamin D deficiency in urban areas [52]. In addition, the sedentary lifestyle associated with urban living reduces exposure to sunlight, exacerbating vitamin D insufficiency [30].

**Implications of vitamin D for fertility**

Several studies confirm vitamin D’s role in biological processes crucial to fertility, including the production of sex hormones such as progesterone and estrogen, promoting oocyte maturation and increasing endometrial receptivity for successful embryo implantation [28,53]. Thus, Irani and Merhi. 2014 demonstrated that vitamin D promotes oocyte maturation, improves embryo quality and participates in improving endometrial receptivity [54].

Although the data concerning vitamin D and fertility are not conclusive, a large number of studies have shown that vitamin D concentrations above 30 ng/ml were associated with higher pregnancy rates [28,55]. In addition, pre-pregnancy vitamin D values above 30.05 ng/mL have been associated with a greater likelihood of pregnancy, fewer pregnancy losses and an increase in the number of live births [56,57], while very low vitamin D values have been associated with an increased risk of preterm delivery, gestational diabetes, pre-eclampsia (very high blood pressure during pregnancy) and bacterial vaginosis [57,58]. Vitamin D deficiency and inadequate levels had a negative impact on the success of in vitro fertilization (IVF). Women with adequate levels had a higher probability of clinical pregnancy per initiated IVF cycle (52.5% versus 34.7%; p<0.001) than those with inadequate levels (34.7%) [59].

Studies show that adequate vitamin D levels are associated with improved fertility treatment outcomes, including pregnancy rates after in vitro fertilization (IVF). In our study, only 18.63% of women had optimal vitamin D levels, highlighting a potential fertility defect and the need for preventive interventions.

**Implications for management**

All these findings suggest the need to maintain vitamin D concentrations at optimal levels that could have a positive impact on fertility. A proactive approach, including systematic screening for hypovitaminosis D, nutritional assessment and possible vitamin D supplementation, would be important elements to consider in the management of a couple's fertility.

Further research is needed to assess the effect of supplementation on fertility outcomes in this at-risk population**.**

**Conclusion**

Hypovitaminosis D (vitamin D deficiency or insufficiency) is defined as a low serum level of 25-hydroxyvitamin D [25(OH) VIT D]. The prevalence of hypovitaminosis D among infertile women in Abidjan is alarming. This finding is all the more worrying as vitamin D plays an essential role in reproductive health, suggesting that targeted interventions are needed to improve reproductive health and prevent the complications associated with hypovitaminosis D.

In this study we used a single socio-demographic factor, suggesting that other factors, such as nutritional, environmental or genetic influences, may play a great role in the prevalence of this hypovitaminosis D. These results underline the importance of comprehensive management including vitamin D supplementation in infertility treatment protocols in this population.

**Study limits**

It would have been interesting to work on a larger population. In addition, a case-control study would enable us to compare women with and without fertility problems, and to establish cause-and-effect relationships with factors taking into account data on sun exposure and diet in a cross-sectional study would enable us to generalize the study’s conclusions.

**Artificial intelligence disclaimer**

The authors hereby declare that no generative artificial intelligence technologies such as large language models (ChatGPT, COPILOT, etc.) and text-image generators were used during the writing or editing of this manuscript.

**Ethical approval**

The study was approved by the local ethics committee of the Ministry of Health. A free and informed consent form was obtained from all participants.

**Références**

1.WHO. https://www.who.int/news/item/04-04-2023-1-in-6-people-globally-affected-by-infertility. 2024 [cited August 15, 2024]. 1 in 6 people globally affected by infertility: WHO. Available at: https://www.who.int/news/item/04-04-2023-1-in-6-people-globally-affected-by-infertility

2. Cox CM, Thoma ME, Tchangalova N, Mburu G, Bornstein MJ, Johnson CL, et al. Infertility prevalence and the methods of estimation from 1990 to 2021: a systematic review and meta-analysis. Hum Reprod Open. 2022;2022(4):hoac051.

3. Organization WH. Infertility prevalence estimates, 1990–2021. World Health Organization; 2023. 98 p.

4. Allah F, Anongba S, Bohoussou E, Dia JMIY, Guie P, Nguessan E, et al. Epidemiological and etiological aspects of infertile couples in Abidjan. Rev Int Sci Méd Abidj. 2014;22‑6.

5. Konan P. Couple infertility in Abidjan [Internet]. [UFR Sciences Médicales Abidjan]: University Félix Houphoüet Boigny, Abidjan, Côte d’Ivoire; 2015 [cited 14 August 2024]. Available at: https://biblio.uvci.edu.ci/records/30vq7-cn243

6. Zegers-Hochschild F, Adamson GD, Dyer S, Racowsky C, de Mouzon J, Sokol R, et al. The International Glossary on Infertility and Fertility Care, 2017. Fertil Steril. Sep 2017;108(3):393-406.

7. Potashnik G, Lunenfeld E, Levitas E, Itskovitz J, Albutiano S, Yankowitz N, et al. The relationship between endogenous estradiol and vitamin D3 metabolites in serum and follicular fluid during ovarian stimulation for in-vitro fertilization and embryo transfer. Hum Reprod. 1992;7(10):1357-60.

8. Smolikova K, Mlynarcikova A, Scsukova S. effect of 1α, 25-dihydroxyvitamin D. Endocr Regul. 2013;47:123‑31.

9. Kinuta K, Tanaka H, ​​Moriwake T, Aya K, Kato S, Seino Y. Vitamin D is an important factor in estrogen biosynthesis of both female and male gonads. Endocrinology. 2000;141(4):1317‑24.

10. Parikh G, Varadinova M, Suwandhi P, Araki T, Rosenwaks Z, Poretsky L, et al. Vitamin D Regulates Steroidogenesis and Insulin-like Growth Factor Binding Protein-1 (IGFBP-1) Production in Human Ovarian Cells. Horm Metab Res. Sep 2010;42(10):754‑7.

11. Vigano P, Lattuada D, Mangioni S, Ermellino L, Vignali M, Caporizzo E, et al. Cycling and early pregnant endometrium as a site of regulated expression of the vitamin D system. J Mol Endocrinol. 2006;36(3):415‑24.

12. Evans KN, Nguyen L, Chan J, Innes BA, Bulmer JN, Kilby MD, et al. Effects of 25-hydroxyvitamin D3 and 1, 25-dihydroxyvitamin D3 on cytokine production by human decidual cells. Biol Reprod. 2006;75(6):816‑22.

13. Ozkan S, Jindal S, Greenseid K, Shu J, Zeitlian G, Hickmon C, et al. Replete vitamin D stores predict reproductive success following in vitro fertilization. Fertil Sterile. 2010;94(4):1314‑9.

14. Rudick B, Ingles S, Chung K, Stanczyk F, Paulson R, Bendikson K. Characterizing the influence of vitamin D levels on IVF outcomes. Hum Reprod. 2012;27(11):3321‑7.

15. Rudick BJ, Ingles SA, Chung K, Stanczyk FZ, Paulson RJ, Bendikson KA. Influence of vitamin D levels on in vitro fertilization outcomes in donor-recipient cycles. Fertil Sterile. 2014;101(2):447‑52.

16. Merhi Z, Doswell A, Krebs K, Cipolla M. Vitamin D alters genes involved in follicular development and steroidogenesis in human cumulus granulosa cells. J Clin Endocrinol Metab. 2014;99(6):E1137‑45.

17. Anagnostis P, Karras S, Goulis DG. Vitamin D in human reproduction: a narrative review: Vitamin D and reproduction. Int J Clin Pract. March 2013;67(3):225-35.

18. Lerchbaum E, Obermayer-Pietsch B. Mechanisms in endocrinology: Vitamin D and fertility: a systematic review. Eur J Endocrinol. 2012;166(5):765-78.

19. Bouillon R, Carmeliet G, Verlinden L, van Etten E, Verstuyf A, Luderer HF, et al. Vitamin D and human health: lessons from vitamin D receptor null mice. Endocr Rev. 2008;29(6):726-76.

20. Yoshizawa T, Handa Y, Uematsu Y, Takeda S, Sekine K, Yoshihara Y, et al. Mice lacking the vitamin D receptor exhibit impaired bone formation, uterine hypoplasia and growth retardation after weaning. Nat Genet. 1997;16(4):391-6.

21. Ott J, Wattar L, Kurz C, Seemann R, Huber JC, Mayerhofer K, et al. Parameters for calcium metabolism in women with polycystic ovary syndrome who undergo clomiphene citrate stimulation: a prospective cohort study. Eur J Endocrinol. 2012;166(5):897-902.

22. Møller UK, Streym S, Heickendorff L, Mosekilde L, Rejnmark L. Effects of 25OHD concentrations on chances of pregnancy and pregnancy outcomes: a cohort study in healthy Danish women. Eur J Clin Nutr. 2012;66(7):862‑8.

23. Skowrońska P, Pastuszek E, Kuczyński W, Jaszczoł M, Kuć P, Jakiel G, et al. The role of vitamin D in reproductive dysfunction in women-a systematic review. Ann Agric Environ Med [Internet]. 2016 [cited May 27, 2024];23(4). Available at: https://bibliotekanauki.pl/articles/989717.pdf

24. Harmon QE, Kissell K, Jukic AMZ, Kim K, Sjaarda L, Perkins NJ, et al. Vitamin D and Reproductive Hormones Across the Menstrual Cycle. Hum Reprod Oxf Engl. Feb 18, 2020;35(2):413‑23.

25. Arslan S, Akdevelioğlu Y. The Relationship Between Female Reproductive Functions and Vitamin D. J Am Coll Nutr [Internet]. 18 August 2018 [cited 15 August 2024]; Available on: https://www.tandfonline.com/doi/abs/10.1080/07315724.2018.1431160

26. Maaherra Armstrong P, Augustin H, Bärebring L, Osmancevic A, Bullarbo M, Thurin-Kjellberg A, et al. Prevalence of Vitamin D Insufficiency and Its Determinants among Women Undergoing In Vitro Fertilization Treatment for Infertility in Sweden. Nutrients. 20 June 2023;15(12):2820.

27. Díaz-López A, Jardí C, Villalobos M, Serrat N, Basora J, Arija V. Prevalence and risk factors of hypovitaminosis D in pregnant Spanish women. Sci Rep. 25 Sept 2020;10(1):15757.

28. Lumme J, Morin-Papunen L, Pesonen P, Sebert S, Hyppönen E, Järvelin MR, et al. Vitamin D Status in Women with a History of Infertility and Decreased Fecundability: A Population-Based Study. Nutrients. 29 Mai 2023;15(11):2522.

29. Duda-Wiewiórka M, Pityński K. WITAMINA DA PRAWIDŁOWA I ZMIENIONA PATOLOGICZNIE BŁONA ŚLUZOWA JAMY MACICY VITAMIN D IN NORMAL AND PATHOLOGICALLY CHANGED ENDOMETRIUM. Wiad Lek. 2019;72(3):452‑6.

30. Holick M. Vitamin D deficiency. N Engl J Med. 2007;357:266‑81.

31. Holick MF. Vitamin D deficiency. N Engl J Med. 19 juill 2007;357(3):266‑81.

32. HoRsT RL, Reinhardt TA, Reddy GS. Vitamin D metabolism. Vitam D. 2005;1:15‑36.

33. O'Riordan JL. Rickets in the 17th century. J Bone Miner Res. 2006;21(10):1506‑10.

34. Pinkas J, Bojar I, Gujski M, Bartosińska J, Owoc A, Raczkiewicz D. Serum lipid, vitamin D levels, and obesity in perimenopausal and postmenopausal women in non-manual employment. Med Sci Monit Int Med J Exp Clin Res. 2017;23:5018.

35. Jeon SM, Shin EA. Exploring vitamin D metabolism and function in cancer. Exp Mol Med. Avr 2018;50(4):1‑14.

36. Vranić L, Mikolašević I, Milić S. Vitamin D Deficiency: Consequence or Cause of Obesity? Medicine (Mex). Sept 2019;55(9):541.

37. Jayaprakasan K, Deb S, Batcha M, Hopkisson J, Johnson I, Campbell B, et al. The cohort of antral follicles measuring 2–6 mm reflects the quantitative status of ovarian reserve as assessed by serum levels of anti-Müllerian hormone and response to controlled ovarian stimulation. Fertil Steril. 2010;94(5):1775‑81.

38. Hauhouot-Attoungbré ML, Yayo E, Konan JL, Koné F, Kouamé C, Diafouka F, et al. Biochemical profile of infertile women in Côte d'Ivoire. Biochim Clinic. 2012;36(5):359.

39. Trably C, Brosse A, Plotton I, Berthillier J, Du Mesnildot P, Hadj S, et al. Predictive value of vitamin D dosage on large fat cells in a cohort of patients undergoing IVF. Gynécologie Obstétrique Fertil. 2015;43(11):722‑7.

40. Moreira P, Fall C, Dieng T, Fall A, Diouf A, Moreau JC. Assisted reproductive technology: indications and perceptions among couples presenting for infertility at Dakar University Hospital. Mali Med. 2008;23(1):50‑6.

41. Ranzanici G, Redzepi B, Perez L, Torriani O. Infertilité et procréation médicalement assistée. [cited 6 January 2025]; Available at: https://www.psychaanalyse.com/pdf/infertilite\_et\_PMA\_.pdf

42. MERVIET P, Lourdel E, Cabry R, ​​Temstet R, Jacques A, Claeys C. L'exploration de la réserve ovarienne dans le bilan de l'infertilité. Lett Gynécologue. 2009;(343):31‑6.

43. Vranić L, Mikolašević I, Milić S. Vitamin D Deficiency: Consequence or Cause of Obesity? Med Kaunas Lith. 28 August 2019;55(9):541.

44. Alzaheb RA. The Prevalence of Hypovitaminosis D and Its Associated Risk Factors Among Women of Reproductive Age in Saudi Arabia: A Systematic Review and Meta-Analysis. Clin Med Insights Womens Health. 1 Jan 2018;11:1179562X1876788.

45. Mogili KD, Karuppusami R, Thomas S, Chandy A, Kamath MS, Aleyamma TK. Prevalence of vitamin D deficiency in infertile women with polycystic ovarian syndrome and its association with metabolic syndrome–A prospective observational study. Eur J Obstet Gynecol Reprod Biol. 2018;229:15‑9.

46. ​​Nassar K, Rached H. Hypovitaminosis D in sub-Saharan Africa: Myth or reality? Afr J Public Health. 2021;

47. Majid MA, Hassan WN, Ridha AF. Prevalence of 25-Hydroxyvitamin D (Vitamin D) Deficiency in a Group of Infertile Women from Baghdad City. Biochem Res Int [Internet]. 2023 [cited 27 May 2024];2023. Available at: https://www.hindawi.com/journals/bri/2023/6597730/

48. Balci BK, Ergun B. Prevalence of low vitamin D levels in infertile patients - a single center pilot study. Clin Exp Obstet Gynecol. 10 févr 2019;46(1):104‑7.

49. Nagi DK, Khorshid NS, Aboelfetoh MA. Prevalence of vitamin D deficiency among Egyptian women with infertility and its relation to body mass index. Middle East Fertil Soc J. 2019;24(4):267‑72.

50. Khan AH, Iqbal R, Naureen G, Dar FJ, Ahmed FN. Prevalence of vitamin D deficiency and its correlates: results of a community-based study conducted in Karachi, Pakistan. Arch Osteoporos. 2012;7:275‑82.

51. Cashman KD, Dowling KG, Škrabáková Z, Gonzalez-Gross M, Valtueña J, De Henauw S, et al. Vitamin D deficiency in Europe: pandemic? Am J Clin Nutr. 2016;103(4):1033‑44.

52. Fadupin GT, Ada ME, Adeosun SO. Prevalence and determinants of vitamin D deficiency among healthy Nigerian adults. Afr J Biomed Res. 2018;21(1):53-57.

53. Kiely ME, Zhang JY, Kinsella M, Khashan AS, Kenny LC. Vitamin D status is associated with uteroplacental dysfunction indicated by pre-eclampsia and small-for-gestational-age birth in a large prospective pregnancy cohort in Ireland with low vitamin D status. Am J Clin Nutr. 2016;104(2):354‑61.

54. Irani M, Merhi Z. Role of vitamin D in ovarian physiology and its implication in reproduction: a systematic review. Fertil Steril. août 2014;102(2):460-468.e3.

55. Rudick B, Ingles S, Chung K, Stanczyk F, Paulson R, Bendikson K. Characterizing the influence of vitamin D levels on IVF outcomes. Hum Reprod Oxf Engl. nov 2012;27(11):3321‑7.

56. Pacis MM, Fortin CN, Zarek SM, Mumford SL, Segars JH. Vitamin D and assisted reproduction: should vitamin D be routinely screened and repleted prior to ART? A systematic review. J Assist Reprod Genet. mars 2015;32(3):323‑35.

57. Mumford SL, Garbose RA, Kim K, Kissell K, Kuhr DL, Omosigho UR, et al. Association of preconception serum 25-hydroxyvitamin D concentrations with livebirth and pregnancy loss: a prospective cohort study. Lancet Diabetes Endocrinol. sept 2018;6(9):725‑32.

58. Kiely ME, Zhang JY, Kinsella M, Khashan AS, Kenny LC. Vitamin D status is associated with uteroplacental dysfunction indicated by pre-eclampsia and small-for-gestational-age birth in a large prospective pregnancy cohort in Ireland with low vitamin D status. Am J Clin Nutr. août 2016;104(2):354‑61.

59. Garbedian K, Boggild M, Moody J, Liu KE. Effect of vitamin D status on clinical pregnancy rates following in vitro fertilization. CMAJ Open. mai 2013;1(2):E77-82.