REVIEW ARTICLE

Diet, sun exposure, and dietary supplementation: effect on serum levels of vitamin D

Alimentação, fotoexposição e suplementação: influência nos níveis séricos de vitamina D

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ABSTRACT

Vitamin D has a biologically active form, calcitriol, which regulates cell growth and differentiation, prevents progression and apoptosis of cancer cells, and reduces proliferation and metastasis. Its deficiency, hypovitaminosis D, is common and courses with hypocalcemia, hypophosphatemia, and osteoporosis. Given the importance of this nutrient, this study was outlined to describe the factors that influence serum levels of vitamin D such as sun exposure, diet, and dietary supplementation. This was a review conducted in Belo Horizonte by searching the term vitamin D in the PUBMED, SCIELO, CAPES, BIREME, and Up To Date databases, totaling 22 articles published between 1983 and 2013. It was observed that the literature is scarce on the subject, particularly in regards to clarification of contradictions about risk factors and that this scarcity is more evident in tropical regions such as Brazil. It was concluded that studies on this subject are important to improve the conduct and treatment related to hypovitaminosis D.

Key words: Vitamin D; Vitamin D Deficiency; Sunlight/adverse effects; Sunscreening Agents; Feeding; Supplementary Feeding.

RESUMO

A vitamina D possui forma biologicamente ativa, o calcitriol, que regula o crescimento e a diferenciação celular, previne progressão e apoptose de células cancerígenas e reduz a proliferação e as metástases. Sua deficiência, a hipovitaminose D, é comum, e cursa com hipocalcemia, hipofosfatemia e osteoporose. Dada a importância desse nutriente, delineou-se este estudo para descrever os fatores que influenciam os níveis séricos de vitamina D, como fotoexposição, alimentação e suplementação dietética. Trata-se de revisão realizada em Belo Horizonte, pesquisando o termo vitamina D nas bases de dados PUBMED, SCIELO, CAPES, BIREME e Up To Date, totalizando 22 artigos no período compreendido entre 1983 e 2013. Observou-se que é escassa a literatura sobre o assunto, principalmente no que se refere a esclarecimento das contradições sobre os fatores de risco e que essa escassez é mais evidente em regiões tropicais como o Brasil. Concluiu-se que estudos sobre esse assunto são importantes para direcionar melhor a conduta e o tratamento da hipovitaminose D.

Palavras-chave: *Vitamina D; Deficiência de Vitamina D; Luz Solar/efeitos adversos; Protetores Solares; Alimentação; Suplementação Alimentar.*

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INTRODUCTION

The calcitriol steroid hormone is popularly known as vitamin D and plays an important role in the human body, especially in calcium absorption and bone me-

tabolism.[1] It is comprised of two bioequivalent forms: vitamin D_2, also known as ergocalciferol and obtained from plant feeding sources and oral supplements; and vitamin D_3 or cholecalciferol, mainly obtained from the exposure to ultraviolet B radiation (RUVB) present in sunlight, ingestion of foods such as fish oil sources and variably fortified foods (milk, juices, margarine, yogurts, cereals, and soy), and oral supplements.[2]

The serum levels considered satisfactory go from 25 to 80 ng/ml serum. Values below 20 ng/mL result in hypovitaminosis D[2]. Sun exposure with an average duration of 15 minutes per day at times of RUVB emission is necessary to achieve proper values. However, other factors also influence the serum levels of vitamin D, such as the time of day when there is sun exposure, season, latitude, altitude, clothing, use or not of sunscreen, skin pigmentation and age, and nutritional status.[3] Worldwide, vitamin D is predominantly obtained from exposure to mid-wavelength ultraviolet radiation – 280-315 nm (RUVB) – in the form of sunlight, as well as food sources such as cold and deep water fish, some mushrooms, milk, eggs, and fortified foods.[2,4]

The biologically active form of vitamin D helps regulate cell growth and prevent cancer progression from the reduction of angiogenesis, increased cell differentiation, apoptosis of cancer cells, and reduction in cell proliferation and metastasis.[5]

The number of people with vitamin D levels below the recommended has progressively increased[6], and its deficiency is increasingly common, which can lead to hypocalcaemia, hypophosphatemia, and osteoporosis.[6-8]

This objective review aims to list the main factors that influence the serum levels of vitamin D such as sun exposure, diet, and supplementation.

METHODOLOGY

This review included the selection of 22 relevant articles, among them cohort, cross-sectional, review, and clinical trial studies. The PUBMED, SCIELO, CAPES, BIREME, and Up To Date databases were used. All selected articles were published in English and Portuguese between 1982 and 2013. The terms searched were: vitamin D, vitamin hypovitaminosis D, sun exposure, photoprotection, nutrition, and supplementation. The search and selection of articles followed the scheme referenced in Figure 1. Studies on Vitamin D only related to skin cancer were excluded.

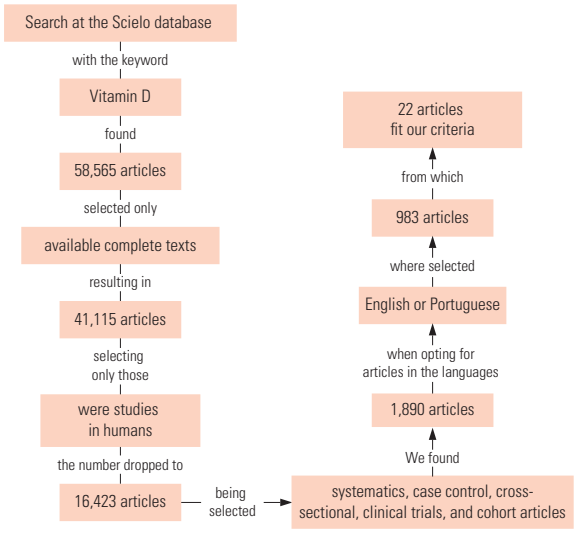

Figure 1 - Fluxogram showing the search strategy to find the articles used in this review.

DISCUSSION

Currently, the insufficiency/deficiency of vitamin D has been considered as a public health problem worldwide because of its implications for the development of several diseases.[9]

Metabolism

The metabolism of vitamin D involves the conversion of its precursor, 7-dehydrocholesterol that is present in the skin, in pre-vitamin D when exposed to RUVB. Pre-vitamin D undergoes thermal isomerization to form vitamin D_3, which in the bloodstream is directed to the vitamin D binding protein and carried to the liver where the hydroxylation process initiates. After several metabolic processes in the liver, the vitamin goes to the kidney, where it undergoes a new hydroxylation and reaches its active form exercising its function in target organs (Figure 2).[10]

Vitamin D deficiency

There are several factors that lead to vitamin D deficiency such as aging, reduction of fat absorption (it is known that this vitamin needs cholesterol to be synthesized), use of drugs (glucocorticoids, especially prednisone, and fat absorption blockers), and insufficient sun exposure.[11]

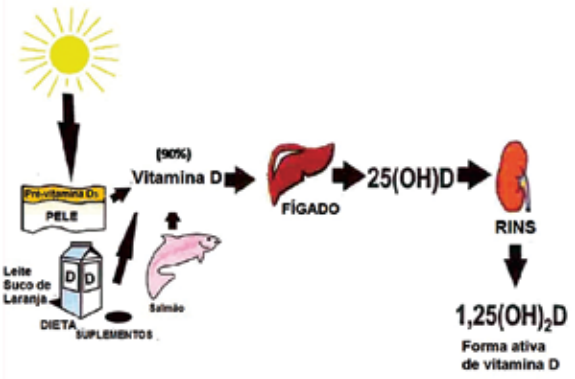

Figure 2 - Mechanism of the vitamin D synthesis. Source: Adapted from Al-Mutairi N. et al, 2012.

There are numerous implications in deficiencies of the calcitriol hormone (vit. D). Therefore, it is important to evaluate its symptoms such as bone metabolism disorders, muscle spasms, and laboratory findings of reduced serum levels of calcium and phosphorus.[12]

Sun exposure

The popular knowledge is well-established about the damaging effects of sunlight, including the risk of skin cancer, which leads everyone to protect themselves from the sun. This may reflect the detriment serum levels of vitamin D because sun exposure is necessary for its metabolism to occur.[4,10,13,14]

Al-Mutairi et al.[4] in Kuwait showed the effectiveness of sunscreens in the studied population. However, the population of that country mostly presents skin types III and IV, which are more resistant to sunlight on the conversion of vitamin D due to the high concentration of melanin.[4] Moreover, the study considered vitamin levels below 50 ng/ml as unsatisfactory, which is a value above the currently accepted. Considering that the population of Kuwait has the habit of wearing long garments that cover large body surfaces due to climatic conditions, with long summers and temperatures going up to 50 °C, one cannot conclude that sunscreens were the only responsible factor for the low levels of vitamin D found in the study.

Another study describes the influence of the use of sunscreen in 2012 on the proper level of vitamin D conducted by Lee SH et al..[13]. However, this study had the limitations of being conducted in the winter, in South Korea (October-November), and on a small sample of 20 women who were exposed to only 20 minutes a day to sunlight.

Pittaway JK et al..[14] described a study with external validity of data higher than the previous studies because it lasted 15 months and was conducted in different cities of Australia, from the winter of 2009 to the spring of 2010, which highlighted the role of sunscreen in different seasons of the year. Taking into account the generalization of data for the population of Brazil, this research presents as a positive point the fact that the Australian climate and latitude approach those of Brazil, which could relate to the effectiveness of sunscreens also in our country.

Cultural factors

The synthesis of vitamin D is influenced by cultural factors such as clothing, lifestyle related to outdoor weather, and the extent of body surface exposed to the sun, such as the use of umbrellas and permanence in the shade for prolonged periods. However, the interference of using hats, sunscreen, sunglasses, and long clothing is not observed. It seems that skin color does not affect the synthesis of vitamin D.[4,15,17] There are several Australian studies on the subject (mostly associated with the degradation of the ozone layer). However, these studies are scarce in other tropical regions such as Brazil.

Food

A proper diet is essential, but it is not the only requirement to achieve acceptable levels of vitamin D.[10,11] The daily recommendation of vitamin D is difficult to establish precisely because of its metabolism and the fact that it is produced endogenously; it can be stored beyond the dietary needs, which depends on the levels of phosphorus and calcium.

The main dietary sources of vitamin D are foods rich in omega-3 such as deep-water fish (salmon, tuna, catfish), citrus juices, cereals, liver, egg yolks, and fortified foods such as butter.[10,11,18 19] The consumption of these last four foods has been decreasing due to their high cholesterol content.[11] The intake of seafood products that provide vitamin D should be encouraged.[18] This standard was obtained from studies conducted under the influence latitude and temperature that are not applicable to the Brazilian situation.

Tangpricha V. et al.[20] in 2002 showed no relevance in healthy young adults from Boston in relation to tangible levels of vitamin D correlated to drinking milk. Kimball et al.[9] in 2008 reported that the intake

of milk along with natural sources of vitamin D may increase three to 10 times its absorption, which can be explained by the existence of lactalbumin.

It is important to correlate foods that are rich in vitamin D and their portion sizes (Table 1).[21]

Table 1 - Foods rich in vitamin D

Food	Portion sizes/g	ug
Tuna fish	2 medium (90g)	3.68
Raw sardines	100g	5.20
Canned sardines	100g	17
Fish oil	1 table spoon	40.3
Butter	1 full table spoon	0.45
Bull's Liver	100g	1.12
Chicken liver	100g	1.25
Fresh egg yolk	100g	0.53
Fresh chicken egg	100g	0.875
whole milk	I cup of 240 ml	0.17
Mushrooms	100g	0.62

Source: Adapted from the United States Department of Agriculture (USDA), 2013.

Supplementation

Currently, supplementation is available in the oral form as vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol), which is more powerful because it is responsible for the hormone conversion under the effect of ultraviolet radiation.

As for the supplementation dosage, it is relevant to consider that they also vary according to geographical location, climate, local food, and population profile of each country. For example, according to the American Academy of Pediatrics (AAP) and Pediatric Endocrinology Society (SEP), the determination is an intake of 400 IU/d of vitamin D by all children under one year of age, and after that age, 600 IU/day.[8] Pires[8] does not specify the actual criteria for determining the characteristics that patients should fill to fit themselves to it. Thus, there is the inability to assert that the intake of the same amount of vitamin would be enough to meet the needs of children in various territories. The Canadian Cancer Society (CCS) recommended the intake of 1,000 international units of vitamin D during the fall and winter and throughout the year for those who have deficiencies in production in the summer (elderly, blacks, and people who use sunscreens).[22] In Brazil, the Brazilian Society of Endocrinology (SBE) and the Unified Health System (SUS) provide tablets of 400 IU of vitamin D for the population, however, only in association with calcium salts, which can be disadvantageous.[23] Most patients do not need calcium supplementation because they get sufficient quantities in the diet, requiring larger amounts of vitamin D to correct any deficiency. This correction requires loading doses of 7,000 IU/day for periods of two to three months, which prevents the use of these associations. Therefore, still according to the SBE, to provide vitamin D_3 in versatile isolated presentations that enable the dose titration for different clinical situations is urgent.[23] This reinforces that this is a low-cost measure with great clinical relevance.

Skin biotype

Among all the factors affecting absorption levels, 80% of the response is composed of a combination of UV-B radiation dose and basic skin type (phototype).[24] Melanin reduces the absorption of the vitamin, but it does not block it, thus requiring longer sun exposure.[24] In agreement with this, lighter skin tones need lower doses of ultraviolet radiation for converting the hormone.[26] Moreover, it has been demonstrated that the dosing of serum vitamin D levels after sun exposure in blacks shows considerable increase in its level.[27]

Another study confirms that UVB radiation increases the levels of vitamin D, however, because the relationship between dose and the effect of skin pigmentation were not well characterized, the authors decided to set the ratio between UVB exposure and vitamin D concentration as a function of skin color. Therapeutically important changes in the doses of 25-OH-D were obtained with minimal sun exposure in lighter-skinned people. Although 80% of the variation response to treatment is explained by the dose of UVB and skin coloration, four weeks are not sufficient to reach a steady state for more elevated doses.[26]

According to the study by Bogh et al.[27], the absorption of vitamin D can be changed by the amount of melanin produced by the individual, increasing proportionally to the exposed body area. Therefore, even though people with black skin manage to achieve the same level of vitamin D as a person with skin type I, the time and body area of sun exposure are greater.

Seasons

Seasons and latitudes are also important factors in vitamin D physiology because they influence di-

rectly in sunlight incidence. Vitamin D deficiency is more prevalent during the fall and winter months of less incidence of sunlight. Studies of the relationship between body concentration of vitamin D and seasonal periods used the parameter of 40 ng/mL as vitamin D deficiency, which is a satisfactory figure in countries like Brasil.[18] One must also consider that tropical and subtropical regions, such as Australia, receive more intense solar radiation and during longer periods compared to those in high latitudes.[17,19]

Intrinsic skin Factors

Difficulty to maintain acceptable serum levels may result from intrinsic factors related to the skin itself such as inadequate skin production of vitamin D, abnormality in the transport at the skin level, and synthesis regulation despite sun exposure and correct feeding. Hall et al..[28] in 2010, compared two different ethnic groups; one of the European descendants and another of Africans descendants. As a result, it was observed that people of African descent have increased difficulty achieving satisfactory levels of vitamin D. The main limitation of this study to consider the generalization of its data is the small number of participants.

Brazilian reality

There are not enough studies linking vitamin D to factors discussed in Brazil, which explains the difficulty of relating them in our country. Brazil has climatic, cultural, racial, social, and economic peculiar characteristics that do not resemble those of international studies. The analyzes guided by the white population in developed countries are not necessarily applicable to other countries because the measurements vary according to the characteristics of each region.[11] Hypovitaminosis is affecting much of the Brazilian population, thus, exact steps to correct serum hormone levels are needed, starting with guidance to health professionals to prevent patients from suffering the many consequences of this deficiency.

CONCLUSION

The importance of vitamin D for health is in focus, and each day arouses interest and concern of the general public and medical profession. The number of studies on vitamin D deficiency is especially low in tropical countries such as Brazil, which causes difficulty in recognizing what the best approach and treatment would be. According to published studies, we note that there are many controversies regarding the risk factors for vitamin D deficiency, which include the use of sunscreens and food. In Brazil, the low sunlight incidence variation during the year and high population miscegenation (most favorable biotypes to sun exposure) favor the prevention of hypovitaminosis D. However, there is a low supply of deepwater fish (main dietary source of vitamin D). This deficiency could be counterbalanced with supplementation that still requires further adjustments to the standards recommended by the SBE. It is concluded that studies on this matter are essential to address and clarify the practice to prevent and treat hypovitaminosis D.

LIST OF ABBREVIATIONS

- Vitamin D2 (Vit D2.);
- Vitamin D3 (Vit D3.);
- Ultraviolet B radiation (RUVB);
- Canadian Cancer Society (CCS);
- Brazilian Society of Endocrinology (SBE);
- Unified Health System (SUS);
- Brazilian Society of Endocrinology (SBE);
- American Academy of Pediatrics (AAP);
- Pediatric Endocrinology Society (SEP).

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