Association between physical activity and vitamin D: A narrative literature review

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Summary

This narrative review of the medical literature assessed whether outdoor and indoor physical activity would increase the plasma levels of vitamin D. Synthesis of this liposoluble vitamin is mainly mediated by sunlight on the skin, where it is activated to perform its main action, which is to control the serum levels of calcium as soon as the element is absorbed in the intestines, assisting in the regulation of bone metabolism. Physical activity is any body movement that results in energy expenditure, while outdoor physical activity refers to physical activity carried out at public parks or other open spaces, as is the case of the popular practice of taking walks. Exercising outdoors would have both the benefits of physical activity and of sun exposure, namely the synthesis of vitamin D. However, according to the studies analyzed, increased plasma concentration of vitamin D occurs with physical activity both indoors and outdoors.

Keywords: vitamin D, physical activity, environmental exposure, sunlight, external work environment.

Introduction

Vitamin D is a liposoluble compound with antioxidant properties, essential for maintaining the body's mineral balance. It can be acquired from an exogenous source (feed) or endogenously synthesized from the incidence of the sun's ultraviolet rays on the skin. Although it is a vitamin, it is also considered a hormone, since its activation is made by means of chemical reactions inside the organism.[1]

Vitamin D occurs in the form of two biologically inert precursors or prohormones, vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Ergocalciferol is of vegetable origin, whereas cholecalciferol is of animal origin, being formed by ultraviolet B radiation on 7-dehydrocholesterol.[2] Vitamin D in these forms must be converted into active hormone to be able to exert biological influence on mineral metabolism and other physiological functions.[1]

Physical activity is any movement of the body produced by skeletal muscles that results in greater energy expenditure than that of rest levels. Performing physical activity in an outdoor environment, with sun exposure, would provide benefits both from the physical work itself and from vitamin D synthesis and action in the body.[3] Based on current evidence, our narrative review of the literature aimed to answer whether physical activity performed both outdoors (with sun exposure) and indoors (without sun exposure) would increase vitamin D plasma levels.

Historical aspects

Elmer V. McCollum at the end of the 19th century, in experiments on fats associated with the cure of certain diseases (rickets), observed how this process took place in the organism and its relation in the interruption of inadequate bone mineralization during growth due to lack of sun exposure. Today, this substance is called vitamin D.[4]

Physical activity has always existed throughout history, both indoors (Figure 1) and outdoors[5] (Figure 2). Millennial accounts of Greeks, Chinese and Indians in relation to the practice of physical activity affirm the idea that a stimulated body becomes strong regardless of variation in the environment. The important thing is for the individual to become an adept of this practice.[6,7]

FIGURE 1 Indoor physical activity.

FIGURE 2 Outdoor physical activity.

Vitamin D

The needs of the human body, in relation to vitamin D, are supplied to a lesser extent by the exogenous absorption of dietary sources: vitamin D2, found in vegetables and called ergocalciferol, and vitamin D3, of animal origin, found in fish and called cholecalciferol. But most of it is endogenously synthesized.[8]

Both participate in the same metabolic process. These forms of vitamin D are produced in the epidermis by 7-dehydrocholesterol photolysis action/reaction.[9] After synthesis, vitamin D remains inactive, mainly bound to a vitamin D binding protein and, to a lesser extent, albumin, and circulates through the bloodstream until it reaches the liver. There, it undergoes hydroxylation at carbon 25, generating 25-hydroxyvitamin D or calcidiol. It is a rapid process that undergoes little regulation, and the product is deposited in the reservoir of adipose tissue. To be active, this vitamin requires participation of the kidneys and 1-hydroxylase enzyme. Then, vitamin D3 goes back into the bloodstream to the kidneys and, mediated by the enzyme hydroxylase, forms 1,25-dihydroxyvitamin D or calcitriol. This renal action is controlled by several factors, unlike the previous stage, in the liver, which is poorly regulated[10,11] (Figure 3).

Vitamin D acts in the control of plasma calcium levels, after its absorption in the intestinal tract, aiding in the regulation of bone metabolism. It also acts in non-calcemic effects, such as strengthening the immune system, improving balance and preventing premature aging.[4]

Researchers' interest in vitamin D has been enhanced by recent advances related to biology, as it plays an important role far beyond calcium metabolism in various extra-skeletal tissues such as adipocytes, skeletal striated muscle, and pancreatic tissue. It also participates in the modulation of immunity and inflammation, which shows its therapeutic potential in diseases such as multiple sclerosis, type 1

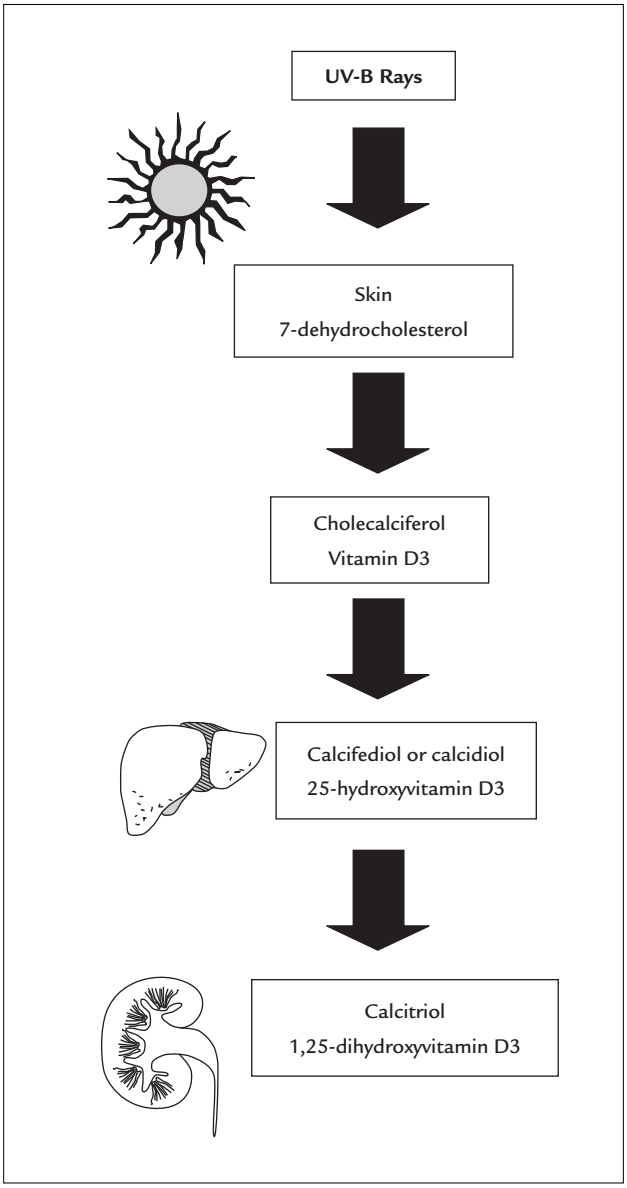

FIGURE 3 Scheme of vitamin D formation.

and 2 diabetes, and autoimmune dermatological and thyroid diseases. Obesity has a negative correlation with plasma vitamin D levels, and vitamin D deficiency causes an increased risk for the development of metabolic syndrome, as well as increased oxidative burden.[4]

Physical activity

Although physical activity is thought to be synonymous with physical exercise, it is actually any movement caused by a muscle contraction resulting in increased energy expenditure than at rest.[3] Physical exercise is defined as well-structured, planned and repetitive physical activity, aiming at improving health, well-being, and maintaining physical fitness.[12] The purpose of their use is what sets them apart. Physical activity is therapeutic and its purpose is treatment, while physical exercise improves physical fitness.[13,14]

Physical fitness, in turn, is defined by the amount of energy that a person has while performing physical work, according to physical valences, and involves flexibility, strength, endurance and motor coordination.[15] From a physical point of view, an inactive individual is one who does not practice physical activity for at least 150 minutes per week.[16]

There is a type of exercise called green, which is given to activity practiced in nature, with behavioral results in stress relief in acute exercise sessions.[17]

Outdoor physical activity would be its accomplishment in squares, parks and field environments.[18] The most popular of these activities is walking, practiced by the elderly with the goal of improving health and preventing diseases.[19]

Studies show that some cities joined the creation of outdoor fitness centers, with the incorporation and adaptation of gymnastics and bodybuilding equipment, with a view to physical, mental and social improvement[20] (Figure 4).

Association between physical activity and vitamin D

Regular practice of physical activity has several benefits to the human being, but it is regulated by innumerable demographic, social, physical, environmental, economic and psychological factors that can be both stimulating and inhibiting.[21]

Vitamin D, important in the absorption of calcium at the intestinal level, also acts in the immune, cardiovascular and musculoskeletal systems. Solar exposure in outdoor environment allows the synthesis of this vitamin, with a consequent process of gain of bone tissue through its mineralization. According to current knowledge, the skin is the only organ capable of producing vitamin D, which is also absorbed from dietary intake.[22]

FIGURE 4 Outdoor fitness Center.

There is research indicating the practice of physical activity in outdoor settings, but they do not mention the importance of vitamin D.[17,23] Similarly, there are studies on the synthesis of vitamin D from the incidence of sun rays on the skin, but they do not mention physical activity with sun exposure.[24] Why not consider outdoor physical activity in view of the benefits of such activity along with the possibility of vitamin D synthesis from skin exposure to ultraviolet B? It is important to establish if this type of activity, in outdoor environment, would be the only one capable of increasing vitamin D plasma levels (Figure 2).

Sela and Sela identified the beneficial results of outdoor sports, with elderly individuals having better disposition for this activity, as well as less depression, and a reduction in body weight and medication intake, favoring their quality of life.[25] A systematic review by Mochcovitch et al. also demonstrated that regular physical activity may be effective for the improvement of anxiety symptoms in older adults; however, they concluded that more research would be necessary to identify the modality, frequency, duration and intensity to optimize the positive effects of this activity on anxiety in the study population.[26] The authors did not mention physical activity with sun exposure for vitamin D synthesis, as seen in the study by Al-Eisa et al., who reported the improvement of the individual's physical performance associated with vitamin D and calcium levels as factors to prevent muscle fatigue.[27]

Vitamin D sufficiency related to physical activity provides better neuromuscular performance, including with increased type II muscle fibers, and also improves the regulatory role of the immune system. Indoor environments, more pigmented skin and excessive use of sports equipment favor vitamin D deficiency.[28]

Pagels et al. compared indoor and outdoor physical activity among 179 children aged 7 to 14 years from schools in Sweden, and found that outdoor physical activity led to a moderate and vigorous increase in physical activity, during all seasons of the year.[22] This strong correlation between the variables of moderate/vigorous physical activity and outdoor environment was also found in the studies by Sallis et al.[29] and Cooper et al.[30] These authors did not, however, study the association with serum levels of vitamin D.[22,29,30]

Pagels et al., in another recent study, report that outdoor environment, due to suberythemal exposure to the sun even at high latitudes, has a favorable health impact, helping students to acquire vitamin D.[31] Therefore, moderate exposure to ultraviolet rays in outdoor environment during school days in northern European countries has a positive impact on the immune system, bone mineralization and, possibly, mental health.[22]

Florez et al. conducted a cross-sectional study and found an association between vitamin D levels, body mass index and outdoor physical activity in white Hispanic, and non-Hispanic patients. In Hispanics, there was a high prevalence of hypovitaminosis D among the obese compared to non-obese individuals. The practice of outdoor physical activity decreased the prevalence of hypovitaminosis D, with individuals 47% less likely to have this condition.[32]

Valtueña et al. investigated 408 Spanish athletes from 34 different modalities, both male and female, and concluded that 82% had suboptimal levels of plasma vitamin D concentration, demonstrating that outdoor physical training is the appropriate way to increase this concentration in athletes.[33]

Some studies, however, mention high levels of physical activity associated with increases in vitamin D levels in older adults over the years, regardless of outdoor practice. This, because indoor physical practice would also result in increased levels of vitamin D, suggesting that the concentration of vitamin D is not only attributed to high sun exposure.[34-37]

The findings of the analysis based on data from the US National Health and Nutrition Examination Survey (NHANES) indicate that physical activity is associated with high serum levels of vitamin D, regardless of indoor or outdoor practice.[38] Scragg and Camargo conducted an earlier study using the same database (NHANES III), and found that the association between physical activity and vitamin D was stronger in outdoor compared with indoor environments.[39] Therefore, even though both studies have reported associations between physical activity and vitamin D in older individuals, and despite the fact that the ability of vitamin D synthesis from sun exposure decreases with age, the results were not replicated.[38,39]

Independent effects on sun exposure during physical activity may be associated with increased plasma concentrations of vitamin D. A French study by Touvier et al. supports this claim, with findings of association between physical activity and vitamin D after adjusting for sun exposure and outdoor sports.[40] Maimoun and Sultan also corroborate the hypothesis that other factors, which are known and altered by physical activity, may contribute to elevated levels of vitamin D metabolites in athletes, such as decreased serum phosphate and ionized calcium.[41,42]

In addition, Kimlin et al., in an Australian study, reported that exposure to ultraviolet rays was responsible for only 8% of the variation found in vitamin D concentration, while the largest contribution was clothing coverage (27%), followed by location (20%), season (17%), supplementation (7%) and body mass index/physical activity, with 4% each. These results suggest that modifiable factors related to sun exposure could help maintain the healthy state of vitamin D, such as decreased clothing coverage, rather than increasing the duration of exposure to ultraviolet rays.[43]

Van den Heuvel et al. evaluated the contribution of different physical activity characteristics, such as duration, intensity and location, in relation to plasma levels of vitamin D and concluded that physical activity performed at high intensity had the strongest positive association with vitamin D levels.[44]

It is important to emphasize that exposure of the body to the sun during physical activity should have some particularities in order to raise the plasma concentrations of vitamin D, since it depends on the amount of melanin present in the skin, the type of clothing and the use of sunscreen, as well as hour of the day, season of the year, latitude of the place and age of the individual.[28,45,46]

The studies included in our narrative review are presented in Table 1 (outdoor physical activity and vitamin D synthesis) and Table 2 (indoor physical activity and vitamin D synthesis), and show sample size, study design and their main findings.

Directed attention plays a fundamental role in cognitive functions, but once it is weakened, the individual's ability to concentrate for certain tasks is reduced, leading to mental fatigue.[47] The practice of physical activity interacting with nature may be important for recovery of this directed attention, which is closely linked to the process of regaining balance.[48-51]

TABLE 1 Summary of studies in the narrative review: Outdoor physical activity and synthesis of vitamin D.

Studies	Year	Sample	Study design	Main findings
Pagels et al.[31]	2016	196	Cross-sectional	Suberythemal exposure to the sun contributed to the synthesis of vitamin D
Florez et al.[32]	2007	291	Cross-sectional	The practice of outdoor physical activity decreased the prevalence of hypovitaminosis D
Valtueña et al.[33]	2014	408	Cross-sectional	Outdoor physical training is the appropriate way to increase the plasma concentration of vitamin D in athletes
Scragg and Camargo[39]	2008	15,148	Cross-sectional	The association between physical activity and vitamin D was stronger outdoors compared to indoor environments

TABLE 2 Summary of studies in the narrative review: Indoor physical activity and synthesis of vitamin D.

Studies	Year	Sample	Study design	Main findings
Scott et al.[34]	2015	615	Cohort	Exercising indoors would also result in increased levels of vitamin D, suggesting that vitamin D concentration is not only attributed to high sun exposure
Gerdhem et al.[35]	2005	986	Cohort	
Scott et al.[36]	2010	686	Cohort	
Bell et al.[37]	1988	28	Cohort	
Touvier et al.[40]	2015	1,828	Cross-sectional	There was an association between physical activity and vitamin D, even after adjusting for exposure to the sun and outdoor sports
Maimoun and Sultan[41]	2009	24	Systematic review	Other factors, which are known and altered by physical activity, may contribute to elevated vitamin D levels in athletes
Kimlin et al.[43]	2014	1,002	Cross-sectional	Modifiable factors related to sun exposure could help maintain healthy vitamin D status, such as decreased clothing coverage, rather than increasing the duration of exposure to ultraviolet rays
Van den Heuvel et al.[44]	2013	1,255	Cross-sectional	High-intensity physical activity had the strongest positive association with vitamin D levels
Wanner et al.[38]	2015	6,370	Cross-sectional	Physical activity is associated with high serum levels of vitamin D, regardless of the practice environment, outdoors or indoors

The sufficiency of vitamin D has been related to the mental health of the individuals due to the presence of receptors of this vitamin in cells inside the brain,[52-54] also favoring their cognitive performance.[55,56] 25(OH)D, in a cross-sectional analysis, was associated with the cognitive decline of subjects over 65 years.[57] Therefore, both the practice of physical activity and the status of vitamin D are relevant to the reduction of common mental illnesses.[52-58]

Conclusion

According to the studies included in our narrative review, there is an elevation of the plasma concentration of vitamin D both with physical activity indoors and outdoors. However, randomized controlled trials are needed to compare the synthesis of vitamin D (serum level) associated with physical activity in both settings, so that the difference between the groups would be the incidence or absence of sunlight alone.

Resumo

Associação entre atividade física e vitamina D: revisão narrativa da literatura

Esta revisão narrativa da literatura avaliou se tanto a atividade física realizada ao ar livre quanto aquela em ambiente interno aumentariam os níveis plasmáticos da vitamina D. A síntese dessa vitamina lipossolúvel ocorre, principalmente, por meio da radiação solar na pele, que, após sofrer processo de ativação no organismo, estabelece sua principal ação no controle dos níveis séricos do cálcio, assim que é absorvido no trato intestinal, auxiliando na regulação do metabolismo ósseo. Atividade física é qualquer movimento corporal que resulte em gasto energético, enquanto atividade física ao ar livre é aquela realizada em parques ou praças, cuja prática mais popular é a caminhada. Esse ambiente externo teria os benefícios propriamente ditos da atividade física, além da exposição solar com a

síntese da vitamina D. Entretanto, segundo os estudos apresentados, há elevação da concentração plasmática da vitamina D na realização de atividade física tanto em ambiente interno quanto ao ar livre.

Palavras-chave: vitamina D, atividade física, exposição ambiental, luz solar, ambiente externo de trabalho.

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