

# The effects of indoor and outdoor sports participation and seasonal changes on vitamin D levels in athletes

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## Abstract

**Objective:** Nowadays, people tend to spend more time in the closed areas and benefit less from sunlight. In this study, we examined the results of vitamin D measurements of athletes from different disciplines in different months and aimed to determine if the synthesis of vitamin D decreases or not according to exercise environment and month.

**Methods:** The study was conducted in participants aged 5–52 years. A total of 555 elite-level sportsmen who were admitted to our Sports Medicine Clinic in the study participated in this study. Indoor and outdoor environmental and seasonal effects on the measurements in different months were statistically evaluated. Independent-samples test and definitive statistics were used for statistical analyses and a p-value less than 0.05 has been considered significant.

**Results:** The study group consisted of 229 male and 326 female athletes. The serum 25-hydroxyvitamin D concentration was observed; 120 (21.6%) athletes have severe serum vitamin D deficiency (<11–20 ng/mL). Vitamin D levels were not significantly different from outdoor athletes (393; 70.8%). Winter measurements of vitamin D levels were significantly lower than those measured in autumn (p=0.000).

**Conclusion:** Increasing vitamin D levels are very important especially in participating athletes and additional supplements are recommended whenever necessary. Gender and indoor/outdoor sports participation showed no statistically significant outcomes on vitamin D levels. However, winter season had a negative effect on vitamin D levels. Therefore, adequate precautions should be taken to increase vitamin D, especially during winter, to maintain the best performance of the athletes.

## Keywords

Athletes, seasonal change, vitamin D, indoor, outdoor

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## Introduction

Understanding the utility of vitamin D in extrasosseous processes such as the immune system, cell proliferation, differentiation, and hormone regulation has resulted in an increased attention to this hormone. In this way, its effects on various systems are being highlighted in an increased manner.<sup>1</sup>

In normal conditions, 90%–95% of vitamin D in human body is formed in the skin tissue from sunlight. Ultraviolet B (UVB) rays convert provitamin D (7-dehydrocholesterol) to previtamin D<sub>3</sub> and then to vitamin D<sub>3</sub>. Any obstacle that prevents 290- to 310-nm UVB from reaching the earth surface or human skin tissue results in vitamin D deficiency.<sup>2</sup>

Plasma 25(OH)D levels are dependent on some unchangeable factors (season, time of day, elevation above sea level, local weather condition, air pollution, atmospheric characteristics, and latitude), changeable lifestyle factors (clothing,

dietary habits, daily routine, time spent outdoor, obesity, use of a sun protection cream), and unchangeable personal factors (race, pigmentation, skin thickness, and age).<sup>3</sup>

Even though there is a discrepancy regarding the ideal level of vitamin D, many studies showed that a worldwide vitamin D deficit occurs, especially in winter.<sup>4–6</sup>

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Muscle and fat tissues of athletes store 40 ng/mL of vitamin D. The 25(OH)D target of 40 ng/mL is recommended for athletes because at this level vitamin D begins to be stored in the muscle and fat for future use. Furthermore, at levels below 32 ng/mL, vitamin D is not likely to be readily available for the advanced processes involved in the autocrine pathways, which is the pathway that is most likely to influence performance. This amount can be utilized whenever necessary. The performance of the muscles is impaired if the level of vitamin D falls below 32 ng/mL.<sup>7,8</sup> The first symptoms of vitamin D deficiency are muscle weakness, hypotonia, and prolonged muscle contraction accompanied by prolonged muscle relaxation,<sup>9</sup> which may affect any athlete. Severe vitamin D deficiency, particularly with 25(OH)D levels less than 12 ng/mL, leads to osteomalacic myopathy characterized by severe muscle weakness and pain.<sup>10</sup>

An increase in vitamin D level may result in several benefits in the muscular and skeletal systems of athletes. Their protein synthesis and adenosine triphosphate (ATP) concentration in the muscle tissue increase, and as a result their muscle strength, jumping height, jumping power, exercise capacity, and physical performance increase. However, conversely, the tendency to stress fractures decreases.<sup>11</sup> The results of a meta-analysis of 23 studies including 2313 athletes from all around the world showed that 56% of the athletes had inadequate vitamin D levels. Vitamin D inadequacy risk in athletes significantly increases in higher latitudes, in winter and early spring seasons, and for indoor sport activities.<sup>12</sup>

## Methods

Approval of the Research Ethics Committee and Hospital Training Planning Board was obtained prior to the study. Medical records of the athletes who had applied to our institution for routine medical checks from 2014 to 2015 were retrospectively evaluated. For the study, 555 athletes (229 males and 326 females; mean age: 15.9 (range: 5–52) years) from 44 different disciplines who were admitted to the Sports Medicine Clinic of our hospital for license renewal from September 2014 to February 2015 have been recruited. Past vitamin D measurements were acquired retrospectively from the medical database archive of the hospital. Exclusion criteria were malignancy, inflammatory joint disease, diabetes mellitus, neuromuscular disease, generalized cardiovascular disorder, thyroid/parathyroid dysfunction, and the use of antiepileptic, steroid, anticoagulant, and antiandrogenic drugs. Non-fasted venous blood samples were collected in the morning. The participants were asked to refrain from exercise for at least 24 h before blood collection.

We assessed the predominantly performed sport based on indoor and outdoor types (e.g. ballet, dance, defense sports, gymnastics, basketball, volleyball for indoor and football and athletics for outdoor sports).

The deficiency and insufficiency classification criteria from the “Diagnosis and Treatment Guideline for Metabolic Bone Disorders” published by The Society of Endocrinology and Metabolism of Turkey were used. According to this guideline, patients were classified under severe vitamin D deficiency (serum 25(OH)D < 10 ng/mL), vitamin D deficiency (serum 25(OH)D < 11–20 ng/mL), vitamin D insufficiency (serum 25(OH)D < 21–30 ng/mL), and sufficiency of vitamin D (serum 25(OH)D > 30 ng/mL) groups. 25-OH-VD levels were measured using a Zivak Tandem Gold (Zivak Technologies, Istanbul, Turkey) LC-MS/MS analysis device by liquid chromatography and mass spectrometry.<sup>13</sup>

Data analysis was performed using SPSS for Windows v.14 software. Significance of the difference between the mean values of the groups was evaluated using sample t-test. The p-values less than 0.05 were considered significant.

## Results

Vitamin D values according to the age groups were  $21.4 \pm 14.3$  ng/mL for ages between 5 and 17,  $15.1 \pm 9.6$  ng/mL for ages between 18 and 30, and  $19.5 \pm 11.4$  ng/mL for ages above 30. The difference between the 5–17 age group and the 18–30 age group and the difference between the 18–30 age group and the above-30 age group were statistically significant ( $p=0.000$  and  $0.026$ , respectively), whereas there was no difference between the 5–17 age group and the above-30 age group. Mean vitamin D values in the outdoor athletes were 23.7 and 17.2 ng/mL for the fall and winter seasons, respectively. Vitamin D values of the indoor athletes during fall and winter were measured as 29.1 and 16.7 ng/mL, respectively. There was no significant effect of the sports environment on mean vitamin D values (Table 1).

Of the subjects, 229 (41.3%) were male and 326 (58.7%) were female. There was no difference in vitamin D levels between the two gender groups ( $p=0.437$ ). Of the athletes, 120 (21.6%) demonstrated severe deficiency (serum 25(OH)D < 11–20 ng/mL), 237 (42.7%) had deficiency (serum 25(OH)D < 11–20 ng/mL), and 108 (19.5%) had insufficiency (serum 25(OH)D < 21–30 ng/mL). Only 90 athletes (16.2%) had adequate levels of vitamin D. A total of 393 athletes (70.8%) performed indoor sports and 162 did outdoor sports. There was no difference between these two groups ( $p=0.054$ ) in terms of vitamin D levels. The mean vitamin D level in the winter (16.92 ng/mL) showed a statistically significant decrease when compared to the fall value (28.13 ng/mL;  $p=0.000$ ; Table 2).

## Discussion

Our results show that vitamin D insufficiency is prevalent in Turkish athletes, with 19.5% of the athletes presenting a vitamin D insufficiency (serum 25(OH)D < 21–30 ng/mL) and 42.7% with vitamin D deficiency (serum 25(OH)

**Table 1.** Vitamin D values in different age groups and vitamin D values of indoor and outdoor athletes for autumn and winter.

Age group	N	Vitamin D (ng/mL), mean $\pm$ SD	p-value	
5–17	409	21.4 $\pm$ 14.3	0.000*	
18–30	110	15.1 $\pm$ 9.6	0.440**	
30+	36	19.5 $\pm$ 11.4	0.026***	
Feature				
Autumn months	Outdoor athletes	29	23.7 $\pm$ 15.7	0.132
	Indoor athletes	126	29.1 $\pm$ 17.8	
Winter months	Outdoor athletes	133	17.2 $\pm$ 9.6	0.643
	Indoor athletes	267	16.7 $\pm$ 10.3	

SD: standard deviation.

\*Comparison between the 5–17 and 18–30 age groups.

\*\*Comparison between the 5–17 and 30+ age groups.

\*\*\*Comparison between the 18–30 and 30+ age groups.

**Table 2.** Mean vitamin D levels in the groups.

Classification of vitamin D level	N	Percentage	
Severe deficiency (<10)	120	21.6	
Deficiency (<11–20)	237	42.7	
Insufficiency (<21–30)	108	19.5	
Sufficiency (>30)	90	16.2	
Feature	n	Vitamin D (ng/mL), mean $\pm$ SD	p-value
Female	229	19.35 $\pm$ 14.83	0.437
Male	326	20.54 $\pm$ 12.61	
Feature	n	Vitamin D (ng/mL), mean $\pm$ SD	p-value
Outdoor athletes	162	18.40 $\pm$ 11.15	0.054
Indoor athletes	393	20.73 $\pm$ 14.41	
Feature	n	Vitamin D (ng/mL), mean $\pm$ SD	p-value
Autumn months	155	28.13 $\pm$ 17.53	0.000*
Winter months	400	16.92 $\pm$ 10.10	

SD: standard deviation.

D < 11–20 ng/mL). In addition, the 25-OH-VD concentrations at the lowest point in winter were 7 and 5 ng/mL in athletes who did indoor and outdoor sports, respectively. Latitude of the countries plays a major role in the seasonal change of the vitamin D values. Between November and February, countries located on and beyond the 37th parallel north receive sunlight by a much more oblique angle and most of the rays are absorbed by the ozone layer of the atmosphere, which leads to the lack of vitamin D synthesis during this period. Due to receiving less UVB during winter, people living in the northern countries, located beyond the 37th parallel, tend to have vitamin D deficiency.<sup>14,15</sup> Therefore, some countries such as Norway, Denmark, Belgium, and Portugal have regulations regarding vitamin D supplementation with margarine. Some Southern European countries like Greece, Italy, and Spain do not have such regulations and vitamin D deficiency is nearly 90% in

these countries during winter.<sup>16</sup> Otherwise, vitamin D deficiency can be seen in countries even if their location permits endogenous synthesis throughout all the year. A study conducted on 20 runners between the ages of 19 and 45 living at 30°N found that 40% of the subjects had insufficient vitamin D (25(OH)D < 32 ng/mL); however, no correlation was detected between the vitamin D level and the season, gender, weekly training schedule, or vitamin D supplementation.<sup>17</sup> In our country, there are no policies regarding supplementation and fortification of foods with vitamin D. Children's only support of vitamin D sunlight in summer which cannot in during winter time.

Differences in vitamin D levels were also found when comparing the indoor and outdoor sports. Yet, these variations were only found during fall, winter, and spring when athletes who practice indoor sports already present low vitamin D levels.<sup>11</sup> Seasonal changes of vitamin D levels were

also evaluated in the English Premier League players ( $n=20$ ,  $53^{\circ}\text{N}$  parallel). Serum 25-OH-VD levels were measured at  $41.6 \pm 8.4$  (range: 27–60) ng/mL in August and at  $20.4 \pm 7.6$  (range: 8–34) ng/mL in December. The prevalence of vitamin D deficiency in winter months was 65% ( $<20$  ng/mL).<sup>18</sup> 25(OH)D3 levels decreased significantly in Italy Series A soccer players (mean age:  $28 \pm 4$  years) during the months of the fall and winter but showed no difference in the other months.<sup>19</sup> In this study, 25-OH-VD levels of indoor sports athletes were measured at  $29.1 \pm 17.8$  ng/mL in fall and  $16.7 \pm 10.3$  ng/mL in winter. Turkey is located between the 36th and 42nd northern parallels. The prevalence of severe vitamin D deficiency in our athletes was 21.6% ( $<10$  ng/mL). Our vitamin D measurements showed deficiency (28.1 ng/mL) in fall and insufficiency (16.92 ng/mL) in winter. As stated in previous studies, we also found a significant decrease in vitamin D during winter. Despite the variable results, geographical location (latitude) and gender do not seem to effect vitamin D deficiency in athletes. Conversely, indoor sports and inadequate exposure to sunlight seem to be the major risk factors for this condition.<sup>20</sup> We also did not find any gender-related differences. In a study conducted on the National Collegiate Athletic Association (NCAA) players, the measurement of indoor sports performers like wrestlers, basketball players, and swimmers and outdoor sports performers like football players, track and field, and athletics ( $n=41$ ) revealed that vitamin D concentrations above 40 ng/mL were measured in 75.6% of the players in fall, 15.2% in winter, and 36% in spring.<sup>21</sup> Comparison of the two groups showed that outdoor athletes had higher vitamin D values; however, they had significantly lower vitamin D concentrations. Another study was conducted on 98 athletes, aged between 10 and 30, and the concentration of 25(OH)D was evaluated regarding age, gender, and the sports branch, and vitamin D deficiency (25(OH)D  $<30$  ng/mL) was detected in 73% of the study group.<sup>22</sup> Dancers (94%), basketball players (94%), and taekwondo players (67%) demonstrated deficiency. The deficiency rate was 48% in outdoor athletes and 80% in indoor athletes. In our study, the prevalence of vitamin D deficiency was 59% in outdoor athletes and 64% in indoor athletes.

A cross-sectional study showed that vitamin D deficiency or insufficiency was quite frequent among 18 female elite gymnasts aged between 10 and 17. Dietary calcium intake was low in 13 athletes, and in 6 subjects vitamin D levels were below 20 ng/mL (8 ng/mL; 33% insufficiency). This finding also supports the importance of vitamin D deficiency in indoor sports performers who cannot adequately benefit from sunlight (83% deficiency).<sup>23</sup> In this study, 25-OH-VD levels in 35 of the 229 female athletes (15.3%) were less than the borderline insufficiency at 20 ng/mL (71.6% deficiency). These results demonstrated that vitamin D deficiency manifests as an intense issue even in athletes.

Outdoor athletes are presumed to have a greater advantage regarding vitamin D sufficiency. Conversely, as shown in several studies, participating in outdoor sports alone may

not be enough to provide sufficient levels of vitamin D. It is stated that seven male cyclers, aged between 20 and 39, who mostly perform outdoor exercises ( $43^{\circ}\text{N}$ ) had vitamin D levels just around the lowest limit or below.<sup>24</sup> Vitamin D levels of 54 male horse riders aged between 13 and 16 and living at  $49^{\circ}\text{N}$  were followed up for 18 months. Their vitamin D level measurements were 28.8 ng/mL in summer and 8 ng/mL in winter.<sup>25</sup> Vitamin D levels of 93 surfers from Hawaii (30 women and 63 men) were evaluated and the maximal 25(OH)D concentration by excess exposure to sunlight reached 60 ng/mL.<sup>26</sup> Otherwise, 51% of those subjects had a low level of vitamin D. In another study carried out in Spain on 408 athletes performing 34 different sports disciplines, the results revealed that 82% of the subjects had vitamin D levels below the optimal level ( $<30$  ng/mL). Synchronized swimmers who exercise all day long in the open air had higher 25(OH)D concentrations than those training only in the morning or late in the evening.<sup>27</sup>

Athletes may not increase their vitamin D levels beyond a certain point even if they exercise in an open air environment. This is caused by the inappropriate exercise hours that will not permit enough exposure to sunlight and high protective factor ingredients of the materials used (they used Sun Protection Factor 30 for protection). In a survey study, 110 athletes from New Zealand were asked about their concern regarding vitamin D levels and skin cancer. It turned out that the subjects were much more anxious about the possibility of skin cancer. Unfortunately, athletes had less knowledge about vitamin D supplements than the normal population.<sup>28</sup>

Another study examining different sports disciplines did not reveal any differences in vitamin D levels between the volleyball, lacrosse, and football players. Besides, there was no difference between indoor and outdoor sports players in terms of vitamin D deficiency.<sup>29</sup> This finding is similar to our study.

Peeling et al.<sup>30</sup> found that 25(OH)D level in a young indoor athlete was significantly lower compared to those who performed outdoors athletics or a mixture of both. This study showed that the vitamin D levels in the Turkish indoor athletes were lower during the winter months compared to the outdoor athletes. Outdoor athletes' levels were lower during the fall months compared to the indoor athletes.

Synthesis of vitamin D decreases gradually by age. In addition, longer exposure periods are needed for people who have a darker skin color, especially in winter. We observed significantly lower levels of vitamin D in the 5–17 and 18–30 age groups. Conversely, we found significantly higher levels of older age groups.

The most stable and major metabolite of vitamin D in serum is 25(OH)D and its half-life is 3 weeks. A vast majority of circulating vitamin D is 25(OH)D and therefore it is accepted as the best indicator in determining the vitamin D levels. It also represents both intake and endogenous production. We also used 25(OH)D measurements in our study.<sup>31</sup> Valtueña et al.<sup>27</sup> found that outdoor physical training is the most appropriate way to increase the plasma concentration of vitamin D in athletes.



Three independent lines of evidence, age-related changes in muscle function, muscle morphology, and the presence of the vitamin D receptor (VDR) in muscle cells, support the proposition that vitamin D may play a significant role in the muscle function. However, athletic performance at all levels is multifactorial. Vitamin D deficiency is performance limiting, or the maintenance of vitamin D at supraphysiological levels will result in enhanced muscle development and performance.<sup>32</sup>

There are some limitations to our study that have to be acknowledged. Comparison between different literature results is difficult because the differences between demographic information of the selected individuals, geographical varieties, and the different methods of measuring 25(OH)D. Prospective and randomized studies exploring the cause and outcome correlation are necessary to better understand the relationship between athletes and vitamin D deficiency. The evaluation of risk factors and other parameters related to vitamin D together would be a more suitable approach. Our study bears additional value because there are not any other studies carried out with athletes in Turkey.

Individualization of the treatment should be considered by monitoring the 25(OH)D3 variation of each athlete. Also, governmental policies can be developed to add supplements to some nutritional products as performed in some countries. We should also pay more attention to high-risk athletes, indoor sports performers, and those who cannot benefit enough from sunlight. Open air training programs can be planned to increase the duration of sunlight exposure (e.g. 1.5 h during winter between 10:30 and 12:00; scheduled sun exposure should be planned during summer). Vitamin D supplements should be taken during winter if necessary.

## Conclusion

Increasing the vitamin D levels is very important, especially in the participation athletes, and additional supplements are recommended whenever necessary. No statistically significant relationship was found between gender, indoor/outdoor sports participation, and vitamin D levels. However, the winter season had a negative effect on vitamin D levels. Therefore, adequate precautions should be taken to increase the vitamin D level, especially during winter to maintain the best participation. Further studies are needed to evaluate vitamin D deficiency-related seasonal and indoor-outdoor sports.

## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Ethical approval

Ethical approval for this study was obtained from the Institutional Review Board of Baltalimani Metin Sabanci Bone and Joint Diseases Training and Research Hospital (Approval No./ID: 08-06-2015/26).

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## Informed consent

Written informed consent was obtained from all the subjects before the study.

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