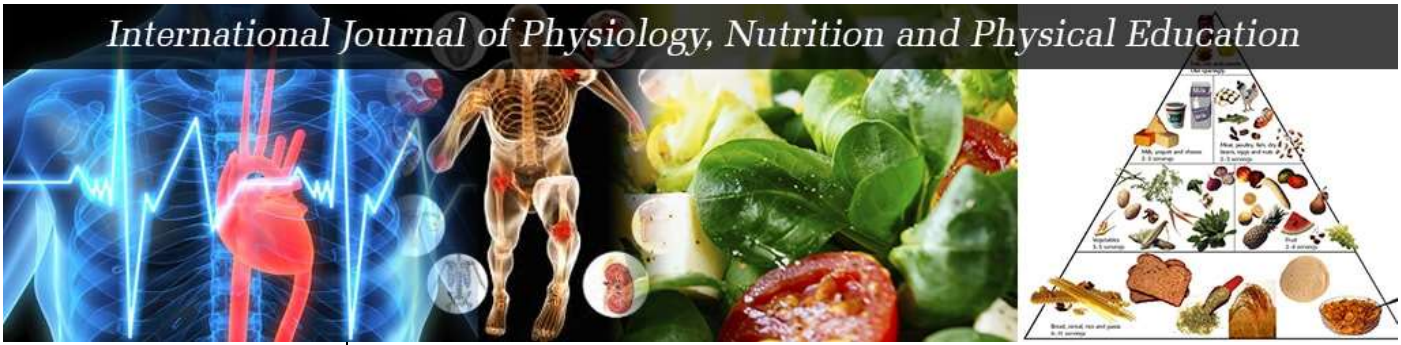
International Journal of Physiology, Nutrition and Physical Education 2024; 9(2): 08-12



ISSN: 2456-0057
IJPNPE 2024; 9(2): 08-12

www.journalofsports.com
Received: 06-05-2024
Accepted: 09-06-2024

Usha Sri Kaniganti
(1) Scientific Officer, Department of Exercise Biochemistry, Sports Authority of India, NSSC, Bengaluru, Karnataka, India
(2) Ph.D. Scholar, Department of Biochemistry, Bangalore University, Bengaluru, Karnataka, India

Dr. CS Karigar
Professor, Department of Biochemistry, Bangalore University, Bengaluru, Karnataka, India

Corresponding Author:
Usha Sri Kaniganti
(1) Scientific Officer, Department of Exercise Biochemistry, Sports Authority of India, NSSC, Bengaluru, Karnataka, India
(2) Ph.D. Scholar, Department of Biochemistry, Bangalore University, Bengaluru, Karnataka, India

Relationship between serum 25-hydroxy vitamin D and intact parathyroid hormone levels in Indian athletes: Implications for bone health

Usha Sri Kaniganti and Dr. CS Karigar

DOI: https://doi.org/10.22271/journalofsport.2024.v9.i2a.2929

Abstract
Vitamin D is crucial for various bodily functions, including bone health, immune response, and muscle activity. Athletes, especially those who play indoors are more susceptible to vitamin D deficiency. Numerous studies have demonstrated that suboptimal vitamin D levels could lead to secondary hyperparathyroidism (SHPT) which in turn might lead to increased bone resorption and weakened bones.
Objective: To evaluate the relationship between serum 25-hydroxy vitamin D, parathyroid hormone, alkaline phosphatase, calcium, and phosphate levels among Indian athletes.
Materials & Methods: A total of 240 athletes (90 Female athletes and 150 male athletes), with an average age of 21.51±4.23 years, an average weight of 61.02±11.25 kg, and an average height of 170.15±8.96 cm, were included in this study. Participants were being trained in different sports disciplines such as Athletics, Hockey, Taekwondo, and Weightlifting. Blood samples were collected to evaluate various bone health parameters, including 25(OH) vitamin D, intact parathyroid hormone (iPTH), alkaline phosphatase (ALP), serum calcium, and phosphate levels.
Results and Discussion: The data was analyzed using SPSS software (version 23.0). All values are presented as mean±standard deviation. The Spearman's rho correlation analysis will be employed to examine the linear relationship between 25(OH) vitamin D, iPTH, serum calcium, and phosphate, considering the non-normal distribution of data and potential outliers.
Conclusion: The study highlights significant correlations between vitamin D status, iPTH, and ALP levels, underscoring the pivotal role of vitamin D in bone health and metabolism. Outdoor players with higher vitamin D levels exhibited lower iPTH and ALP levels compared to indoor players. Players maintaining vitamin D levels above 30 ng/mL demonstrated lower iPTH and ALP levels, indicating enhanced bone health.

Keywords: Intact parathyroid hormone, hypovitaminosis D, secondary hyperparathyroidism, 25-hydroxy vitamin D

Introduction
Vitamin D plays a crucial role in various physiological processes, including bone health, immune function, and muscle metabolism [1]. Studies have reported suboptimal vitamin D levels in athletes, particularly in indoor athletes. Factors contributing to suboptimal vitamin D levels in athletes include inadequate sun exposure, increased sunscreen use, geographical location, and skin pigmentation. Additionally, modern training regimes often involve indoor practices and competitions, further limiting the opportunity for natural vitamin D synthesis [2].

Consequences of Vitamin D Deficiency include
Impaired Musculoskeletal Health: Vitamin D is essential for calcium absorption and bone mineralization. Inadequate levels can lead to decreased bone density, increasing the risk of stress fractures, muscle weakness, and osteoporosis [3].

Decreased Athletic Performance: Vitamin D deficiency has been associated with reduced muscle strength, endurance, and overall athletic performance. Athletes may experience decreased power, speed, and agility, all of which are critical in competitive sports [4, 5, 6, 7, 8].

Compromised Immune Function: Vitamin D plays a pivotal role in modulating the immune system [9]. Vitamin D-deficient athletes may be more susceptible to infections and illnesses, potentially leading to missed training sessions and competitions [10].

Prolonged recovery times: Inadequate vitamin D levels can delay the recovery process after intense exercise or injuries. This can hinder the athlete's ability to return to peak performance [11, 12, 13].

Increased risk of chronic diseases: Emerging research suggests that vitamin D deficiency may be linked to a higher risk of chronic conditions such as cardiovascular disease, diabetes, and certain types of cancer. These risks can be exacerbated in athletes who may already face heightened physical stress [14, 15].

Parathyroid hormone response in vitamin D deficiency

Vitamin D inadequacy is often reported to be associated with elevated intact parathyroid hormone (iPTH) levels due to secondary hyperparathyroidism and this can lead to increased bone resorption (breakdown) and decreased bone mineral density (BMD) over time, potentially resulting in weakened bones [16, 17, 18, 19, 20].

This study aims to correlate the levels of 25(OH) D with intact PTH levels and other bone health markers such as alkaline phosphatase (ALP), calcium, and phosphate among Indian athletes.

Materials and Methods

A total of 240 athletes (90 Female athletes and 150 male athletes), with an average age of 21.51 years (SD = 4.23) were included in this study. Thirty-two participants were from indoor sports (Taekwondo-21; Weightlifting-11) and 208 from outdoor sports (Athletics-131; Hockey-77). The average weight of the participants was 61.02 kg (SD = 11.25), and their average height was 170.15 cm (SD = 8.96). The participants were selected from the pool of athletes who regularly underwent biochemical evaluations at the Department of Exercise Biochemistry, Sports Authority of India, NSSC, Bengaluru. Blood samples were collected to evaluate various bone health parameters, including 25(OH) vitamin D, intact Parathyroid hormone, ALP, serum calcium, and phosphate levels. To obtain other details related to health status, history of hospitalization, medication usage, supplementation practices, and dietary habits, comprehensive questionnaires were filled in by the participants. Before they took part in the study, all participants were briefed about the objectives and procedures of the study. Written informed consent was obtained from all participants, ensuring their understanding and voluntary agreement to take part in the research.

- **Inclusion and Exclusion criteria:** Both male and female athletes who are between 15-37 years of age with no known comorbidities were included in the study. Athletes with known illnesses of renal disease, liver disorder, endocrine disorders, and skin diseases were excluded from the study.
- **Specimen collection and assay:** All the participants refrained from sports training 24 hours before the sample collection (Pre-exercise) to avoid acute exercise-induced shifts in plasma volume. Overnight fasting blood samples were collected from the participants in a seated position from the median cubital vein into plain evacuated tubes with a clot activator. Following clotting, the samples were centrifuged at 1500 g for 10 minutes to separate the serum for analysis. 25(OH) vitamin D levels were analyzed by using 25(OH) vitamin D ELISA kit by Calbiotech. iPTH levels were measured by an ELISA kit from Calbiotech. ALP, serum calcium, and phosphate levels were measured by using an Erba em360 fully automated biochemistry analyzer.
- **Statistical Analysis:** The collected numerical data were analyzed using SPSS software, version 23.0. All values are presented as mean±standard deviation and descriptive statistics are provided separately for total participants, as well as indoor and outdoor players. The Spearman's rho correlation analysis was employed to examine the linear relationship between 25(OH)vitamin D, iPTH, ALP, serum calcium, and phosphate levels across the entire dataset, considering the non-normal distribution of data and potential outliers. Further participants were divided into three groups based on the vitamin D levels: vitamin D deficient Group (25(OH)D: < 20 ng/mL), vitamin D insufficient Group (25(OH)D: 20 to 30 ng/mL), and vitamin D sufficient Group (25(OH)D:30 to 100 ng/mL). Descriptive statistics were performed to examine the levels of calcium, phosphate, and intact parathyroid hormone (iPTH) across these three groups.

Results and Discussion

Table 1: Basic details of the participants (N= 240)

Variable	Mean±SD
Age	21.51±4.23
Weight	61.02±11.25
Height	170.15±8.96

Table 2: Descriptive statistics

Parameters	Total Mean±SD. N= 240	Indoor players Mean±SD. N= 32	Outdoor players Mean±SD. N= 208
25(OH)D (ng/ml)	35.52±16.83	22.00±6.91	37.60±16.95
iPTH (pg/ml)	19.89±11.97	23.36±19.15	19.35±10.42
ALP (U/L)	83.42±29.52	95.28±43.18	81.59±26.5
Calcium(mg/dl)	9.96±0.57	10.0±0.42	9.94±0.59
Phosphate (mg/dl)	3.75±0.46	3.70±0.47	3.76±0.46

Table 3: Group wise descriptive of 25(OH)D, iPTH, ALP, calcium, phosphate, and levels

Parameters	25(OH)D Deficient Group (N= 25)	25(OH)D Insufficient Group (N=81)	25(OH)D Sufficient Group (N=134)
25(OH)D (ng/mL)	15.88±2.38	25.06±2.82	45.51±16.24
iPTH (pg/mL)	25.60±20.12	21.18±9.55	18.04±10.91
ALP (U/L)	90.68±33.82	90.53±31.54	77.76±26.24
Calcium (mg/dL)	10.09±0.41	9.85±0.52	10.00±0.61
Phosphate (mg/dL)	3.64±0.42	3.87±0.46	3.70±0.45

Table 4: Correlation analysis between 25(OH)D, iPTH, ALP, calcium, and phosphate levels

Variable	25(OH)D (ng/mL)	iPTH (pg/mL)	ALP (U/L)	Calcium (mg/dL)	phosphate (mg/dL)
25(OH)D (ng/ml)	1.000				
iPTH (pg/mL)	-.235**	1.000			
ALP (U/L)	-251**	.111	1.000		
Calcium (mg/dL)	.036	-.175**	-.056	1.000	
Phosphate (mg/dL)	-.102	.012	.230 **	-.018	1.000

Note: ** Correlation is statistically significant at the level *p*<0.01.

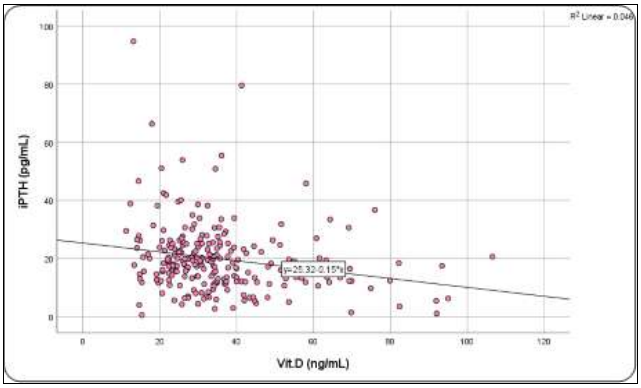


Image I: Correlation between 25(OH)D and iPTH levels

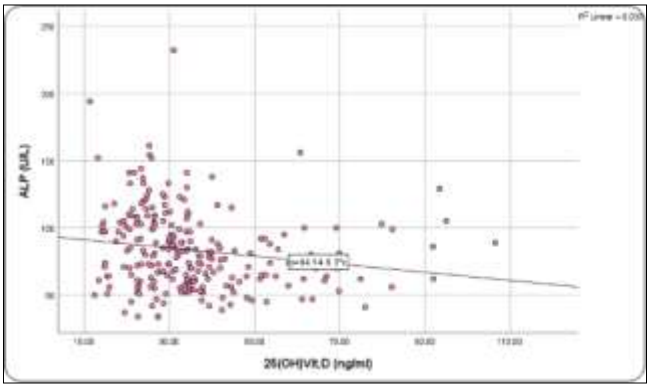


Image II: Correlation between 25(OH)D and ALP levels

The results presented in Table 2 reveal that outdoor players have slightly higher 25(OH)D levels (37.60±16.95 ng/mL) compared to indoor players (22.00±6.91 ng/mL). Moreover, the intact parathyroid hormone (iPTH) levels are marginally higher in indoor players (23.36±19.15 pg/mL) relative to outdoor players (19.35±10.42 pg/mL), suggesting a potential rise in iPTH levels due to low vitamin D levels. Additionally, indoor players also displayed higher levels of ALP (95.28±43.18 U/L) compared to outdoor players (81.59±26.5 U/L) demonstrating the role of vitamin D on bone metabolism. However, the calcium and phosphate levels remain stable across both groups, highlighting the effective homeostatic regulation. The findings of the present study are consistent with those previously reported by Barsan *et al* and Arya *et al*., thus reinforcing the robustness of our results [21], [22]. These findings suggest that outdoor players benefit due to greater sunlight exposure, resulting in comparatively high 25(OH)D levels and low iPTH and ALP levels. In contrast, indoor players, with low vitamin D and high iPTH and ALP levels, may require interventions such as increased sunlight exposure or vitamin D supplementation to mitigate the risk of vitamin D deficiency or insufficiency and associated health problems. However, it is important to notice that only thirty-two participants practicing indoor sports engaged in this study, which is comparatively lower than the number of participants engaged in outdoor sports.

The results presented in Table 3 reveal an inverse relationship between 25(OH)D and iPTH levels. iPTH levels are highest in the vitamin D-deficient group (25.60±20.12 pg/mL), lower in the insufficient group (21.18±9.55 pg/mL), and lowest in the sufficient group (18.04±10.91 pg/mL). Our results align with the observations made by Gupta *et al*. These findings emphasize the importance of maintaining adequate vitamin D levels to prevent elevated iPTH and the associated health risks.

The analysis of ALP levels across the different 25(OH)D groups reveals notable variations as presented in Table 3. The deficient group exhibited an average ALP level of 90.68±33.82 U/L, which is comparable to that of the insufficient group 90.53±31.54 U/L. However, the sufficient group demonstrated a notably lower average ALP level of 77.76±26.24 U/L. These findings suggest that higher 25(OH)D levels are associated with lower ALP levels, underscoring the potential role of vitamin D in bone metabolism. Mckenna *et al*. also reported elevated ALP levels in elderly Irish people with hypovitaminosis D [23].

The correlation matrix in Table 4 presents insights into the relationships between serum levels of 25(OH)D, iPTH, ALP, calcium, and phosphate.

25(OH)D and iPTH: There is a significant negative correlation between 25(OH)D and iPTH levels (r = -0.235, $p<0.01$), indicating that higher vitamin D levels are associated with lower iPTH levels. The scatter plot depicted in image I illustrates the relationship between vitamin D (ng/mL) and intact parathyroid hormone (iPTH) (pg/mL). The trend line $y=25.32-0.15x$ indicates a weak inverse relationship, with an R^2 value of 0.04. This suggests that having higher vitamin D levels might slightly reduce iPTH levels. This inverse relationship highlights the regulatory role of vitamin D in parathyroid hormone secretion and the risk of secondary hyperparathyroidism (SHPT) due to vitamin D deficiency. SHPT can lead to high bone resorption, mineralization defects, and fractures. Adequate vitamin D levels help in calcium absorption in the intestines, which might reduce the need for and secretion of parathyroid hormone (PTH) to maintain calcium homeostasis.

The study conducted by Lips *et al*. [24] reported that PTH levels decrease and attain a plateau when 25(OH)D levels are above 78 nmol/L (31.2 ng/mL). In our study, 49.2% of the participants had vitamin D levels below 31.2 ng/mL, and those with sufficient vitamin D levels exhibited low iPTH levels compared to the 25(OH)D insufficient and deficient groups. Webb *et al*. [25] observed that 73% of elderly participants with serum 25(OH)D concentrations between 20.0 and 37.5 nmol/L (8-15 ng/mL) had elevated circulating concentrations of PTH, suggesting that elderly people need to maintain 25(OH)D levels higher than 37.5 nmol/L (15 ng/mL) to keep their PTH within the normal range. In our study, only three participants had PTH levels above the normal range (>65 pg/mL); two of them had low 25(OH)D levels, while one had 25(OH)D levels in the normal range.

Our study observed a weak inverse correlation between vitamin D and iPTH levels, and the majority of participant's iPTH levels fell within the normal reference range (11-65 pg/mL). However, it is noteworthy that an exceedingly small percentage (<5%; 11 out of 240) of our participants had 25(OH)D levels less than 15 ng/mL, and research by Webb *et al*. (1990) reported that iPTH levels can increase due to secondary hyperparathyroidism when vitamin D levels fall below 15 ng/mL [25].

25(OH)D and ALP: There is a significant negative correlation between 25(OH)D levels and ALP (alkaline phosphatase) levels (r = -0.251, $p<0.01$). This inverse relationship suggests that higher vitamin D levels may contribute to lower ALP activity, reflecting potential benefits for bone metabolism and health. ALP is considered an indicator of bone metabolism and turnover and some researchers have suggested that elevated ALP levels can serve as a diagnostic indicator for vitamin D deficiency, particularly in cases of rickets and osteomalacia [23], [24], [26].

25(OH)D and Calcium: The correlation between 25(OH)D and calcium levels is positive but not statistically significant (r = 0.036). This suggests that although vitamin D aids in calcium absorption, other mechanisms might maintain stable calcium levels regardless of vitamin D variations. One such mechanism could be through parathyroid hormone (PTH), which regulates calcium levels. The study found a negative correlation between iPTH and calcium levels (r = -0.175, $p<0.01$). PTH rises when calcium levels are low to increase calcium by promoting bone resorption, enhancing kidney reabsorption, and facilitating enhanced intestinal absorption through activated vitamin D.

25(OH)D and Phosphate: There is a negative but non-significant correlation between 25(OH)D and phosphate levels (r = -0.102). This indicates that changes in vitamin D levels do not have a strong direct impact on phosphate levels. However, the correlation analysis shows a positive relationship between alkaline phosphatase (ALP) and phosphate levels (r = 0.230, $p<0.01$). This indicates that the higher ALP levels observed during suboptimal vitamin D are associated with improvements in phosphate levels in the participants.

Conclusion

The findings from the presented data highlight the critical role of vitamin D in maintaining bone health and metabolism. Outdoor players, benefiting from higher 25(OH)D levels due to increased sunlight exposure, exhibit lower iPTH levels, suggesting a reduced risk of secondary hyperparathyroidism compared to indoor players. Adequate vitamin D levels help prevent elevated iPTH and associated complications such as high bone resorption and fractures. The correlation analysis reveals a weak negative correlation between 25(OH)D and iPTH, emphasizing the importance of maintaining adequate vitamin D levels to manage iPTH and associated health risks effectively. Additionally, a significant inverse relationship between iPTH and calcium underscores the role of PTH in calcium homeostasis. Higher ALP levels are observed in participants with low vitamin D levels, indicating a potential impact of vitamin D deficiency on bone health and metabolism. However, the lack of direct significant correlations between 25(OH)D, calcium, and phosphate suggests the presence of robust homeostatic mechanisms that maintain stable calcium and phosphate levels independently of vitamin D variations. Further research could explore these relationships in larger sports populations, including bone-specific markers, to better understand the complex interactions between these variables. These insights emphasize the potential benefits of having sufficient vitamin D, particularly among individuals at risk of deficiency due to indoor lifestyles or limited sun exposure.

References

1. Larson-Meyer DE, Willis KS. Vitamin D and athletes. Curr Sports Med Rep; c2010. doi: 10.1249/JSR.0b013e3181e7dd45.
2. Willis KS, Peterson NJ, Larson-Meyer DE. Should we be concerned about the vitamin D status of athletes? Int J Sport Nutr Exerc Metab. 2008;18(2):204-24. doi: 10.1123/IJSNEM.18.2.204.
3. Larson-Meyer E. Calcium and Vitamin D. In: The Encyclopaedia of Sports Medicine. Chichester, UK: Wiley; c2013. p. 242-62. doi: 10.1002/9781118692318.ch20.
4. de la P Yagüe M, Yurrita LC, Cabañas MJC, Cenzual MAC. Role of vitamin d in athletes and their performance: current concepts and new trends. Nutrients. 2020;12(2). doi: 10.3390/nu12020579.
5. Barker T, *et al*. Higher serum 25-hydroxyvitamin D concentrations associate with a faster recovery of skeletal muscle strength after muscular injury. Nutrients. 2013;5(4):1253-75. doi: 10.3390/nu5041253.
6. Ceglia L. Vitamin D and skeletal muscle tissue and function. Mol Aspects Med; c2008. doi: 10.1016/j.mam.2008.07.002.
7. Girgis CM, Clifton-Bligh RJ, Hamrick MW, Holick MF, Gunton JE. The roles of vitamin D in skeletal muscle: Form, function, and metabolism. Endocr Rev. 2013;34(1):33-83. doi: 10.1210/er.2012-1012.
8. Cannell JJ, Hollis BW, Sorenson MB, Taft TN, Anderson JJB. Athletic performance and vitamin D. Med Sci Sports Exerc. 2009;41(5):1102-1110. doi: 10.1249/MSS.0b013e3181930c2b.
9. Maruotti N, Cantatore FP. Vitamin D and the immune system. J Rheumatol. 2010;37(3). doi: 10.3899/jrheum.090797.
10. He CS, Yong XHA, Walsh NP, Gleeson M. Is there an optimal Vitamin D status for immunity in athletes and military personnel? Exerc Immunol Rev. 2016;22.
11. Owens DJ, Allison R, Close GL. Vitamin D and the Athlete: Current Perspectives and New Challenges. Sports Med. 2018;48. doi: 10.1007/s40279-017-0841-9.
12. Heaton LE, *et al*. Selected In-Season Nutritional Strategies to Enhance Recovery for Team Sport Athletes: A Practical Overview. Sports Med. 2017;47(11):2201-18. doi: 10.1007/s40279-017-0759-2.
13. Owens DJ, Fraser WD, Close GL. Vitamin D and the athlete: Emerging insights. Eur J Sport Sci. 2015;15(1):73-84. doi: 10.1080/17461391.2014.944223.
14. Rai V, Agrawal DK. Role of Vitamin D in Cardiovascular Diseases. Endocrinol Metab Clin North Am. 2017;46(4):1039-59. doi: 10.1016/j.ecl.2017.07.009.
15. Holick MF. Vitamin D: Importance in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis. Am J Clin Nutr. 2004;79(3):362-371. doi: 10.1093/ajcn/79.3.362.
16. Ferrari P, Meneghello M, Zamboni F, Schenk K, Ferrari M. Annual variations of vitamin D levels and exercise capacity in Italian amateur cyclists. Med Sport. 2020;73(1). doi: 10.23736/S0025-7826.20.03653-4.
17. Gupta R, Bohat V, Kapoor A, Singhal A, Soni A, Masih G. High prevalence of Vitamin D deficiency among North Indian athletes. Indian J Community Med.

2021;46(3):559-561. doi: 10.4103/ijcm.IJCM_170_21.
18. Guillemant J, Cabrol S, Allemandou A, Peres G, Guillemant S. Vitamin D-dependent seasonal variation of PTH in growing male adolescents. Bone. 1995;17(6). doi: 10.1016/8756-3282(95)00401-7.
19. Viljakainen HT, *et al*. Wintertime vitamin D supplementation inhibits seasonal variation of calcitropic hormones and maintains bone turnover in healthy men. J Bone Miner Res. 2009;24(2):346-352. doi: 10.1359/jbmr.081009.
20. Ducher G, *et al*. Vitamin D Status and Musculoskeletal Health in Adolescent Male Ballet Dancers A Pilot Study.
21. Bârsan M, Chelaru VF, Râjnoveanu ȘL, Popa SL, Socaciu AI, Bădulescu AV. Difference in Levels of Vitamin D between Indoor and Outdoor Athletes: A Systematic Review and Meta-Analysis. Int J Mol Sci. 2023;24(8). doi: 10.3390/ijms24087584.
22. Arya V, Bhambri R, Godbole MM, Mithal A. Vitamin D status and its relationship with bone mineral density in healthy Asian Indians. Osteoporos Int. 2004;15(1):56-61. doi: 10.1007/s00198-003-1491-3.
23. McKenna MJ, Freaney R, Meade A, Muldowney FP. Hypovitaminosis D and elevated serum alkaline phosphatase in elderly Irish; c1985.
24. Lips P. Vitamin D Deficiency and Secondary Hyperparathy-roidism in the Elderly: Consequences for Bone Loss and Fractures and Therapeutic Implications; c2001. Available from: https://academic.oup.com/edrv/article/22/4/477/2424112.
25. Webb AR, Pilbeam C, Hanajin N, Holick MF. An evaluation of the relative contributions of exposure to sunlight and of diet to the circulating concentrations of 25-hydroxyvitamin D in an elderly nursing home population in Boston13; c1990. Available from: https://academic.oup.com/ajcn/article-abstract/51/6/1075/4695285.
26. Frame B. Osteomalacia: Current Concepts. Ann Intern Med. 1978;89(6):966-982. doi: 10.7326/0003-4819-89-6-966.