



Research Article

Prevalence and risk factors of vitamin D deficiency among a diverse cohort of Indian collegiate athletes

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Abstract

Objectives: Vitamin D is essential for optimal musculoskeletal function and athletic performance. While the prevalence of serum 25(OH)D levels below 20.00 ng/mL exceeds 70% in the general population of South Asian countries, research on vitamin D status in athletes from Asian countries, including India, remains limited. This study examines the extent of low serum cholecalciferol levels among Indian athletes and investigates the impact of gender and sport type (indoor vs. outdoor) on serum vitamin D levels.

Methods: Upon receiving consent, 331 athletes (male=243, female=88) who competed in various sporting events were recruited. A serum assay was undertaken to measure vitamin D, calcium, and parathyroid hormone. Serum 25(OH)D levels were categorized using the guidelines provided by the Endocrine Society Clinical Practices Guidelines. Statistical analysis was done using IBM SPSS 20.

Results: The study reported an average serum vitamin D level of 17.76±6.93 ng/mL. Only 8.2% of athletes had sufficient serum 25(OH)D, while 54.4% were deficient. The mean serum 25(OH)D level was significantly lower in female athletes compared to male athletes (15.72±5.92 ng/mL vs. 20.72±7.73 ng/mL, $p<0.001$), with females having a 4.32 times higher risk of vitamin D deficiency. Additionally, indoor athletes had lower mean serum 25(OH)D levels than outdoor athletes (49.24% vs. 74.63%, $p<0.001$), increasing their risk of deficiency by 3.03 times.

Conclusion: The rate of low serum cholecalciferol levels is high among athletes. Females and athletes partaking in indoor sports were at a higher risk for having lower vitamin D. Biannual serum assessments of those at risk for developing deficiency could help to better assess the situation.

Keywords: Athlete, cholecalciferol, deficiency, India, prevalence, vitamin D

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Lower vitamin D levels have been shown to hamper athletes' performance and increase their risk of muscle injuries, stress fractures, and upper respiratory tract infections. Research indicates a beneficial association between vitamin D levels with jump performance and muscle strength [1–4]. Analysis of serum 25-hydroxyvitamin D is a reliable investigation for measuring vitamin D levels but consensus regarding adequate serum 25(OH) D levels remains uncertain for

the general population due to various medical societies' different clinical and health approaches. Endocrine Society Clinical Practice Guidelines suggest that serum 25 (OH) D levels lower than 20 ng/mL as deficiency and insufficiency as levels between 20 and 29.99 ng/mL, while National Academy of Medicine (NAM) (previously known as Institute of Medicine) recommends a lower cut-off of >20 ng/ml as sufficient and <12 ng/mL as deficient [5, 6].

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The lower cut-off of >20.00 ng/ml of serum 25(OH)D has been recommended as sufficiency in a recent consensus statement for a clinical perspective for the public health to avoid over diagnosing and overtreatment [7]. Whereas, research on Indian population recommended an even lower cut-off of 13.5 ng/mL as the lower cut-off of normal range [8]. However, an accord has not been reached for what is a sufficient serum level for vitamin D among athletic population who might have higher demand and nutrient utilization, [9] but a few reports suggest that serum 25(OH) D above 40.00 ng/mL is optimal for maintaining health and optimizing performance in athletes [10].

A pooled prevalence study which included 7,947,359 participants showed that 76.6% had vitamin D levels <30ng/mL [11]. Reports indicate that among the global athletic population, 44–67% of athletes have inadequate serum 25(OH)D [12]. These high rates were linked to living in higher latitudes (>40° North or South), winter-spring months, lower-middle income countries, female gender, and the Eastern Mediterranean region [11]. In outdoor and indoor athletes, a slightly higher serum cholecalciferol was noted among outdoor athletes, but it could vary based on confounding factors such as season, latitude and race [13].

The magnitude of vitamin D inadequacy among the Indian adult population has been reported to be higher than 50%. A larger magnitude of vitamin D deficiency amid Indians could be attributed to darker skin tone, urbanization, increased use of sunscreens, cultural and religious restrictions that reduce skin surface exposure to sunlight, and genetic variations leading to lower serum 25(OH)D [14–16]. While multiple studies have been published regarding vitamin D status among healthy, pregnant, and lactating children in India, very few studies have focused on low vitamin D and the risk factors of among athletes. This study attempts to identify and classify the serum vitamin D levels among Indian athletes. It also aims to investigate the impact of gender and types of sports (indoor vs. outdoor) on vitamin D levels.

Materials and Methods

Athletes who resided in Tamil Nadu (13.0843° N, 80.2705° E), which is the south-eastern state of India, were recruited for the study after obtaining the Institutional Ethical Clearance. The study was approved by Sri Ramachandra Institute of Higher Education and Research Ethics Committee (No: IEC/22/APR/171/35, Date: 14/06/2022). The athletes were briefed about the importance of cholecalciferol and provided an overview of the research methodology. After receiving the participants' written informed consent, the data collection was completed for 331 athletes between August 2022 and November 2023, following the principles of the Declaration of Helsinki.

Both female (n=88) and male (n=243) athletes aged 18 to 25 years who actively participated in competitive events in team or individual sports and indoor or outdoor sports at national and international levels and trained for a mean total duration 20 hours per week were recruited. This duration was established to

ensure that the athletes were regularly training in their specific sport. Athletes who took vitamin D supplements in the six months leading to the study recruitment period and those who had any comorbidities, such as skin disease affecting melanin content and liver or renal disease that affected the metabolism and absorption of vitamin D, were not included in the study.

Demographic details such as age, gender, type of sport, and total training duration were collected. To ensure standardized data collection, a level 2 International Society for the Advancement of Kinanthropometry (ISAK) certified kinanthropometrist performed all anthropometric measurements, such as weight, height, girth, and skinfold thickness, following the ISAK guidelines [17]. A trained phlebotomist drew blood to analyze serum vitamin D, parathyroid hormone (PTH), and calcium levels.

Recommendations by the Endocrine Society Clinical Practices Guidelines and/or the National Academy of Medicine (NAM) are used globally (Table 1) [5, 6]. The results of this study are reported based on the serum cut-offs suggested by the Endocrine Society Clinical Practice Guidelines. The normal cut-offs for parathyroid hormone were 12–88pg/mL, and for calcium, was 8.8–10.6 mg/dL.

Statistical analysis

The prevalence rate of 83.7% low serum cholecalciferol (insufficient and deficient vitamin D levels) among athletes from a previous study conducted in India [18] was used to determine a minimum sample size of 285, considering a 99% confidence interval and 10% relative precision. Data analysis was completed using IBM SPSS 20 (SPSS Inc, Chicago, USA). Variables were calculated as mean±SD or percentage. The association between gender and type of sport and vitamin D status was identified using a chi-square test. Odds Ratio was performed to identify the group at higher risk for low vitamin D levels. P-value <0.05 was interpreted as statistically significant.

Results

Three hundred and thirty-one athletes were recruited for the study, who were further divided based on gender and type of sports for correlation. Of the 331 athletes (Mage=19.68±1.78 years), 73.4% were male (Mage=19.74±1.73 years), and 26.6% were female (Mage=19.30±1.56 years) athletes. When categorized based on sport, 79.46% of athletes participated in

Table 1. Vitamin D status categorisation

Status	NAM guidelines		Endocrine society	
	ng/mL	nmol/L	ng/mL	nmol/L
Deficient	<12	<30	<20	<50
Insufficient	12–20	30–50	20.01–29.99	50.01–74.99
Sufficient	>20	>50	>30	>75

NAM: National academy of medicine.

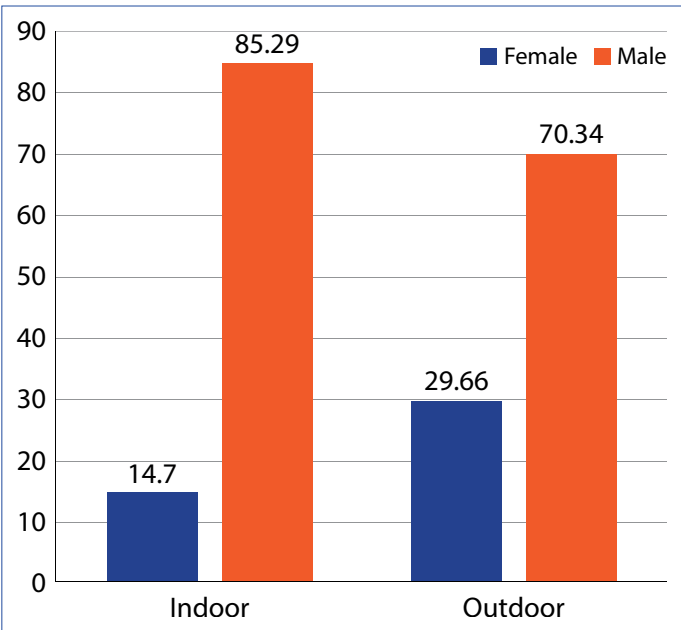


Figure 1. Distribution of gender across indoor and outdoor sports.

outdoor sports such as Athletics, Basketball, Cricket, Football, Hockey, Kabbadi, Kho-kho, Rowing, Tennis, Throwball, and Volleyball. In comparison, 20.54% played indoor sports such as Badminton, Combat sports, Shooting, and Swimming.

The distribution of athletes based on gender across the type of sports is provided in Figure 1.

The female athletes were found to train for significantly longer hours than their male counterparts (29.41 ± 8.05 vs 25.90 ± 7.88 , $p<0.001$). Biochemical details of the athletes based on gender and type of sports are given in Table 2.

The mean serum cholecalciferol levels were 17.76 ± 6.93 ng/mL, which is below the indication for deficiency set by Endocrine Society Clinical Practice Guidelines (<20.00 ng/ml). The mean serum calcium and PTH levels were 9.67 ± 0.38 mg/dL and 25.76 ± 14.99 pg/mL, respectively, both values were within the sufficient range.

In this study the use of categorisation by Endocrine Society Clinical Practices Guidelines indicated that only 8.2% had sufficient levels while 91.8% had low serum cholecalciferol (Fig. 2). Across genders, female athletes had significantly lower mean vitamin D levels (15.72 ± 5.92 ng/ml vs 20.72 ± 7.73 ng/ml, $p<0.001$) than male athletes. Deficiency rates among female

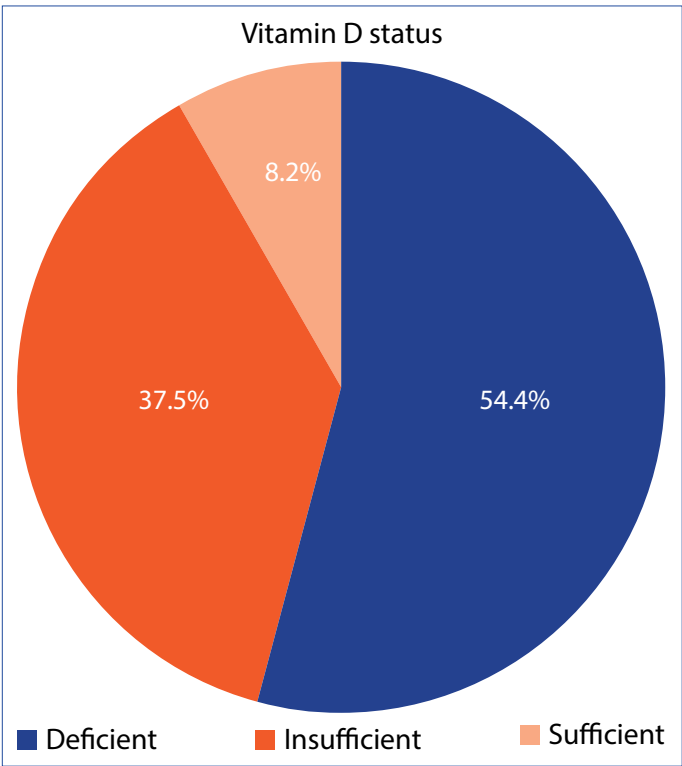


Figure 2. Vitamin D status among study population.

athletes were higher in comparison to male counterparts (78.41% vs 45.68%, $p<0.001$) (Table 3). The odds ratio was 4.32, and the 95% CI was 2.45 to 7.61 indicating that females were at a higher risk for developing lowered vitamin D levels. The extensiveness of vitamin D deficiency was significantly lower amid outdoor athletes in comparison to indoor athletes (49.24% vs 74.63%, $p<0.001$) (Table 3). The odds ratio was found to be 3.03, and the 95% CI was 1.66 to 5.53. A similar sample size among both the groups would help to confirm this effect.

Discussion

Vitamin D is an essential fat-soluble nutrient that affects the athletic population's general health and sports performance [1]. While serum 25(OH)D has been considered the best measure, there is inconsistency in the serum cutoffs used to categorize vitamin D levels among general population [9]. Low serum vitamin D was highly prevalent among the athletes who participated in the study. The results from a meta-analysis on prevalence among basketball players [19] showed

Table 2. Biochemical details among gender and types of sport						
Parameter (Mean±SD or %)	Female (n=88)	Male (n=243)	p	Indoor (n=68)	Outdoor (n=263)	p
Vitamin D (ng/mL)	15.72±5.92	20.72±7.73	<0.001^	15.04±6.12	20.42±7.63	<0.001^
Calcium (mg/dL)	9.59±0.43	9.69±0.35	0.059	9.77±0.32	9.64±0.40	0.006*
PTH (pg/mL)	24.97±16.22	26.06±14.54	0.559	21.62±13.49	25.75±15.03	0.029*

Significant at p-value <0.05* and <0.001^, SD: Standard deviation; PTH: Parathyroid hormone.

Table 3. Vitamin D status of collegiate athletes

	Sufficient (%)	Insufficient (%)	Deficient (%)	p
Gender				
Male	10.7	43.6	45.7	<0.001*
Female	1.1	20.5	78.4	
Type of sport				
Indoor	1.5	23.9	74.6	<0.001*
Outdoor	9.8	40.9	49.2	

Significant at p-value <0.001*.

that 77% of the athletes had vitamin D inadequacy, while another meta-analysis reported that the rates were as low as 30% among elite adult athletes versus 39% among adolescent athletes [20]. Serum assessment on Indian athletes reported a higher rate of serum vitamin D deficiency [16, 18]. Inadequate vitamin D levels seem prevalent across different sports, though reports of prevalence rates could vary based on the cut-off criteria used by the concerned organization. The lack of a global consensus on the cut-off for athletes could result in an over or underestimation of deficiency rate, and lead to difficulty in summarizing the prevalence rates of vitamin D inadequacy among athletes.

Women have been found to have higher chances of vitamin D deficiency than men among the general Indian population and this has been attributed to the limited outdoor movement and traditional clothing among females [14]. Similarly, our study identified a higher rate of low serum vitamin D levels among female athletes than male athletes. Only 1.14% of females reported adequacy compared to 10.70% of male athletes, which indicated a 4.32 times higher risk for females in developing vitamin D deficiency. However, among Turkish [21], and German elite athletes, [22] no significant difference has been noted between genders regarding serum vitamin D, and similar results were noted in a pooled analysis of elite athletes [20]. The impact of gender on vitamin D levels has been poorly studied among athletes, most studies are conducted on male athletes, making it difficult to conclude the effect of gender. The uneven distribution among the genders in the study could have led to the results that we obtained.

The evaluation between indoor and outdoor sports in our study reports a remarkably higher rate of deficiency among athletes participating in indoor sports than outdoor sports. Indoor athletes' mean serum vitamin D levels were significantly lower than outdoor athletes (15.04 ± 6.12 vs 20.42 ± 7.63 , $p < 0.001$). These results indicate that the prevalence of low vitamin D levels is higher among indoor athletes in comparison to outdoor athletes, indicating a 3.03 times greater risk among indoor athletes. Similar results were identified among elite male Japanese collegiate athletes [23], Caucasian adolescent athletes [24], and elite German athletes [22] who noted a positive link between vitamin D levels and outdoor sports participation. Similarly, during the winter months, athletes

who trained for outdoor sports were found to have improved mean 25(OH)D, while severe deficiency was prominent among indoor athletes [25]. This could be due to sunlight exposure during outdoor physical activity, which can increase vitamin D synthesis in human skin. [26]. Contrasting results were found while assessing elite and sub-elite Indian athletes, where indoor athletes were found to have higher mean vitamin D levels than outdoor athletes (20.19 ± 2.55 ng/mL vs 10.49 ± 2.03 ng/mL) [16]. However, the study conducted among Turkish athletes did not show a significant correlation between the type of sports and serum cholecalciferol levels [21].

Since the extensiveness of vitamin D insufficiency and deficiency depends on the serum cut-off levels, the authors recommend a global or regional consensus on defining and categorizing vitamin D categories in athletes as the first step towards tackling the issue of low serum cholecalciferol. Since athletes undergo high-intensity training and are prone to musculoskeletal injuries, they could benefit from periodical screening, and supplementation in high-risk groups can prevent deficiencies [3, 7]. Providing nutrition education that focuses on dietary sources, safe sunlight exposure habits, the inclusion of fortified food, and careful supplement intake could help reduce the prevalence of low serum vitamin D. Sunlight exposure is an economical and beneficial way to improve vitamin D levels, [27] therefore safe sunlight exposure practices should be endorsed among athletes.

The present study used valid assessment techniques and robust methodology but is not without limitations. However, details regarding regular exposure to sun/UVB light and intake of vitamin D sources and other confounding factors that could affect serum 25(OH)D levels were not collected. Such information could have given a more comprehensive picture of the risk factors. A larger sample size and similar distribution of athletes from both genders and type of sport would provide a better understanding of the risk ratio. Future studies could also look at the prevalence of serum vitamin D levels among different disciplines of sport, the effect of vitamin D on athletic performance and general health among Asian and Indian athletes and the impact of cholecalciferol supplementation on their performance.

Conclusion

The concerning high rate of serum vitamin D deficiency and insufficiency among athletes indicates that policies should be modified to ensure frequent assessment of their vitamin D levels. Female athletes and those participating in indoor sports can be considered more prone to having inadequate serum vitamin D status and should undergo regular assessment. Future research could focus on the identification of optimal levels in athletes which ensures optimal musculoskeletal health and improve performance. Research could also look at the impact of vitamin D on athletic performance and if supplementation in those with lower serum levels could help by providing an ergogenic boost.

Ethics Committee Approval: The study was approved by the Sri Ramachandra Institute of Higher Education and Research Ethics Committee (no: IEC/22/APR/171/35, date: 14/06/2022).

Informed Consent: Informed consent was obtained from all participants.

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