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Influence of vitamin D supplementation on mental health in collegiate footballers

Ansa Saju[1], Jolly Roy[1*], Suvarna Jyothi Kantipudi[2], Thiagarajan Alwar[3] & Arumugam Sivaraman[3]

[1]*Faculty of Sports and Exercise Sciences, Sri Ramachandra Institute of Higher Education and Research, Chennai, India*; [2]*Department of Psychiatry, Sri Ramachandra Institute of Higher Education and Research, Chennai, India;* [3]*Department of Arthroscopy and Sports Medicine, Sri Ramachandra Institute of Higher Education and Research, Chennai, India*

ABSTRACT

Introduction: Mental health in athletes has been gaining more attention in recent years. A strong association has been noted between vitamin D and psychiatric outcomes. This study examined the effects of six weeks of vitamin D supplementation on mental health among collegiate footballers. **Methods:** Thirty-one footballers (*N*=31; 18 males and 13 females) were recruited for the study. Serum 25(OH)D was measured to assess vitamin D and mental health was assessed using the Patient Health Questionnaire–9 (PHQ-9) and Generalised Anxiety Disorder-7 (GAD-7). Based on serum 25(OH)D levels, footballers were further categorised as (a) 'deficient' (<20.0 ng/mL), (b) 'insufficient' (21.0-29.9 ng/mL), and (c) 'sufficient' (>30.0 ng/mL). The deficient and insufficient groups were given 60,000 IU cholecalciferol supplementation per week for six weeks and post-intervention assessments were conducted. Paired *t*-test was used to ascertain the differences within groups. **Results:** Prevalences of vitamin D deficiency (48.0%), insufficiency (52.0%), depressive symptoms (13.0%), and anxiety symptoms (26.0%) were observed at baseline among footballers. Supplementation improved vitamin D levels from 20.7±5.4 ng/mL to 38.1±11.4 ng/mL (p<0.001). The rate of footballers with higher than cut-off scores for PHQ-9 and GAD-7 scores increased (32.3% and 29.0%, respectively) from baseline to post-intervention. **Conclusion**: Vitamin D supplementation enhanced serum 25(OH)D levels. However, no positive effects were noted regarding mental health symptoms. Additionally, changes in vitamin D levels might require more time to manifest observable effects on mental health.

Keywords: collegiate athlete, football, mental health, supplement, vitamin D

INTRODUCTION

Vitamin D, popularly known as the sunshine vitamin, can be produced endogenously through sunlight exposure on the skin. This converts 7-dehydrocholesterol to pre-cholecalciferol, which is later converted to vitamin D3. It can also be obtained from a diet that includes fatty fish, egg yolks, sun-dried mushrooms, fortified cereals, and milk (Larson-Meyer & Willis, 2010).

*Corresponding author: Prof Jolly Roy
Faculty of Sports and Exercise Sciences, Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai, India
Tel: +91 9945113611; E-mail: jollyroy@sriramachandra.edu.in
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Research suggests that in the Indian subcontinent, vitamin D deficiency is between 70.0-100.0% among the general population and equally prevalent in both rural and urban settings (G & Gupta, 2014). The authors stated that serum 25(OH)D levels of 20.0 ng/mL with elevated parathyroid hormone (PTH) and reduced calcium absorption are considered vitamin D deficiency; insufficiency is defined as levels ranging from 20.0-29.9 ng/mL. The prevalence of vitamin D insufficiency among athletes largely depends on area of residence and training, type of sport, skin pigmentation, sunscreen use, season, and genetics (Saju *et al.*, 2023).

Vitamin D supplementation could benefit athletes since there is an increase in the prevalence of suboptimal levels, which might result from higher vitamin utilisation and limited availability of vitamin D-rich food sources. Vitamin D supplementation indirectly improves performance by improving immunity, enhancing training adaptations (Maughan *et al.*, 2018), and acting as an anti-inflammatory agent (Peeling, Sim & McKay, 2023). The heterogeneity of the results from research has made it challenging to identify the correct dosage for vitamin D supplementation, but toxicity is a possibility from supplementation with high doses (Ogan & Pritchett, 2013).

Research studies have indicated mental health problems among athletes (Anglin *et al.*, 2013; Gouttebarge, Frings-Dresen & Sluiter, 2015; Junege & Feddermann-Demont, 2016). Depressive symptoms affect today's athletic population and mental health data among athletes have revealed more disturbing facts. Mental health disorders and symptoms varying from mild to more severe are common among male and female athletes (Junge & Feddermann-Demont, 2016; Reardon *et al.*, 2019), with a sevenfold increased risk of depression among semi-elite female athletes (Henderson *et al.*, 2023) and twice as likely in high-performance female athletes in comparison to their male counterparts (Gorczynski, Coyle & Gibson, 2017).

In addition, studies have documented that about 38.0% of professional soccer players exhibit depressive symptoms (Gouttebarge *et al.*, 2015; Gouttebarge *et al.*, 2016), while anxiety symptoms are less common among athletes (Henderson *et al.*, 2023; Weber *et al.*, 2023). Female athletes show a higher likelihood of having anxiety symptoms than their male counterparts (Junge, Wellmann & Zech, 2023; Junge & Feddermann-Demont, 2016). Most often, the age for the onset of mental health problems overlaps with the actual competitive period in an athlete's career. With the increasing prevalence of mental health issues among athletes, sports psychologists have turned their attention to this critical issue (Wolanin, Gross & Hong, 2015).

Typically, sports are enjoyable activities; however, symptoms of possible mental health issues, such as sadness, irritability, anger, loss of interest and passion for sports, could surface frequently. These symptoms can interfere with athletes' training, daily lives, and competition outcomes. Research studies have reported a few stressors among athletes, including pressure to win, fitness issues, inter-relations, training intensity and volume, and travel schedules. Student athletes are vulnerable to developing mental health issues during their university/ college years because of the pressure to win while staying committed to their studies.

Vitamin D is generally recognised for its role in maintaining bone health. Recently, the role of vitamin D in maintaining mental health is gaining attention, particularly to examine how depressive symptoms can influence

an athlete's performance and life (Owens, Allison & Close, 2018). Recent epidemiological studies indicate a strong association between vitamin D and mental health outcomes, which suggests that low cholecalciferol alters the secretion of neurotransmitters such as dopamine and serotonin, leading to lower motivation, pleasure drive, and satisfaction with rewards (Schaad *et al.*, 2019).

Studies have reported that low vitamin D among individuals are associated with depressive symptoms (Anglin *et al.*, 2013). Similar studies in a military context and older adults have reported that individuals with low vitamin D may be at a higher risk of developing depressive symptoms (Li *et al.*, 2019; Schaad *et al.*, 2019). However, there is conflicting evidence about the link between vitamin D deficiency and depressive symptoms. For instance, research has documented multiple factors, such as the dosage of vitamin D supplements, duration of supplementation, gender, and age (Akpınar & Karadağ, 2022).

Most studies on mental health issues were conducted in the Western population and limited research addressed mental health issues among Indian athletes. Given that athletes often consume vitamin D supplementation (Owens *et al.*, 2018), we considered it essential to assess if there was evidence of depressive and anxiety symptoms in athletes and whether vitamin D consumption reduced these symptoms among Indian collegiate footballers. More specifically, this study examined the role of vitamin D supplementation in managing mental health among footballers and highlighted areas that might need attention.

The study's outcome would help to identify the influence of vitamin D on mental health in the short term and dispel common confusion related to vitamin D deficiencies and mental health. Furthermore, the outcome could facilitate meaningful implications for educating athletes on mental health issues and associated supplementations.

The first aim was to identify baseline serum vitamin D levels and mental health symptoms (depressive and anxiety symptoms) in footballers. The second aim examined the effect of six weeks of vitamin D supplementation on depressive and anxiety symptoms in footballers.

MATERIALS AND METHODS

Study design

A quasi-experimental nature with pre- and post-intervention within the subject design was conducted between November 2022 and January 2023. The Sri Ramachandra Institute Ethical Committee approved the study (REF: IEC/22/APR/171/35). The project overview (Figure 1) was explained to the coaches and footballers; voluntary participation was encouraged. The briefing included: (1) a quick introduction to mental health among footballers and associated symptoms, (2) the need to identify depressive symptoms among footballers, (3) the role of vitamin D supplementation, (4) possible preventive interventions (e.g., education/ treatment/supplementation), and (5) approximate timeline and assessment measures.

Participants

Football players from both genders (N=31; 18 males, mean age = 19±2 years; 13 females, mean age = 19±1 years) who trained outdoors for >5 hours (h)/week, participated at university competition levels, and between the ages of 17.0 – 25.0 years were recruited through professional contact in sports from the same city. Footballers were screened for eligibility and were excluded if they (a)

suffered from chronic disease or skin disorder and were immunocompromised, (b) were attending rehabilitation during study recruitment, and (c) consumed vitamin D supplementation in the last three months leading to recruitment. Eligible footballers were briefed about the project's purpose and informed consent was obtained.

Measures

To assess mental health, the Patient Health Questionnaire–9 (PHQ-9) and Generalised Anxiety Disorder (GAD-7) short screening tools were used for the detection of depressive and anxiety symptoms.

Depressive symptoms

The PHQ-9 (Löwe *et al.*, 2004) employed in this study was a self-administered version of the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic tool, which was designed to assess common mental disorders. PHQ-9 is a reliable and valid tool for assessing depression (Cronbach's alpha = 0.8). The PHQ-9, serving as a depression module, assigns scores ranging from 0 (not at all) to 3 (nearly every day) to each of the 9 Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria. A score ≥10 as a cut-off on PHQ-9 demonstrates a sensitivity of 88.0% for the diagnosis of depressive symptoms.

Anxiety symptoms

GAD-7 was used to identify anxiety symptoms. It is a self-reported questionnaire (Spitzer *et al.*, 2006). GAD-7 is a reliable and valid tool with good internal consistency (Cronbach's alpha = 0.9). Participants had to reflect on their anxiety-related concerns over the past two weeks before responding to the items of GAD-7 on a four-point scale. The scores ranged from 0 to 21, with a cut-off score set at nine; a footballer scoring ≥9 was considered to have anxiety. The choice of this cut-off score was informed by its sensitivity of 89.0% and specificity of 82.0% for detecting GAD, as determined through comparison with structured psychiatric interviews.

Serum 25(OH)D investigation and supplementation

Two ml of blood was drawn via venipuncture to assess serum 25(OH) D levels using a fully automated chemiluminescent immunoassay (CLIA). Serum cut-offs suggested by the Endocrine Society Clinical Practices Guidelines (Holick *et al.*, 2011) were considered to categorise the serum values as deficient, insufficient, and sufficient (<20.0 ng/mL, 21.0-29.9 ng/mL, and >30.0 ng/mL), respectively. Participants were categorised as having hypovitaminosis D if they presented with serum levels ≤29.9 ng/ml and were informed that they would be part of the supplemental group. A pharmaceutical analogue of cholecalciferol with a dosage of 60,000 IU (Singh *et al.,* 2019) was provided once a week for six weeks in the presence of hypovitaminosis D.

Procedure

Pre-intervention

Upon receiving their consent, participants' demographic data (age and training experience) were collected and baseline data collection was initiated. Participants underwent the initial blood draw to assess their serum 25(OH) vitamin D levels. For assessment of anxiety and depressive symptoms, the baseline questionnaires (GAD-7 and PHQ-9) were explained to the participants and assessed. The total test duration was 15-20 minutes.

Intervention

Participants with serum 25(OH)D levels <30.0 ng/mL were recruited for the

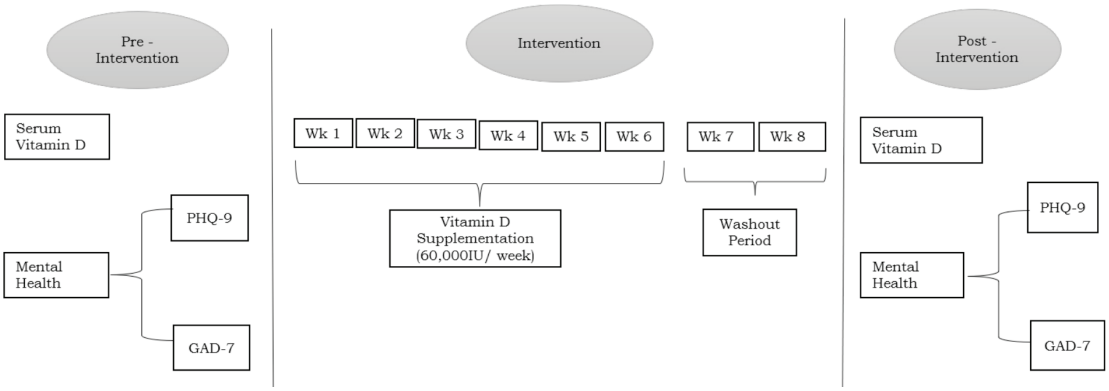

Figure 1. Study design
GAD-7: Generalised Anxiety Disorder-7; PHQ-9: Patient Health Questionnaire–9

supplementation phase of the study (*N*=31). The participants were given six capsules of cholecalciferol (dosage: 60,000 IU) to be consumed once per week for six weeks. Participants were reminded via messages weekly to improve compliance with taking the supplement. Two weeks were provided as a cool-off period post-supplementation before starting post-intervention testing.

To ensure compliance, weekly reminders were sent on a fixed day in the week for six weeks to ensure consumption of vitamin D supplements. Footballers were requested to confirm by answering a poll with the options 'Yes, I consumed' or 'Not yet'. Footballers who marked 'Not yet' in the poll were called to check on the reason and a second reminder was given to them accordingly.

Post-intervention

After completing the six-week supplementation, footballers were given two weeks of wash-out period (phase without supplementation) and were reassessed after the eighth week for post-intervention outcomes. After the eighth week, footballers reported back at the study site and underwent post-intervention serum analysis for 25(OH) D levels. Participants also completed the PHQ-9 and GAD-7 questionnaires for post-intervention data collection. The total duration was 15-20 minutes.

Data analysis

Statistical analysis was completed using IBM SPSS Statistics for Windows version 27.0 (IBM Corp., Armonk, New York, United States). Values were calculated as mean and standard deviation (*SD*) or percentages. Paired *t*-test was used to compare the means calculated between baseline assessment and post-intervention phase. Statistical significance was considered if *p*-value was <0.05.

RESULTS

Thirty-one football players (mean age = 19±1 years) who trained outdoors for an average of 8.2 ± 2.3h/week were recruited for the study, of which 42.0% were female and 58.0% were male athletes. There were no athletes with sufficient vitamin D levels at baseline; therefore, supplementation and mental health symptoms for those with sufficient levels are not discussed.

After six weeks of vitamin D supplementation, the rate of vitamin D deficiency reduced from 48.4% to 0.0%

Table 1. Vitamin D and mental health status of college footballers (*N*=31)

Variable	*Mean±SD*		*df (N-1)*	*t*	*p*
	Baseline	*Post-intervention*			
Vitamin D	20.7±5.4	38.1±11.4	30	-9.62	0.008
GAD – 7	5.0±4.1	5.9±4.4	30	-1.64	<0.001
PHQ – 9	5.2±3.7	7.8±4.3	30	-3.03	0.135

GAD-7: Generalised Anxiety Disorder-7; PHQ-9: Patient Health Questionnaire–9

and the rate of vitamin D insufficiency reduced from 51.6% to 29.0%. Thus, the rate of vitamin D sufficiency increased from 0.0% to 71.0%. Contrary to our expectation, there was an increase in depressive and anxiety symptoms in 32.3% and 29.0% of footballers, respectively.

Paired sample *t*-test (Table 1) was used to test the changes over two time periods (pre- and post-intervention). A significant increase in vitamin D levels was observed from 20.7±5.4 ng/mL at baseline to 38.1±11.4 ng/mL at post-intervention follow-up, $t(30)=9.62$, ($p<0.001$). A significant increase in depression levels among footballers was noted with PHQ scores at baseline (mean=5.2±3.7) and post-intervention (mean=7.8±4.3), $t(30)=3.03$, ($p=0.005$). No significant changes were observed in the anxiety levels of footballers at baseline (mean=5.0±4.1) and post-intervention (mean=5.9±4.4), $t(30)=1.64$, ($p=0.111$).

DISCUSSIONS

The present study examined the effect of vitamin D supplementation on the mental health components of footballers. Few studies have reported the effect of vitamin D supplementation among Indian footballers. The results from this study showed that during baseline assessment, the rates of depressive and anxiety symptoms were 12.9% (PHQ-9 responses) and 25.8% (GAD-7 responses), respectively. Despite taking vitamin D supplementation, an increase in vitamin D levels did not show any reduction in depression and anxiety levels. This implied that vitamin D supplementation alone might not be a factor leading to better mental health and that other factors may contribute to changes in mental health indices. One plausible reason could be that the footballers were only given vitamin D supplements and no corresponding medical or psychological support was provided during the intervention period.

Research findings (Parel *et al.*, 2022) have identified vitamin D as a risk factor for depressive and anxiety symptoms in the general population; however, there is inconclusive data regarding the correlation of vitamin D with mental health disorders and symptoms in athletes. The incidence of depressive and anxiety symptoms was observed at a higher rate (20.4%) in those diagnosed with vitamin D deficiency in comparison to individuals with adequate serum vitamin D levels (4.2%) (Schaad *et al.*, 2019). Nevertheless, opposing results have also been identified among collegiate runners and soccer players, suggesting no significant relationship exists between serum vitamin D and depressive and anxiety symptoms (Tomlinson *et al.*, 2021).

Vitamin D supplementation is an efficient way to improve serum 25(OH) D levels with dosages ≥2,000 IU/day (Sivakumar, Koziarz & Farrokhyar, 2019). Supplementation or higher vitamin D consumption is suggested to

reduce anxiety in collegiate-level female track and field athletes (Miyamoto, Hanatani & Shibuya, 2022). A scientific review suggested that supplementation of cholecalciferol for eight to nine weeks significantly ameliorated symptoms of depression and anxiety in adolescent girls, boys, and adults (Parel *et al.*, 2022); >4,000 IU/day had a more significant effect than doses up to 4,000 IU/day in reducing depressive symptoms (Mikola *et al.*, 2023). The results of this study do not concur with the above findings.

In this study, we identified that depressive and anxiety symptoms and suboptimal levels of vitamin D were present among the athletic population. A larger sample size with a matched control group and an environment where lifestyle, dietary, and sun exposure are controlled might give a better insight. The supplementation regimen with cholecalciferol limited to six weeks helped to improve serum vitamin D levels, but it did not yield a desirable positive outcome in the reduction of depression and anxiety among footballers. The lack of a control group and randomisation could have affected the current outcome, which should be considered in future research. Supplementation for a longer duration, combined with medical and psychological support based on individual requirements might be necessary to see more prominent results. Future studies should examine possible moderating effects concerning different variables, such as other nutritional supplementation, sports counselling support, and psychiatric medical support.

CONCLUSION

This study examined the influence of vitamin D supplementation on mental health in Indian footballers. There was a high incidence of vitamin D 'deficiency' and 'insufficiency' among young Indian footballers. Changes were noticed in the vitamin D levels of footballers after supplementation. Though supplementation improved serum 25(OH)D levels, it did not significantly improve footballers' mental health. The study offers a perspective to add medical and psychological support and vitamin D supplementation to future studies. The outcomes of this study should be interpreted with caution until a larger sample and a longer duration of supplementation are conducted.

Despite the potential limitations, understanding the study results lends support to athletes, coaches, and sports science teams regarding the inadvertent use of supplements. Awareness regarding mental health issues should be imparted more widely among athletes and coaches so that access to help is enhanced. Coaches, athletes, and team leaders must be aware of the damaging consequences of supplementation without appropriate nutrition and medical advice. Monitoring athletes' supplement intake may help promote mental health and well-being. A holistic approach, with medical support from doctors and psychological support from psychologists during the intervention phase could yield desirable changes in the mental health index.

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Authors' contributions

Saju A, principal investigator, conceptualised the study, led the data collection, assisted in drafting the manuscript, and reviewed the final manuscript; Roy J, developed the study design,

prepared the draft of the manuscript, and reviewed the manuscript; Kantipudi SJ, conducted the data analysis and interpretation, assisted in drafting, and reviewed the manuscript; Alwar T and Sivaraman A, assisted in critically reviewing the manuscript and finalisation of the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

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