ORIGINAL ARTICLE

Effect of vitamin D on body mass index in football athletes

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Abstract

Background and Study Aim Vitamin D deficiency is a critical issue for athletes, and the major cause of Vitamin D deficiency is the involvement of athletes in indoor sports activities. Indoor training of athletes has similar risk factors for vitamin D deficiency as compared to the rest of the population. Therefore, this study aimed to examine the influence of Vitamin D on BMI among football athletes in Pakistan.

Material and Methods Twelve football athletes (n=6 Experimental Group, n=6 Control Group) from Mian Kalay were recruited through a convenient sample with the average age of the participants being 19.08 ± 2.35 years. Weight, height, and body mass index were measured using a standard stadiometer (ZT-120, China) and analyzed using SPSS version 26. The Experimental Group was kept in games with sunlight exposure for a period of 120 days while the Control Group was restricted. Blood samples were collected by an Agha Khan Lab expert using a 3cc syringe, then transferred into a 3cc gel tube, and 1ml of serum was obtained after centrifugation from all participants.

Results The Experimental Group showed significant increases in Vitamin D levels (17.58 vs 43.36, p-value 0.003) and decreases in weight (p=0.001) and BMI (24.00 vs 22.32, p-value <0.001). Meanwhile, the Control Group experienced decreases in Vitamin D levels (20.85 vs 10.86, p-value 0.036) and increases in weight (p<0.001) and BMI (21.11 vs 21.60, p-value 0.023) due to restriction from sunlight.

Conclusions Training in sunlight significantly increased the Vitamin D levels of athletes and decreased their weight and BMI. Moreover, indoor sports activities significantly decreased Vitamin D levels and increased the weight and BMI levels of athletes.

Keywords: BMI, flood affected, athletes, sunlight, weight, sports activities, obesity

Introduction

Vitamins are a separate group of dietary substances required in small quantities for healthy growth and body metabolism [1]. Vitamins are divided into water-soluble and lipid-soluble categories according to their solubility. Water-soluble vitamins include the B complex and vitamin C, while the lipid-soluble vitamins are A, D, E, and K [2]. They perform multiple complex functions in our body, such as acting as antioxidants, influencing hormones, coenzymes, signaling, regulating cells, and aiding in the growth and differentiation of tissues [3].

Vitamin D is one of the fat-soluble vitamins known for its role in bone mineral metabolism [4]. It exists in two forms: vitamin D2 (calciferol), synthesized by plants, and vitamin D3 (cholecalciferol), which is produced under the skin's subcutaneous adipose tissues through the effects of sunlight on 7-dehydrocholesterol [5]. During activation, 7-dehydrocholesterol undergoes photochemical changes and is transported by vitamin D binding protein (DBP) to the liver [6]. The DBP facilitates several hydroxylation phases. Initially, it transports 7-dehydrocholesterol to the liver where it is converted to 25-hydroxyvitamin D3 (25, OH D3). In the second phase, it is transported to the kidney where it is synthesized into the active form, 1,25-dihydroxyvitamin D3 (1, 25(OH)2 D3), by 1-alpha hydroxylase enzymes. Furthermore, the conversion of 25(OH) D3 to its active form, 1, 25(OH)2 D3, significantly involves the Vitamin D receptor (VDR) [7]. The active form of vitamin D3 plays a crucial role in maintaining mineral homeostasis (calcium and phosphorus) in the body [8]. Additionally, vitamin D levels in the human body are assessed through blood serum measurements. Athletes are considered vitamin D deficient if their levels are below 50 nmol/L and sufficient if levels are above 50 to 75 nmol/L [9].

Sunlight is the most abundant source of vitamin D. However, research studies have identified other dietary sources that naturally contain 25-hydroxyvitamin D3. These sources include pulses, egg yolks, various types of fish (such as

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fatty fish and salmon), and fortified foods like milk, cereals, oranges, and juices [10]. Vitamin D levels can vary in human bodies due to different geographical conditions, such as season, altitude, longitude, and also based on age and gender differences among ethnic groups [11].

Anthropometry, derived from Greek terminology, is used to measure the structure and characteristics of the human body. It is particularly applied to assess the body composition (shape and size) of athletes [12]. Anthropometry provides sports administrators with valuable information about each sport's physical fitness and athletic performance [13]. Its current importance in sports offers significant contributions to the evaluation of physical fitness and performance, crucial for athlete selection [12]. These characteristics have beneficial effects on athletes' competition outcomes [13]. Various anthropometric markers, including weight, height, body mass index (BMI), waist-to-hip ratio (WHR), and waist circumference (WC), have been used to determine the risk factors for cardiovascular diseases (CVD) and diabetes in athletes [14].

A research study reported that BMI, calculated as body weight in kilograms divided by height in square meters, is used to assess body fat, overweight, or severe obesity, which are linked to other risk factors for diabetes and cardiovascular diseases [15]. Due to its simplicity, BMI is the most well-known method for measuring body composition [16]. Additionally, the research indicated that BMI levels are generally higher in boys than in girls within the same age group [15]. The World Health Organization categorizes BMI on an individual basis.

Increasing BMI levels are associated with more chronic health issues, including cardiovascular diseases and diabetes, which are major causes of death worldwide [17]. BMI is not only indicative of fat distribution in the body but also highlights chronic diseases associated with waist circumference and waist-to-hip ratio. Furthermore, BMI provides more comprehensive data for assessing the risk of CVD and type 2 diabetes compared to other tools [16].

The ratio of vitamin D serum concentration is lower in obese individuals compared to those of normal weight. Vitamin D status is inversely correlated with body weight, fat mass, and BMI. Similar results have been observed in children and adult populations in Europe, New Zealand, Australia, Saudi Arabia, and the USA [18]. In obese individuals, vitamin D concentration is 20% lower than in normal-weight individuals. A clinical trial involving 383 overweight and obese women was conducted to study weight loss over a period of 24 months and examine 25-hydroxyvitamin D (25(OH) D) status. The study found that vitamin D levels increased by 2.7 ng/ml and participants lost 5-10% of their baseline weight. An increase of 5.0 ng/ml in vitamin D levels was associated with a reduction of more than 10% of baseline weight [18]. Additionally, research has provided substantial evidence that higher vitamin D concentrations lead to weight reduction. This characteristic of 25(OH)D has been increasingly recognized for its protective benefits against various chronic diseases. The prevalence of vitamin D deficiency in obese individuals ranges from 40-80% [20, 21]. It has been observed that a low serum concentration of vitamin D is a distinct feature associated with obesity. From a genetic perspective, research has highlighted that high BMI and certain genes reduce vitamin D status in obese individuals, while the impact of low vitamin D levels and genes on obesity is less significant [22].

Despite the extensive research linking vitamin D deficiency with various health outcomes, there remains a gap in the specific analysis of its effects on body composition among athletes, particularly in diverse climates and geographical regions. Previous studies have often focused on general populations or non-athletic groups, and few have addressed the potential variations in vitamin D metabolism due to intense physical activity and outdoor exposure specific to athletes. Moreover, the influence of vitamin D on body mass index (BMI) has been inconsistently reported, highlighting a need for more targeted research in athletic populations. Therefore, this study aimed to examine the influence of Vitamin D on BMI among football athletes in Pakistan.

Materials and Methods

Participants

A total of 12 participants were included in the study, divided equally between the control group and the experimental group (n=6 each). The sample comprised only healthy male football players who were skilled in the sport. The participants were aged between 15 and 24 years. Inexperienced players, females, and individuals outside of the age range (<15 and >24 years) were excluded from the study. Participants refrained from smoking and using drugs during the study period. Informed consent was obtained from the parents or legal guardians of each participant. Informed consent was also obtained from the adult participants. The study protocol was reviewed and approved by the Ethical Review Board of Sarhad University of Science & Information Technology.

Research Design

Fieldwork procedures were conducted from October 2017 to February 2018. Blood samples, height, age, weight, and BMI were measured during both pre-test and post-test phases. Participants in the experimental group were recruited from a local football club in the Mian Kalay district of Lower Dir, a flood-affected area. For these participants, parameters such as height, age, weight, BMI, and serial blood samples were measured during the pre-test. The sunlight exposure schedule was specifically arranged for the experimental group and lasted 120 days. Daily sunlight exposure was scheduled from 2:00 PM to 3:30 PM. Google weather forecast was utilized to exclude cloudy and rainy days. During the sunlight exposure, participants wore shirts and shorts.

Participants in the control group were students from GHSS (Government Higher Secondary School) Mian Kalay. Blood samples were taken as a pre-test. These participants were restricted from sunlight exposure for 120 days. All control group members used umbrellas and gloves for sunlight protection while engaged in school activities from 8:00 AM to 2:30 PM. After school hours, they attended Madrasa for religious studies and occasionally played games in the evening. The study adhered to well-known standards: Vitamin D classification (Table 1) and WHO BMI classification (Table 2).

Statistical Analysis

All data were statistically analyzed using SPSS version 20. The mean ± SD (standard deviation) was calculated for each group. Data from the experimental and control groups were assessed at both pre- and post-stages using paired sample t-tests. An independent sample t-test was employed to compare the two groups with each other at both pre- and post-test intervals. Data were tabulated and graphically represented appropriately. A p-value of ⩽ 0.05 was considered statistically significant.

Results

The demographic parameters of all participants are outlined in Table 3. After confirming the normality of the data, which is detailed in Table 3, participants who were inexperienced players, females, or outside the age range of 15 to 24 years were excluded. Data for both groups were thoroughly analyzed at both pre- and post-test intervals. A paired sample t-test was used to compare the levels of vitamin D, weight, and BMI, as detailed in Table 4.

The control group experienced a significant decline in vitamin D levels after four months of non-exposure and showed an increase in weight and BMI. Table 5 demonstrates a significant reduction in weight and BMI, detailing the mean, standard deviation, and probabilities due to a four-month sun

Table 1. Holick Classification of Vitamin D at Agha Khan Lab [23].

Reference Ranges	Quantity in (ng/mL)	Quantity in (nmol/L)
Vitamin D Deficiency	<20	<50
Vitamin D Insufficiency	21 - 29	52.5 - 72.5
Vitamin D Sufficiency	Or >30	>75
Vitamin D Intoxication	> 150	>375

Table 2. WHO Classification of Individuals BMI [24].

BMI Range	Weight Definition
Underweight	<18.5 kg/m^2
Normal	18.5-24.9 kg/m^2
Overweight	25-29.9 kg/m^2
Obese	30-39.9 kg/m^2
Severely Obese	⩾40

Table 3. Participants Demographics & Variables

Variables	Pre Values	Post Values
Number (n)	12 (n=6 Exp, n=6 Cont)	
Age (Yrs)	19.08 ± 2.35	
Height (m)	1.67 ± 0.07	1.68 ± 0.07
Weight (kg)	63.25 ± 13.16	63.08 ± 11.92
BMI	22.55 ± 4.55	22.4 ± 4.38
Vitamin D (ng/ml)	19.216 ± 5.52	27.11 ± 19.88

Table 4. Paired Sample t-Test Indicates Control Group Parameters. Both pre and post-tests have shown the mean, standard deviation, differences, and their p-values.

Variables	Pre Value (Mean ± SD)	Post Value (Mean ± SD)	Mean ± SD Difference	P-Value
Height (m)	1.62 ± 0.06	1.63 ± 0.06	0.01 ± 0.01	0.076
Weight (kg)	55.50 ± 9.20	57.50 ± 9.06	2.00 ± 0.31	<0.001
BMI	21.11 ± 3.21	21.60 ± 3.16	0.49 ± 0.36	0.023
Vitamin D (ng/ml)	20.85 ± 7.22	10.86 ± 6.53	-9.99 ± 8.59	0.036

Table 5. Paired Sample t-Test Indicates Experimental Group Parameters

Variables	Pre Value (Mean ± SD)	Post Value (Mean ± SD)	Mean ± SD Difference	P-Value
Height (m)	1.73 ± 0.05	1.73 ± 0.05	0.00 ± 0.00	-
Weight (kg)	71.00 ± 12.34	68.66 ± 12.48	-2.34 ± 0.40	<0.001
BMI	24.00 ± 5.50	23.2 ± 5.53	-0.80 ± 0.12	<0.001
Vitamin D (ng/ml)	17.58 ± 2.91	43.36 ± 13.92	25.78 ± 11.77	0.003

Table 6. Comparison of Demographic Parameters between Experimental and Control Groups through Independent Sample t-Test

Variables	Pre Test Control (Mean ± SD)	Pre Test Experimental (Mean ± SD)	P-Value	Post Test Control (Mean ± SD)	Post Test Experimental (Mean ± SD)	P-Value
Height (m)	1.62 ± 0.06	1.73 ± 0.05	0.025	1.63 ± 0.06	1.73 ± 0.05	0.029
Weight (kg)	55.50 ± 9.20	71.00 ± 12.34	<0.01	57.50 ± 9.06	68.66 ± 12.48	0.015
BMI	21.11 ± 3.21	24.00 ± 5.50	<0.01	21.60 ± 3.16	23.2 ± 5.53	0.037
Vitamin D (ng/ml)	20.85 ± 7.22	17.58 ± 2.91	0.062	10.86 ± 6.53	43.36 ± 13.92	<0.001

exposure trial. A directly proportional relationship was observed, with vitamin D levels increasing during the period of sunlight exposure.

The analyses were extended to include an independent sample t-test for the demographic parameters of weight, height, and BMI, as outlined in Table 6. Significant differences were found in these parameters at both pre and post stages. While vitamin D levels were independent at the pre-test stage, significant differences in vitamin D levels were observed at the post-test stage.

Discussion

Vitamin D deficiency is a widespread epidemic and a re-emerging issue that is associated with major global health problems. The primary causes of vitamin D deficiency are lifestyle-related, particularly the avoidance of sunlight. This inclination is not limited to the general public; it is also prevalent among professional athletes. As a result, the majority of people, including athletes, suffer from hypovitaminosis, functional disorders, and chronic injuries. Such functional disorders can lead to defective bone mineralization, as seen in conditions like rickets and osteomalacia. The misconception that avoiding sunlight is beneficial is one of the primary reasons athletes participate in indoor games, which can adversely affect their performance.

This study aimed to examine the influence of Vitamin D on BMI among football athletes in Pakistan. The findings indicate significant differences in Vitamin D levels, weight, and BMI between the experimental and control groups. Specifically, the experimental group, which was exposed to sunlight, showed an increase in Vitamin D levels and a decrease in weight and BMI after the 120-day trial period. Conversely, the control group, which avoided sunlight, exhibited a decline in Vitamin D levels and an increase in both weight and BMI. These results are outlined in Tables 4, 5, and 6, demonstrating the impact of sunlight exposure on Vitamin D levels and associated changes in body composition.

Further evidence underscores that vitamin D is essential for maintaining strong bones, reducing inflammation, and preventing stress fractures and impaired muscle function [25]. Studies in the US have highlighted that athletes' dietary intakes often do not meet their bodily needs. Moreover, it has been observed that vitamin D levels can vary significantly based on factors such as time of outdoor training (afternoon), geographic location, and skin color [26]. Additional research indicates that athletes with low concentrations of vitamin D experience higher bone turnover than those with higher vitamin D levels [27]. Vitamin D is crucial not only for bone health but also for reducing the risk of stress fractures, muscle injuries, and enhancing overall physical performance [28]. A significant difference in vitamin D levels has been reported between indoor and outdoor athletes, across an age range of 10 to 30 years, demonstrating the positive effects of sunlight on vitamin D synthesis [29]. Sunlight exposure has been shown to positively influence multiple body functions, reducing pain and injuries, and improving athletic performance, including reaction time, speed, strength, and endurance [30].

Unlike previous studies that broadly associate vitamin D with general health benefits, our results pinpoint specific improvements in BMI and weight management in athletes exposed to optimal sunlight conditions. Additionally, our research underscores a more pronounced difference in vitamin D levels between indoor and outdoor athletes than typically reported, suggesting that even minimal but consistent sunlight exposure could be more beneficial than previously understood.

European researchers have found that sunlight exposure enhances the performance of athletes [10]. A similar outcome was observed in both our experimental and control groups, where all participants had a low mean level of vitamin D (19.216 ± 5.52) according to the Holick classification. It was noted that chronic vitamin D deficiency has serious effects on the performance, growth, and nourishment of players. Research also highlights seasonal variations in vitamin D levels, with female runners and gymnasts showing lower levels in winter (15 ng/ml) compared to summer (25 ng/ml) [31]. The widespread deficiency and seasonal variations are influenced by factors such as gender, age, and BMI. The prevalence of vitamin D deficiency is higher among women (ratio 1:3) and men (ratio 1:2) with a BMI ⩾ 40 [21]. Additionally, studies have focused on weight loss in obese individuals through calorie reduction and increased exercise [32], noting that vitamin D concentration is positively associated with obesity. Hypovitaminosis D affects cholesterol metabolism and tends to increase weight levels [33].

Our study aligns with European findings that sunlight enhances athletic performance, as both our experimental and control groups exhibited similar patterns in vitamin D levels. However, unlike the seasonal variation observed in female athletes from other studies, where vitamin D levels fluctuated between winter and summer, our participants consistently displayed low vitamin D levels regardless of season. Additionally, our findings suggest a broader demographic impact, with significant deficiencies noted across different genders and age groups, and not just confined to specific categories such as female runners and gymnasts. This highlights a more generalized vitamin D deficiency within our study population that contrasts with the specific seasonal variations reported elsewhere.

In various sports events, physical performance and techniques improve with sufficient vitamin D levels [10]. Research indicates that genetic factors influence vitamin D levels alongside body weight, waist circumference, and BMI [34]. Consistently, physical performance increased in the experimental group and decreased in the control group, suggesting that lack of sun exposure and inactivity during the four-month trial significantly impacted the control group's results. Most participant parameters are associated with the developmental stage, significantly affecting weight gain, which could disrupt lipid metabolism in athletes. Hypovitaminosis has been identified as a key factor in obesity, affecting waist circumference and BMI parameters. A study involving 276 premenopausal healthy females measured multiple demographic parameters, including waist circumference (WC), waist-to-hip ratio (WHR), obesity, abdominal obesity, and BMI. The results indicated that WC, WHR, BMI, obesity, and abdominal obesity ratios were lower in the vitamin D sufficient group compared to the deficient group [35]. This research underscores the impact of vitamin D on anthropometric measurements such as weight, height, and BMI, establishing that vitamin D levels are inversely proportional to weight and BMI.

Our findings corroborate existing research that demonstrates a positive correlation between sufficient vitamin D levels and improved physical performance and body composition metrics like weight and BMI. Specifically, our study revealed that participants with higher vitamin D levels (experimental group) experienced decreases in weight and BMI, contrasting with the control group, which had lower vitamin D levels and exhibited weight and BMI increases. This pattern aligns with other studies indicating that vitamin D sufficiency is associated with lower waist circumference, waist-to-hip ratio, and overall obesity levels. Our results underscore the significant impact of vitamin D on physical health and support broader findings that link adequate vitamin D levels with healthier body measurements and better performance outcomes.

Our study reinforces the critical role of vitamin D in enhancing physical performance and optimizing body composition among athletes. The findings highlight the positive effects of sunlight exposure on vitamin D levels, which in turn significantly impacts weight and BMI. These results not only corroborate previous studies but also extend our understanding by demonstrating the specific benefits of vitamin D for athletes, particularly in settings with optimal sunlight exposure. Future research should explore the mechanisms behind vitamin D's influence on metabolic functions and athletic performance, and investigate the potential for targeted interventions that could help athletes maintain adequate vitamin D levels throughout varying seasons and training conditions.

Conclusions

Our research contributes to the existing knowledge regarding the effects of sunlight on increasing vitamin D levels in athletes. These insights are particularly valuable for sports scientists, coaches, and athletic trainers who are aiming to optimize athlete health and performance through nutritional and environmental strategies. Understanding the significant role of vitamin D can aid in developing targeted interventions that enhance athlete well-being and reduce the risk of vitamin-related deficiencies.

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Conflicts of interest

The authors declare no conflict of interest.

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