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**Research paper**

# The Effect of Vitamin D Supplementation on Physical Performance of Male Soccer Players: A Systematic Review

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## Abstract

**Background**: Nowadays soccer has been a popular field among societies. Furthermore, soccer attracts millions of television spectators while the economic impact of elite soccer affects almost every culture around the world. Therefore, soccer studies can significantly affect improvement in each component. The aim of the study was to investigate the effect of vitamin D supplementation on male soccer players' physical performance.

**Methods:** The research articles were searched from selected electronic databases, including Medline, Scopus, PubMed, Web of Science, and ScienceDirect. The search was done in the last mounth of 2022. There were no filters applied to the soccer players' level, race, or age to increase the analysis power . The length of the studies ranged from 6 weeks to 12 weeks. The literature search identified a total of (N=189) papers related to the topic, but only 4 articles had all the inclusion criteria. 124 participants of all papers were included in the systematic review; professional or elite (N=64) and young players (N=60). The supplement dosage also varied from study to study, ranging from 5000 to 6000 IU per day. as well as a paper with 200000 IU Single dosage. The mean concentration of four studies at baseline was 31.475 ng/mL.

**Results:** We found that there is a strong relation between VD deficiency and the reduction of male soccer players. There was not significant correlations between the 25(OH)D concentration sprint times on the distances of 5 m, 10 m, and 30 m. There is no relation

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between the level of VD serum concentration and aerobic capacity. There is no relation between the level of VD serum concentration and aerobic capacity.
**Conclusion:** VD supplementation doesn't have any practical effect on the performance of soccer players with normal level of VD serum concentration. In contrast, VD supplementation is benefical to improve sprint, explosive power and shuttle run of male soccer players with the lower level of VD serum concentration.

**Keywords:** Vitamin D, Soccer, Performance, Sprint.

## Introduction

Soccer is the most popular sport inover the world. The number of players is progressively increasing especially women players. Furthermore, soccer attracts millions of television spectators, so famous sponsors want to support soccer matches ( Cornelissen & Maennig, 2010; Menon, Anayath, Garg, Ravi, & Pisharody, 2020; Wiciński, et al., 2019). Accordingly, the study of soccer and the variables that affect performance in this difficult team sport could have a positive impact on sports research (Stojanović, Radovanović, Hew-Butler, Hamar, & Jakovljević, 2022; Zhang & Cao, 2022).

During official matches and training sections, soccer players are exposed to varied physical demands, including running, jumping, sprints, accelerations, decelerations, and constant changes in direction (Dambroz, Clemente, & Teoldo, 2022). Developed soccer is characterized by the continuous combination of short-distance sprints, power strength, agility, jumping, shooting, tackling, and rest times for recovery (Haycraft, Kovalchik, Pyne, & Robertson, 2017). Likewise, these physical fitness components, players' techniques and cognitive capacity, tactics, and psychological factors might also have an impact on overall soccer performance (Krustrup et al., 2006; Sporis, Jukic, Ostojic, & Milanovic, 2009). Unlike other team sports, such as basketball or handball, soccer is a low-scoring game; thus, the chance of winning a match is lower than the others, particularly at the elite level.

As has been demonstrated in this research, the study of the effects of ergogenic aids on performance has become an important issue for players, coaches, and sports scientists. The desire to succeed and overcome the high physiological pressure of the game has led players to use supplements (Chia, Barrett, Chow, & Burns, 2017). Although it is not known whether vitamin D (VD) impacts muscle function directly or indirectly, several mechanisms underlying this action have been postulated. There are receptors in muscle fibers where VD may control the serum level of calcium directly affecting muscle contraction.

Vitamin D is primarily synthesized endogenously following cutaneous exposure to ultraviolet B radiation (UVB) (Holick, 2002; Muir & Montero-Odasso, 2011). Apart from its effect on calcium homeostasis and bone metabolism, vitamin D exerts a host of other physiological effects on neural and muscular tissues, the immune system, and energy homeostasis, thus affecting other parameters of physical performance (Moran, McClung, Kohen, & Lieberman, 2013).

There are two ways that VD absorbed, skin synthesis and dietary intake/supplement are the main factors determining the nutritional status of VD (Zhang & Cao, 2022). The active form of VD, 1,25-dihydroxyvitamin D (1,25(OH)2D) is synthesized from 25-hydroxyvitamin D (25(OH)D). Serum 25(OH)D is the best marker of VD status, as it reflects both cutaneous production and dietary intake of VD (Lanteri, Lombardi, Colombini, & Banfi, 2013). The serum concentration of the active steroid hormone's precursor, 25(OH)D, is the best indicator of VD status because it has a long half-life of 15 days.

One of the reasons that increased the importance of VD serum concentration, is the Corona pandemic that occurs all over the world. Most soccer players faced confinement or another kind of limitation which deprived players of the best source of VD, sun exposure (J. Jastrzębska et al., 2022).

VD is considered a key factor in enhancing musculoskeletal health during childhood and adolescence (Saggese et al., 2015). Being involved in the regulation of transcription, gene expression, and metabolism in skeletal muscle (Boland, 2011; Ceglia, 2008), VD can play a role in muscle function and may impact the physical performance of athletes (Dahlquist, Dieter, & Koehle, 2015; Hamilton, Whiteley, Farooq, & Chalabi, 2014; Koundourakis, Androulakis, Malliaraki, & Margioris, 2014). Vitamin D deficiency is widespread among both athletic and non-athletic populations (Hamilton, 2011), and in athletes, its prevalence varies from 11% to 83% (Close et al., 2013; Ogan & Pritchett, 2013). Some studies suggest that poor VD status negatively affects musculoskeletal health and physical performance (Close et al., 2013; El-Hajj Fuleihan et al., 2006; Ward et al., 2009). The obtained results provided ambiguous results. Numerous researchers have reported that an optimal (>30–50 ng/) mL or high level (>50–100 ng/) mL of 25(OH)D could have a moderate effect on improving the athlete's performance (Dahlquist et al., 2015; Jastrzębska et al., 2018).

Due to the nature of professional soccer, players are at particular risk for VD insufficiency. The reason for this is the large number of matches played during a year where the difference between the pre-season and competitive periods has become indistinct and the offseason sometimes lasts less than two weeks.

Most of the studies on VD supplementation are limited to the disease population or total population of sports fields. In this systematic review, we investigated the effect of VD supplementation on the performance of soccer players. It's the first review study that investigated the effect of VD among male soccer players in the original studies.

## Methods

### Search Strategies

The research articles were searched for and selected from electronic databases, including Medline, Scopus, PubMed, Web of Science, and Science Direct. The search was conducted in the last mounth of 2022. These databases were searched using the terms vitamin D OR vitamin D supplementation OR vitamin D2 OR vitamin D3 OR 1-alpha hydroxyvitamin D3 OR 1-alpha hydroxycalciferol OR 1,25-dihydroxyvitamin D3 OR 1,25 dihydroxycholecalciferol OR 25 hydroxycholecalciferol OR 25-hydroxyvitamin D OR calcitriol OR ergocalciferol OR cholecalciferol or calcifediol or alfa-calcidol or calcidiol or calciferol AND soccer or football AND physical performance OR physical endurance OR physical OR endurance OR performance OR aerobic OR anaerobic.. All titles and abstracts from the search were downloaded to Endnote X9 and manual cross-referencing was performed to identify duplicates and find missing studies. Titles and abstracts were screened for a subsequent full-text review. The search for published studies was independently performed by different authors and disagreements were resolved through discussions between authors.

### Inclusion and Exclusion Criteria

There were no filters applied to the soccer players' level, race, or age to increase the power of the analysis. However, for the articles obtained in the database search, the following inclusion criteria were applied to select the final studies: (1) in which there was an experimental condition that included the supplementation of VD before and/or during exercise which was compared to an identical experimental condition with the ingestion of a placebo; (2) testing the effects of VD supplementation on soccer-specific tests and/or real or simulated matches; (3) with a blinded and randomized design; (4) with clear information regarding the administration of VDs; (5) soccer players with previous training backgrounds in this sport; and (5) published in any language. On the other hand, the following exclusion criteria were applied to the experimental protocols of the investigation: (1) research that was not conducted with soccer players; (2) studies that were performed for clinical purposes or therapeutic use; (3) the absence of a true placebo condition; and (4) studies carried out using participants with a previous medical condition, illness, or injury.

Covidence(http://community.cochrane.org/tools/reviewproductiontools/covidence) is an online Cochrane priamary screening and data extraction tool that has inbuilt keysteps including the PRISMA flow diagram and the Cochrane risk of bias assessment tool (http://www.cochrane.org). This platform was used to screen, select,and assess the quality of the papers. The trial was scored as low risk if adequately described high risk if not described, and unclear if inadequately described. We were unable to assess reporting bias because of the lack of access to protocols. The citations from the initial search after excluding duplicates were uploaded in Covidence. The review articles were cross-referenced to identify additional articles. Titles and abstracts were reviewed for eligibility in duplicate and independently. Two authors then independently reviewed the full texts of the selected articles for further eligibility. Disagreements were resolved through consensus.

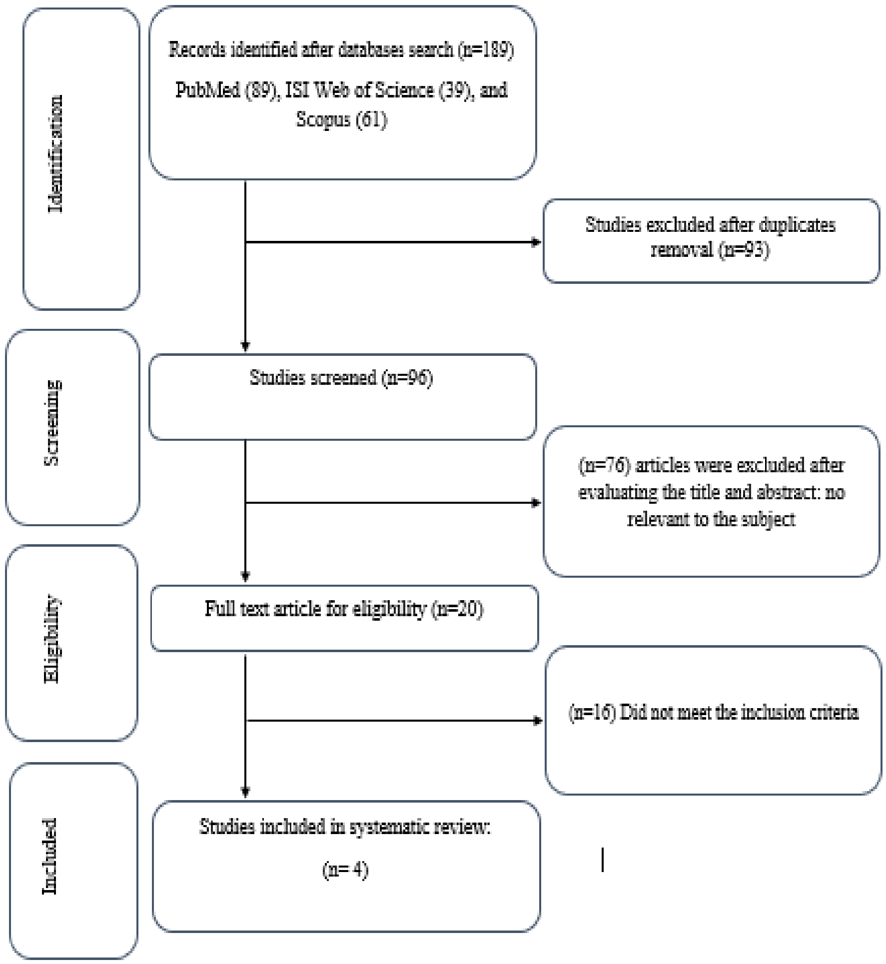


**Figure1.PRISMA protocol for data acquisition**

**Table1. Summary of the papers included**

| Study | year | Population | Control group | season | Base line of 25(OH)D (ng/mL) | Post suplemention 25(OH)D concentrations (ng/mL) | Intervention | Outcome analyzed | Conclusions |
|---|---|---|---|---|---|---|---|---|---|
| Jastrzebska (2022) | 2022 | 24 young soccer players | same team n=11 | winter | 26.4 ± 15.32 ng/mL | 40.5 ± 6.86 ng/mL | 8 weeks 5000IU/d | • Vo2 max<br>• 10 m<br>• 30 m<br>• CMJ | ↔<br>↑<br>↑<br>↔ |
| Michalczyk (2020) | 2020 | 28 elite soccer players | administered a placebo n=13 | winter | 32.37 ± 6.3 ng/mL | 54.03 ± 7.4 ng/mL | 6 weeks 6000 IU/d | • Vo2 max<br>• 5 m<br>• 30 m<br>• explosive power | ↔<br>↑<br>↔<br>↔ |
| Bezrati (2020) | 2020 | 36 young soccer players | placebo (n=17) | winter | 19.3±4.87 ng/mL | above >35 ng/mL | 12 weeks 200\000 IU Single dose | • Vertical jump<br>• 10 m<br>• 30 m<br>• Shuttle run | ↑<br>↑<br>↑<br>↑ |
| Jastrzebska (2016) | 2016 | 36 well-trained soccer players | n=16 | winter | 48±12.4 ng/mL | above >50 ng/mL | 8weeks 5000 IU\d | • 5 m<br>• 10 m<br>• 30 m<br>• CMJ | ↔<br>↔<br>↔<br>↔ |

## Results

The literature search identified a total of (N=189) papers related to the topic, categorized by databases, PubMed (89), Web of Science ISI (39), and Scopus (61). 76 articles were excluded after evaluating the title and abstract due to no relevant to the subjec.I the next step, 16 papers were excolouded because of the following inclusion criteria which were applied to select the final studies: (1) in which there was an experimental condition that included the supplementation of VD before and/or during exercise which was compared to an identical experimental condition with the ingestion of a placebo; (2) testing the effects of VD supplementation on soccer-specific tests and/or real or simulated matches; (3) with a blinded and randomized design; (4) with clear information regarding the administration of VDs (4) soccer players with previous training backgrounds in this sport; and (5) published in any language. On the other hand, the following exclusion criteria were applied to the experimental protocols of the investigation: (1) research that was not conducted with soccer players; (2) studies that were performed for clinical purposes or therapeutic use; (3) the absence of a true placebo condition; and (4) studies carried out using participants with a previous medical condition, illness, or injury. Finaly, only 4 articles had all the inclusion criteria.

The length of the studies ranged from 6 weeks to 12 weeks. The literature search identified a total of (N=189) papers related to the topic, but only 4 articles had all the inclusion criteria (Figure 1). 124 participants included in the systematic review; professional or elite (N=64) and young players(N=60).

The supplement dosage also varied from study to study, ranging from 5000 to 6000 IU per day, and a paper with 200\000 IU Single dosage. The mean concentration of four studies at baseline was 31.475 ng/mL. There seems to be no harmony between researchers regarding the level of 25(OH) D required for optimal health.

All the papers have the same measurement of sprint tests. The sprint tests were performed indoors on a running track at 5m, 10 m, and 30 m. The subjects performed two attempts at each distance (with an adequate time of recovery), and only the best (the shortest) time was considered. Besides, in a study by Jastrzębska et al. (2022), the special protocol of warming up was considered. Before the test, the subjects performed a 20 min warm-up involving accelerations.

The general structure of explosive and countermovement jump (CMJ) wasn't different. The participants performed three CMJ with the hands by the hip and a knee bend of approximately 90°. The heights of the jump were measured using a photoelectric system. CMJ was performed on a hard surface with the participants wearing running shoes. In the study conducted by Bezrati et al. (2020) in which the shuttle run test was performed, agility was evaluated with the 4×9-m shuttle run test.

For assessment of Vo2max in Michalczyk study (Michalczyk et al., 2020), the athletes ran on a treadmill with a starting speed of 6 km/h with speed increases of 2 km every 3 minutes until exhaustion. Oxygen uptake was monitored throughout the test. However, the other study by Jastrzębska et al. (2022) reported Vo2max . The researchers didn't use the laboratory method. The Progressive Aerobic Cardiovascular Endurance Run test was applied to assess the level of $VO_2$max. The Yo-Yo test was carried out by soccer players. The test was performed on the running track in the indoor sports complex Thus, the external conditions were identical during each attempt. The test consists of running for as long as possible between two lines, distancing 20 m in two directions, and running back and forth until exhaustion. In the test, the participant moves from one point to another, changing direction to the rhythm imposed by an audio signal. The speed obtained in the last completed stage for each player was considered as individual maximal aerobic speed, as well as the total distance reached. It was used to estimate the $VO_2$max.

## Discussion
It is the first review study that investigated the effect of vitamin d supplementation on the physical performance of male soccer players in a systematic way. Two studies ( Jastrzębska et al., 2016; Michalczyk et al., 2020) reported no significant differences between supplemented group and placebo in physical performance. Although the protocol of studies carried out in winter, in these papers, Base line of 25(OH)D in soccer players was sufficient. Actually, VD supplementation resulted in both positive and futile effects on sprint tests, explosive power, agility, and aerobic capacity. The role of VD in muscle function has long attracted attention. VD serum concentration deficiency was closely associated with atrophy of type II fibers, consequence in reduced muscle function, and VD supplementation improved muscle power and strength in VD-deficient animals and humans (Endo et al., 2003).
The study by Jastrzębska et al. (2016) and Wyon et al. (61) was conducted on 36 professional males. Before supplementation, the mean serum concentration of 25(OH)D was 48±12.4 ng/mL. Over the course of 8-weeks, 5,000 IU of vitamin D3 was administered to the experimental group daily. None of the sprint tests and CMJ improved significantly. Additionally, in Michalczyk et al. (Michalczyk et al., 2020) paper, 28 elite soccer players (height 181.5 cm; body mass 77.81 ± 8.8 kg; body fat 12.38% ± 2.4% and muscle mass 40.27 ± 5.3 kg) completed the study. All soccer players were randomly were assigned either to an experimental group—EG (n = 15)—or a placebo group—PG (n = 13) and it was administered 6000 IU/d cholecalciferol or a placebo, respectively, during 6 weeks. Before supplementation, the mean serum concentration was 32.37 ± 6.3 ng/mL which increased after 6 weeks of supplementation to 54.03 ± 7.4 ng/mL, which indicated reaching the lower limit for a high concentration of VD, and after the summer season, 25(OH)D serum concentration. Vo2max increased after 6 weeks (57.8 ± 4.8 to 58.92 ± 5.3 ml/kg/min) in EG, but it wasn't significant in comparison with PG. Moreover, neither 10m nor 30m improved significantly. In contrast, the soccer players achieved better results on the 5 m speed test. In two studies ( Jastrzębska et al., 2022; Michalczyk et al., 2020) in which the players had a sufficient level of VD in the serum concentration, Vo2 max wasn't increased significantly after supplementation interventions in the supplemented group. Furthermore, CMJ measured in two articles (J. Jastrzębska et al., 2022; Michalczyk et al., 2020), didn't increase significantly in the supplementation

group. all the players had considerably sufficient 25(OH)D serum concentration at the baseline. VD is actively used in lots of physiological pathways. More VD intake is recommended to fulfill adequate levels of availability, replenishment, and body resources in athletes (Backx et al., 2016; Willis, Peterson, & Larson-Meyer, 2008). Researches suggest an annual evaluation of VD serum concentration for athletes to maintain optimal 25(OH)D conventions 40 ng/ml (Ogan & Pritchett, 2013).

As it was a hypothesis that insufficient VD could affect physical performance, Several studies suggest roles for the vitamin D/VDR axis in myogenesis (formation of skeletal muscle), skeletal muscle regeneration and calcium homeostasis, but the link with performance is complex due to conflicting results generated by large randomised controlled trials (RCTs)(Bollen et al., 2022). The importance of Vitamin D is supported by the fact that receptors are found in almost every tissue in the body. Discovery of these receptors in muscle cells also indicates its special role as one of the important regulators of muscle tissue function (Girgis, Clifton-Bligh, Hamrick, Holick, & Gunton, 2013; Menon et al., 2020). Studies have found that D vitamin metabolites affect muscle by stimulating protein synthesis, increasing the ratio of fast twitch muscle fibers, improving cell function and proliferation (Ceglia & Harris, 2013; Menon et al., 2020; Motavari et al., 2022). Recent studies have also reported a relationship between vitamin D and cardiac respiratory capacity through increasing energy production in cardiac myocytes when sufficient levels are present.

In Bezrati et al. (2020), thirty-six soccer players were randomly assigned to a single dose (200,000 IU) of VD3 (n=19) or placebo (n=17). Plasma 25-hydroxyvitamin D (25-OHD) was assessed and measures of physical performance (i.e., vertical and standing broad jumps, 10-m and 30-m sprints, shuttle run) were performed before and 12 weeks after the loading dose. The mean serum concentration was 19.3±4.87 ng/mL, which increased after 12 weeks of supplementation to above >35 ng/mL. Significant improvements were reported after 12 weeks of intervention, vertical jump ($F=14.9$, $p=0.001$, $\eta p2=0.394$), 10-m ($F=4.46$, $p=0.046$, $\eta p2=0.162$), 30-m ($F=6.56$, $p=0.017$, $\eta p2=0.222$) sprints, shuttle run ($F=13.4$, $p=0.001$, $\eta p2=0.369$). Recent study on rats reports that prolonged, 12 months, VD insufficiency induces characteristics of sarcopenia that include poor anaerobic capacity, lower lean mass, and a trend towards smaller fast twitch fiber cross-sectional area that can impair the sprint performance. It can be noticed that the vitamin D resources stored in soccer player's body effectively influence the level of their anaerobic fitness (Książek et al., 2019).

It should be declared that the benefit of VD on muscle performance of athletes have been observed when any deficiency and insufficiency have been corrected by administering vitamin D3 supplements (Chiang et al.,2017) . Although only soccer players with initially low VD levels had a positive effect on power, strength and performance by increasing VD concentrations (Cannell et al., 2009), it could be discussed that the available studies on the effect of VD on physical performance are in-consistent and limited to investigatig the effect of supplementary VD on muscle performance in athletes with VD deficiency. Although in Greek male soccer players, a significant correlation between VD status and squat jump, counter-movement jumps (CMJ), 10 m and 20 m sprint test was carried out, the pathways by which VD affects muscular strength (as measured by squat jump and CMJ) and sprint performance are still hypothetical. However, there are several potential mechanisms pesuading these effects. The ergogenic effects of vitamin D may be related to the regulation of muscle protein synthesis which could affect muscle mass. Furthermore, alterations in VD serum levels also affect its receptors at the expression and activation levels, muscle mass (Lee et al., 2003), neuromuscular coordination, and the relative number and the cross-sectional area of type II muscle fibers (Lämmle etal., 2013). Since it well documented that the major determinants of jumping and sprinting ability are muscle strength (Fatemi et al., 2012), type II muscle fibers and neuromuscular coordination (Kopeć et al., 2012), any potential effect of vitamin D on these parameters would in turn affect jumping and sprinting capacity in a similar manner.

In Jastrzebska et al. (2020), 24 young soccer players (age: 17.2 ± 1.16 years, mass: 70.2 ± 5.84, height:179.1 ± 4.26 cm) were divided into a supplemented (GS) group and a placebo group (GP). Variables such as 25(OH)D, aerobic capacity, speed, and explosive power were measured.Soccer players of the supplemented group (GS) were given the vitamin D bottle (Vigantol Merck), whereas the non-supplemented group placebo (GP) received identical bottles with sunflower oil The GS group received 5000 IU of vitamin D daily in the morning. All participants were asked to take 10 droplets per day (vitamin D or sunflower oil). Before supplementation, the mean serum concentration was 32.37 ± 6.3 ng/mL which increased after 8 weeks of supplementation to 40.5 ± 6.86 ng/mL. After 8 weeks sprint test improved significantly but Vo2max didn't increase. Relations between VD level and aerobic fitness in athletes are unclear yet. In a study. no changes was found in aerobic capacity (Vo2max) of athletes with higher 25(OH)D concentration (Fitzgerald et al., 2014). Besides, in the other study, Forney et al. (2014) resulted that higher VO2max values in participants were supplemented with VD. Despite many theoretical mechanisms of action, the effects of vitamin D on physical performance remain to be fully elucidated in soccer players. Further research in this field is required to determine mechanisms of action, dosage at which vitamin D modulates skeletal muscle function, and whether biological changes in serum 25(OH)D translate into improved physical performance in soccer players. There are significant negative correlations between the 25(OH)D concentration sprint times on the distances of 5 m, 10 m, and 30 m suggesting that players with a higher vitamin D level reached better times in the speed tests. There isn't any relation between the level of VD serum concentration and aerobic capacity; although VD serum concentration increased after interventions, Vo2max didn't enhance even in soccer players with inadequate VD concentration. The current facts indicated that the supplementation of 5000 IU/day led to significantly enhances in VD concentrations and achieved sufficiency among male soccer players. The effect of VD supplementation on the physical performance of male soccer players should be examined in different soccer positions (like Right Midfielder or Winger), especially because of the significant correlation between sprint performance and VD serum concentration in diverse ethnicities principally, in players with a different baseline of VD serum concentration. Meanwhile, since lacing papers investigated the relationship between strength and soccer as an important component of athletic performance in male soccer players, researchers should investigate the effect of VD status on the muscle strength of male soccer players.

## Conclusion

VD supplementation doesn't have any practical effect on the performance of soccer players with normal level of VD serum concentration. In contrast, VD supplementation is benefical to improve sprint, explplosive power and shuttle run of male soccer players with the lower level of VD serum concentration.We found that there is a strong relation between VD deficiency and the reduction of male soccer players. Subjects that had insufficient or deficient VD statues (<29 ng/ml) and enhanced by supplementation D3, were confronted with better performance like sprint tests. It can be concluded that a high concentration of VD may improve 5 m, 10 m, 20 m, and 30 m sprint tests.

## Conflict of Interest

There is no conflict of interest concerning this article.

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**Author Contributions:** All authors discussed the results and contributed to the final manuscript.

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