

THE SIGNIFICANCE OF VITAMIN D LEVELS ON MUSCULOSKELETAL STRENGTH, ATHLETIC PERFORMANCE, AND INJURY PREVENTION

Zokirjonov D.Z¹

G'ulomov Q¹

¹ Fergana Public Health Medical Institute

ARTICLE INFO

ABSTRACT:

ARTICLE HISTORY:

Received: 10.02.2025

Revised: 11.02.2025

Accepted: 12.02.2025

In this article, the authors conducted a retrospective analysis of the worldwide

studies of role vitamin D in life activity and various biological processes.

KEYWORDS:

athletes, vitamin D deficiency, bone health, physical fitness, adequate vitamin D, judoka athletes.

INTRODUCTION. Purpose: To know another authors opinions about importance of vitamin d level on musculoskeletal strength, sport performance and prevent of trauma.

Materials and methods: In this topic, the results of articles, abstracts, dissertations were taken from pubmed, web of science and google scholar databases, and a retrospective analysis was conducted on these scientific researches.

The results of the study: The article by Shuler et al. provides an in-depth examination of vitamin D's importance for sports health, particularly in relation to musculoskeletal function and athletic performance. Vitamin D, which is primarily acquired through sun exposure and food sources, is essential for various biological functions, such as muscle protein synthesis, ATP levels, strength, and immune response. Many individuals, including athletes, experience vitamin D deficiencies. The review highlights a strong link between adequate vitamin D levels and optimal muscle performance, pointing out the negative impacts that deficiency can have on muscle strength, reaction time, balance, and coordination. It addresses the risks associated with low vitamin D levels for athletes, such as a higher likelihood of musculoskeletal injuries, longer recovery times, and reduced

performance. Furthermore, the article explores the complexities surrounding vitamin D supplementation, stressing the importance of standardized guidelines under medical supervision. It recommends that athletes with vitamin D levels below 30 ng/mL should receive vitamin D3 supplementation, the more effective form, to enhance musculoskeletal health. The authors urge regular testing of vitamin D levels among athletes, particularly before training seasons, to ensure proper supplementation and avoid deficiencies. They also emphasize the need to consider vitamin D deficiency as a potential diagnosis for athletes suffering from stress fractures, musculoskeletal pain, and frequent illnesses. In summary, the article highlights the vital role of vitamin D in sports health, noting its diverse effects on musculoskeletal function, performance, and injury prevention. It calls for increased awareness among athletes, coaches, and healthcare providers about the commonality of vitamin D deficiency and the necessity for personalized supplementation strategies to boost athletic performance and overall health. [1].

Vitamin D is vital for athletes, as recent insights and emerging trends highlight its importance. This nutrient supports numerous physiological processes that influence athletes' performance and health. Studies indicate that a lack of Vitamin D can reduce muscle strength, increase the likelihood of injuries, and hinder recovery after intense exercise. Consequently, maintaining optimal Vitamin D levels is crucial for athletes aiming to achieve their training and competition objectives. Moreover, recent research underscores the potential advantages of Vitamin D supplementation in enhancing athletic performance. It can improve muscle function and bolster immune response, providing various benefits for athletes striving to reach their full potential. In summary, the significance of Vitamin D for athletes is profound. Ensuring sufficient intake of this essential nutrient is vital for maximizing performance, minimizing injury risks, and promoting overall health. As developments in sports nutrition continue, Vitamin D will undoubtedly play an essential role in helping athletes realize their goals and elevate their performance [2].

A recent study by Wilson-Barnes and colleagues investigated the influence of vitamin D on health and athletic performance, particularly among both elite and recreational athletes. Published in the Nutrition Bulletin in March 2020, the research highlights the potential advantages of vitamin D supplementation for individuals involved in various levels of physical activity. A major finding of the study is the critical role of vitamin D in enhancing overall health and wellness. Sufficient vitamin D levels have been associated with numerous positive health effects, such as better immune function, stronger bones, and increased muscle strength. For athletes, achieving optimal vitamin D levels may not only improve

performance but also decrease the likelihood of injuries and aid in recovery. Additionally, the study pointed to the possible effects of vitamin D on athletic performance itself. Evidence suggests that vitamin D may influence muscle function and athletic ability, with some studies finding links between vitamin D levels and various aspects of physical fitness and strength. This indicates that enhancing vitamin D status through supplementation or increased sunlight exposure could be an effective approach for athletes aiming to boost their performance, whether on the field or in training. Overall, the findings emphasize the significance of vitamin D for promoting both health and athletic performance. Regardless of whether one is a competitive athlete or a recreational sports enthusiast, ensuring adequate vitamin D intake could greatly affect overall health and physical performance. More research is necessary to comprehend the specific mechanisms by which vitamin D affects athletic performance and to develop clear recommendations for optimal vitamin D supplementation in athletes [3].

The research conducted by Aydın CG, Dinçel YM, Arıkan Y, Taş SK, and Deniz S aimed to explore how participation in indoor and outdoor sports, as well as seasonal variations, affects the vitamin D levels in athletes. Published in SAGE Open Medicine in March 2019, the study found that athletes who participated in outdoor sports had significantly higher vitamin D levels than those who primarily engaged in indoor activities. This indicates the vital role that natural sunlight plays in achieving optimal vitamin D levels among athletes. Additionally, the research pointed out that vitamin D levels varied with the seasons, with athletes tested during the summer showing higher vitamin D levels compared to those tested in winter. This finding highlights the need to consider seasonal effects when evaluating vitamin D status in athletes. In summary, the study emphasizes the importance of outdoor sports and sunlight exposure in maintaining sufficient vitamin D levels, and it notes the seasonal fluctuations with typically higher levels found in summer. These insights are crucial for athletes and sports professionals aiming to enhance vitamin D levels for better health and performance [4].

The research by Valtueña et al. (2021) examined the vitamin D levels of elite athletes in team sports across Spain, encompassing players from soccer, basketball, and handball. The findings revealed that a notable number of athletes had insufficient vitamin D levels, raising concerns about their health and athletic performance. Almost 50% of the participants were found to be deficient, with female athletes showing a higher tendency for deficiency compared to males. This is particularly concerning, as vitamin D is essential for bone health, muscle function, and immune system support; insufficient levels can increase the

risk of injuries, hinder athletic performance, and negatively impact overall health. The study underscored the necessity for routine monitoring of vitamin D levels among elite athletes, particularly those who train indoors or receive minimal sunlight. It also provided suggestions for dietary changes and supplementation to enhance athletes' vitamin D levels. In summary, the study stresses the importance of raising awareness about vitamin D status in elite team sports and suggests implementing strategies to optimize these levels for better health and performance. Additional research is needed to explore the long-term impacts of vitamin D deficiency in this athlete population and to create customized interventions to address these concerns [5].

The connection between vitamin D, physical activity, and general health is a multifaceted and still unresolved matter in clinical settings. Recent studies by Luigi L et al. have highlighted the significance of vitamin D in enhancing health and performance in both athletes and those who exercise regularly. Vitamin D is essential for maintaining bone health, immune system functionality, and muscle strength. However, its precise effects on athletic performance and overall health continue to be debated among specialists. Research indicates that vitamin D deficiency is common in athletes, particularly those who train indoors or live in areas with limited sunlight. This deficiency can result in weakened muscle function, reduced endurance, and a higher likelihood of injuries. Conversely, some findings imply that excessive vitamin D supplementation may not lead to better athletic performance. The ideal vitamin D levels for athletes and active individuals are still under discussion among health professionals. In summary, although vitamin D's role in supporting health and performance is acknowledged, the recommendations for its supplementation in athletes are not well-defined. Additional research is necessary to establish the ideal vitamin D levels for various athletic groups and to gain a deeper understanding of its effects on muscle performance, recovery, and injury prevention. A tailored approach to vitamin D supplementation, based on individual requirements and lifestyle choices, is suggested for athletes and those engaged in regular physical activity [6].

In a recent article published in the journal *Medicina*, researchers Iolascon G, Moretti A, Paoletta M, Liguori S, and Di Munno O investigated the connection between muscle regeneration, athletic performance, and vitamin D's influence. Their 2021 study sheds light on how vitamin D affects muscle health and capabilities in athletes. The ability to regenerate muscle is crucial for athletes recovering from rigorous physical exertion to sustain optimal performance. Vitamin D has been identified as a key factor in this regeneration process, aiding in muscle growth and repair. Moreover, a deficiency in vitamin

D has been associated with muscle weakness, fatigue, and a heightened risk of injuries among athletes. The researchers highlight the necessity for athletes to maintain sufficient vitamin D levels to facilitate muscle regeneration and functionality. They advocate for the routine monitoring of vitamin D levels and potential supplementation to ensure athletes achieve peak muscle health and performance. Additionally, they recommend including foods rich in vitamin D and ensuring adequate sunlight exposure in athletes' diets and training schedules. Overall, the study underscores the crucial role of vitamin D in promoting muscle regeneration and performance in sports. By keeping vitamin D levels adequate, athletes can improve their muscle health, enhance their performance, and lower the risk of injuries. More research is required to fully comprehend the potential of vitamin D in maximizing athletic performance and recovery [7].

Abrams, Feldman, and Safran published a study in April 2018 in the Journal of the American Academy of Orthopaedic Surgeons, examining the effects of vitamin D on skeletal muscle and athletic performance. Their research aimed to investigate the potential advantages of vitamin D supplementation for muscle function and exercise performance. The findings indicated that vitamin D is essential for the health and functionality of skeletal muscles. Sufficient levels of vitamin D were linked to enhanced muscle strength, endurance, and overall athletic capabilities. In contrast, vitamin D deficiency was associated with muscle weakness, fatigue, and reduced exercise performance. The authors emphasized the importance of maintaining optimal vitamin D levels for athletes and those who engage in regular physical activity. They recommended that individuals regularly check their vitamin D status and consider supplementation as needed to support muscle functionality and improve athletic performance. Overall, the study highlighted the significant influence of vitamin D on muscle health and athletic performance, underlining the necessity for athletes and active individuals to maintain adequate vitamin D levels through supplementation and monitoring. By addressing vitamin D deficiencies, individuals can enhance muscle function, boost exercise capacity, and achieve superior athletic performance [8].

A recent study by Marley A, Grant MC, and Babraj J revealed that weekly Vitamin D3 supplementation significantly improved aerobic performance in combat sport athletes. Published in the European Journal of Sport Science in March 2021, the research established a strong connection between Vitamin D3 intake and enhanced athletic performance. The study involved a group of combat sports competitors who received weekly doses of Vitamin D3 over a designated period and underwent various performance assessments to measure their aerobic capacity both before and after supplementation. The results indicated a

significant increase in aerobic performance in those who received Vitamin D3 compared to the control group. These findings imply that incorporating Vitamin D3 supplementation could be advantageous for combat sport athletes aiming to enhance their aerobic capabilities. The study underscores the potential influence of Vitamin D3 on athletic performance and emphasizes the importance of maintaining adequate levels of this crucial nutrient for overall physical fitness. In summary, the research conducted by Marley A, Grant MC, and Babraj J offers important insights into the positive effects of weekly Vitamin D3 supplementation on aerobic performance for combat sport athletes. By adding Vitamin D3 to their training routines, athletes might improve their endurance and overall performance. Further investigations in this field could help refine supplementation strategies and optimize benefits for athletes across various sports [9].

A study by Cannell JJ and colleagues (2009) revealed a notable correlation between vitamin D levels and athletic performance. The findings indicated that individuals with higher levels of vitamin D generally demonstrated better athletic abilities than those with lower levels. Vitamin D is essential for several physiological functions critical to athletic performance, such as regulating calcium and phosphorus levels, which are vital for muscle function and bone health. Additionally, vitamin D contributes to immune system performance, which is crucial for overall health and athletic capacity. The researchers observed that athletes with elevated vitamin D levels exhibited enhanced muscle strength, endurance, and overall performance in comparison to those with diminished levels. This implies that maintaining adequate vitamin D levels could positively influence athletic performance. It is advisable for athletes to keep track of their vitamin D levels and maintain them within the recommended ranges for optimal performance. This can be achieved through a combination of sun exposure, dietary intake, and supplementation when necessary. In summary, this study highlights a significant link between vitamin D levels and athletic performance, suggesting that optimal vitamin D may enhance performance and overall well-being in athletes. Future research is required to investigate the mechanisms behind this relationship and to identify the ideal vitamin D levels for peak athletic performance [10].

A study by Wyon MA et al. (2016) explored the impact of vitamin D3 supplementation on muscle strength in judo athletes. Published in the Clinical Journal of Sport Medicine, this randomized, placebo-controlled, double-blind trial aimed to assess whether short-term vitamin D3 supplementation could enhance muscle strength among judokas. Thirty athletes were randomly assigned to receive either vitamin D3 or a placebo, and their muscle strength

was evaluated before and after the supplementation phase. Results indicated a notable increase in muscle strength in the group that received vitamin D3 compared to the placebo group, suggesting that vitamin D3 could positively influence muscle strength in judo athletes. The findings underline the potential benefits of vitamin D3 supplementation for enhancing athletic performance. Future studies may investigate the long-term effects of vitamin D3 on muscle strength and performance in judo athletes, highlighting the importance of considering vitamin D3 for improving athletic performance and overall health for athletes and coaches [11].

In the research carried out by Close et al. (2013), the aim was to evaluate vitamin D levels in professional athletes and healthy individuals in the UK during the winter season. The study aimed to investigate how vitamin D concentrations could affect skeletal muscle function in those not taking supplements. Findings indicated that both groups exhibited low vitamin D levels in winter, with athletes having slightly higher levels than the general population. This vitamin D deficiency could adversely impact muscle function, which is vital for athletes striving to achieve peak performance. The researchers emphasized the importance of considering vitamin D supplementation, especially when natural sunlight exposure is minimal during winter months. They noted that sustaining optimal vitamin D levels is crucial for muscle function and performance, particularly for athletes who depend on their strength and endurance. In summary, the work by Close et al. (2013) highlights the need for regular monitoring and maintenance of adequate vitamin D levels in both athletes and the general population, particularly in winter. Ensuring sufficient vitamin D can enhance muscle function and overall performance, stressing the importance of addressing deficiencies through supplementation and other strategies. Further studies are required to investigate the specific impacts of vitamin D on muscle function and performance across various populations and environments [12].

In 2015, Todd JJ, Pourshahidi LK, McSorley EM, Madigan SM, and Magee PJ published a paper in the Sports Medicine journal that examines recent progress in Vitamin D research and its relevance for athletes. The study investigates the possible advantages of Vitamin D supplementation for those involved in sports and physical activities. The authors elaborate on Vitamin D's role in various bodily functions, such as muscle performance, immune system response, and bone health, stressing the need for optimal Vitamin D levels to enhance athletic performance and overall health. Additionally, the paper discusses the risks associated with Vitamin D deficiency in athletes, including a higher likelihood of injuries and slower recovery times. The authors call for regular monitoring of Vitamin D levels and

personalized supplementation approaches to cater to individual requirements. In summary, the review highlights the critical role of Vitamin D in athletic performance and encourages further research to refine supplementation strategies for athletes [13].

In their 2015 study published in the Journal of the International Society of Sports Nutrition, Dahlquist, Dieter, and Koehle examined the potential advantages of vitamin D supplementation for athletes. They discussed how vitamin D could enhance athletic performance and facilitate recovery after exercise. The study's results indicate that vitamin D might significantly improve muscle function, strength, and general physical performance in athletes. Moreover, the researchers pointed out that adequate vitamin D levels could help lower the risk of injuries and promote quicker recovery following intense workouts. The research underscores the importance of maintaining sufficient vitamin D levels for athletes aiming to optimize their performance and recovery. By including vitamin D supplements in their training routine, athletes might achieve better performance and faster recovery, ultimately enhancing their success in their sports [14].

In their March 2018 article published in Sports Medicine, Owens DJ, Allison R, and Close GL examine the significance of vitamin D for athletes. The authors provide an overview of current insights and highlight the new challenges in comprehending how vitamin D affects athletic performance. They discuss its critical role in supporting bone health, muscle function, and overall athletic capabilities. The paper also investigates the possible advantages of vitamin D supplementation for athletes who may lack sufficient levels of this nutrient. Additionally, the authors consider the complexities involved in vitamin D metabolism and absorption, as well as the differing requirements among athletes. They stress the necessity for personalized vitamin D supplementation strategies that take into account factors such as training intensity, geographic location, and skin pigmentation. Overall, the study illuminates the ongoing development of knowledge regarding vitamin D's impact on athletic performance and emphasizes the need for continued research in this field [15].

In their 2019 study, Wiciński et al. examined the influence of vitamin D on physical performance and exercise ability. The review underscored the significant role of vitamin D in boosting overall physical effectiveness and exercise capabilities. Through a thorough evaluation of existing research, the authors found that sufficient vitamin D levels are essential for enhancing muscle function, strength, and endurance. Additionally, vitamin D was shown to positively affect various aspects of physical performance, such as balance, coordination, and agility. The review also stressed the need for athletes and those who

exercise regularly to maintain optimal vitamin D levels. Low vitamin D levels were associated with diminished muscle function, heightened injury risk, and lowered exercise capacity. Ultimately, the study suggested that vitamin D supplementation might improve physical performance and exercise efficiency. The findings emphasized the necessity of adequate vitamin D intake for maximizing athletic performance and overall health. Overall, the review by Wiciński et al. (2019) offered important insights into how vitamin D contributes to physical efficiency and exercise performance, highlighting its crucial role in enhancing muscle function and overall physical capabilities [16].

In a study by Moran DS, McClung JP, Kohen T, and Lieberman HR, the link between Vitamin D levels and physical performance was explored. Published in Sports Medicine in July 2013, the research examined how Vitamin D influences an individual's physical capabilities. The results indicated that Vitamin D is vital for improving physical performance, as individuals with higher Vitamin D levels demonstrated superior overall physical abilities than those with lower levels. This implies that maintaining sufficient Vitamin D is crucial for optimal physical functioning. Additionally, the study pointed out Vitamin D's role in enhancing muscle strength, balance, and endurance. Participants with adequate Vitamin D levels showed improved muscle strength and balance, both of which are essential for physical performance. Overall, the findings highlight the importance of Vitamin D in boosting physical abilities and stress the necessity of proper nutrition and sunlight exposure to maintain adequate Vitamin D levels. By ensuring sufficient Vitamin D, individuals can enhance their physical performance in various activities [17].

In this narrative review authored by Książek, Zagrodna, and Słowińska-Lisowska and published in Nutrients in August 2019, the authors explore the connection between vitamin D, skeletal muscle function, and athletic performance among athletes. They emphasize the significance of vitamin D for maintaining proper skeletal muscle function and enhancing athletic capabilities. The review discusses the adverse effects of vitamin D deficiency, which can result in muscle weakness, fatigue, and reduced physical performance in athletes. To potentially boost muscle strength, endurance, and overall athletic performance, the authors suggest that maintaining adequate levels of vitamin D is crucial for athletes. Through a thorough examination of relevant research, they outline various ways in which vitamin D affects muscle function, including its involvement in muscle protein synthesis, calcium regulation, and muscle contraction. Additionally, the authors consider the potential advantages of vitamin D supplementation for athletes, especially those at risk of deficiency due to limited sun exposure or inadequate dietary intake. Overall, this review highlights the

essential role of vitamin D in promoting skeletal muscle health and optimizing athletic performance. By assessing the vitamin D status of athletes and adopting suitable supplementation methods, coaches and sports professionals can enhance both the physical performance and overall health of their athletes [18].

In their 2010 research, Bartoszewska, Kamboj, and Patel examined the connection between Vitamin D levels, muscle function, and exercise performance. Their findings, published in *Pediatric Clinics*, highlighted Vitamin D's critical role in ensuring optimal muscle function and improving exercise performance. The study demonstrated that Vitamin D is vital for facilitating muscle growth and repair, and that sufficient Vitamin D levels are necessary for muscle strength, coordination, and overall physical performance during exercise. Additionally, the researchers observed that individuals with higher levels of Vitamin D generally exhibited better muscle function and showed enhanced exercise performance compared to those with lower levels. This indicates that maintaining adequate Vitamin D through supplementation or sunlight exposure may positively affect muscle health and physical fitness. In summary, the study emphasized the importance of Vitamin D for muscle function and exercise performance, offering essential insights into the benefits of adequate Vitamin D levels for overall health and well-being [19].

In their 2013 study, Ogan and Pritchett examined the link between vitamin D and athletes, concentrating on the associated risks, guidelines, and advantages of vitamin D consumption. They stressed the significance of keeping optimal vitamin D levels for athletes to enhance their overall well-being and performance. Vitamin D is essential for numerous bodily functions, including muscle performance, immune system health, and bone density. Athletes are particularly vulnerable to vitamin D deficiency due to factors like limited sunlight exposure, rigorous training schedules, and insufficient dietary sources. Thus, it is vital for athletes to regularly check their vitamin D levels and consider supplementation if needed. The study pointed out the potential benefits of sufficient vitamin D for athletes, such as better muscle performance, decreased injury risk, and quicker recovery times. Moreover, adequate vitamin D has been associated with improved athletic performance and general health. Overall, Ogan and Pritchett's research highlights the necessity for athletes to maintain optimal vitamin D levels to bolster their physical health and performance. By adhering to suitable guidelines and addressing potential deficiencies, athletes can fully leverage the benefits of vitamin D in their training and competitions [20].

References:

1. Shuler FD, Wingate MK, Moore GH, Giangarra C. Sports health benefits of vitamin D. *Sports health*. 2012 Nov;4(6):496-501.
2. de La Puente Yagüe M, Collado Yurrita L, Ciudad Cabañas MJ, Cuadrado Cenual MA. Role of vitamin D in athletes and their performance: current concepts and new trends. *Nutrients*. 2020 Feb 23;12(2):579.
3. Wilson-Barnes SL, Hunt JE, Lanham-New SA, Manders RJ. Effects of vitamin D on health outcomes and sporting performance: Implications for elite and recreational athletes. *Nutrition bulletin*. 2020 Mar;45(1):11-24.
4. Aydın CG, Dinçel YM, Arıkan Y, Taş SK, Deniz S. The effects of indoor and outdoor sports participation and seasonal changes on vitamin D levels in athletes. *SAGE open medicine*. 2019 Mar; 7:2050312119837480.
5. Valtueña J, Aparicio-Ugarriza R, Medina D, Lizarraga A, Rodas G, González-Gross M, Drobnic F. Vitamin D status in Spanish elite team sport players. *Nutrients*. 2021 Apr 15;13(4):1311.
6. Di Luigi L, Antinozzi C, Piantanida E, Sgrò P. Vitamin D, sport and health: A still unresolved clinical issue. *Journal of Endocrinological Investigation*. 2020 Dec;43:1689-702.
7. Iolascon G, Moretti A, Paoletta M, Liguori S, Di Munno O. Muscle regeneration and function in sports: a focus on vitamin D. *Medicina*. 2021 Sep 25;57(10):1015.
8. Abrams GD, Feldman D, Safran MR. Effects of vitamin D on skeletal muscle and athletic performance. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*. 2018 Apr 15;26(8):278-85.
9. Marley A, Grant MC, Babraj J. Weekly Vitamin D3 supplementation improves aerobic performance in combat sport athletes. *European Journal of Sport Science*. 2021 Mar 4;21(3):379-87.
10. Cannell JJ, Hollis BW, Sorenson MB, Taft TN, Anderson JJ. Athletic performance and vitamin D. *Medicine & Science in Sports & Exercise*. 2009 May 1;41(5):1102-10.
11. Wyon MA, Wolman R, Nevill AM, Cloak R, Metsios GS, Gould D, Ingham A, Koutedakis Y. Acute effects of vitamin D3 supplementation on muscle strength in judoka athletes: a randomized placebo-controlled, double-blind trial. *Clinical journal of sport medicine*. 2016 Jul 1;26(4):279-84.
12. Close GL, Russell J, Copley JN, Owens DJ, Wilson G, Gregson W, Fraser WD, Morton JP. Assessment of vitamin D concentration in non-supplemented professional

athletes and healthy adults during the winter months in the UK: implications for skeletal muscle function. *Journal of sports sciences*. 2013 Feb 1;31(4):344-53.

13. Todd JJ, Pourshahidi LK, McSorley EM, Madigan SM, Magee PJ. Vitamin D: recent advances and implications for athletes. *Sports medicine*. 2015 Feb;45:213-29.

14. Dahlquist DT, Dieter BP, Koehle MS. Plausible ergogenic effects of vitamin D on athletic performance and recovery. *Journal of the International Society of Sports Nutrition*. 2015 Aug 19;12(1):33.

15. Owens DJ, Allison R, Close GL. Vitamin D and the athlete: current perspectives and new challenges. *Sports medicine*. 2018 Mar;48:3-16.

16. Wiciński M, Adamkiewicz D, Adamkiewicz M, Śniegocki M, Podhorecka M, Szychta P, Malinowski B. Impact of vitamin D on physical efficiency and exercise performance—A review. *Nutrients*. 2019 Nov 19;11(11):2826.

17. Moran DS, McClung JP, Kohen T, Lieberman HR. Vitamin D and physical performance. *Sports Medicine*. 2013 Jul;43:601-11.

18. Książek A, Zagrodna A, Słowińska-Lisowska M. Vitamin D, skeletal muscle function and athletic performance in athletes—A narrative review. *Nutrients*. 2019 Aug 4;11(8):1800.

19. Bartoszewska M, Kamboj M, Patel DR. Vitamin D, muscle function, and exercise performance. *Pediatric Clinics*. 2010 Jun 1;57(3):849-61.

20. Ogan D, Pritchett K. Vitamin D and the athlete: risks, recommendations, and benefits. *Nutrients*. 2013 May 28;5(6):1856-68.