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The Effect of Vitamin Deficiency on Youth Athletes in Pathogenesis —— Taking Vitamin B, C, D as Examples

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Abstract. With the rapid development of youth sports and increasingly demanding competitive standards, scientific nutritional support has become a core strategic element in cultivating elite young athletes. However, vitamin deficiency remains prevalent among this population. This nutritional imbalance not only leads to health risks such as compromised immune function and abnormal bone development, but also directly impacts key athletic performance indicators including power output, endurance levels, and recovery efficiency. This paper examines the pathogenesis and consequences of deficiencies in Vitamin C, Vitamin B, and Vitamin D, highlighting their influence on immunity, bone health, energy metabolism. Research shows that insufficient intake not only impairs physical performance but also increases the risk of long-term injuries and illnesses, ultimately offering a theoretical foundation for optimizing dietary plans and promoting the sustainable development of youth sports.

Keywords: vitamin, athlete, disease, illness

1. Introduction

The rising emphasis on youth athletic performance has highlighted the critical role of nutrition, particularly vitamins, in optimizing physical development and preventing sports-related health risks. Despite growing awareness, deficiencies in key vitamins—such as C, B-complex, and D—remain prevalent among young athletes, impairing immune function, energy metabolism, and musculoskeletal health. Recent studies reveal that these deficiencies not only hinder short-term performance but also pose long-term risks, including muscle atrophy, bone fragility, and metabolic dysfunction. This paper examines the pathogenic mechanisms of vitamin C, B, and D deficiencies in youth athletes, analyzing their effects on muscle recovery, bone strength, and endurance. By synthesizing findings from clinical and sports science literature, we evaluate both the benefits and limitations of supplementation, emphasizing the need for balanced dietary strategies over isolated high-dose interventions. The review underscores the importance of tailored nutrition plans to address vitamin deficiencies while avoiding unintended interference with exercise-induced physiological adaptations. By bridging gaps between research and practical application, this study aims to guide coaches, nutritionists, and athletes in optimizing performance and safeguarding long-term health through evidence-based vitamin management.

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2. Vitamin C deficiency risks and supplementation dilemmas

Vitamin C, also known as ascorbic acid, is a water-soluble vitamin essential for various bodily functions, including tissue growth and repair, wound healing, and immune system support. Deficiency of Vitamin C can lead to impaired collagen formation, weakened immune response, and delayed wound healing.

A recent study published in Scientific Reports has provided a link between vitamin C deficiency and the progressive loss of muscle mass and physical function. The research provides compelling evidence that a lack of this essential nutrient leads to muscle atrophy and a significant decline in physical performance, effects that are reversible with vitamin C supplementation [1]. The findings revealed that insufficient intake led to muscle atrophy and a significant decline in performance capacity. Importantly, these adverse effects were shown to be reversible through appropriate vitamin C supplementation, emphasizing the nutrient's vital role in maintaining muscular health. For young athletes, this suggests that monitoring vitamin C levels is not only crucial for recovery and immune defense but also for preserving long-term muscle function and preventing performance decline. Regarding vitamin C's effect on reducing muscle breakdown, the evidence is mixed: among 14 reviewed studies, only three demonstrated efficacy in decreasing post-exercise muscle damage markers. Notably, these positive results often occurred when vitamin C was combined with other supplements like quercetin or vitamin E. Studies on vitamin C alone did not show a significant positive impact on long-term muscle damage markers or delayed-onset muscle soreness (DOMS) [2]. These findings suggest that while vitamin C deficiency clearly compromises muscular health, standalone supplementation may not sufficiently protect against exercise-induced muscle injury. Instead, a balanced dietary approach that considers the interactions of multiple nutrients may be more effective in supporting recovery and performance among youth athletes.

A critical finding of the review is the potential for high-dose antioxidant supplementation to interfere with the body's natural and beneficial adaptations to exercise. The production of reactive oxygen species (ROS) during exercise is a natural signal that triggers mitochondrial biogenesis and muscle hypertrophy [2]. The review highlights multiple studies where vitamin C, usually with vitamin E, blunted these training adaptations. For instance, placebo groups often showed significant improvements in muscle strength, lean mass, and markers of mitochondrial growth, while the supplemented groups did not. These findings highlight that while deficiency clearly compromises health and performance, indiscriminate supplementation may blunt beneficial physiological adaptations, suggesting the importance of achieving balance rather than pursuing excessive vitamin intake in youth athletes.

Since the sprinters' performance mostly depends on their muscle contraction ability, they are crucial to consume vitamin C in their daily lives. First of all, vitamin C deficiency may cause the muscular soreness, affecting that young athletes have troubles with their sleeping and flexible ability, which is the decisive factor for their performance. Furthermore, since vitamin C has no significant impact on mitigating long-term muscle damage, young athletes often underestimate its importance, leading to prolonged recovery periods due to inadequate intake.

3. Vitamin B deficiency risks and supplementation dilemmas

The B-vitamins represent a group of water-soluble micronutrients that are indispensable for energy metabolism and neurological function. Vitamin B1 plays a key role in carbohydrate metabolism, ensuring efficient conversion of glucose into energy, which is vital during endurance exercise. Vitamin B2's functions as a coenzyme in oxidative energy production and supports antioxidant

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defense, helping athletes adapt to high-intensity training. Vitamin B12 is essential for red blood cell production and nerve function, preventing fatigue, anemia, and impaired coordination in athletes [3].

From a clinical perspective, vitamin B1 deficiency is associated with beriberi, which manifests as muscle weakness, fatigue, and impaired cardiovascular function [4]. B12 deficiency is linked to megaloblastic anemia, fatigue, and coordination problems. At the cellular level, lack of B-vitamins disrupts ATP production, amino acid metabolism, thereby weakening both muscular and cognitive performance. B2 deficiency may result in cheilitis, glossitis, and reduced oxidative metabolism [3].

While maternal B12 supplementation provided an early advantage in bone mass, this effect was not permanent. By one year of age, the bone mass of offspring from supplemented mothers was similar to that of the control group, suggesting that the maternally derived stores of B12 are eventually depleted [5]. Consequently, some competitive athletes may overestimate the sustained efficacy of vitamin B12 for recovery, leading to daily supplementation without evidence-based justification. Research suggests that endurance athletes and those engaged in high intensity training require higher B vitamin intake due to increased metabolic demands. Ensuring sufficient levels through diet or supplementation can prevent energy imbalance, reducing the risk of overtraining injuries, and optimize both short- and long-term athletic recoveries.

While maternal B12 supplementation provided an early advantage in bone mass, this effect was not permanent. By one year of age, the bone mass of offspring from supplemented mothers was similar to that of the control group, suggesting that the maternally derived stores of B12 are eventually depleted [5]. The prioritization of vitamin B12 supplementation by athletes may represent an inefficient allocation of nutritional resources, with unsubstantiated claims regarding its isolated benefits.

A research suggested that a single injection of vitamin B12 into the B12-deficient mothers during gestation was sufficient to completely prevent the bone defects in their offspring, restoring bone mass and strength to normal levels. Offspring from mothers who received vitamin B12 supplements showed a significant, dose-dependent increase in bone mass compared to the control group [5]. This was attributed to an increase in bone formation, specifically an increase in the number and activity of osteoblasts, which is bone-building cells. These findings demonstrate that maternal vitamin B12 status is a critical determinant of offspring bone quality and strength. Therefore, while vitamin B12 contributes to bone health, athletes should contextualize its importance within comprehensive nutritional strategies tailored to their specific sport demands.

4. Vitamin D deficiency risks and supplementation dilemmas

Vitamin D is a fat-soluble vitamin that regulates calcium and phosphorus metabolism, supports bone mineralization, and contributes to immune and muscular functions. For young athletes, sufficient Vitamin D is essential not only for skeletal strength but also for muscle contraction, immune defense, and overall physical resilience [6].

Vitamin D deficiency can lead to multiple pathological outcomes. A lack of Vitamin D reduces intestinal calcium absorption, resulting in decreased bone mineral density and a higher risk of stress fractures. It also impairs immune responses, making athletes more vulnerable to infections and prolonged recovery times [6]. Recent studies have established that vitamin D is crucial not only for general health but also specifically for athletic performance. It highlights that insufficiency in this vitamin is a significant issue in internal medicine, with certain groups like infants, the elderly, and premenopausal women being at higher risk for related problems such as osteoporosis. This concern extends to the athletic population, with research indicating female athletes demonstrate particular susceptibility to vitamin D deficiency.

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Vitamin D directly affects athletic performance by reducing bone strength, increasing injury risk, and impairing muscle function. Athletes with low Vitamin D levels often experience reduced endurance, slower reaction times, and diminished training efficiency. Moreover, monitoring Vitamin D status and ensuring adequate sun exposure or supplementation are critical for optimizing youth athletic performance and long-term health. Particularly among female athletes, current research underscores the necessity of monitoring vitamin D intake to prevent bone-related pathologies.

A study on boys with type 1 diabetes by Myśliwec and colleagues suggested that those with vitamin D deficiency likely experienced greater glycemic variability during exercise. Larson-Meyer and colleagues highlighted the challenges in accurately assessing vitamin D intake through questionnaires due to influences like body size and dietary sources [7]. These findings underscore vitamin D's physiological significance while highlighting the complexities in monitoring its adequate intake—necessitating refined assessment protocols and personalized nutritional interventions for young athletes.

5. Conclusion

This paper has explored the significance of Vitamin C, B-complex, and Vitamin D in the health and performance of youth athletes. Each of these vitamins plays an irreplaceable role in supporting energy metabolism, immune defense, bone strength, and muscular recovery. Deficiencies not only disrupt physiological functions but also contribute to specific pathological conditions that may remain undetected yet significantly impair athletic development. The consequences of vitamin deficiency in young athletes extend beyond immediate performance decline, potentially compromising long-term musculoskeletal and metabolic health. Thus, evidence-based nutritional strategies—including dietary optimization and individualized supplementation—are critical for mitigating deficiency risks, enhancing athletic performance, and safeguarding lifelong well-being in young athletes. Collaborative efforts among coaches, nutritionists, and athletes to implement science-driven nutrition protocols will empower young athletes to maximize their potential while minimizing health risks.

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