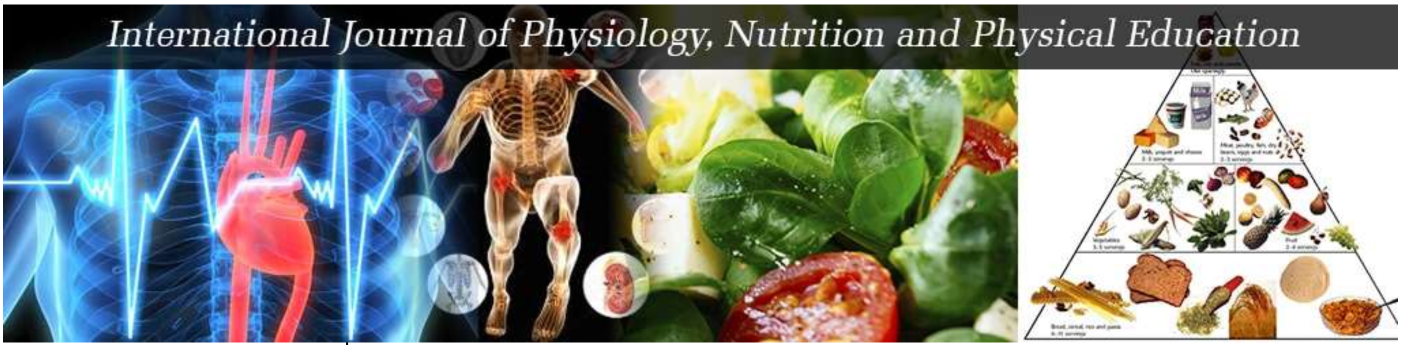

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Optimizing bone strength: Impact of calcium intake in athletes

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Abstract
Minerals are required for a wide variety of metabolic and physiologic processes in the human body. Some of the physiologic roles of minerals essential to athletes are their involvement, such as muscle contraction, normal heart rhythm, and conduction of nerve impulses, oxygen transport, oxidative phosphorylation, enzyme activation, immunity, antioxidant activity, bone strength, and acid-base balance of the blood. Athletes should pay attention to their bone strength and physical stature, whether this links to their longer-term bone health (e.g., risk of osteopenia and osteoporosis) or their shorter-term risk of bone injuries. Conceivably the most apparent method to do this would be to revise their practice loads, although this view seldom shows common with coaches and athletes for apparent reasons, so various circumstances to support the athletes' bone strength need to be explored. Energy availability is vital in the athlete's bone health, although improving energy balance points is highly unreliable for many athletes. On the balance of the possible evidence, it would seem dubious that higher animal protein intakes, in the amounts suggested to athletes, are detrimental to bone health, especially with sufficient calcium intake. Dermal calcium losses might be a vital consideration for endurance athletes, particularly during long training periods. In these circumstances, some forethought should be given to pre-exercise calcium intake. Vitamin D is essential for an athlete to conserve their bone health. There remains a lack of knowledge about the longer-term effects of different dietary and nutritional practices on athletes' bone strength, which needs to be addressed soon.

Keywords: Vitamin D, calcium, minerals, osteopenia and osteoporosis

Introduction
The muscular system, which indicates to skeletal muscles and bones, is the most substantial element of the human body and functions, as one unit, to give the body fitness, support, and movement. The muscle contractions put a mechanical strain on bone and significantly impact bone density, size, and strength (Brotto & Bonewald, 2015; Sleivanen *et al*., 1996) [4, 21]. The support of optimal bone health depends on the interplay between numerous physiological, genetic, and lifestyle factors that include adequate nutrition and optimum hormone levels; besides, exercise and a deficiency in one aspect cannot be compensated for by improvement others. Athletes seem to have sufficient levels of Vitamin D. The deficiency of vitamin D is generally widespread in the athletic population, with an increase in morbidities and the appearance of osteomalacia and osteoporosis (Koundourakis *et al*., 2016; Bikle *et al*., 2014) [11, 2]. The purpose of this review is to analyse the relevance of vitamin D in athletic performance. This review points out advances in this field and novel insights about vitamin D supplementation in athletes.

Synthesis and Metabolism of Vitamin D
Vitamin D is a micronutrient for its deficiency that can be treated by supplementation or additional intake, and it is also a prohormone, seeing that its precursors are transformed into active metabolites. It appears in two biologically inactive forms, cholecalciferol (vitamin D3) and ergocalciferol (vitamin D2) (Zhang *et al*., 2010; Last 2001) [24, 12]. Vitamin D is synthesized in the skin. Cholecalciferol, or vitamin D3, is the prime source of endogenous Vitamin D and is produced through ultraviolet B radiation after sun exposure with 7-dehydrocholesterol, which is stored inside the plasma membrane of our skin cell. Ergocalciferol, or vitamin D2, represents a small fraction and has its source in exogenous

dietary intake (Plum,& DeLuca 2009; Norman 2008) [18, 15]. The significant metabolite of vitamin D is administered through the bloodstream by the binding protein vitamin D (BPD), transferring various skeletal and extra skeletal target organs.

Mechanism of Action

The functions of Vitamin D are performed in the body via two pathways through endocrine and autocrine mechanisms (Forrest & Stuhldreher, 2012) [7]. The endocrine mechanism is the most studied research work. Vitamin D is needed in bone growth, density, and remodeling (Ovesen *et al*., 2003) [16]. When vitamin D levels decrease a below normal limit, the Parathyroid hormone increases bone resorption to meet the body's demands for calcium. This means that low levels of Vitamin D lead to an increment in bone turnover with a risk of bone injury, consist of stress fractures, which are common in Athletes. The second mechanism of action of vitamin D comprises an autocrine pathway. Nevertheless, this pathway is essential since it controls many of the organism's key metabolic processes, such as signaling mechanism, gene expression, and genetic response, hormone synthesis, protein synthesis, immune/inflammatory response, turnover, and cell synthesis. Without Vitamin D, the ability to respond to physiological and pathological symptoms effectively would be totally altered (Wang *et al*., 2012) [22]. This vitamin D works as a modulator of up to 2000 genes involved in cell growth, immune function, and protein synthesis (Norman *et al*., 2008) [15].

Deficiency and Insufficiency of Vitamin D on Athletes

Over the last years, several studies have identified athlete groups with deficient or inadequate circulating vitamin D (Owens *et al*., 2015) [17]. The connecting link between low vitamin D levels (serum 25-hydroxyvitamin D levels below 25 nmol·L^{-1}) and bone, where it plays a vital role in calcium and phosphorus regulation in the body, is highly convincing that athletes who are deficient in vitamin D will be at risk of low bone mass (Holick, 2007) [9] and bone injuries, such as stress fractures. Osteoporosis and related frailty fractures represent a severe global public health problem projected to increase as our society ages (Cumming *et al*., 2002; Kannus *et al*., 2002) [5]. In cases where infants had deficient calcium intakes (below 200 mg per day) and normal vitamin D levels, there was a radiographic appearance of rickets (Hildbolt, 2005). The first group's bone mineral content was 14 percent less, and the height was 4 percent less compared to children in the second group (Faulkner *et al*., 1993) [6]. Continued dietary deficiency of calcium has not been studied in humans; however, it is known that the malnourished bones are very thin and fragile (Himes, 1978). There is a requirement to promote more information on the potential for vitamin D deficiency, according to the Scientific Advisory Committee on Nutrition (SACN), as vitamin D deficiency is linked to poor musculoskeletal health. Developing evidence implies that vitamin D may be necessary for stress fracture prevention in the athletic group (Wilson *et al*. 2020; Bechard *et al*. 2020) [23, 1]. These can be attributed to a sudden elevation in physical activity, decreased lower extremity strength, low bone density, and menstrual disturbance history (Amnenorrhea) (Moran *et al*. 2013) [14]. Stress fractures have also been reported most commonly within prospective military recruits' studies and have been attributed to the elevated physical activity during intensive training programs. Researches in this area are complex. Many factors, including vitamin D deficiency, can lead to a stress fracture, including overtraining, low-quality diet, smoking, drinking, age, and amenorrhoea (absence of menstruation) in female Athletes (Mayer *et al*. 2014) [13]. In a project work of 25 female distance runners developed for two years, higher daily consumption of calcium, skimmed milk, milk, and value-added dairy products was observed to be linked with a 68% lower incidence of stress fractures (Shane *et al*. 2010) [20]. Furthermore, a dose-response study would pro-vide greater insight as to whether enhanced vitamin D status is associated with greater muscle power and muscle strength

Conclusion

The available scientific evidence clearly indicates that a sufficient amount of calcium should be provided in the diet to ensure a healthy bone mass and allow individuals to reach their genetic potential. Osteopenia has been recognized only at deficient levels of calcium intake, below 500 mg per day. Nonetheless, higher consumptions appear to be expedient. Other conditions also need to be performed; these include sufficient intake of other nutrients inevitable for bone formation, such as vitamins C, A and K, zinc and copper, and high mechanical demand on the skeletal system through an adequate weight-bearing exercise level. This observation points to the general reference that individuals consume an equitable, healthy diet, should be correlated with physical activity, to get rid of osteoporosis as well as other chronic diseases.

Conflicts of Interest: The author declares no conflict of interest

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